© 2018 IJSRSET | Volume 4 | Issue 2 | Print ISSN: 2395-1990 | Online ISSN : 2394-4099
National Conference on Advanced Research Trends in Information and Technologies (NCARTICT-2018), Department of IT, L. D. College of Engineering, Ahmedabad, Gujarat, India In association with International Journal of Scientific Research in Science, Engineering and Technology

Survey of IoT Frameworks for Smart Water Metering

Urja Mankad[*1], Harshal A. Arolkar[2]

[*1]Assistant Professor, L. J. Institute of computer Applications, Ahmedabad, Gujarat, India
[2]Associate Professor,GLS Institute of Computer Technology, Ahmedabad, Gujarat, India

ABSTRACT

Applications designed for Internet of Things (IoT) needs support of interoperable physical infrastructure, communication protocols, data storing and managing techniques and user-friendly interface. IoT is not as simple as the TCP/IP suite where protocols and communication structure are fixed.The key challenge for IoT is to have a standardized framework to connect any 'thing' to an IoT network. Here the major challenge is of heterogeneity of objects. Many researchers have tried to propose different frameworks to support IoT applications. This paper surveys different types of IoT frameworks proposed to help get insight about IoT trends and future scope for smart water metering system.

Keywords: IoT; framework; Smart Water Metering; Architecture

I. INTRODUCTION

Use of Internet has increased exponentially in the last decade or so. Approximately half of the world's population uses Internet 0. Similarly deployment of IoT based applications is increasing rapidly now. The idea of IoT is to form an Internet of computing devices or objects with sensors which are connected with computers or mobile phones, operated or monitored by human beings. IoT can be expressed as a wireless network layer on top of the Internet where millions of things are continuously tracked, monitored and managed by people all over the world. It is said that by the year 2020 more than 50 billion objects will be joining this network [34].

IoT technology has been widely used in different sectors like, Healthcare, Agriculture, Education, Industrial and many more [1][12]. Different applications of IoT like Smart building, Smart board teaching, Smart Meters, Smart Parking, Smart Tracking, Smart Health, Intelligent Traffic Management, Environment Monitoring, Waste Management, Air Quality Monitoring, Smart Lighting and others have been proposed and implemented. Smart water metering is one of the upcoming applications of IoT[3].

There are many different frameworks available in the market for IoT applications as well as researchers are trying to propose more and more frameworks suitable for IoT applications[9][22][29][29][31][32][33]. In this paper we have done survey of different frameworks with the focus of suitability for smart water metering system. Section II contains related work, Section III contains present situation for the deployment of smart water meters in India. Section IV concludes with the future thoughts and upcoming challenges.

In today's hi-tech era people don't have time to do all the tracking and monitoring tasks on daily basis. IoT connects different types of devices, objects and people together to communicate and exchange data or information to solve many problems which make theroutine easy and simple. Planning and scheduling of task can also be done easily if our objects are on internet. We can synchronize daily activities without stressing our mind. As a result there are technological developments going on for Things Identification Mechanism (Tagging Objects / Addressing Things), Wireless sensing mechanism (Sensors / RFID), Embedded Systems (Microprocessors / OS), Data Management Technology (Data Mining / Big Data) [24][26]

Basic Architecture of IoT:

Internet of Things can be referred as machine-to-machine interaction with secure connectivity, appropriate infrastructure, large amount of data transfer, computation, storage and analytics for converting data to information for people and businesses [23].Layered model for IoT is similar to the one shown in fig.1.

