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Using an IoT Gateway To Connect The Future "Things" For Worldwide Smart City

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ABSTRACT

Imagine what happen when billions of people, processes and physical objects connect and share data seamlessly. This isn't a what-if scenario it's a real-life case study happening all around us. The primary objective of this research paper is study of Internet of Things which is already changing the world the way we drive, from how we make purchases and how we get the energy from our homes and the devices that soon going to be the part of this world.Internet of things is not just a technique or methodology it's the platform of the future. In 1966, Karl Steinbach a German computer science pioneer said "In a few decades' time, computers will be interwoven into almost every industrial product".In the present with a growing number of devices built to connect to the internet and more global access to broadband internet than ever before, the possible applications for the Internet of Things are endless.

Keywords: Internet of Things, Internet of Everything, IoT network, Future Network, Wi-Fi, machine-to-machine

I. INTRODUCTION

The internet of things - or IoT for short - is a collective term for internet-connected devices that can access and share data between each other and online. It's typically used when referring to Wi-Fi enabled fridges, washing machines and other devices we don't usually associate with the internet. But smartwatches, tablets and smartphones are all IoT devices, too. Being Wi-Fi enabled means these IoT devices can interact in new ways. They can operate autonomously or be controlled, often from an app on your smartphone.The Internet of Things allows objects to be sensed or controlled remotely across existing network infrastructure creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit in addition to reduced human intervention.In 1999 Kevin Ashton executive director of the Auto-ID Center coined the Internet of things term in his statement: "I could be wrong, but I'm fairly sure the phrase "Internet of Things" started life as the title of a presentation I made at Procter & Gamble (P&G) in 1999. Linking the new idea of RFID in P&G's supply chain to the then-red-hot topic of the Internet was more than just a good way to get executive attention. It summed up an important insight which is still often misunderstood."

"Things", in the IoT sense, refers to a wide variety of devices such as heart monitoring implants, biochip transponders on farm animals, cameras streaming live feeds of wild animals in coastal waters, automobiles with built-in sensors, DNA analysis devices for environmental/food/pathogen monitoring, or field operation devices that assist firefighters in search and rescue operationsLegal scholars suggest regarding "things" as an "inextricable mixture of hardware, software, data and service".

TABLE I Definitions of the IoT from different organizations

Organizations	Definitions
CCSA	A network, which can collect information from the physical world or control the physical world objects through various deployed devices with capability of perception, computation, execution and communication, and support communications between human and things or between things by transmitting, classifying and processing information.
ITU-T	A global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies.
EU FP7 CASAGRRAS	A global network infrastructure, linking physical and virtual objects through the exploitation of data capture and communication capabilities.
IETF	A world-wide network of interconnected objects uniquely addressable based on standard communication protocol.

II. HOW IT WORKS

The Internet of Things (IoT) consists of all the web-enabled devices that collect, send and act on data they acquire from their surrounding environments using embedded sensors, processors and communication hardware. These devices can talk to other related devices- a process called machine-to-machine (M2M) communication- and act on the information they get from one another. The process starts with the devices themselves which securely communicate with an Internet of Things platform, this platform integrates the data from many devices and applies analytics to share the most valuable data with applications that address industry specific needs.

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Fig 1 Sensors embedded car

Let's start with a simple example a car after taking a long road trip Rebecca notices that her check engine light has come on she knows that she needs to have her car looked at by a mechanic but is not sure whether it's something minor or something that needs immediate attention as it turns out the sensor.

