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CONVERGED CITIZEN SERVICE IOT PLATFORM REFERENCE MODEL FOR SMART CITIES

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ABSTRACT

Growth of densely populated urban areas brings multiple problems associated with high population density. A Smart City is a new way of managing urban environments with the help of the latest advancements in technology. In this paper we analyze the Smart City related research and conceptualize the smart city platform. We explore the definition of smart cities from a scientific, technological and economic point of view and discuss what defines a smart city platform. In the second part of the paper we discuss a multilayer smart city platform model. The model is aimed to define the components of a smart city and to combine them together into layers. Creating such a logical structure will allow easier development of a scalable and easily maintainable smart city platform.

Keywords: *Network, Platform Reference Model, Smart City, Smart City Platform*

1. INTRODUCTION

The growth of urban population is observed all over the world. According to scientists, by 2050 it accounts for 70% of the world's population [1]. With the increase in megacities, there are many problems associated with high population density, urban traffic, and efficient use of resources. In many countries ambitious projects are being implemented to develop modern urban infrastructure based on the use of modern technologies – this concept was called Smart City. "Smart city" should be characterized by a highly efficient economy and management, a high standard of living, mobility, and respect for the environment for long-term sustainable development.

For a "Smart city" to have an effective management and analytical tool is important to prevent as much as possible negative tendencies. To solve the problems of modern cities, new-generation IT systems are being developed and tested, using the Big Data analytics, complex computer modeling, applying the results of the latest scientific research in the field of sociology and human behavior.

With the help of information and communication technologies (ICT) it is possible to visualize data and solve various problems of sustainable development and rational organization of the urban environment on the scale of the whole ecosystem and its environs.

Number of Smart City projects in the world (planned or already implemented), has exceeded 400. However, only a few clearly define the use of ICT and their role. Most of the projects are focused on energy and traffic management. Only 27 of them are devoted to the development of ICT. And this disproportion has become one of the reasons why Smart City projects face serious problems. Meanwhile, ICTs can play a decisive role in bringing together different approaches, becoming a kind of "circulatory system" linking different infrastructure levels and providing information exchange between them.

For examples of cities of three types, differing both in the design of existing infrastructure systems and the initial level of development, McKinsey Global Institute estimated how about 60 modern solutions for a smart city affect various aspects of the quality of life. The use of these new tools provides a number of positive results: in particular, they can reduce mortality by 8–10%, increase the efficiency of emergency response by 20–35%, reduce the average time spent on and from work by 15–20% , reduce the incidence of 8–15%, as well as reduce greenhouse gas emissions by 10–15% [2, 32].

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At present, 78% of the population live in the cities of the European Union, 85% of GDP is produced in cities [2]. In this regard, in 2007 the European Council adopted a new environmental. The plan includes the so-called "three 20 targets", or in another record - three goals for the climate 20/20/20 [3]. More precisely, in fact the plan contains four sentences, and they are reduced to the following:

- Reduce EU greenhouse gas emissions by 20% by 2020 compared with 1990.
- Increase energy efficiency and reduce by 20% the amount of energy consumed by 2020.
- Achieve 20% of renewable energy in the total energy consumption in the EU by 2020.
- Increase up to 10% of bio-fuel use by cars by 2020.

Higher indicators of the smart city are planned by 2030 as shown in Fig1.

The goal of this paper is to analyze the Smart City related research and conceptualize the smart city platform.

Figure 1: Planned Smart City indicators of the European Union by 2030 [4]

2. LITERATURE REVIEW

Manuscripts must be in English (all figures and text) and prepared on Letter size paper (8.5 X 11 inches) in two column-format with 1.3 margins from top and .6 from bottom, and 1.25cm from left and right, leaving a gutter width of 0.2 between columns.

