Internet of Things in Smart Cities

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Abstract- **The Internet of Things (IoT) is a recent communication paradigm that envisions a near future, in which the objects of everyday life will be equipped with microcontrollers, transceivers for protocol stacks, and suitable digital communications that will make them able to communicate with one another and with the users, becoming an integral part of the Internet [1]. The IoT concept, aims at making the Internet even more pervasive and immersive. Furthermore, by enabling easy access and interaction with a wide variety of devices such as home appliances, surveillance cameras, monitoring sensors, displays, vehicles, and so on, the IoT will foster the development of a number of applications that make use of the potentially enormous amount and variety of data generated by such objects to provide new services to companies, citizens, and public administrations.**

Index Terms- **Communication, Smart, Web Service, Protocol, Technology, Internet.**

I INTRODUCTION

In this scenario, the application of the IoT to urban context is of particular interest, as it responds to the strong push of many national governments to adopt ICT solutions in the management of public affairs, realizing the so-called Smart City concept . Although there is not a formal and accepted definition of “Smart City,” the final aim is to make a use of the public resources, increasing the quality of the services offered to the citizens, operational costs of the public administrations. This objective can be pursued by the deployment of an urban IoT, i.e., a communication infrastructure that provides simple, unified and economical access to a plethora of public services, thus unleashing and increasing transparency to the citizens. An urban IoT may bring a number of benefits to the management and optimization of traditional public services, such as transport and lighting, parking surveillance and maintenance of public areas, preservation of cultural heritage, hospitals, garbage collection and school. The availability of different types of data, collected by a pervasive urban IoT, may also be exploited to increase the transparency and promote the actions of the toward the citizens, enhance the awareness of people about the status of their city, stimulate the participation of the citizens in the management of public administration, and stimulate the creation of services upon those provided by the IoT. The application of the IoT to the Smart City is attractive to local and regional administrations that become the early adopters of such technologies, thus acting as catalyzers for the adoption of the IoT on a wider scale.

II. SMART CITY CONCEPT AND SERVICES

‘Enhancing the quality of life for city dwellers around the globe’ sensors located in the buildings, such as vibration and deformation sensors to monitor the building stress, atmospheric agent sensors in the surrounding areas to monitor pollution levels, temperature and Smart cities includes the city services that residents interact with on a daily basis with connected capabilities. Whether it’s public safety building automation, traffic control, or waste management, enhanced connectivity through effective M2M device management promises to transform every aspect of city life.

Given its potential to streamline municipal communication, and reduce long-term costs, improve quality of life, it’s no wonder progressive cities around the world are jumping at the opportunity to invest in smart technology. Other cities are looking to Bristol, UK as a leader in innovation because of their investment in an IoT ecosystem.

The Smart City market estimated at hundreds of dollars by 2020, with an spending reaching nearly 16 billion. This market springs from the synergic interconnection of key industry and service sectors, such as Smart Governance, Smart Utilities, Smart Mobility Smart Buildings, and Smart Environment.

These sectors are also been considered in the European Smart Cities project (http://www.smart-cities.eu) to define a ranking that can be used to assess the level of "smartness" of European cities. Nonetheless, the Smart City market has not taken off, for a number of technical, political and financial barriers.
Finally, the financial dimension, a business model is still lacking, some initiative to fill this gap has been recently undertaken. The situation is worsened by the adverse global economic situation, which has determined the general shrinking of investments on public services. The situation prevents the potentially huge Smart City market from becoming reality. A possible way of this impasse is to first develop those services that conjugate social utility with very clear return on investment, such as smart parking and smart buildings, and will hence act as catalyzers for the other added-value services.

Structural Health of Buildings: Proper maintenance of historical buildings of a city requires the monitoring of the actual conditions of each building and identification of the areas that are most subject to an impact of external agents. The IoT may provide a distributed of building database structural integrity measurements, collected by sensors to have a complete characterization of the environmental conditions.