This sensor is one of many monitoring processes throughout the car which are constantly communicating with each other as in Fig 1)that triggered Rebecca's check engine light monitors the pressure in her brake line, a component in the car called the diagnostic bus gathers the data from all these sensors then passes it to a gateway in the car the Gateway integrates and sorts the data from the sensors this way only the most relevant diagnostic information will be transmitted to the manufacturers platform but before sending this organized data, the cars gateway and platform must first register with each other and confirm a secure communication. The platform is constantly gathering and storing thousands of bits of information from Rebecca's car and hundreds of thousands of cars like hers, building an historical record in a secure database. The manufacturers added rules and logic to the platform so when Rebecca's car sends a signal that her brake fluid has dropped below a recommended level the platform triggers an alert in her car. The manufacturer also uses the platform to create and manage applications that solve specific issues in this case the manufacturer can deploy an application on the platform, called the asset management system. This application oversees all of their customer’s cars on the road as well as all the parts in their warehouses. It uses the data from Rebecca's car to offer her a potential appointment time to service her car, directions to the nearest certified dealer and a coupon for the service what's more the app will ensure that Rebecca's brakes are covered under her warranty that the correct replacement part is ordered and then sent to the dealership so it is ready when she arrives but the manufacturers analysis does not stop there they have also deployed a continuous engineering application that tracks not only Rebecca's car but hundreds of thousands of others looking for ways to improve the design and manufacturing process of the car itself if the same problem in her brake line crops up in a critical number of other cars the manufacturer uses applications custom-built for the automobile industry to pinpoint the exact problem they can see if these cars were made at the same factory used the same parts or came off the assembly line on the same day so what do all these pieces add up to streamlined inventory management for the dealer a better safer car from the manufacturer and for Rebecca it means she can be back on the road faster and get to where she's going safely all thanks to the Internet of Things.

III. VISION OF FUTURE

Smart cities and the Internet of Things (IoT) have long been discussed as heralding a new age for urban living and development. With the promise to deliver greater safety, lower levels of pollution, more efficient energy usage and an overall better quality of life for those living in urban environments, attention has rightly been focused on the latest technologies and what they can offer.According to Pike Research on Smart Cities, the Smart Citymarket is estimated at hundreds of million dollars by 2020, withan annual spending reaching nearly 16 billion.This market springs from the synergic interconnection of key industry and service sectors, such as. The sectors that been considered in the European Smart Cities project to define a ranking criterion are Smart Governance, Smart Mobility, Smart Utilities, Smart Buildings, and Smart Environment that can be used to assess the level of “smartness” of European cities.

3.1 Smart City Concept

There is no universally accepted definition of a Smart City. It means different things to different people. The conceptualization of Smart City, therefore, varies from city to city and country to country, depending on the level of development, willingness to change and reform, resources and aspirations of the city residents. A Smart City would have a different connotation in India than, say, Europe. Even in India, there is no one way of defining a Smart City.The IERC definition states that “Internet of things (IoT): “A dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where physical and virtual “things” have identities, physical attributes, and virtual personalities and use intelligent interfaces, and are seamlessly integrated into the information network.”. The picture of a Smart City contains a wish list of infrastructure and services that describes his or her level of aspiration. To provide for the aspirations and needs of the citizens, urban planners ideally aim at developing the entire urban eco-system.

To better appreciate thelevel of maturity of the enabling technologies for these services,we report in Table I a synoptic view of the services in terms of suggested type(s) of network to be deployed, expected trafficgenerated by the service, maximum tolerable delay, devicepowering, and an estimate of the feasibility of each servicewith currently available technologies.

