IPT2001

INTER DISCIPLINARY PROJECT REPORT

ON

SURVEY ON RECENT IOT BASED INNOVATION FOR SMART CITIES

AT

G D GOENKA UNIVERSITY, GURGAON

submitted in partial fulfilment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

COMPUTER SCIENCE AND ENGINEERING

Submitted By: *Shubham Gogia, Swarup Ghosh*

Programme: *B.Tech (CSE)*

University Roll No.: *170020203036, 170020203040*

Supervisor Name: *Mr. Nihar Ranjan Roy*

Designation: *Assistant Professor*

Department.: *Computer Science and Engineering*

Department of Computer Science and Engineering,
School of Engineering, G D Goenka University

May, 2019

Declaration

We do hereby declare that that this report submission for the project entitled "**Survey on Recent IoT Based Innovation for Smart Cities**" as an **Inter-disciplinary project** under the supervision of **Mr. Nihar Ranjan Roy** (Assistant Professor, Department of Computer Science and Engineering, GD Goenka University) is our original work and have been done with our own efforts.

Date: 6th May, 2019.

Name: Shubham Gogia

Enrolment Number: 170020203036

Programme: B.Tech (CSE)

Name: Swarup Ghosh

Enrolment Number: 170020203040

Programme: B.Tech (CSE)

Certificate

TO WHOMSOEVER IT MAY CONCERN

This is to certify that **Shubham Gogia** and **Swarup Ghosh -** students of GD Goenka University have undertaken "**Survey on Recent IoT Based Innovation for Smart Cities**" as a part of the partial fulfilment of the requirements for the award of the degree of **B.Tech.** in **Computer Science Engineering**. The collection of data, literature review on the project have been carried out under my supervision and guidance.

Date: 6th May, 2019.

Mr. Nihar Ranjan Roy

Assistant Professor,

Department of Computer Science and Engineering,

School of Engineering,

GD Goenka University.

Acknowledgement

We are very grateful to our university for giving us the opportunity to work on this project in the form of inter disciplinary research on "**Survey on Recent IoT Based Innovation for Smart Cities**" right at this very stage when we are pursuing a bachelor's degree. We also want to express our gratitude and thanks for the supervisor of our project. We are thankful to our team for their constant efforts and dedication to make this project successful.

Table of Contents

1. Introduction

With the evolution of technological means across different fields in the industry there is a growing rise in the use of the equipments available to us. The use of the various devices around us are constantly being improvised, being replaced by newer technologies and thus, becoming more and more efficient in solving real world problems. The former is clearly evident due to the constant research and varied idea nurturing these technological fields. A buzz word that we may find it common to come across in this new era of technology would be the internet of things or more popularly IoT. IoT technologies are being utilised across various domains to deliver smarter devices, systems and end-to-end platforms in the form of connected utilities, some of which may be modelled together to form a smart city.

Cities that make extensive use of IoT technologies to drive technological innovation such that various devices existent in the city are to deliver a smarter experience for the citizens present in that particular city may be referred to as a smart city, for instance. Smart cities technically make extensive use of connected devices in various forms such that the different constrained / embedded equipments functioning across the span of the city makes use of the internet to drive exchange of data and information in large volumes. The idea behind designing and deploying of smarter equipments into any city is to reduce the human intervention required for any real world task. Internet as a platform for data exchange have inspired growth of such devices and equipments by providing the necessary tools to drive machine to machine interaction between such devices in action.

2. Internet of Things (IoT)

The Internet of Things or IoT may be referred to as a network(s) consisting of different devices that may include vehicles, modular appliances, electronics, softwares, sensors, actuators etc. in such a way that various modules present in such networks may connect and interact amongst themselves by use of internet. It can be defined as a combination of different sub-technologies that may allow development of smarter devices harnessing the internet as a tool for exchange of data across sub systems to deliver an experience that is more useful / smarter at the user end.

