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Internet of Things Applications in Smart Cities

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***Abstract*: *The internet of things is the internetworking of physical devices, vehicles, buildings and other items with network connectivity that enable these objects to collect and exchange data. It creates opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit. It finds numerous applications in the areas of smart grids, smart homes, intelligent transportation and smart cities. This paper presents a discussion on internet of things and its applications in smart cities. Emerging technology of IoT make smart cities efficient and responsive.*

***Keywords*: *Internet of Things, Network connectivity, Network Security, Smart Cities.*

I. Introduction

The generation of internet started by the "internet of computers" where the computers through a global network with its services like World Wide Web, were playing the key role that normally consumed information. After years, internet was changed into the "internet of people" where people in addition to using information were creating it through social networks and other ways by which people can create contents And the last generation of internet is "Internet of Things" that as it was mentioned, things are going to produce and use information and have key role in helping people in their everyday life.

The emergence of IoT is driven by the changing nature of hardware, that smartness and connectivity allows for physical objects to be a part of the internet. IoT implies that products, or “things”, are becoming smart and connected. These two attributes have previously existed separately, i.e. physical objects which have been either smart or connected, but are now increasingly being adopted in physical objects simultaneously.

A smart city is a place where traditional networks and services are made more flexible, efficient, and sustainable with the use of information, digital, and telecommunication technologies to improve the city’s operations for the benefit of its inhabitants. Smart cities are greener, safer, faster, and friendlier. The different components of a smart city include smart infrastructure, smart transportation, smart energy, smart health care, and smart technology. Two closely related emerging technology frameworks, the Internet of Things (IoT) and big data (BD), make smart cities efficient and responsive

II. Problem Statement

Rural-urban migration tends to impact on the delivery of services in the cities due to constrained resources. As a result, the concept of a smart city has been adopted to improve delivery of services in urban areas. This research is on how cities can be smartened through the adoption of IoTs. A literature survey was conducted on what constitutes smart cities and what domains of any city can be made smart through the adoption of IoTs. The domains of transport, tourism, health, ambient-assisted living, crime prevention, governance, infrastructure management, disaster management, environmental management and energy management were identified. Through sampling of literature, IoT applications for these various domains were identified. In addition, in a laboratory environment, a prototype technical solution for energy control and comfort in a home for proof of concept of a smart city infrastructure application was developed. Transportation**:**

III. IOT Technologies in Smart Cities

3.1 Transportation:

An integrated transport system would need a single ticket in the form of a smart card which can be loaded with money and is swiped at any point of entry into a transport system using Near Field Communication (NFC) technology to transmit information from the card to the reading machine and back. Payment is deducted accordingly from the card for the trips made. At each parking bay is a meter that detects the presence a car parked through a tag on the number plates as soon as the car enters the bay and starts calculating the charges for the parking as they accumulate. Motorists register etoll accounts with the roads agency and are issued with radio-frequency identifier (RFID)-enabled etoll cards which are attached to the cars. As the car drives under an etoll gate the driver's details and the details of the distance they have travelled are read by the card reader on the etoll gate, and relayed to a server at the roads agency.

3.2 Health Care:

Mobile applications, body area network sensors and personal health management ecosystems have been recognised as essential components of the technological platforms of the next generation of healthcare for their potential to allow citizens to play an active role in the management of their health (Nollo, 2014). Mobile health applications (smart phone and tablet) can connect to medical devices or sensors (e.g. bracelets, smart watches, patches, etc.) and provide personal assistance and reminders. Through the use of sensors directly connected to mobile devices, it is now possible to gather a considerable amount of data.

3.3 Crime Prevention and Community Safety:

Identification of criminals has been made easier through mobile biometric detection machines. Fingerprints of a suspect are captured to a police mobile biometric machine. This data is sent via a network to a fingerprint database located at the Department of Home Affairs for comparison and it returns the identity of the suspect.

3.4 Governance:

The number of available online services, their effectiveness and usage level and their level of interaction are important indicators of the 'smartness levels" of e-government. Water, sewage, electricity and rates bills each have an ID tag which is read by the tag reader at the counter and automatically matched against user details in the database and update with payment is made.

3.5 Disaster Management and Emergency:

Satellites detect heat signatures of a fire that has just started in an area. The satellites relay the information to a control centre that registers the fire in their systems and dispatches fire trucks. The same control centre triggers fire sirens that are placed at strategic points in the area to alert the inhabitants.