Table 1: Services Specification for the Padova Smart City Project

Service	Network type(s)	Traffic rate	Tolerable delay	Energy source	Feasibility
Structural health	802.15.4; WiFi and Ethernet	1 pkt every 10 min per device	30 min for data; 10 s for alarms	Mostly battery powered	1: easy to realize, but seismograph may be difficult to integrate
Waste management	WiFi, 3G and 4G	1 pkt every hour per device	30 min for data	Battery powered or energy harvesters	2: possible to realize, but requires smart garbage containers
Air quality monitoring	802.15.4; Bluetooth and WiFi	1 pkt every 30 min per device	5 min for data	Photovoltaic panels for each device	1: easy to realize, but greenhouse gas sensors may not be cost effective
Noise monitoring	802.15.4 and Ethernet	1 pkt every 10 min per device	5 min for data; 10 s for alarms	Battery powered or energy harvesters	2: the sound pattern detection scheme may be difficult to implement on constrained devices
Traffic congestion	802.15.4; Bluetooth and WiFi; Ethernet	1 pkt every 10 min per device	5 min for data	Battery powered or energy harvesters	3: requires the realization of both air quality and noise monitoring
City energy consumption	PLC and Ethernet	1 pkt every 10 min per device	5 min for data; tighter requirements for control	Mains powered	2: simple to realize, but requires authorization from energy operators
Smart parking	802.15.4 and Ethernet	On demand	1 min	Energy harvester	1: Smart parking systems are already available on the market and their integration should be simple
Smart lighting	802.15.4; WiFi and Ethernet	On demand	1 min	Mains powered	2: does not present major difficulties, but requires intervention on existing infrastructures
Automation and salubrity of public buildings	802.15.4; WiFi and Ethernet	1 pkt every 10 min for remote monitoring; 1 pkt every 30" for in-loco control	5 min for remote monitoring, few seconds for in-loco control	Mains powered and battery powered	2: does not present major difficulties, but requires intervention on existing infrastructures

Waste Management: Waste management is an issue in many modern cities, due to both the cost of the service and the problem of the storage of garbage in landfills. A deeper penetration of ICT solutions in the domain may result in savings and ecological and economical advantages. For the use of intelligent waste containers, which detect the level of load and allow for an optimization of the collector trucks route reduce the cost of waste collection and improve the quality of recycling .

Air Quality: The targets call for a 20% reduction in greenhouse gas emissions by 2020 compared with 1990 levels, a 20% cut energy consumption improved energy efficiency by 2020. To an urban IoT can provide means to monitor the quality of the air in crowded areas, parks, or fitness trails. Communication facilities can be improved to health applications running on joggers' devices be connected to the infrastructure.

Smart Parking: The smart parking is based on road sensors and intelligent displays that direct motorists along the best path for parking in the city. The benefits from the service are manifold: faster time to locate a parking slot means fewer CO emission from the car, lesser traffic congestion, and happier citizens. The smart parking service can be directly integrated in the urban IoT infrastructure, because many companies in Europe are providing market products for this application. Using short-range communication technologies, such as Near Field Communication (NFC) or Radio Frequency Identifiers (RFID), is possible to realize an electronic verification system of parking permits in slots reserved for residents.

Smart Lighting: In particular, this service can optimize the street lamp intensity according to the time of the day, the weather condition, and the presence of people. In order to work, such a service needs to include the street lights into the Smart City infrastructure. It is possible to exploit the increased number of connected spots to provide WiFi connection to citizens.

III. URBAN IOT ARCHITECTURE

From the analysis of the services in Section II, it clearly emerges that most Smart City services are based on a centralized architecture, where a dense and heterogeneous set of devices over the urban area generate different types of data that are then delivered through suitable communication technologies to a control center, where data storage and processing are performed.
A characteristic of an urban IoT infrastructure, hence, is capability of integrating different technologies with the existing communication infrastructures in order to support a progressive evolution of the IoT, with the interconnection of other devices and the realization of functionalities and services.

IV. WEB SERVICE APPROACH FOR IOT SERVICE ARCHITECTURE

Although in the IoT domain many different standards are struggling to be the reference one and the adopted specifically on IETF standards because they are open and royalty-free, are based on Internet best practices, and count on a wide community.

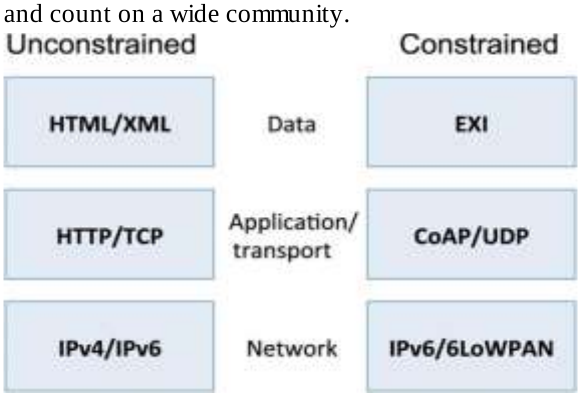


Figure 1: Protocol stacks for unconstrained (left) and constrained (right) IoT nodes.