TABLE II SERVICES SPECIFICATION FOR SMART CITY PROJECT

Service	Network Type(s)	Traffic Rate	Tolerable Delay	Energy Source
Structural Health	801.15.4; Wi-Fi and Ethernet	1 pkt every 10 min per device	30 min for data; 10s for alarms	Mostly battery powered
Waste Management	Wi-Fi; 3G and 4G	1 pkt every hour per device	30 min for data	Battery powered or energy harvesters
Air Quality Monitoring	801.15.4; Wi-Fi and Bluetooth	1 pkt every30 min per device	5 min for data	Photovoltaic panels for each device
Noise Monitoring	801.15.4 and Ethernet	1 pkt every 10 min per device	5 min for data; 10s for alarms	Battery powered or energy harvesters
Service	**Network Type(s)**	**Traffic Rate**	**Tolerable Delay**	**Energy Source**
Traffic Congestion	801.15.4; Bluetooth and Wi-Fi; Ethernet	1 pkt every 10 min per device	5 min for data	Battery powered or energy harvesters
City Energy Consumption	PLC and Ethernet	1 pkt every 10 min per device	5 min for data; tighter requirements for control	Mains powered
Smart Parking	801.15.4 and Ethernet	On demand	1 min	Energy harvester
Smart Lighting	801.15.4; Wi-Fi and Ethernet	On demand	1 min	Mains powered
Automation and Salubrity of public buildings	801.15.4; Wi-Fi and Ethernet	1 pkt every 10 min for remote monitoring; 1 pkt every 30 s for in-loco control	5 min for remote monitoring, few seconds for in-loco control	Mains powered and battery powered

3.2 Smart City Services

From the table, it clearlyemerges that, in general, the practical realization of mostof such services is not hindered by technical issues, but ratherby the lack of a widely accepted communication and servicearchitecture that can abstract from the specific features of thesingle technologies and provide harmonized access to theservices.In the rest of this section, we overview some of the services that might be enabled by an urban IoT paradigm and that are of potential interest in the Smart City context because they can realize the win–win situation of increasing the quality and enhancing the services offered to the citizens while bringing an economical advantage for the city administration in terms of reduction of the operational costs.

3.2.1 Structural Health of Buildings: Proper maintenance of thehistorical buildings of a city requires thecontinuous monitoringof the actual conditions of each building and identification ofthe areas that are most subject to the impact of external agents.The urban IoT may provide a distributed database of buildingstructural integrity measurements, collected by suitable sensorslocated in the buildings, such as vibration and deformationsensors tomonitorthe building stress,atmosphericagentsensorsin the surrounding areas to monitor pollution levels, and temperature and humidity sensors to have a complete characterization of the environmental conditions.Finally, it will be possible tocombine vibration and seismic readings in order to better studyandunderstand theimpactoflightearthquakesoncitybuildings.This database can be made publicly accessible in order to makethe citizens aware of the care taken in preserving the cityhistorical heritage. The practical realization of this service,however, requires the installation of sensors in the buildings and surrounding areas and their interconnection to a controlsystem,whichmayrequireaninitialinvestmentinordertocreatethe needed infrastructure.

3.2.2 Waste Management: Waste management is a primary issue inmany modern cities, due to both the cost of the service and theproblem of the storage of garbage in landfills. A deeper penetration of ICT solutions in this domain, however, may result insignificant savings and economical and ecological advantages.Forinstance,theuseof intelligentwaste containers,which detectthe level of load and allow for an optimization of the collector trucks route, can reduce the cost of waste collection and improve the quality of recycling. To realize such a smart wastemanagement service, the IoT shall connect the end devices, i.e.,intelligent waste containers, to a control center where an optimization software processes the data and determines the optimalmanagement of the collector truck fleet.

3.2.3 Air Quality: The European Union officially adopted a 20-20- 20 Renewable Energy Directive setting climate changer education goals for the next decade.4 The targets call for a 20% reduction in greenhouse gas emissions by 2020 compared with 1990 levels, a 20% cut in energy consumption through improved energy efficiency by 2020, and a 20% increase in the use of renewable energy by 2020. To such an extent, an urban IoT can provide meanstomonitorthequalityoftheairincrowdedareas,parks,or fitness trails. In addition, communication facilities can be provided to-let health applications running on joggers ‘devices be connected to the infrastructure. In such a way, people can always find the healthiest path for outdoor activities and can be continuously connected to their preferred personal training application. The realization of such a service requires that air quality and pollution sensors be deployed across the city and that the sensor data be made publicly available to citizens.