Traditionally, embedded devices are designed in a such a way that space and meaningful resource constraints in these devices delivered in the form an end-user product aim to solve a single real world purpose eg. set top boxes, television sets, regular electrical appliances, kitchen appliances, etc. The idea of such constrained devices exist for the fact that these devices are created keeping in mind a specific problem as opposed to more complete computer systems that are generally used to solve multiple problems of any nature. These devices require extensive human intervention for their operation unlike modern smart devices which aim to reduce the same. Human machine interaction (HMI) have formed an important methodology that has driven huge technological progress across ages. These devices are known to well communicate amongst themselves by events that require meaningful intervention by one or more humans.

Whereas, researchers have felt the immense need to optimise these kind of techniques such that the required amount of human intervention may be reduced to deliver systems that are quicker. Such techniques may be employed by effective use of machine to machine interactions (MMI) instead of human to machine interaction. Historically, the basic goals of IoT are directly interlinked with the concept of designing modern devices in such a way that they make more use of machine to machine interaction by minimising need for human efforts across certain possible tasks. The internet that has largely acted as a massive platform of change for information exchange readily allows for data transfer across multiple devices in action. Thus, embedded devices with access to the internet (more specifically termed IoT devices) makes use of internet to deliver faster responses through MMI over data based networks. These design techniques readily promote use of sensors and actuators into smart devices to deliver connected devices that are data driven instead of being only dependent on the human efforts.

The internet of things when termed as a single technology will include both hardware and software components that help IoT based systems to function with efficiency. Many of the varied technologies that may constitute an IoT system are as follows:

- Internet connectivity hardware (WiFi, GSM, etc.)
- Integrated Chips (ICs)
- Sensors
- Actuators
- Gateways
- Internet Web Services
- Databases
- Data Processing Units
- Data Warehouses
- User Level Interface
- Automation Tools
- Analytics

2.1 Platform and Devices

Any internet connected smart device will require a platform in order to make device communications with data based networks, i.e. internet. The device may make use of any form of internet connectivity like WiFi, GSM, Bluetooth, etc. The platform will directly ensure that the data to and from the IoT device makes meaningful context such that it serves the purpose for which it has been designed ensuring smarter capabilities at the device end.

An IoT platform may be defined as a multi layer technology that can be allow a cluster of IoT devices to connect with it such a way that it will help the device produce meaningful responses. A varied amount of resources are generally available for use with this platform and handles the provisioning, management, connectivity, services etc. of the connected equipment. When the term platform is used generally, it will be used to point out to both the software and hardware components. In an IoT system, usually the software components are responsible for a particular servicing end which may take place with help of the internet.

Generally, it is evident that an IoT platform will be deployed with the help of cloud based resources. The recent rise in cloud computing and with the emergence of cheap, flexible resources from leading cloud platforms that completely reduces the resource provisioning, management and maintenance by automating it marks a high rate of feasibility for cloud based platforms. Although, with the use of on-premises computational resources that connect to the nodal smart devices similar IoT platform may be obtained but research shows that it is generally less efficient, due to the fact that there is huge maintenance overhead.

Some of the common cloud based software IoT platforms are as follows:

- Google Cloud IoT Core
- Amazon Web Services IoT Core
- Microsoft Azure IoT Hub
- IBM Watson IoT
- Bosch IoT Suite

A step start in IoT development would also require one to use a conventional hardware platform. Some of the available hardware platforms are as follows:

- Raspberry Pi
- Arduino
- Intel Edison
- Intel Galileo
- BeagleBone
- Banana Pi
- Node MCU
- Flutter

A comparison of the different publicly available multi layer software IoT platforms has been provided underneath.

