Improving Smart City Frameworks Based on Enterprise Architecture Using Territorial Governance to Manage COVID-19 Crisis

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Abstract—: **In this paper we propose to improve smart cities frameworks based on enterprise architecture with territorial governance for managing Covid-19 crisis using GIS technology. With GIS technology, smart cities are able to meet their technological challenges through the information and technology infrastructure. In the same context, we found that many Enterprise Architecture frameworks are used to build smart cities but we found also that they do not provide a deeper insight on data, application, and technology aspects and they didn't take business process and services into consideration. In this paper we propose to improve theses frameworks by considering territorial governance which will rise to a more sustainable territorial development. Territorial governance is considered as a modality or mechanism for effective coordination of actors or organizational entities in a territory. We think that EAF are the only frameworks which are able to support all the perspectives and roles defined in a territorial governance approach. Through using GIS technology, we will be able to implement effectively these artifacts.**

Keywords— Smart cities, Enterprise Architecture frameworks, GIS, Territorial governance, COVID-19

I. INTRODUCTION

Smart cities are generally considered as new models which provides new concept of knowledge-based digitalization addressing many fields such as information technology, transport infrastructure, resource consumption or environmental impacts. Indeed, they are composed of a well-constructed business plan [1], and a design of information and technology infrastructure. Many authors confirm the important role of Geographical Information system (GIS) for building smart cities. With GIS technology, smart cities are able to meet their technological challenges. Geographical Information System [GIS] is a computer system capable of capturing, storing, checking, integrating, manipulating, analyzing and displaying data in digital form related to the position of the earth surface [2][3].

Due to the rapid growth of technology during these last decades, GIS expressed specific challenges in storage and spatial data analysts. It is considered as an important tool for problem solving and decision making [4].

The mission of every organization is to exist tomorrow and satisfy their customer base. That can only be realized by creating a long-term value and take advantage of opportunities [5]. According to [6], as part of the competences required by organizations to create value now and in the future, they must align the operations of the enterprise including the information systems, processes, and business functions with its strategic direction and business goals [25]. The situation is more complex in smart cities context. In fact, we have to find new method to apply GIS technology to align information technology and business within the organization which is referred to as Enterprise Architecture.

Literature reviews shows that various Enterprise Architecture conceptual frameworks were developed to attain smart city goals. However, they do not provide a deeper insight on data, application, and technology aspects. they do not take business process and services into consideration. Moreover, all the existing frameworks specify different layers of the architecture, but they do not provide clear connection between these layers and the alignment with the smart city strategy. Some of them focus on city goals, objectives and indicators. However, the others give more importance to the solution

architectures and technical details, while neglecting business process and services.

In this paper, we propose a territorial governance approach to enhance the Enterprise Architecture Framework used to build smart cities.

II. GIS USED IN SMART CITIES AND TERRITORIAL GOVERNANCE

Smart Cities use various ICT solutions to address urban challenges such as environmental sustainability, economic, social, and participatory governance as well as improved public services, collaboration planning and decision-making [7].

Smart Cities imply the integration of the current substructure with new information and communication technologies to create a comprehensive system of efficient urban services (Maruf et al., 2020).

They benefit from digital systems to ameliorate the performance and modality of urban services, to reduce financial burden, minimize the consumption of social networks and geolocation resource and ensure communication between citizens (Barr and al, 2021).

According to Pereira [8]., these characteristics allow transforming conventional governance into smart governance.

therefore, it is obvious that smart governance is based on good governance aided by ICT, as proven by Graham [9], it could be defined as a model of governance that allows attaining environmental and economic goals set by citizens.

ICT applied to the urban environment produces a large amount of data and information flow, and the application of technological tools to governance involves complex legal change based on:

- movement of open data.
- growing knowledge of sensor technology and the internet of things (IOT).
- social networks and geolocation.

GIS promotes the intelligence evolution of cities and offers a range of concepts, methods and technologies allowing their development.

In addition, the development and implementation of geo-information sensors, navigation systems, wireless communication system, cyber-infrastructure and (IOT) increases the flow of geographic data and, therefore, accelerates the reaction of society to geographic information [10], which produces a vast ecosystem of data producer and consumer [11].