3.2.4 Noise Monitoring: Noise can be seen as a form of acoustic pollution as much as carbon oxide (CO) is for air. In that sense, thecityauthoritieshavealreadyissuedspecificlawstoreducethe amount of noise in the city center at specific hours. An urban IoT can offer a noise monitoring service to measure the amount of noise produced at any given hour in the places that adopt the service. Besides building a space-time map of the noise pollution in the area, such a service can also be used to enforce public security, by means of sound detection algorithms that can recognize, for instance, the noise of glass crashes or brawls. These services can henceimprove both the quiet of the nights in the city and the confidence of public establishment owners, although the installation of sound detectors or environmental microphones is quite controversial, because of the obvious privacy concerns for this type of monitoring.

3.2.5 Traffic Congestion: On the same line of air quality and noise monitoring, a possible Smart City service that can be enabled by urban IoT consists in monitoring the traffic congestion in the city. Even though camera-based traffic monitoring systems are already available and deployed in many cities, low-power widespread communication can provide a denser source of information. Traffic monitoring may be realized by using the sensing capabilities and GPS installed on modern vehicles, and also adopting a combination of air quality and acoustic sensors along a given road. This information is of great importance for city authorities and citizens: for the former to discipline traffic and to send officers where needed and for the latter to plan in advance the route to reach the office or to better schedule a shopping trip to the city center.

3.2.6 City Energy Consumption: Together with the air qualitymonitoring service, an urban IoT may provide a service tomonitor the energy consumption ofthe whole city, thus enablingauthorities and citizens to get a clear and detailed view of theamount of energy required by the different services (publiclighting, transportation, traffic lights, control cameras, heating/cooling of public buildings, and so on). In turn, this will make itpossible to identify the main energy consumption sources and toset priorities in order to optimize their behavior. This goes in thedirection indicated by the European directive for energy efficiency improvement in the next years. In order to obtain such aservice, power draw monitoring devices must be integrated withthe power grid in the city. In addition, it will also be possible toenhance these service with active functionalities to control localpower production structures (e.g., photovoltaic panels)

3.2.7 Smart Parking: The smart parking service is based on roadsensors and intelligent displays that direct motorists along thebest path for parking in the city. The benefits deriving fromthis service are manifold: faster time to locate a parking slotmeans fewer CO emission from the car, lesser traffic congestion,and happier citizens. The smart parking service can be directlyintegrated in the urban IoT infrastructure, because manycompanies in Europe are providing market products for this application. Furthermore, by using short-range communicationtechnologies, such as Radio Frequency Identifiers (RFID) orNear Field Communication (NFC), it is possible to realize an electronic verification system of parking permits in slots reservedfor residents or disabled, thus offering a better service to citizensthat can legitimately use those slots and an efficient tool toquickly spot violations.

3.2.8 Smart Lighting: In order to support the 20-20-20 directive, theoptimization of the street lighting efficiency is an importantfeature. In particular, this service can optimize the street lampintensity according to the time of the day, the weather condition, and the presence of people. In order to properly work, such aservice needs to include the street lights into the Smart Cityinfrastructure. It is also possible to exploit the increased numberof connected spots to provide Wi-Fi connection to citizens. Inaddition, a fault detection system will be easily realized on top ofthe street light controllers.

3.2.9 Automation and Salubrity of Public Buildings: Anotherimportant application of IoT technologies is the monitoring ofthe energy consumption and the salubrity of the environment inpublic buildings (schools, administration offices, and museums)by means of different types of sensors and actuators that controllights, temperature, and humidity. By controlling these parameters, indeed, it is possible to enhance the level of comfort of thepersons that live in these environments, which may also have apositive return in terms of productivity, while reducing the costs for heating/cooling.