TABLE 2.1 Comparison of some IoT Software Platforms

Platform Name	Device Management	Data Exchange Protocols	Analytics Support	Integration
AWS IoT Platform	Yes	MQTT, HTTPS, HTTP, WebSocket	Realtime Analytics (Amazon Kinesis, AWS Lambda)	REST API, All Other AWS Services
IBM IoT Foundation Device Cloud	Yes	MQTT, HTTPS	Realtime Analytics (IBM IoT Real-Time Insights)	REST API, Real Time API
Ericsson IoT Accelerator	Yes	CoAP, Others	No native support	IoT Accelerator Marketplace Platform
Google Cloud IoT Core Platform	Yes	MQTT, HTTPS	Insights (Cloud Datatable, Data Studio)	REST API, All Other GCP Services
ThingWorx - MDM IoT Platform	Yes	MQTT, HTTPS, HTTP, WebSocket	Predictive analytics(Thing Worx Machine Learning), Real-time analytics (ParStream DB)	REST API

Platform Name	Device Management	Data Exchange Protocols	Analytics Support	Integration
Azure IoT Hub	Yes	MQTT, HTTPS, AMQP	Realtime Analytics (Stream Analytics, Power BI)	REST API, All Other Azure Services

A comparison of the different available hardware platforms has been provided underneath.

TABLE 2.2 Comparison of some IoT Hardware Platforms

Name	Form Factor	Power Input	Approx. Cost	Capabilities
Raspberry Pi	Single Board Computer	5v / 2.0A DC	$35.00	Quad Core ARM Cortex A53 Processor with 1GB LPDDR2 RAM, Ethernet, Broadcom WiFi, GPIO, Linux
Arduino Uno	Microcontroller Module Board	9-12v / 250mA DC or more	$22.00	AT Mega 328 16MHz Processor, Digital I/O, Analog Input Pins, Arduino IDE
Node MCU Dev Kit	Microprocessor Wireless Board	3.3v DC	$10.00	ESP8266 WiFi SoC, GPIO, Arduino compatible
Intel Edison	Systems on Chip (SoC)	7-15v DC	$50.00	Intel Atom Tangier Processor with 1 GB RAM, 4GB eMMC Flash, WiFi

Name	Form Factor	Power Input	Approx. Cost	Capabilities
Intel Gallileo	Microprocessor Mother Board	7-15v DC	$55.00	Intel Pentium Quark Processor, Arduino Compatible
Banana Pi	Single Board Computer	5v / 2.0A DC	$41.00	ARM Cortex A7 Dual Core CPU with 1 GB DDR3 RAM, Gigabit Ethernet, GPIO, Linux

3. Smart Cities

A common application of IoT across the globe includes initiatives that powers the smart cities of today coagulating a enumerable cluster of smart devices into the connected space of internet driven application such that cities may deliver better experience at the citizen's end also, to improve the quality of life of people. Smart cities are an attempt to deliver information system based operational efficiency for the city such that data driven technologies can improve governmental services and citizen welfare.

The features of smart cities may be enlisted as follows:

- Decisions that are data driven
- Enhancement of government citizen interactions
- More workforce into action
- Community safety
- Digital literacy
- Environmentally efficient
- Improved public utilities

The efficient use of smart devices with an ecosystem of connected device space that allows secure interaction amongst the smart devices present in the network may account for a variety of applications. Some of the few well known implementations with regard to smart cities are as follows:

- Smart Homes
- Wearables
- Connected cars
- Smart Healthcare
- Smart Parking
- Smartphone Detection
- Geographical Maps
- Hydrological Monitoring

- Weather Monitoring
- Surveillance

3.1 Tracks

The different tracks that have been observed across the globe when it comes to smart cities have been enlisted underneath.

- **Smart Parking** - Monitoring of parking spaces availability in the city.
- **Structural health** - Monitoring of vibrations and material conditions in buildings, bridges and historical monuments.
- **Noise Urban Maps** - Sound monitoring in bar areas and centric zones in real time.
- **Smartphone Detection** - Detect iPhone and Android devices and in general any device which works with WiFi or Bluetooth interfaces.
- **Electromagnetic Field Levels** - Measurement of the energy radiated by cell stations and and WiFi routers.
- **Traffic Congestion** - Monitoring of vehicles and pedestrian levels to optimise driving and walking routes.
- **Smart Lighting** - Intelligent and weather adaptive lighting in street lights.
- **Waste Management** - Detection of rubbish levels in containers to optimise the trash collection routes.
- **Smart Roads** - Intelligent Highways with warning messages and diversions according to climate conditions and unexpected events like accidents or traffic jams.
- **Air Pollution** - Control of CO_2 emissions of factories, pollution emitted by cars and toxic gases generated in farms.
- **Snow Level Monitoring** - Snow level measurement to know in real time the quality of ski tracks and allow security corps avalanche prevention.
- **Landslide and Avalanche Prevention** - Monitoring of soil moisture, vibrations and earth density to detect dangerous patterns in land conditions.
- **Earthquake Early Detection** - Distributed control in specific places of tremors.