2.1 Smart City Definition

Throughout the world, the provision of acceptable living conditions in a rapidly growing urban population requires a deep understanding of the concept of a smart city. However, as mentioned above, this concept is only being formed. At the same time, the term itself is already used throughout the world in various structures of urban problems, contexts and meanings. A number of variants of the term, often used, is generated by replacing the adjective smart with adjectives such as digital, connected or intelligent.

One recognizes the term “Smart City” as a way of marking a purely urban phenomenon, noting that the marker "smart city" is a concept and it is not always used consistently. Below is a summary of several working definitions that can be found in materials that have scientific, applied and educational purposes and describe the concept from various points of view [4]. This cacophony of definitions undoubtedly requires continuation of conceptual research in the field under consideration, in the following sections the concepts from the most authoritative consulting companies at the global level will be presented, and everything should end with the standardization of concepts and solutions. Summary of working definitions of a smart city:

2.1.1 Scientific view

"A smart city is a safe, environmentally protected, efficient urban center of the future with an advanced infrastructure of sensors, electronics and networks that stimulates sustainable economic growth and a high quality of life" [5].

"The city will become smart when investments in human and social capital and in the traditional (transport) and modern (ICT) communication infrastructure nurture sustainable economic growth and a high quality of life." These investments should be supported by wise management of natural resources through participatory city administration " [6].

"This is a city that strategically builds and implements the development of the economy, human capital, city management system, mobility infrastructure, environmental protection and quality of life." This development is built on a clever combination of endowments and citizens' activities that are consciously and freely making decisions "[7].

2.1.2 Economic view

"The smart city is an advanced and high-tech city that unites people, information and elements of urban infrastructure. It has a simple system of management and servicing of the municipal economy and uses new technologies for the sustainable formation of a green city (improving environmental protection), creating a competitive and innovative Trade and improve the quality of life "[8].

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"To achieve the goals of combating climate change, Amsterdam, as a smart city, uses innovative technologies and the willingness of residents to change their energy consumption behavior." Accordingly, the Amsterdam development program implements a universal approach to the design and formation of a sustainable, economically viable city that reduces its Carbon footprint "[9].

2.1.3 Information and Communication Technology view

"The use of smart computing technologies to make the critical components and services of the city infrastructure more intelligent, interconnected and effective." The city's components and services include: city administration, education, health and public order systems, urban real estate, transport infrastructure and systems Public services" [10].

"A smart city is based on an intelligent exchange of information flowing between a large number of its different subsystems. The city analyzes and translates this information flow into services to citizens and companies and processes it to make its ecosystem more sustainable and economical in resource costs. On the model of smart operating management, developed for sustainable urban development "[11].

"Smart City" is an administrative unit of people's settlement (district, city, region or small country) for which a holistic approach to the use of information technologies operating in real time to ensure its (administrative unit) of sustainable economic development is applied "[12]. Above definitions can be classified as shown in the Table 1.

Table 1: Classification of definitions of the Smart City

Signs of classification	Classification of smart city definitions		
	Ideological dimension	Normative measurement	Technological/instrumental measurement
Goal of creating a smart city	Improving the quality of citizens' life	Creating a green environment for living	Innovative working life
Focus on	Services	Infrastructure	Human/social capital

2.2 Smart City Platform

The City Platform should be the basic elements for the implementation of smart city services [13]. According to the latest document, the European Community has three main objectives:

- Define general requirements and accelerate the process of launching services
- Adapting common open solutions in the industry
- Standardization - bringing the developed solutions to the level of international standards

On the relationship with other components the picture is quite transparent. At the bottom layer - interaction with sensors. These are platforms and standards of the Internet of Things (IoT). A typical example of modern development that has a direct bearing on the topic of Smart Cities is HyperCat [14]. Note that another popular abbreviation - M2M (Machine to Machine) falls into the same category as IoT. In principle, technically this is practically the same; the only difference is the availability (absence) of user interfaces. These interfaces are in IoT and are absent in M2M. In terms of platforms and standards, the picture in M2M is similar to the IoT [15]. The city platform is a higher level, using IoT as a tool. Their main idea is to connect growing data flows with existing services. The components of this initiative (in the European classification) are shown in Fig. 2:

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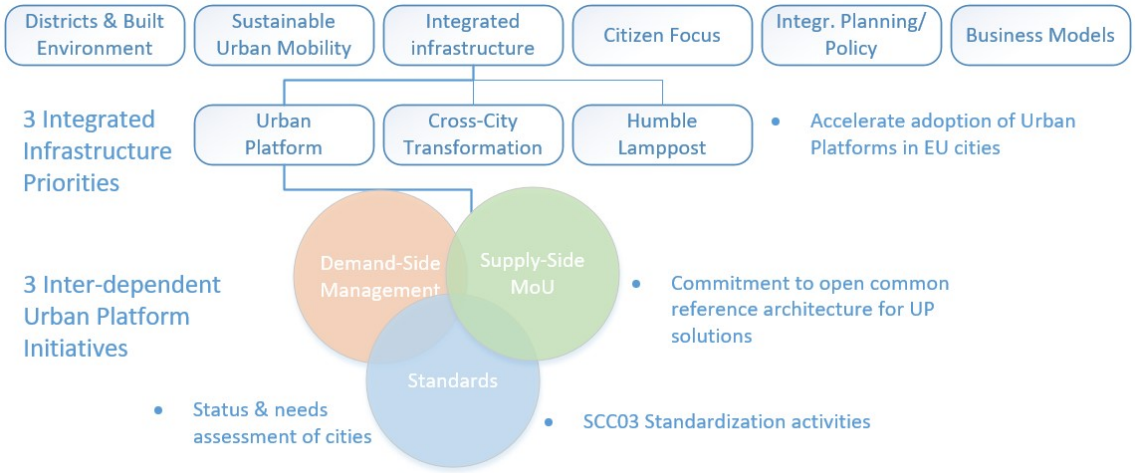

Figure 2: City Platform

The result of European developments should be the implementation of the basic architecture for the city platform, which will have to solve the following tasks:

- Ensure interaction between elements of urban infrastructure.
- Ensure the transfer of solutions between different cities.
- Support scaling of processes with increasing load.
- Provide common programming interfaces (APIs) for developers and related tools (SDKs) to accelerate the development process.

Initially, it is assumed that the architecture should contain (support) several levels. In particular, the following components are mentioned:

- Infrastructure.
- Data management, including semantics and ontologies.
- The level of open interfaces.
- Analytics.
- Creation and support of services.
- Security.
- System Management.

In general, to build a city platform, a solution is needed in three main areas [16]:

2.2.1 Communication

One of the main problems in the transition to the Smart City is inefficient (in the first place – duplicating communication channels. Therefore, the unification of data exchange processes must have the highest priority. At the same time, it is necessary to build on heterogeneous interactions from the very beginning due to the presence of information exchange systems on different network standards. A typical example is the same IoT sensors. There is no single communication protocol and, apparently, never will be.

2.2.2 Model of information representation

The grounds are exactly the same as for communications. Heterogeneity is also present initially. The final City Platform will have to provide interaction (use) of the most diverse existing services, which will have their own semantic models and, not least, their security systems.

2.2.3 Open service development environment

Without engaging Smart City developers, projects cannot take place. In this case, we emphasize the need for software interfaces covering all aspects (all areas) of measurements (measured data). The reason is that most interesting services fall into the category of mashups, that is, applications that use data from several sources. It is the combination of data that gives the most interesting results. Fig. 3 shows the general structure of the City Platform:

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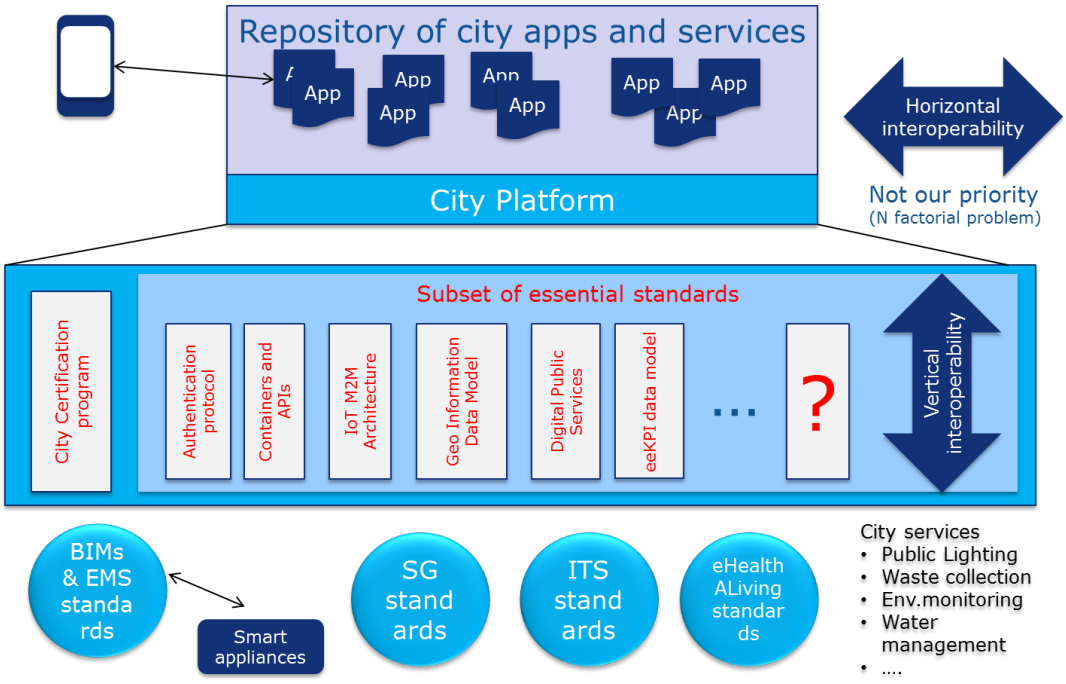

Figure 3: General structure of the City Platform [17]

Naturally, this European initiative, headed by the Fraunhofer Focus [18], is not the only one. Here you can mention, for example, TCS Intelligent Urban Exchange (IUX) [19], Hitachi develops its own platform and already has examples of use [20]. Social Glass [21] is a typical example of the City Platform project designed to integrate and visualize heterogeneous data sources [22]. But in general, it can be noted that the process of creating (most importantly, standardizing) urban platforms is at the beginning of its path. And accordingly, it is a very promising area for starting research.

3. MULTILAYERED SMART CITY CONCEPT REFERENCE MODEL

By analyzing different platforms [17-22] in the literature review, we suppose reference architecture for the future smart city platform as shown in Fig. 4.

3.1 Layer 1 – Hardware Layer

Cities, as urban machines of real events, require real-time system response. They comprise of real-time connections outlets such as radiofrequency transmitters, traffic signals, streets, smart meters, infrastructure sensors, and traffic and transit sensors [23]. In fact, the availability of real-time data is the constituting element of smart cities connecting the physical world with the information world and is the distinctive procurement that justifies the dynamic term of "smartness" [24]. Internet of Things, as a realization of digital into the physical world is expected to greatly contribute to addressing today's urban challenges [25].

Radio frequency identification (RFID), Near Field Communication (NFC), Real-time Locating Systems (RTLS), wireless sensor and actuator networks, and network Embedded Devices provide high-level access and utilization of real-world data and resources. The next generation of Internet technologies will be able to interact with devices connected to almost all objects created by human, because of the extremely large address space of IPv6 [26].