In fact, geospatial data and GIS play an important role in improving the intelligence of most dimensions of the smart city (citizens, mobility, life, environment, governance and economy). Thus, GIS can provide a geographic frame of reference that promotes organized data, decisions based on geo-analysis and public information sharing [12], which makes it.

Therefore, GIS becomes an ideal platform for urban planners, policy makers and the general public to understand, participate and influence urban processes.

III. ENTERPRISE ARCHITECTURE FRAMEWORK FOR SMART CITIES

The smart city implementation assumes applying the city strategy into an effective improvement of life quality for the citizens. This task is complicated because many sectors are involved, stakeholders, high interdependency, cross-sectoral cooperation and novel, dynamic, and interactive services [13]. As said before, Smart city should be composed by a well-constructed business plan [14], and a design of information and technology infrastructure to provide a platform for services integration. Several Enterprise Architecture frameworks have been proposed to describe smart cities architectures in response to this complexity.

Langenberg & Wegmann [15] defines Enterprise Architecture as "blueprint that documents all the information systems within the enterprise, their relationships, and how they interact to fulfil the enterprises mission". EA is aligning information technology with business hierarchically [16]. Enterprise Architecture entails the use of frameworks that support enterprise analysis from the level of business to the level of Information technology. Zachman in 1987 introduced the *Framework for Information Systems Architecture* which is mostly regarded as the initial step towards the EA discipline [17].

The name "Enterprise Architecture" was however not coined until later in 1996 when the government of America via the Clinger-Cohen Act directed federal agencies to implement a holistic methodology to align business goals to information technology. The term enterprise architecture has aroused a lot of thoughts and interests and is now commonly understood as a hierarchical approach to aligning business and information technology. Some very popular frameworks are The Open Group Architecture Framework (TOGAF), The Federal Enterprise Architecture Framework (FEAF), Zachman Framework for Enterprise Architecture, and The Gartner Methodology. According to [18] All of these different frameworks were initiated with the intention of solving two problems:

- **The Complexity of Systems** – Huge sums of money were being spent by organizations to build IT systems; and
- **Poor alignment of Business** – Organizations found it continuously difficult to align the rather high cost of IT systems with business need.

Enterprise architecture (EA) is the process of translating business vision and strategy into an effective enterprise change by creating, communicating and improving the key requirements, principles and models that describe the enterprise's future state and enable its evolution [19]. The benefits of applying EA are visible in increased stability of an enterprise in an environment of constant change, better strategic agility, and improved alignment with

business strategy [23][24]. Enterprise architecture approach can support the development and transformation of smart city based on the city strategic plan.

In the next section, we will detail some EAF enterprise architecture framework used in the context of smart cities and we will align the major problems observed.

- Cisco Smart City Framework does not address layers and connections between data, application, and technology. The Framework for Smart City Applications Based on Participatory Sensing k does not address completely the business layer with the specification of smart city goals, processes and business services.
- A Conceptual Enterprise Architecture Framework for Smart Cities it focuses only on the application layer of the smart city.
- A framework for the realization of smart cities through the Internet of Things, there are no additional details about components of the business layer such as goals, processes, organization units or business services.
- A Community Architecture Framework for Smart Cities consists of data, function, network, organization, schedule and strategy components. The connection between these components is represented through different artifacts and models. However, the details of these artifacts or models are not present.

As we can notate, the cited EAF are enable to propose a global approach taking into account the different layers. In fact, Smart City is a city with a development concept using existing resources effectively and efficiently and can be used to maximize the benefits of citizens through the use of information and communication technology. And that's why we need to enhance the Enterprise Architecture Framework for smart cities with territorial governance approach.