3.6 Environmental Management:

The city engineers install sensors across the city which measure temperature, relative humidity, carbon monoxide, nitrogen dioxide, noise and particles. If any of the parameters go above a set threshold, the GPS-enabled sensors send an alarm to a central node. The node in turn sends the information to the cell phones of the habitants.

3.7 Refuse Collection and Sewer Management:

The municipality has sensors placed in the septic tanks so as to raise an alarm when the septic tank reaches a preset level. Trucks are then dispatched to remove the waste from the septic tanks. The municipality places bins at strategic positions in the city. The bins have sensors which raise alarms when the bin is full and a refuse collection truck is dispatched to collect the waste.

IV. Energy Management

An estimated 70% of the energy grid is more than 30 years old, making it prone to stress and failure, requiring high maintenance, and posing environmental risks. There is widespread agreement that the ways in which the world has traditionally produced, distributed, and consumed energy must change, for both environmental and economic reasons. Fossil fuels still account for more than 80% of global energy production, but renewable sources are gaining ground year after year, now approaching 10% of total generated power. The distribution system will need to accommodate energy from an array of sources—wind, solar, hydro, wave, and geothermal—in addition to coal-fired generators. Moreover, energy from natural processes is unpredictable. Providers will need to be able to plan for variability of supply.

The smart energy grid—which is somewhere between vision and reality—promises to address these issues.

1.) It will integrate traditional and emerging power sources and make the delivery of energy cleaner, safer, and more economical.
2.) Operators will have the transparency and visibility to monitor and analyze the flow of energy, and two-way communication with consumers' smart meters to analyze consumption patterns.
3.) Intelligent devices that collect and analyze massive volumes of data will enable operators to plan for contingencies for variable resources.
4.) Smart IoT devices will manage the distribution of energy based on real-time data and situational awareness, as opposed to historical data patterns.

5.) Predictive maintenance capabilities will alert operators when a component needs attention or repair, reducing the need for ongoing inspections.
6.) Adaptive analytics will enable systems to automatically balance energy loads to reduce stress and prevent overheating.
7.) Intelligent energy distribution also pays an environmental dividend. Connected devices can perform power management tasks with finer precision and faster response times than manual, human-dependent systems, thereby saving energy, prioritizing usage, and setting policies for response to outages.

4.1 Addressing Challenges:
Realizing this vision faces four major challenges:
4.1.1 Securing the Grid from Hackers and Acts of Cyber Sabotage:
The ability for devices to communicate over wired or wireless networks makes the grid vulnerable. According to the U.S. Department of Homeland Security, energy systems are under virtually constant attack. This requires a comprehensive security approach from the boundaries of the Internet to the device level. Security needs to be built into every device starting at the base of the software stack.

4.1.2 Connecting And Protecting Legacy "Brownfield" Systems—The Older, Aging Parts Of The Existing Energy Infrastructure:
This can be accomplished by building secure Internet gateways that enable cloud-based central control systems to collect local intelligence data from the systems while blocking attacks.

4.1.3 Building Intelligence into "Greenfield" Systems Out Of The Box:
New systems and devices built for the smart grid must deliver manageability, security, and connectivity. Smart systems should be able to perform more tasks with fewer devices, driving down the cost of development and deployment.

4.1.4 Protecting the Privacy of Energy Consumers:
The data generated from smart metering has the potential to expose sensitive customer information. The same security principals that apply to the energy enterprise must also be applied at the consumer level.

4.2 Case Study:
The Benefits of IoT Analytics for Renewable Energy: Par Stream helps Envision Energy improve wind turbine productivity by 15%.

4.2.1 The Challenge:
Renewable energy companies have experienced strong growth, but face pressure to improve profitability and productivity as the industry scales globally. To that end, Envision realized that the energy business can no longer be differentiated just by mechanical engineering, but by their ability to monitor and maintain high performance over time. That's why each of Envision's wind turbines are built with over 150 advanced sensors that continually assess acceleration, temperature and vibration. Extracting data from their wind turbine sensors lets them see trends and create predictions for performance optimization to increase productivity and predictive maintenance to minimize downtime.

The company's network of 20,000 wind turbines is one of Envision's best competitive advantages, but managing massive amounts of real-time data and continuous monitoring of their vast wind turbine network is a cumbersome task. Envision is currently analyzing over 20TB of historical data at a time. However, data is growing at over 50% annually as Envision continues to collect more data, more frequently from each of their wind turbines. To complicate things even further, the wind farms which house their turbines, are geographically dispersed.