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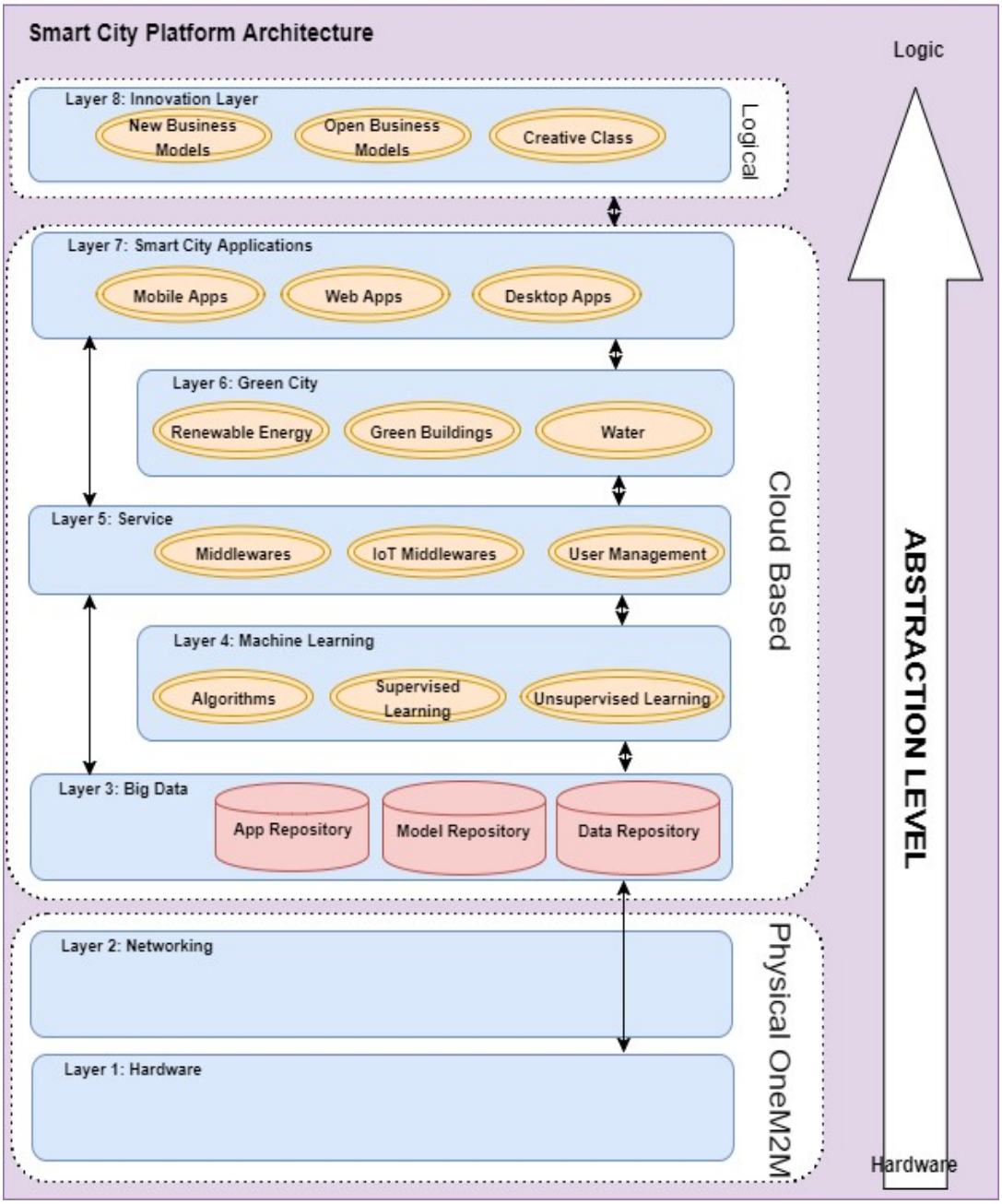