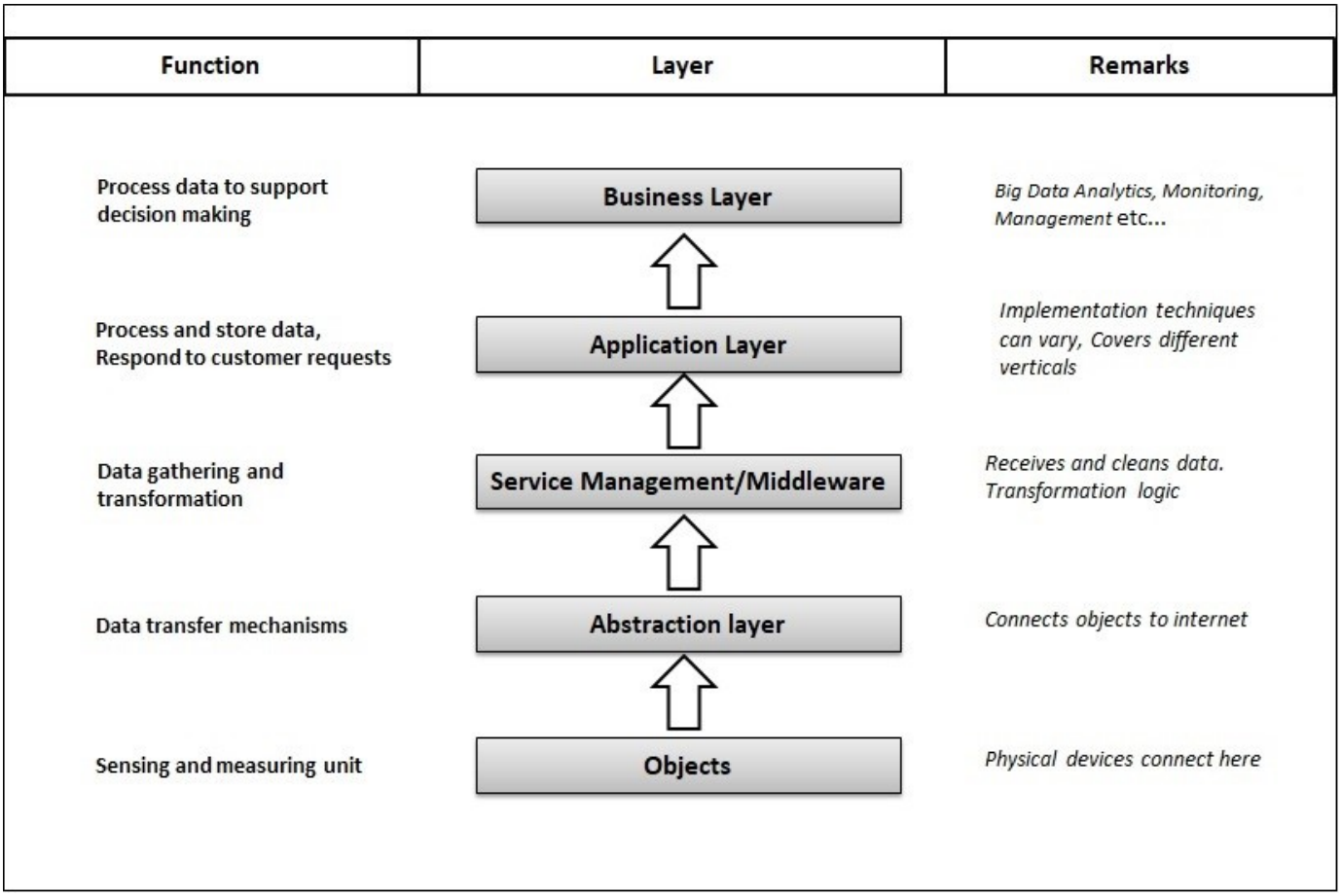

Figure 1. Layered Model for IoT

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1. Object Layer: Physical objects / sensors, of IoT are connected at this layer. Large amount of data are generated at this layer and from there digitized data are send to the abstraction layer using a secure channels.
2. Abstraction Layer: Data gathered from the objects are sent to the service management layer using different connectivity/communication services of the internet.
3. Service Management Layer: Provides a middleware for facilitating IoT applications to run on different hardware platforms.
4. Application Layer: This layer provides high quality smart services to customers depending on their request.
5. Business Layer: This layer manages system activities and services. It is responsible to build abusiness model to support decision support system based on Big Data analysis.

II. METHODS AND MATERIAL

When we talk about Internet we have different types of networks like Wired Network, Mobile Network, Sensor network and so on but there the nodes are of same type and are using same methods and protocols to exchange data to communicate in between. But when we say Internet of Things, the main challenge is of heterogeneity of objects and their communication techniques and the physical connections[27].

Due to an incredible advancement in IoT services, different frameworks based on interoperability hardware, data exchange methods, low power communication with cloud services, data compression and security have been proposed by researchers[6][7][28].

For the IoT implementations a conceptual layered structure is needed to serve as a support for building applications [2]. The IoT framework should provide interrelation between objects at physical layer, operating system / mainframe support, communication mechanism and application programming interface standards etc.
The Internet of Things Middleware framework joins different components together for enabling smooth communication between objects or devices or people in the network. The IoT interface provides the interaction between the Internet and Things. [14][17]

Many enterprises and alliances have come up with different IoT frameworks or Platforms to increase the connectivity of the devices / objects into the cloud/ network services. These frameworks and platforms provide interoperability among devices and powerful analytic power for the applications to build on [11]. Some frameworks also provide value added services like security and authentication to access the data from different applications of IoT [17][21]. Here the survey is carried out from two perspectives that are commercial frameworks / open source frameworks and frameworks proposed by researchers.
Commercial frameworks used by some of the organizations are proprietary solutions. They provide their components and technologies for a specific problem.