IV. PROPOSED APPROACH:

In this paper we propose to improve smart cities framework based on enterprise architecture with territorial governance using GIS technology. Territorial governance covers all situations of cooperation and construction of collective action in non-hierarchical organizations where the State plays the role of precursor through the establishment of regulatory instruments and mechanisms. Territorial governance is considered as a modality or mechanism for effective coordination of actors or organizational entities in a territory. Associating with public actors (State, local authorities, etc.), private actors, belonging to the business world and /or civil society understood in the broad sense (associations, non-governmental organizations, trade unions, etc.) Territorial governance is therefore synonymous with the involvement of civil society in decision-making and local actors who are asked to respond collectively to the issues that concern them. We think that EAF are the only frameworks which are able to support all the perspectives

and roles defined in a territorial governance approach. Through using GIS technology, we well be able to implement effectively these artifacts.

GIS designers should have a basic understanding of enterprise architecture if they wish to import enterprise architecture principles, methods or ideas into their system.[26]

Enterprise architecture is defined by Lankhorst as "a coherent whole of principles, methods, and models that are used in the design and realization of an enterprise's organizational structure, business processes, information systems, and infrastructure", with a "focus on alleviating the infamous business-information technology alignment problem". Such alignment is typically achieved through the creation of models describing an enterprise, including business and IT elements, so that it can realize management requirements and be maintained over the period of its useful life.

Enterprise Architecture is a hierarchical way of describing how the information systems, business processes and people in an organization function as a whole. It provides a blueprint for defining the structure and operation of organization through these four layers, business, data, application and technology.

When implementing an Enterprise Architecture, several steps must be followed.
- We must first start by determining goals and objectives. A goal is a statement of what the organization will accomplish. Each goal is written in an easy-to-understand sentence structure. Under the guidance of Enterprise architect, the design team will use several tools to establish an early vision of the organization, and guide the organization's efforts in developing the enterprise architecture.
- When a vision of the organization is established, the next step is to determine who is responsible for each part of the vision. Establishing and defining roles and responsibilities is important for creating the architecture's structure and chain of command [10]. The only way to develop the enterprise architecture and bring it to life is by filling the positions within the architecture. Each position carries with it certain amount of responsibility, and the person who assumes the role must complete the associated tasks.
- The next step is how to organize your data and information. Data and information are two very important resources in the overall enterprise architecture. Data converted into accurate and reliable information will impact almost every decision made at each level of the organization. Converting data into valuable information that can help the organization adapt and thrive is the heartbeat of the data architecture. Reliable, accurate, and current information can only be created from a good set of data. Good clean data sets are the results of establishing data

standards, principles, and practices. The data architecture will establish data standards, principles, methods and a governance policy. (USGS 2016) Establishing a set of data standards is important to getting everyone on the same "data page" when communicating ideas or developing applications.

- The last step is to choose the necessary tools to help designing the framework. Architectural languages are modeling tools and set of concepts and notations that support the framework and help enterprise architect to create, visualize, analyze and model the enterprise architecture. Some of the tools that may help are: Archi,ARIS, Abacus, SAP Power Designer….

Our approach consists of 4 phases [20] [21] [22]:
- Perform an analysis of the existing and produce a map of this existing: To understand the situation and to know where we start from.
- Consider the strategic and operational objectives: Make sure you understand why and how to evolve the information system to respond to strategic objectives of the institution.
- Define the target information system: Identify the functional needs associated with the evolution and business process improvement needs, State the guiding principles of the information system urbanization, Describe an "ideal target". Define the evolution plan: Qualify what to do to move towards the target, in which order, under which conditions and for which results.
- Choose the necessary tools to help design the framework.

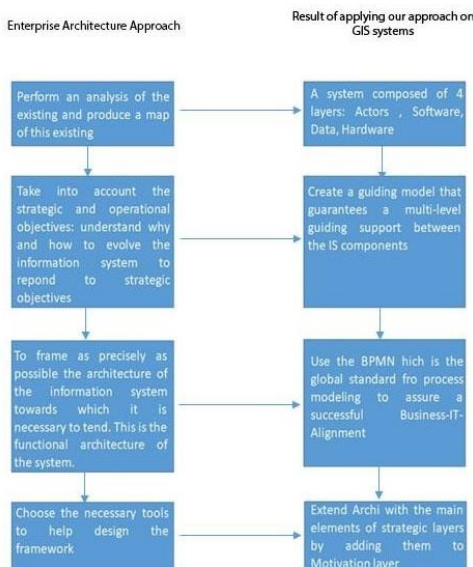Applying this approach on a GIS will result in:

Fig.1. Result of applying our proposed approach on GIS systems

We must improve GIS performance through the incorporation of ideas, tools, and methods from enterprise architecture. The most effective way to create unified, organized, and efficient GIS is through enterprise architecture.