Figure 4: Smart City Convergence Platform Reference Model

3.2 Layer 2 – Networking Layer

The lowest layer of the Smart City architecture is "Networking" layer that in charge of administration and management processes of the city by scalable and extensible way. This layer responsible for identification of all the infrastructural components, devices and applied systems that connected to the platform including sensors, actuators, agents, controllers, servers, terminals, mobile and devices, etc. In the Smart City concept Networking layer can warranty the following properties [27]:

- Supports extensible management
- Resiliant failures to maintain uptime
- Has a guaranteed level of performance

Offers low latency

3.3 Layer 3 – Big Data Management Layer

The Big Data Management layer manages all data on the platform, including data collected from the city, users, devices, and data generated by the

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platform. To that extent, this layer has three repositories:

- Application Repository to storage applications, including source code, images, video and the app related documents
- Model Repository models for storing urban models, such as traffic patterns, sensor network models, data models, city maps and energy distribution models;
- A data repository for storing data collected from sensors, citizens and applications

Moreover, the big data processing module is also responsible for processing the city data. There are two types of data processing that are suitable for different situations: stream processing and analytics, to perform real-time analytics and data flow processing; And batch processing (HPC), to analyze large data sets. In addition, this module should be able to perform useful preprocessing tasks, such as data filtering, normalization and transformation.

Information Visualization is an important component, along with a Data Cleaning component for deleting data that is no longer needed and archiving old data on slower, high capacity stores. The Big Data Management layer has interconnection with all the other layers of the platform.

In resource [34], the authors offers communication platform for the development of smart city services and for remote control of various systems of smart city such as smart parking or smart travel by using big data management as noted in Figure 5.