Maven Systems [39] uses a device called WiArt which is used as a wireless connectivity module and collects data from the smart meters using GSM. This data are sent to the data concentrator using GPRS. They provide cloud storage for collected data and different management reports can be generated. Maven systems have their own mesh topology in which communication occur using ISM bands.

Sensus[40] have SensusRF as a LPRF wireless connectivity module. Other solutions are Connit[41][42], IoTSens[43], WebNMS[44], Smarter Homes [45]. Many proprietary solutions are available in the market. Table 1 shows comparison of few of them.

Table 1. Comparison of Commercial solutions for smart water metering

	Maven	**Sensus**	**Connit**	**IoTSens**	**WebNMS**
Data collection/ connectivity devices	WiART, Wireless connectivity module (LPRF), GSM based smart metering modul	Sensus RF, Wireless connectivity module (LPRF), GSM/GPRS/3G	Blue Pulse Mini, Blue Pulse XL2i, LPRF (SigFox), GSM/GPRF communication	Watchmeter Data Logger, Limnimeter, Wireless connectivity (2.4 GHz), GSM Based connectivity	Devices are 3rd party (flow meter, pressure meter), Connect to gateway over RS232, MODBUS, GSM/Ethernet connectivity from gateways
Data concentrator units	Wireless (GPRS)/Wired (Ethernet) Data Concentrator Units, Walk by/Hand held data collector units also available	GPRS / Ethernet based data collection, Hand held collection units also available	GPRS/3G/Ethernet	Not specified by provider	Not specified by provider
Meter data management (cloud software)	Close storage, Reporting	Close storage, Reporting	Close storage, API export, Reporting	Not specified by provider	Cloud storage, Alerts, notification, analytics/reporting, Rule based process automation

Meter types/ integration	Analog and Digital inputs	Not specified by provider	Pulse meters	Not specified by provider	Not specified by provider
Communication Technologies	Maven SmartMesh (Mesh topology) on ISM Band - Works on 433 MHz, 865-868 MHz (802.15.4g) SmartMesh using wired connectivity - UART, TTL, RS232, RS485 ZigBee (on 2.4 GHz)	Mesh topology on ISM Band - Works on 433 MHz, 868 MHz (902 MHz in USA) ZigBee (2.4 GHz)	Star topology using SigFox on ISM Band - 868 MHz (902 MHz in US)	SigFox, LoRa/LoRaWAN - Works on 433 MHz, 868 MHz (902 MHz in US) ZigBee (2.4 GHz), WiFi (2.4 GHz), Bluetooth (2.4 - 2.485 GHz), NB-IoT (Narrow Band IoT), M2M (Data, SMS, Voice) using GSM network	REST, SNMP, MQTT, SOAP, XML

Limited Open source frameworks are available in the market [18]such as Open Source Grid Platform, Open Meter Project etc. but they do have some loopholes which are under research by the researchers [15][16]

OSGP (Open Smart Grid Protocol) is supported and maintained by OSGP Alliance. They have developed a generic, scalable and independent 'Internet of Things' open source platform. Using this platform, smart objects can be easily connected, controlled and monitored. The platform can also help simulate development of smart solutions like Smart Water Metering. As it is open source, it can be used for our own applications and devices with reduced time and development cost.

Weakness of OSGP[15][16]:

1. RC4 algorithm is used for encryption in which stream cipher have known IVs so attackers can easily break WEP within seconds
2. Weak Digest function that may allow meet-in-the-middle attack by sending NACK for wrong digest
3. Sending unsecure broadcast message for firmware updates
4. Session key is the same as master key for encryption, so it is fairly exposed to a number of attacks, and a compromise of this key is possible

Jan Sliwa[26] has proposed a generalized framework for data exchange between objects of IoT system. Here he has analyses different types of data and provided classification for IoT data exchange schemes. There is a general structure and a support platform structure where a Data Broker, the main system element which will manage data among different types of recipients.

Kevin Laubhan et.al.[17]have presented a framework for low power data transmission from sensors to cloud. Here the node architecture has a low power microcontroller which will collect data from the sensors and the regional hub will be collecting data from the node architecture. The cloud architecture will provide efficient data processing and accessibility. The author still has to find different methods of node deployment to maximize coverage area, and optimize scheduling algorithm for minimizing energy usage.

Neeharika Cherukutota et.al.[10]has proposed an IoT framework for smart water meter reading system. They have used a Mediatek cloud sandbox and RESTfull web services to communicate between water meters and cloud.