Bringing enterprise architecture into GIS can be and should be done by everyone designing or developing plans for a GIS system. Merging the two types of enterprise systems might seem like a daunting task; it requires more thought and effort, but this extra level of planning will simplify system implementation, maintenance, and upgrading. The return on the investment of extra effort, thought, and planning is a well-organized, efficient, responsive GIS system that converts data into valuable information.

V. CASE STYDY

In this section we will take Tunisia's health care information system as an example to improve managing hospitalization of a patient infected with COVID-19.

Using GIS won't be of much help to insure finding an available bed in a hospital. There are some cases where patients taken to a hospital had to be taken to another hospital due to insufficient beds, even in other cases not only COVID, Taking a patient to a hospital without knowing if there are available beds or staff can be fatal.

That's why we will try to show how EAF will contribute to improve the process of health care information system response to COVID-19 patient specially by considering territorial governance.

We adopt QGIS because it is a free and open-source cross-platform desktop GIS application that supports viewing, editing, and analysis of geospatial data. To have a better response we tried using QGIS and locate all the hospitals in the country as shown in yellow in the figure below:
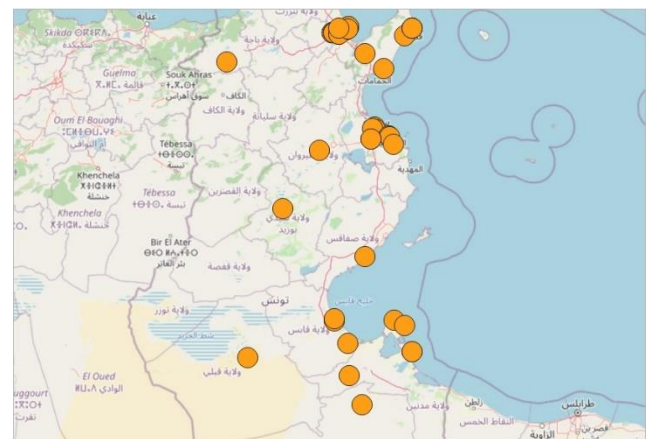

Fig. 2. Location of hospitals using QGIS

Then, we tried to look at all the data available to check the nearest hospital and how many beds/staff/ER etc. are available. But sadly the data that we found doesn't help at all because it lacks every single important information needed. After looking at the data available to us, we

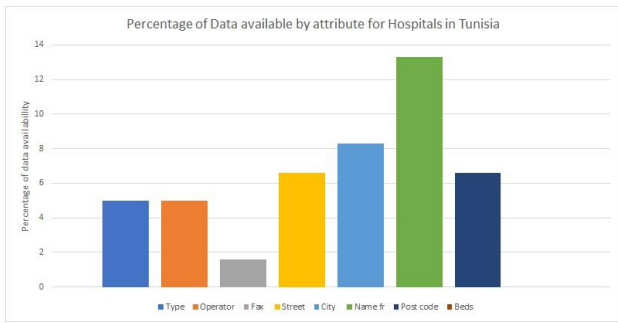notice that most of the data about the hospitals are nonexistent as shown in figure 3:

Fig. 3. Hospital's data using QGIS

As shown in the Fig 3, some attributes have 0% data available which will hinder our process to choose the best hospital for an emergency case.