- **Potable water monitoring** - Monitor the quality of tap water in cities.
- **Chemical leakage detection in rivers** - Detect leakages and wastes of factories in rivers.
- **Swimming pool remote measurement** - Control remotely the swimming pool conditions.
- **Perimeter Access Control** - Access control to restricted areas and detection of people in non-authorised areas.
- **Liquid Presence** - Liquid detection in data centres, warehouses and sensitive building grounds to prevent break downs and corrosion.
- **Green Houses** - Control micro-climate conditions to maximise the production of fruits and vegetables and its quality.
- **Meteorological Station Network** - Study of weather conditions in fields to forecast ice formation, rain, drought, snow or wind changes.
- **Compost** - Control of humidity and temperature levels in alfalfa, hay, straw, etc. to prevent fungus and other microbial contaminants.
- **Energy and Water Use** - Energy and water supply consumption monitoring to obtain advice on how to save cost and resources.
- **Remote Control Appliances** - Switching on and off remotely appliances to avoid accidents and save energy.
- **Intrusion Detection Systems** - Detection of windows and doors openings and violations to prevent intruders.
- **Patients Surveillance** - Monitoring of conditions of patients inside hospitals and in old people's home.
- **Ultraviolet Radiation** - Measurement of UV sun rays to warn people not to be exposed in certain hours.

The collection of data in large volumes at each stage through IoT based sensors and devices in the aforementioned systems allows for an efficient means to improve the efficiency of such technologies. Also, meaningful analytics and predictive actions in these regards have helped IoT evolve as an important tool for the modern era.

A few cities that are presently known as smart cities by virtue of their technological advancement in the above stated field are as follows:

- Singapore
- Southampton
- Dubai
- Amsterdam
- Stockholm
- New York
- Madrid
- Barcelona

Some of the cities of India are proposed to becoming smart cities in the future. This is directly a result of the Government of India's Smart Cities Mission. Some the cities have been enlisted underneath.

- Agra
- Ahmedabad
- Bareilly
- Bhubaneswar
- Chandigarh
- Coimbatore
- Guwahati
- Indore
- Itanagar
- Kochi
- Ludhiana
- New Delhi
- New Town Kolkata

- Panaji
- Pune
- Srinagar
- Surat
- Warangal

3.2 Global Initiatives

The different cities across the globe that have taken smart initiatives to drive IoT based innovation as a part of their smart city infrastructure have been tabulated below.

TABLE 3.1 Comparison of some IoT Software Platforms

Sl. No.	City	Country	Smart Initiatives
1	Seoul	South Korea	Residents were provided with tablets and smartphones to assure they received timely medical attention.
2	Vienna	Austria	Renowned for traffic management and smart building utilization, projected to install over 300,000 solar panels by 2020 and has the world's largest biomass plant.
3	Boston	United States	Ranked as one of the world's top-five smart cities since 2015. Boston is among the best cities regarding governance, public management, and has been ranked No. 1 on Human Capital.