4.2.2 The Solution:
Envision realized that there are measurable business benefits in analyzing turbine sensor data with greater granularity. As such, they have moved from analyzing turbine data every ten minutes to every minute, and then on to every few seconds. By immediately analyzing real-time sensor data from their wind turbines, Envision is able to quickly identify actionable insights with significant business benefits. Two key use-cases for Envision include Performance Optimization and Predictive Maintenance, which combined, help to deliver an overall 15% improvement in productivity.

4.2.3 Performance Optimization:

Envision uses sensor data to make smart decisions about altering the angle and speed of the turbine blades in order to optimize performance at any given time, based on changing environmental conditions.

According to **Dr. Guido Jouret, President of Envision Digital Innovation Center**, "through the use of real-time sensor data, we can boost a customer's total energy output by up to 15% from their wind farms"

4.2.4 Predictive Maintenance:

Envision's sensor technology checks for any irregularities in operational performance for their 20,000 wind turbines, which allows Envision to predict potential failures before they happen. They match real-time data against historical data to determine which parts need adjustments or replacements, significantly reducing downtime.

"ParStream's unique ability to analyze terabytes of data with sub-second response times further improves our ability to generate significant value from our IoT applications."

- Dr. Guido Jouret, President, Envision Digital Innovation Center.

4.2.5 Results:

Envision needed an analytics solution, which allowed them to handle terabytes of data with sub second response time, along with the capability to run distributed queries/edge analytics closer to the source of data. Envision wanted an integrated platform to continuously import and store large amounts of real-time sensor data with the ability to run fast and flexible queries. They also wanted the ability to run queries at any given time, whether in their own data center, in the cloud, or in customer locations. With so many moving parts, Envision needed a big data analytics provider that could be nimble enough to run queries across huge data sets, while also being reliable enough to protect their critical IoT investments.

V. Home Automation

The houses we live in can be configured to identify individuals, whether they are the usual family members, guests, or unauthorized people. Individuals are identified by means of what they have one person, for example, a smart phone that is identified through radio waves. If an individual inside the house has no such ID then they are identified as unauthorized and an alarm signal is routed to the relevant external body or to the house owners.

Internet of Things technology can be applied to create new concept and providing development space for smart phones to provide intelligence. The impact an value of Internet of Things brings to our daily life. People can make easy decision about to select best restaurant in the cities and finding its route. IoT developing technology will providing people personal and commercial goods with unimaginable work. As much as home automation still seems to be part of the future, there are actually a number of applications that exist in the present that allow for varying degrees of home connectivity.

Mobi plug is an app that allows the user to connect Hundreds of wireless enabled household items regardless of manufacturer or wireless protocol .The user can make presets on their app that will automate certain settings. For instance, a Go to sleep preset may dim the lights, turn off the heater or AC. The Mobi plug applications also uses geofencing, which creates a basic perimeter around the home and uses location information for apps. One example of how geofencing could be used is that once the home senses the user within the wi-fi range, it could open the garage door. Smart Things is the do-it-yourself of home automation. Each kit comes with heat, motion, and open/closed sensors as well other outlets and applications that the user puts throughout their house.

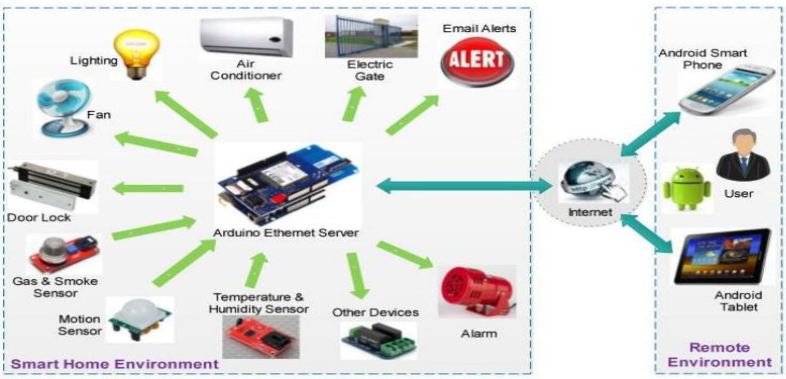

Fig.1 HOME AUTOMATION

VI. Architecture

6.1 Components of the Systems:

The control system consists of a microcontroller circuit called an Arduino, a microcontroller circuit called a Raspberry Pi, an ultrasonic distance sensor, a passive infrared sensor, a current sensor, window and door status sensors, middleware, an infrared transmitter, an air conditioner, a data analytics component, and an application to control the system.