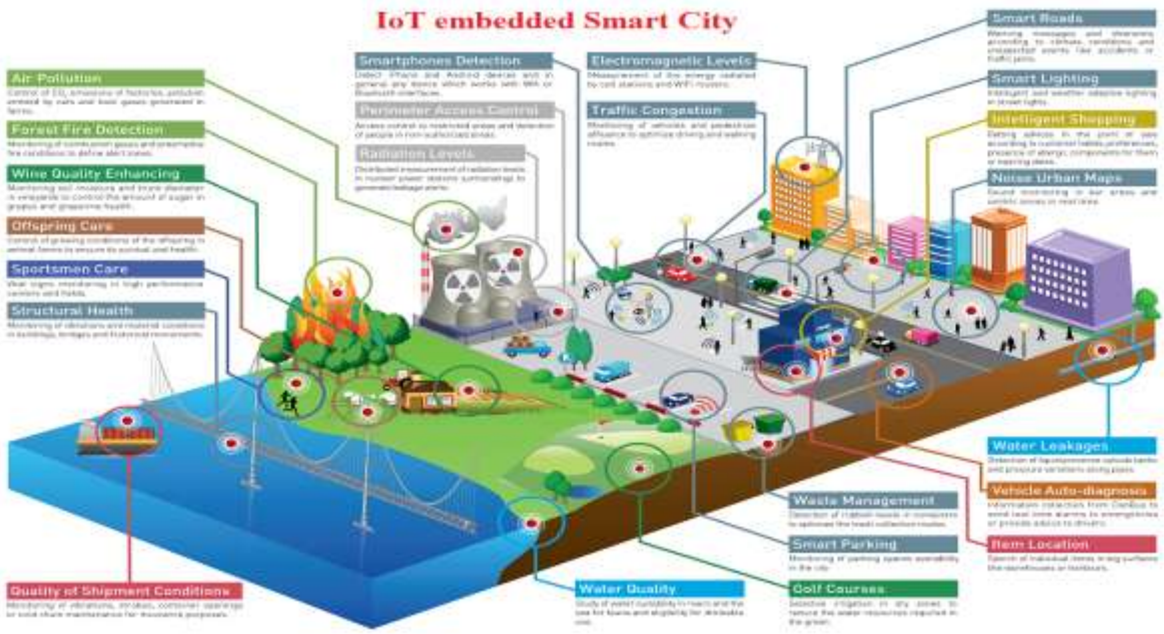

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Fig 2 IoT Embedded Smart City

IV Barriers

The proposed IoT based smart environment will offerenormous benefits to the society. Many business sectors andgovernment services are integrated through this smartenvironment. Several devices and objects are connected with the help of sensors.Thus, this proposed smartenvironment is a multifaceted in nature. However, thedevelopment of IoT is a step-by-step process. Currently, however,the IoT itself lacks theory, technology architecture, and standards that integrate the virtual world and the real physicalworld in a unified framework. Following key challengesare thus listed.

4.1 Object Naming: The proposed smart environment will connect several thousands of devices and objects for different services. Every device and object needs to be uniquely identified over the network. So, a dynamic mechanism of object naming and identification is needed to manage large number of devices connected.

4.2 Interoperability: The devices and objects are heterogeneous in their functioning. Each device and object will use their own technologies and they may not be compatible to use the services of others. Interoperability to all the objects and devices like RFID tags, sensors should be ensured. The manufacturing of devices and objects are not with same standard and the standardization object and device manufacturing is needed

4.3 Security Attack: Information from the devices and objects connected to this smart environment are prone to security attacks like firsthand attack, gossip attack, observation attack, inference attack, automated invasion attack. A proper security mechanism should be devised to address these mentioned attacks.

4.4 Network Congestion: As millions of objects and devices connected, certainly there will be network congestion in data transmission. The future research on IoT should also focus to avoid network congestion without data loss. Security measures should be taken to ensure the transmission of data without the external interferences.

V. CONCLUSION

The IoT based Smart Environment will be another phase lift in Next Generation Network.A revolution in the domestic appliances is possiblewith the help of technological advancements.The IoT encompasses several technologies such asinformation technology, cognitive sciences, communication technology, and low-power electronics. IoT creates a newerinformation society and knowledge economy. But thechallenges from research, industries, and the governmentwill keep pushing and investing. This paperdescribed how IoT could integrate the different business and domestic domains under smart environment.

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