Sl. No.	City	Country	Smart Initiatives
4	Amsterdam	Netherlands	City's efforts to stay innovative and utilize renewable energy include electric trucks that pick up garbage, along with solar power and use of roofing insulation, automatically dimming light switches, smart meters, and ultra-low energy LED lights.
5	Tokyo	Japan	City develop a suburban "Smart Town" that produces zero carbon emissions, and was powered completely by renewables and ranks especially high in smart parking, WiFi hotspots
6	Stockholm	Sweden	The first city to introduce 4G/LTE mobile services. Public transportation vehicles receives their fuel from two wastewater treatment plants producing biodiesel.
7	Paris	France	City's public transportation utilizes green and renewable energy. Citizens utilize public transportation on a regular basis, including a bike sharing program called Velib.
8	London	United Kingdom	Ranked among the best cities for international outreach, human capital, innovative economies, and launched Europe's largest free WiFi Network. London even has an institution called the Smart Cities Research Center.

Sl. No.	City	Country	Smart Initiatives
9	San Francisco	United States	Not only does the city’s grid currently run on 41 percent renewable energy, but San Francisco’s smart grid deployment sector has grown 130 percent in recent years. The city has over 100 public charging stations for electric vehicles, and increased its public transportation services.
10	New York City	United States	Declared the “smartest city” in 2017. Partnered with IBM city provide all its residents with internet access and also developed smart hubs with NFC technology and WiFi. City ranks among the top cities in car sharing services, education, innovative economies, internet speed, and WiFi hotspots.

4. Pub Sub Messaging

Internet, an interconnection of different networks extensively makes use of the TCP/IP stack. A wide variety of programs have evolved for the purpose of information exchange over networks; also for the same reason many number of protocols have been developed. The protocols typically would make use of the de facto server client architecture to facilitate the communication of data. Besides, server-client architecture there is also another model that is well suited for communication for IoT based devices. It is also acclaimed to have low power usage on the boards. Pub/Sub style also known as publish subscribe mode of messaging is being referred to as here. The generic protocol for transmission of data over IoT networks is MQTT protocol - **Message Queuing Telemetry Protocol**. A majoritty of IoT software platforms as aforementioned natively support the MQTT protocol.

There are different QoS levels in MQTT. The three different quality of service levels as enlisted below:

- QoS 0
    - **at most once**
    - service level guarantees best effort delivery
    - no guarantee of delivery
    - recipient does not acknowledge receipt
    - one way without any acknowledgement
- QoS 1
    - **at least once**
    - sender shares message until it gets PUB-ACK packet from receiver
    - acknowledgement from recipients
    - multiple times send or delivery may be possible
- QoS 2
    - **exactly once**
    - highest level of service

- guarantees each message receive exactly once
- guarantee provided by at least two request response flows
- 4 part handshake with PUB-REC, PUB-REL, PUB-COMP packets

The different service levels have been illustrated with their respective acknowledgement and message packets in the figure beneath.