Fig. 1 shows reference architecture for the urban IoT system that entails an unconstrained and a constrained protocol stack. The first consists of the protocols that are currently the de-facto standards for Internet communications, and commonly used by regular Internet hosts, such as XML, HTTP, and IPv4. These protocols are mirrored in the protocol stack by their low-complexity counterparts, i.e., the Efficient XML Interchange (EXI), the Constrained Application Protocol (CoAP), and 6LoWPAN, which is suitable even for very constrained devices. The transcoding operations between the protocols in the left and right stacks in Fig. 2 can be performed in a low complexity manner, thus easy access and interoperability of the IoT nodes with the Internet. It may be worth remarking that systems that do not adopt the EXI/CoAP/6LoWPAN protocol stack can be included in the urban IoT system, provided that are capable of interfacing with all the layers of the left-hand side of the protocol architecture in Fig. 1.
In the protocol architecture shown in Fig. 1, we can distinguish three distinct functional layers, namely (i) Data, (ii)Application/Transport, and (iii) Network, that may require dedicated entities to operate the transcoding between constrained and unconstrained formats and protocols. In the rest of this section, we specify in greater detail the requirements at each of the three functional layers in order to guarantee interoperability among the different parts of the system.

V. DEVICES

We finally describe the devices that are essential to realize an urban IoT, classified based on the position they occupy in the communication flow.

A. Backend Servers

At the root of the system, we find the backend servers, located in the control center, where data are collected, stored, and processed to produce added-value services. In principle, backend servers are not mandatory for an IoT system to properly operate, though they become a fundamental component of an urban IoT where they can facilitate the access to the smart city services and open data through the legacy network infrastructure. Backend systems commonly considered for interfacing with the IoT data feeders include the following.

Database management systems: These systems are in charge of storing the large amount of information produced by IoT peripheral nodes, such as sensors. Depending on the particular usage scenario, the load on these systems can be quite large, so that proper dimensioning of the backend system is required.

Web sites: The widespread acquaintance of people with web interfaces makes them the first option to enable interoperation between the IoT system and the “data consumers,” e.g., public authorities, service operators, utility providers, and common citizens.

Enterprise resource planning systems (ERP): ERP components support a variety of business functions and are precious tools to manage the flow of information across a complex organization, such as a city administration. Interfacing ERP components with database management systems that collect the data generated by the IoT allows for a simpler management of the potentially massive amount of data gathered by the IoT, making it possible to separate the information flows based on their nature and relevance and easing the creation of new services.

B. Gateways

Moving toward the 'edge' of the IoT, we find the gateways, whose role is to interconnect the end devices to the main communication infrastructure of the system. With reference to the conceptual protocol architecture depicted in Fig. 2, the gateway is hence required to provide protocol translation and functional mapping between the unconstrained protocols and their constrained counterparts, that is to say XML-EXI, HTTP-CoAP, IPv4/v6-6LoWPAN.

Note that while all these translations may be required in order to enable interoperability with IoT peripheral devices and control stations, it is not necessary to concentrate all of them in a single gateway. Rather, it is possible, and sometimes convenient, to distribute the translation tasks over different devices in the network. For example, a single HTTP-CoAP proxy can be deployed to support multiple 6LoWPAN border routers.

Gateway devices shall also provide the interconnection between unconstrained link layer technologies, mainly used in the core of the IoT network, and constrained technologies that, instead, provide connectivity among the IoT peripheral nodes.

C. IoT Peripheral Nodes

Finally, at the periphery of the IoT system, we find the devices in charge of producing the data to be delivered to the control center, which are usually called IoT peripheral nodes or, more simply, IoT nodes. Generally speaking, the cost of these devices is very low, starting from 10 USD or even less, depending on the kind and number of sensors/actuators mounted on the board. IoT nodes may be classified based on a wide number of characteristics, such as powering mode, networking role (relay or leaf), sensor/actuator equipment, and supported link layer technologies. The most constrained IoT nodes are likely the Radio Frequency tags (RFtags) that, despite their very limited capabilities, can still play an important role in IoT systems, mainly because of the extremely low cost and the passive nature of their communication hardware, which does not require any internal energy source. The typical application of RFtags is object identification by proximity reading, which can be used for logistics, maintenance, monitoring, and other services.