Enrique Carrillo et.al [8]has proposed a framework for smart systems where computational power needed by the system is provided by the cloud services. The proposed framework uses Arduino integrated development environment for managing and monitoring things connected in the network. Raspberry PI work as a main gateway controller for all Arduino andMicrosoft Azure cloud services are used for computational power.

Mohammed ShahanasK., andDr.BagavathiSivakumar P. [25] have proposeda framework for a smart water management system in the context of smart city initiatives inIndia. They have tried to provide cloud based cost effective solution for data transmission and management.

Sanchez, Tomas, et al [24] have implemented an Adhoc network with clustering of objects and proposed a framework for improving network lifetime in collecting data.
Lloret, Jaime, et al[18] has also proposed a three layered communication architecture. They also says that proprietary solutions for meter communications cannot be suitable for all types of smart meters as there is a lack of standardization in communication protocols which can provide better interoperability among smart meters.

III. DISCUSSION

In this section we have a discussion related to the present situation for the deployment of smart waters in India. Water scarcity has become a serious threat to the globe. So we need some smart systems that will continuously measure the water usage and will help the utility companies in proper decision making. Manual meter reading is not just waste of human resources but also inconvenient and inaccurate. Many researchers have given solutions for Automated Meter Reading Systems in many countries. We would like to connect all water meters into the internet through the IoT as a global solution towards smart city. By the year2020 life will become easier with the help of all automated things. Almost all the things will be interacting with each other and human interaction will be negligible for the task of daily routine. Using smart water meter we can minimize the human load by taking automatic meter reading and sending it to the utility office for further decision making and generating bill. It will also helpful to the customers to know their real time water usage and can get the actual bill in time.

Smart water metering is defined in[29] as the system where smart meters provide meter reading data by monitoring water usage and transfer the consumption data frequently to the utility office, where it is integrated with the business system, like Billing System and the information is also shared with the customers via SMS or web portal. Using smart meters the water consumption data can be gathered automatically without physical visit by a human. Smart water meters can be used to find the solution for the problems like, Water losses, water quality, disasters and drought. Basic Components of Smart Water Metering System are defined by[12][13]. Fig 2 shows the basic components of smart water metering.

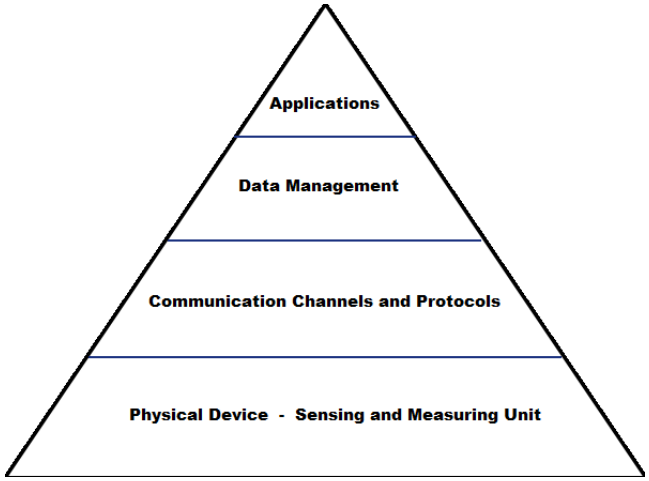

Figure 2. Smart Water Metering System Components

Smart Water Meter components are used in such a way that they can solve many problem of routine life related to water. Like Waste water management, Prevention of water losses due to leakage problem, Managing water quality and water level etc.. To achieve this goal we require a generalized framework architecture which can help easy and efficient implementation of smart water metering system.Many researchers have tried to give a generalized framework for IoT applications. Where Neeharika[10] has proposed an architectural framework for IoT based water meter.

Shahanas[25] has proposed an architecture for implementing smart water monitoring system. It includes basic three units . 1. Collecting water level from the tanks using sensors, 2. Transmit the data to a centralized server using Arduino and Raspberry Pi. 3. Visualizing the data through a web interface and also in the cloud using Ubidots cloud Platform. SMS and email alert system are also included as a part of user interface.
Ankith S et.al.[4]have proposed a design of smart water flow meter system for India. They have designed a prototype using HTTP Compatible CoAP based monitoring and control system. They have compared their system with the other [18][19][20] smart water meter reading systems and automated meter reading systems which are using ZigBee wireless technology for communication between water meters and base stations and data concentrators. In their proposal they have used 6LoWPAN protocol for wireless communication and they have tried to prove that it has more advantages over ZigBee. They stated that 6LoWPAN is more suitable for IoT based applications because using 6LoWPAN protocol sensor networks can be directly connected to the Internet without IP conversion. Proposed system's

prototype is simulated using ContikiOS, MySQL database and visual studio for web application which provides GUI to the users for the interpretation of usage data in the graphical way.