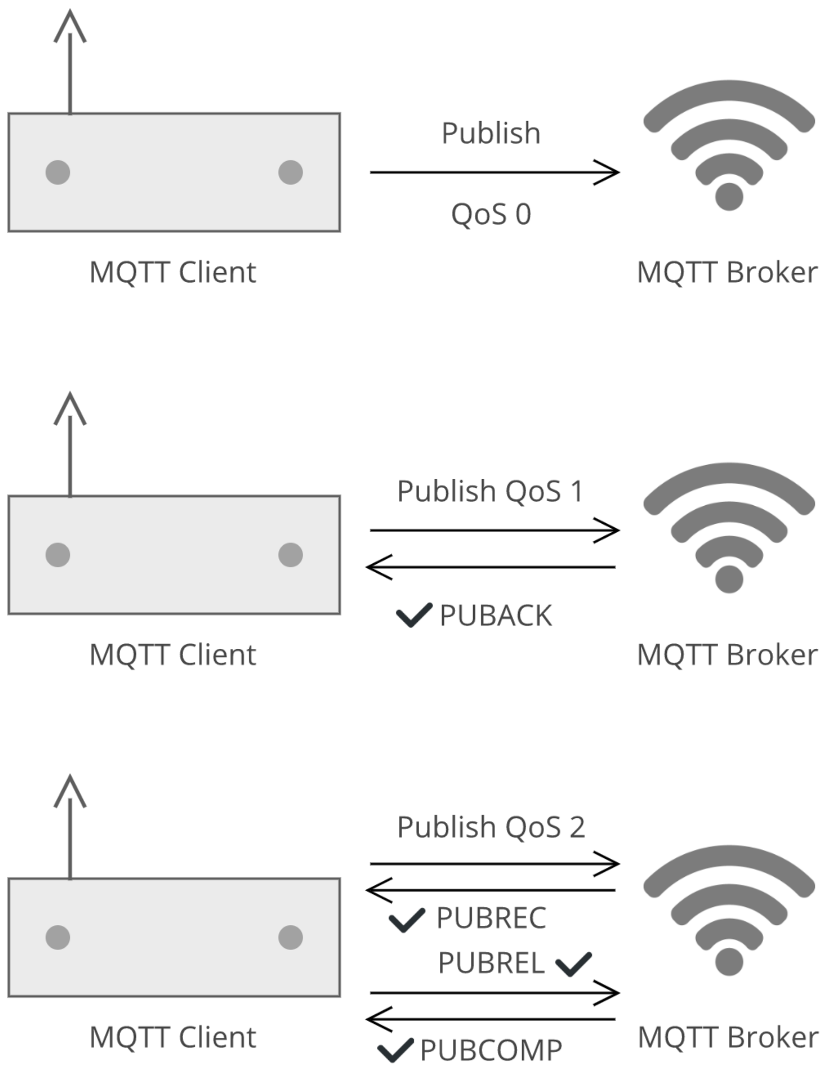

FIG 4.1 Different QoS Levels of MQTT Pub Sub

5. Challenges

With the rise of IoT technologies across the globe different new challenges have turned up that the industry are facing at a major level adding to several crises which hamper experience at the user end as well as adding difficulties to citizens when we bring smart cities into the picture.

Some of the challenges that a smart city obviously is subjected to is the rise of unemployment due to the increase of automation technologies. The growth of such technologies at a scale that can easily surpass the time frame required for the people to develop and maintain new skillsets is the major issue behind the cause. Otherwise, in some cases the privacy of the citizens are a major issue that is supposed to be dealt with an utmost priority. Increased collection of data from the different IoT devices adds to the multiple open data connection streams which when used with unsecured transmission channels opens it to the hand of perpetrators. When these multi level IoT technologies are ill-designed such that security paradigms are not taken care of, adds a huge amount of hazard due to the underlying breeches. In such a case, hackers or penetrators gaining access to one object would imply that the entire data chain being available to them. This is also the case that comes under the head of cyber crime which needs to be dealt efficiently by the societies living in a smart city through increased opportunities in the world of cyber security for such systems.

The different devices that the consumer receives in lieu of IoT are often ill-calibrated in terms of sensors since cheap sensors with less lifetime are being used by multiple enterprises to cater to faster development of products. IoT platforms have allowed developers to grow their idea from prototype stage to planet scale at little or no time, leaving behind the different hardware level challenges which are still unsolved to some extent in most cases. eg. use of DHT calibrated sensors for IoT based projects are kind of recommended, yet products are made without them. A minute lack of standards in this regard also increases this issue.

Apart from the above stated challenges IoT systems face a problem commonly known as interoperability. Although, most systems are known to abide with open data standards and generic protocols for their working, there still is a lack of concrete concept for smart city development due the fact that these technologies are new for the industry. The problem adds to the fact that we start to rely on software and hardware ecosystems built by the tech giants leaving the other solutions provider out from the picture. While in some other cases lack of interoperability also makes systems used in smart cities region specific, system specific, domain grounded, enterprise level-only, etc.

Thus, the above mentioned challenges can be broadly categorised into the following heads.

