IoT Ecosystem Overview

In IoT ecosystems, computing interactions are driven by smart objects, which are system entities considered the main building blocks of the IoT environment. By putting intelligence into everyday objects (i.e., dedicated embedded systems into everyday physical devices), these devices are turned into smart objects able not only to collect information from the environment and interact/control the things of the physical world, but also to be interconnected to each other through the Internet to autonomously exchange pervasive data and information. The expected huge number of interconnected devices and the significant amount of available data, open new opportunities to create smart services that will bring tangible benefits to the society, environment, economy, and individual citizens.

IoT considers the pervasive presence of a variety of smart objects interacting and cooperating in the physical environment through available ubiquitous services. Thus, the goal of the IoT is to enable things to be interconnected at anytime, anyplace, with anything and anyone, ideally using any path/network and any source.

Let us consider the "city ecosystem" as an example of how the city of the future (i.e the Smart City) will look like in the coming years. Indeed, a smart city is a kind of city that should be able to operate simultaneously on two representation levels, physical and virtual, respectively. These abstractions should imply in the provision of intelligent solutions that ensure efficiency at multiple levels, aiming basically to: (i) a more aware and optimized usage of the resources of the city, (ii) a minimization of environmental impact (e.g.,by reducing CO2 emissions), and (iii) an increase in the life quality of citizens' in terms of safety, health, and wellness. This smart capability is desired due to the fact that, today, half of the global population is concentrated in the cities, and hence, is increasingly consuming the city's resources (e.g., light, water) every day. Besides, quality, sustainability, and security are crucial requirements and unavoidable issues for the city.

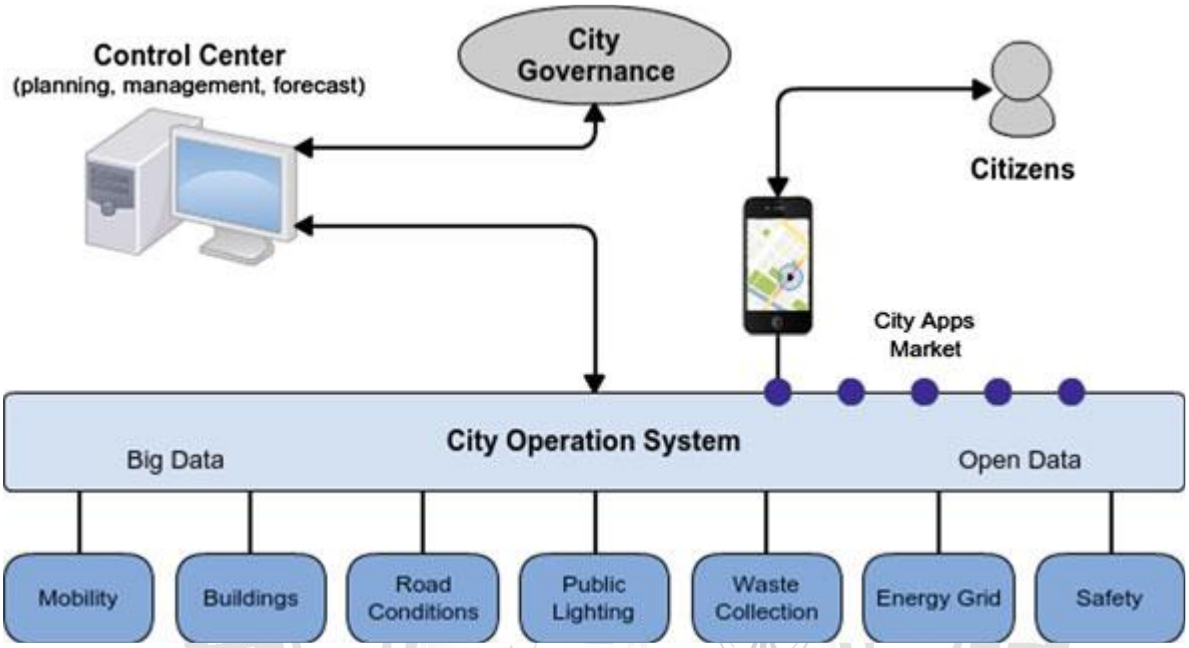

Fig.2.3 Schematic representation of a Smart City ecosystem

[Ref: L.A. Amaral et al. Middleware Technology for IoT Systems: Challenges and Perspectives Toward 5G,2016]

A smart city should provide autonomous management of its public services (e.g., transport, energy, lighting, waste management, health, and entertainment) through the widespread adoption of Information and Communication Technologies (ICT). Such technologies are the basis for the provision of a logical/virtual infrastructure that should be able to control and coordinate the physical infrastructure of the city in order to adapt the city services to the actual citizen needs, while reducing waste and making the city more sustainable. In this way, IoT is essential in this transition process since it has helped conventional cities to be turned into smart cities where traditional and more emerging sectors such as mobility, buildings, energy, living, and governance will also benefit from this transition. For example, smart mobility services can

be created to provide effective tools to the citizens to accurately plan their journeys with public/private transportation.

Figure 2.3 provides a schematic representation of a smart city ecosystem. In this perspective, the city will be equipped with physical devices or things (i.e., network of sensors, cameras, speakers, smart meters, and thermostats) that will collect information of the environment. The gathered information, the so-called "Big Data" (the name refers to its large volume and its heterogeneity in terms of content and data representation), will not only be used for the improvement of just a single city service/application, but it will also be shared among different services into the smart city ecosystem. In this sense, a common platform for the operational management of city elements—a sort of City Operating System, will be responsible for managing, storing, analyzing, processing, and forwarding the city data anywhere and anytime, to anyone and anything, helping the city to improve and adapting the city services to users' needs. This management layer, no longer vertical but horizontal, will ensure interoperability, coordination, and optimization of individual services/applications through the analysis of heterogeneous information flows. Citizens/authorities will access the services offered by the platform through their applications, will consume them and will actively participate by creating additional content (i.e., new data or applications) that will be provided as further input to the City Operating System.