6.1.1 Arduino:

The Arduino is an open-source prototyping platform based on flexible and easy-to-use hardware and software. It is a single-board microcontroller, designed to make the process of using electronics in multidisciplinary projects easier. The exposed connectors in the Arduino enable the processor to be connected to add-on modules. The Arduino is able to communicate with software executing on a connected computer. The Arduino system easily interfaces with a computer via USB when programming is required. The Arduino on the other hand has no significant permanent storage abilities, but mostly incorporates volatile RAM. The Arduino cannot just directly connect to either a monitor or keyboard and usually does not host an operating system. In the laboratory environment, and the envisioned real-world application, the Arduino in the smart home obtains the IR codes from the sensors in the home. The codes are temperature up, temperature down, turn the appliance up, and turn the appliance down. The obtained codes are then embedded into the Arduino to be transmitted when the need arises.

6.1.2 The Raspberry Pi:

The Raspberry Pi is a single-board computer developed by the Raspberry Pi foundation. It uses a Linux kernel-based operating system. Compared to a desktop computer, the Raspberry Pi is limited in RAM and CPU power. It can be connected to a monitor, keyboard and mouse. It also connects to the internet directly and has storage facilities and an operating system.

6.1.3 Middleware:

The middleware is a system that allows easy communication between things and humans via a number of protocols (or communication channels) such as email, Extensible Messaging and Presence Protocol (XMPP), Hyper Text Transfer Protocol (HTTP), Facebook, Jabber (Instant messaging), MXit, Radio Frequency Identification (RFID) tags, Quick response (QR) codes, Short Messaging Servic. Multimedia Messaging Service (MMS) and Twitter. The main component of the middleware is the controller. The middleware is the interface between business services and the channels. These Businesses are services can range from a calculator, to a tweet back on dam levels or the temperature of an object, to the determination of a plant's moisture levels, etc. Requests for services in middleware come from the user via any of the above-mentioned channels. They are routed via the controller to the business services.

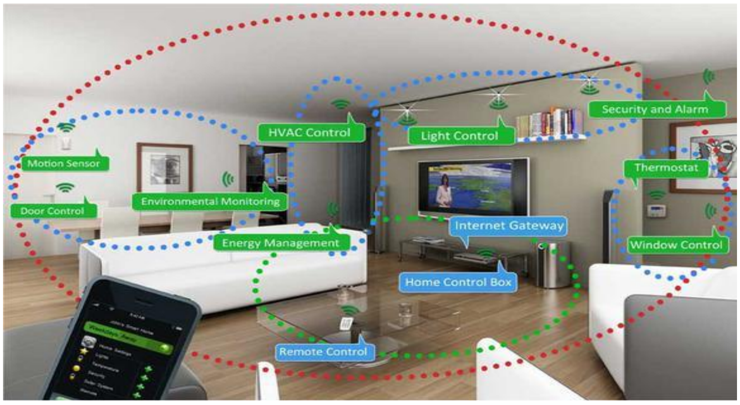

Fig.2. Smart Home Appliances

6.1.4 Data Analytics Component:

Analysis of data is the process of inspecting, cleaning, transforming, and modelling data with the goal of discovering useful information, suggesting conclusions and supporting decision-making. In this case the system continuously monitors the temperature of the room according to the presence of people in the room and according to certain rules, controls the air conditioning. The temperature in the room is kept constant even when the numbers of people in the room varies. The information generated is transmitted to a rules engine which then decides where to turn the air conditioning on or off.

VII. Conclusion

In summary, there are many benefits that will arise by using Internet of Things in our everyday life such as reducing costs and power supply. IoT has the potential to drive integrated solutions that can make a difference. By using IoT in our life, the whole world is going to be changed and people will get many opportunities in order to commit their insignificant activities to their smart things. The adoption of IoT in city services and infrastructure has transformed the way cities operate and deliver services. The application domains for IoTs in smart cities range from transport, tourism, health, ambient assisted living, crime prevention, governance, infrastructure, disaster management, environment management, smart homes to smart energy.

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