- Vulnerability to Hacks
- Security and Privacy Concerns
- Interoperability Problems
- Systems Scalability
- Hardware Level
- Volume of Data

6. Conclusion

The internet of things have driven different technological implementations across the globe. It is considered to be a collection of different layers of technological means that serves a promising new field which is helping solve the real world problems around us in smarter ways such that it help drive change at a very quick rate. It is noticeable that the rise of these technologies in varied forms have allowed us to witness smart cities around us. Although, there are certain challenges when different innovative techniques come in to the picture that aim to solve city level problems through IoT, these can be overcame with careful design level decisions and increased permission mechanisms at the user level. A careful analysis of the industry and comparison of it with former technological trends tells us that IoT is at a nascent stage, yet gaining popularity from the masses due to the rapid evolution in this field at a regular basis.

References

1. Internet of Things for Smart Cities - IEEE Journals & Magazine - https://ieeexplore.ieee.org/document/6740844
2. Smart Cities and the Future Internet: Towards Cooperation Frameworks for Open Innovation | SpringerLink - https://link.springer.com/chapter/10.1007/978-3-642-20898-0_31
3. Top 10 Smartest Cities In The World - https://www.ecnmag.com/blog/2017/11/top-10-smartest-cities-world
4. Multi-Node Wireless Energy Charging in Sensor Networks - IEEE Journals & Magazine - https://ieeexplore.ieee.org/abstract/document/6747384
5. Autonomous recovery from multi-node failure in Wireless Sensor Network - IEEE Conference Publication - https://ieeexplore.ieee.org/abstract/document/6503187
6. IoT Applications for Smart Cities - Internet of Things Innovation - https://internet-of-things-innovation.com/insights/the-blog/iot-applications-smart-cities/#.XA_4l3QzZPY
7. IoT Applications for Smart Cities - Internet of Things Innovation - https://internet-of-things-innovation.com/insights/the-blog/iot-applications-smart-cities/
8. 2019 IoT Products | Overview of the Most Popular Smart Home Devices - https://www.postscapes.com/internet-of-things-award/winners/
9. An IoT-based appliance control system for smart homes - IEEE Conference Publication - https://ieeexplore.ieee.org/document/6568171
10. Thinking about becoming a smart city? 10 benefits of smart cities | Explore Our Thinking | Plante Moran - https://www.plantemoran.com/explore-our-thinking/insight/2018/04/thinking-about-becoming-a-smart-city-10-benefits-of-smart-cities
11. Smart city - Wikipedia - https://en.wikipedia.org/wiki/Smart_city
12. Top 50 Internet of Things Applications - Ranking | Libelium - http://www.libelium.com/resources/top_50_iot_sensor_applications_ranking/

13. Internet Of Things Challenges || GoodWorkLabs || 2017 || - https://www.goodworklabs.com/challenges-iot-smart-cities/

14. 10 Real World Applications of Internet of Things (IoT) - Explained in Videos - https://www.analyticsvidhya.com/blog/2016/08/10-youtube-videos-explaining-the-real-world-applications-of-internet-of-things-iot/

15. What is the Internet of Things Platform - All About IoT Technology and Applications - https://www.kaaproject.org/what-is-iot/

16. 10 Best Internet of Things (IoT) Cloud Platforms - DevTeam.Space - https://www.devteam.space/blog/10-best-internet-of-things-iot-cloud-platforms/

17. Internet of things - Wikipedia - https://en.wikipedia.org/wiki/Internet_of_things

18. Addressing Fault and Calibration in Wireless Sensor Networks - http://web.eecs.umich.edu/~girasole/wp-content/uploads/2013/04/FaultCalibration.pdf

19. Fault Detection and Diagnosis - https://www.researchgate.net/profile/Mohamed_Mourad_Lafifi/post/How_and_what_form_of_state_space_modeling_is_necessary_for_a_model_based_fault_detection_using_fuzzy/attachment/59d6356e79197b8077993020/AS%3A384175594065920%401468606007030/download/Fault+4.pdf

20. Smart Cities in India - https://www.rvo.nl/sites/default/files/Smart%20Cities%20India.pdf

21. IoT-based Smart Cities: a Survey - https://www.researchgate.net/publication/301790173_IoT-based_Smart_Cities_a_Survey