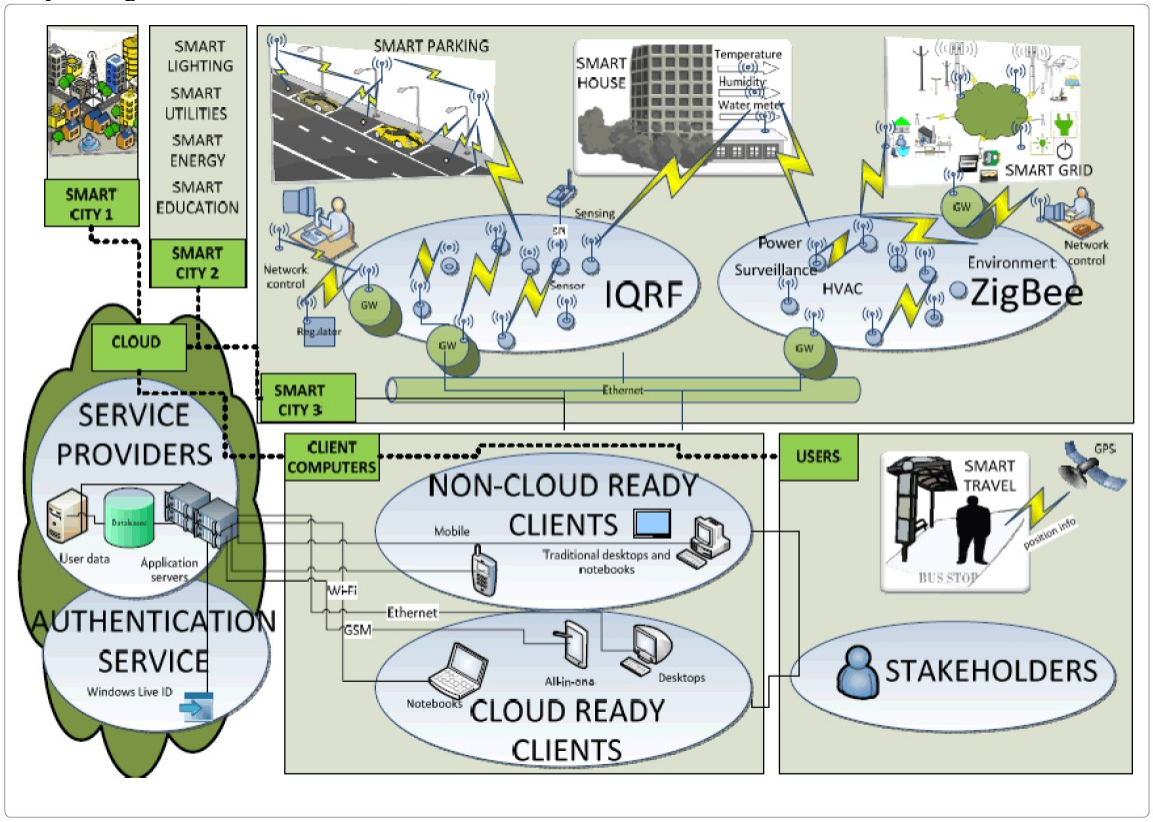

Figure 5: Planned Smart City indicators of the European Union by 2030 [4]

3.4 Layer 4 – AI and Machine Learning Layer

Next layer is a Machine Learning layer, which facilitates understanding of the city by automatically building behavior models of city processes and making predictions of city phenomena. Since a Smart City will produce enormous amounts of data. Cities are melting pots of many complex and interdependent problems. Machine learning can solve these related problems by optimizing city planning and integrating urban services for personalized results, even if people have not previously used specific services. For example, machine learning can track waste levels in garbage containers and individual data collection services

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based on waste forecasts. This could also provide insights into variable recycling rates.

To bring efficiency to the prediction process and to increase the accuracy of the models, we need smart algorithms to understand the pattern and learn from that. The machines should learn from experiences. Experiences are samples of labeled data fed by humans to the machines. The system observes pattern from different training samples and improve itself. Inter-connectivity of various devices creates a case for application of deep neural network. Because the interconnected weights from one layer to another can only be learned better using a deep neural network to generate final prediction of an event. Another reason why we need to apply deep neural network in solving internet of things, complex relationship among disjoint datasets constituting structured and unstructured data. It is very difficult for other algorithms to work in such complex system involving huge datasets.

3.5 Layer 5 – Service Layer

On top of the "Green City" layer of the reference architecture, the "Service Layer" is located that includes the IoT Middleware and the Service Middleware components. IoT Middleware responsible for managing the smart city IoT network and provides effective communication between platform and devices including sensors, actuators, controllers, mobile devices, terminals and servers. In its own case, Service Middleware is responsible for managing the services that the platform provides to applications, performing operations such as the publication, adoption, monitoring, compilation and synchronization of these services. In order to provide better services to citizens, it is important for the platform to have access to some user data and preferences, which is the role of the User Management component. However, to ensure the confidentiality of users, these data must be properly protected, and the permission for their storage must be purchased from the user. Moreover, since there will be many applications on the city platform, it may be useful to offer a single registration mechanism.

Layer 6 – Green City Layer

Cities grow rapidly, especially in developing countries. Carefully planning transport networks, land use and energy efficiency standards, it is possible to avoid economic models that are harmful to resource saving. This will also increase the access of the poor people to jobs and opportunities, while reducing air pollution.

The green city concept inspired by new urbanization theories suggested by Greenburg [28] and initiatives of the Leadership in Energy and Environmental Development (LEED) [29]. Sustainable future of the city interconnected to smart city structures. Green cities become holistic playgrounds for smart cities in the direction of sustainability. In this layer the "green city" structure constructs a favorable environment that broadband networks, sensors and actuators, energy management agents, smart grids and intelligent technologies could create a big impact to environment. For example, the European Union's Smart Cities Initiative proposes, that, to move to reducing greenhouse gas emissions by 40% through sustainable use and energy production through intelligent urban technologies, by 2020 [30]. Changing from conventional city to green city planning requires green governance, policy integration and control, and development of green ecosystem including green transportation, energy efficient green building specifications, smart grids, and applying alternative energy resources.