Mobile devices, such as smart phones, tablet PCs, or laptops, may also be an important part of an urban IoT, providing other ways to interact with it. For instance, the NFC transceiver integrated in last-generation smartphones may be used to identify tagged objects, while the geolocation service provided by most common operating systems for mobile devices can enrich the context information associated to that object. Furthermore, mobile devices can provide access to the IoT in different ways, e.g., 1) through an IP connection provided by the cellular data-link service or 2) setting up a direct connection with some objects by using short-range wireless technologies, such as

Bluetooth Low Energy, low-power WiFi, or IEEE 802.15.4. Furthermore, it is possible to develop specific applications for mobile devices that can ease the interaction with the IoT objects, and with the system as a whole.

VI. IOT SOLUTIONS

A. Operator Solutions

Currently about 10 billion connected devices that need to be managed. Internet of Things brings in even more connected devices operators will need to be prepared to meet the expectations of customers as well as industries using connected devices. Our solution allows operators to reduce device management costs and simplify deployment of mobile services, and create new revenue streams.

B. Device Manufacturer Solutions

Device manufacturers not only able quick certify devices to the market but need to easily manage the devices once they are out on the market. We make this simple for device manufacturers with our solutions which allow them to activate and manage connected devices.

C. Service Provider Solutions

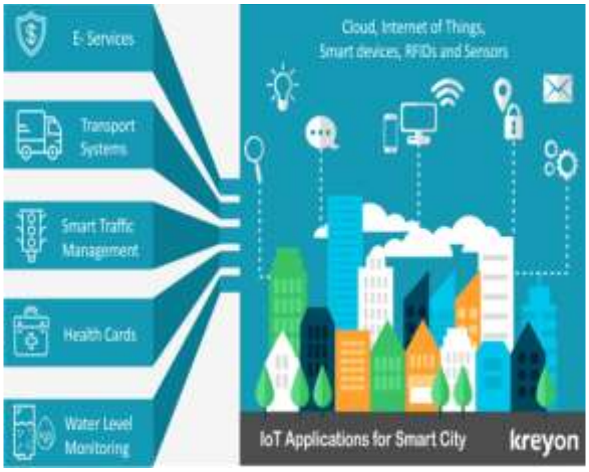
Service providers tasked are with a complex managing and sometimes disjointed process delivers reliable service. Our solutions allow service providers reduce costs remotely managing devices. We can also simplify operations with analytics provide insights into efficiency and improve customer service. This solution allows service providers to gain new revenue streams to grow business.

D. Enterprise Solutions

Enterprises challenge of connecting thousands of employees may be spread country across the even the world. This companies need to be able effectively manage data center demands, unique visibility requirements and authorization requirements.

E. Automotive Solutions

The intelligently connected car and its promise of seamless connectivity and personalization is strongly influencing car purchasing with 37 percent of McKinsey 2015 Consumer Survey respondents saying they'd switch car manufacturers the only one that offered full access to apps, media and data. Now Automakers must partner with mobile providers to create smart cars that can manage complex in-car components keep drivers and connected while being scalable and easy to manage.



VII. CONCLUSION

In this paper, we analyzed the solutions currently available for the implementation of urban IoTs. In fact, while the range of design options for IoT systems is rather wide, the set of open and standardized protocols is significantly smaller. The technologies, furthermore, have reached level of maturity that allows for the practical realization of IoT solutions and services, starting from field trials that will hopefully help clear the uncertainty that still IoT paradigm. A concrete proof-of-concept implementation, deployed in collaboration with the city of Padova, Italy, has also been described as a relevant example of application of the IoT paradigm to smart cities.

REFERENCES

[1] L. Atzori, A. Iera, G. Morabito, "The internet of things: A survey", Comput. Netw., vol. 54, no. 15, pp. 2787-2805, 2010.

[2] P. Bellavista, G. Cardone, A. Corradi, L. Foschini, "Convergence of MANET and WSN in IoT urban scenarios", IEEE Sens. J., IEEE, vol. 13, no. 10, pp. 35583567, Oct. 2013.

[3] Laya, V. I. Bratu, J. Markendahl, "Who is investing in machine-to-machine communications?", Proc. 24th Eur. Reg. ITS Conf., pp. 20-23, Oct. 2013.