We then tried to compare the data availability of Tunisian hospitals to other cities that have a better healthcare system like New York, Munich, Philadelphia and Chicago as shown below:
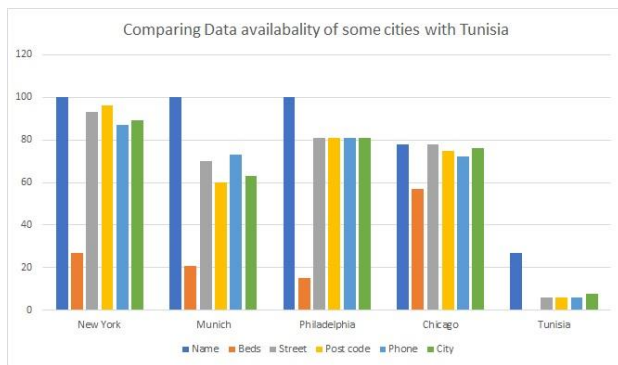

Fig. 4. Comparing data availability of some cities with Tunisia

In the fig. 4 we can see that some attributes in other cities have an availability percentage of 100% compared to Tunisia which has around 27%. The figure shows that the Tunisian hospitals don't even have their names registered in QGIS which shows the lack of data concerning the healthcare system provided by the government. In Chicago we can see that almost 60% of hospitals provide the number of beds available to patients whereas in Tunisia the attribute itself is not considered in the data registered in QGIS which explains the 0% we have in the figure. If we take New York as an example, looking at the amount of data available we can easily figure out which hospital to go to in case of an emergency since we know the name, the location, phone number and even the available beds which will help in rescuing the patient faster.

After looking at the data tables of hospitals in Tunisia we noticed that only 79% of data are missing which will make choosing a hospital harder. In the figure below we can see that in Philadelphia the amount of data provided is over 50 % which is a good percentage compared to Tunisia's percentage, having a 50% would greatly enhance the healthcare system. This shows that data

plays a great role, if not the most important role, in having a good healthcare system.
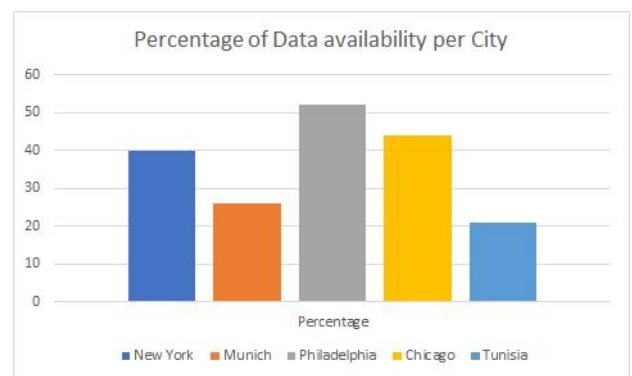

Fig. 4. Percentage of Data availability per City

This is where the need for a guiding approach to help solve this problem. Using our approach, we created a guiding model that will help create a system where using a GIS can help to find out the nearest hospital with available equipment, staff, material and if the hospital is capable of prioritizing the new patient or not.

With available equipment, staff, material and if the hospital is capable of prioritizing the new patient or not.

Data will play a big role in assuring this process, we already mentioned how we need to create data standards and the need to gather correct and up-to-date information which is why adopting our guiding approach into GIS will make the health care staff make better decisions and will make it easier to start the treatment as fast as possible and avoid putting the patient's life in danger.

We need first to have enough data to help make a decision, for that reason we updated the attribute table of hospitals by adding important factors like: number of beds, number of doctors, number of nurses etc..... so, we created a new CSV file with the new data (random data) to be added and we kept the same "id" that represents each hospital and only added the data we needed to each hospital. The figure below represents the data that we will add:

Fig. 5. New Data to update the attribute table

After adding the table above, the attribute table of Tunisia's hospitals will be updated to be like presented below:

Fig. 6. Updated attribute data

Having this data will make it easier to decide on which hospital is better, which hospital have enough material and stuff to take the new patient to.

VI. Innovative Contribution

In this article we tried to explain how an Enterprise Architecture can address Enterprise GIS systems lacking, as in strategy, principles, standards, or even goals. By using Enterprise Architecture methodologies, we were capable of creating a strategy that leads us through the whole process of implementing an EGIS, by creating principles, standards and goals to determine our desired system. These elements mentioned above allowed us to avoid the problems that comes up from implementing an EGIS without having a strategy or goal like duplicate, misnamed, or improperly formatted datasets, redundant projects, efforts, data format, and employee efforts, which will create staff confusion, wasted time and effort.

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