Thus, the green trend of the smart city will be maximum reduction of energy consumption and minimization of human impact on the environment. The Green City will be able to generate more than 70% of the energy for its needs through renewable energy sources. In the green city, hydraulic systems and smart energy-saving devices will also be used.

Layer 7 – Smart City Applications Layer

Smart cities reflect the city's momentum in real time as a system with systems. The city is also endowed with the technology as the main systems on which they are based, are instrumental and interconnected, enabling new levels reasonably responsive activities. The system includes infrastructure such as a broadband network, intelligent networks along with various types of renewable energy production and the construction of new mobility systems based on distributed networks. The system includes interconnected and instrumental real-time operators that work in real time and historical data and provide information through several forms of ICT applications such as intelligent energy networks, intelligent transport, electronic traffic, electronic payments and e-government [31].

The concept of "smart cities" offers a revolutionary vision of the sustainability of cities. Utilizing the intellectual application of new technologies, smart cities also integrate considerations of social and environmental capital to transform the life and

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work of cities. Urban space is a place where many solutions intersect for a reasonable sustainable world.

Open and flexible Web technologies facilitate developing innovative applications in the Internet where end users become producers and consumers of content and services. We assume that these technologies together with the possibilities provided by embedding sensor and actuators, cloud computing, and Big Data will pave the way to a whole nzw set of smarter applications.

Smart planners should develop policies and measures to expand the impact and dissemination of information in urban areas, i.e., in the center, districts, streets, houses [31]. For example, prediction of emergency situations, situation awareness, and traffic jams, etc.

The platform must also provide an application development toolkit, including tools such as an Integrated Development Environment (IDE), libraries, and frameworks, as well as a Smart City Simulator for debugging and experimenting with applications before actual deployment. Finally, a number of non-functional properties, notably security and privacy, must be supported across all layers.

Layer 8 – Innovation Layer

Innovation layer is in charge to further progress of the Smart City. It represents the highest level of abstraction that translates all of the technology of the lower layers into real life processes. The meaning behind this is to represent the activity of the companies and startups that develop and provide services, as well as government organizations to innovate new applications of smart city technologies to real life though the city planner.

The city planner allows any qualified company or business organization to build city infrastructure and provide city services. The city planner however will impose some requlatory obligations to reduce the costs of integration of diffent servces and resolve possible conflicts and associated growth pains.

To remain relevant, value creators in a smart city must constantly improve and innovate their services to interested parties. Smart cities actively contribute to this through various innovative programs, including laboratories, innovation zones, training, idea workshops, skills development, and partnerships with universities and businesses [31].

The main reason for this layer is that a smart city is not just a one-time event, a smart city is a constantly evolving process that has to adjust to the newly developed technologies and the everchanging demographic situation and city infrastructure.

For this reason, the complex network of interactions between businesses that create and run the systems that make up the smart city ecosystem can be represented as another layer of interconnected components that make use of the physical and economic resourses or the real world, alongside with the components of the lower 7 layers to drive the development and spread of smart city technologies into various areas of urban life.

Resource [33] considers innovation in management and policy, also the authors note, that since the unique context of each city shapes the technological, organizational and policy aspects of that city, a smart city can be considered a contextualized interplay among technological innovation, managerial and organizational innovation, and policy innovation [33].

4. CONCLSION

In this paper we discussed the definition of a smart city and how a platform for a smart city should function. It is clear that for a smart city to be robust, maintainable, scalable and successful standardization and careful architectural planning is the main two keys.

Designing the a versatile and adaptable structure of a smart city will allow to create a foundation for a true smart city – a living and evolving system that consists of thousands of components that can function autonomously, yet are interconnected with ever-present information technology and telecommunications.

The next step is standardization. Making all of the components following a single standard is important not only for development of new components, apps and services, but also for maintenance and scalability. Currently there are many proposals of different standards and structures aiming to be chosen as the de facto accepted. Once such a standard emerges the true smart cities will begin to grow because there will be no longer a barrier to overcome for making all of the systems work together as one.

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