Table 2 shows comparison of the frameworks proposed by various researchers with respect to metering components and major IoT challenges.

The comparison shows that most of the proposals are all vertically defined according to the situation and need. Some are talking about communication protocols; some are talking about data gathering techniques. Further there are different solutions for water flow measuring, leakage management, billing patterns, cloud computations etc…but not a single solution provides flexible, generalized framework which can be suited for any scenario at any location for the implementation of smart water metering system. Hence it is required to set a framework in which any type of smart water metering system implementation becomes easy.

Table 2. Comparison of Frameworks

	Smart Water Metering Components			IoT Major Challenges		
Proposals	**Sensing Technique**	**Channel Acquisition & Communication Mechanism**	**Data Gathering and Analyzing**	**Interoperability**	**Scalability**	**Security**
3	X	✓	✓	X	X	X
4	✓	✓	✓	X	X	X
5	✓	✓	✓	X	X	X
6	✓	✓	X	X	X	✓
7	X	X	✓	X	X	X
29	✓	X	✓	X	✓	X
31	X	X	✓	✓	X	X
32	X	X	✓	✓	X	X
33	X	X	X	✓	X	X

As shown in Table 2, major IoT Implementation challenges are Interoperability Scalability and security. When we talk about smart water metering system, there may be different water meters communicating with each other as well as may send or receive data to other devices I the Internet, so Interoperability requirement is must. Apart from that, as the residential and commercial area will increase, smart metering range must be increasing with same communication speed and accuracy so that will be a big challenge. And last but not the least is the security. When user's personal device information is shared in the Internet, security is the main concern of an individual.

IV.CONCLUSION

The study of IoT framework concludes that no common framework can be used to develop any type of IoT applications or to deploy any system under IoT network. The main issue of the available IoT architectures is lack of full interoperability, privacy and security. Due to heterogeneity in IoT frameworks they have many network related problems like, channel allocation, routing mechanism, interface design and so on, many organizations and researchers are trying to build a uniform architectural framework that can fulfil the technical need for IoT. So, there is a strong requirement of a generalized framework to deploy a smart water metering system under IoT.

V. REFERENCES

[1] Agrawal, Shashank, and Dario Vieira. "A survey on Internet of Things-DOI 10.5752/P. 2316-9451.2013 v1n2p78." Abakós 1.2 (2013): 78-95

[2] Al-Fuqaha, Ala, et al. "Internet of things: A survey on enabling technologies, protocols, and applications." IEEE Communications Surveys & Tutorials 17.4 (2015): 2347-2376.

[3] Andrea Zanella et al. Senior Member, IEEE, "Internet of Things for Smart Cities", IEEE Internet of Things Journal, vol. 1, no. 1, Feb. 2014.DOI: 10.1109/JIOT.2014.2306328

[4] Ankith, S., et al. "Design of IPv6 Network enabled Smart Water Flow Meter System for India."

Proceedings of the Asia-Pacific Advanced Network 40 (2015): 115-120.

[5] Atzori, Luigi, Antonio Iera, and Giacomo Morabito. "The internet of things: A survey." Computer networks 54.15 (2010): 2787-2805.

[6] Baoding Zhang, Jialei Liu, "A kind of design schema of wireless smart water meter reading system based on ZigBee technology" in E-Product E-Service and E-Entertainment (ICEEE), 2010 International Conference on, Nov. 2010, pp 1-4

[7] Beal, Cara, and Joe Flynn. "The 2014 Review of Smart Metering and Intelligent Water Networks in Australia and New Zealand." Report prepared for WSAA by the Smart Water Research Centre, Griffith University, 2014.

[8] Carrillo, Enrique, et al. "IoT framework for smart buildings with cloud computing." Smart Cities Conference (ISC2), 2015 IEEE First International. IEEE, 2015

[9] Chauhan, Saurabh, et al. "IoTSuite: a framework to design, implement, and deploy IoT applications: demonstration abstract." Proceedings of the 15th International Conference on Information Processing in Sensor Networks. IEEE Press, 2016

[10] Cherukutota, Neeharika, and Shraddha Jadhav. "Architectural framework of smart water meter reading system in IoT environment." Communication and Signal Processing (ICCSP), 2016 International Conference on. IEEE, 2016

[11] Datta, Soumya Kanti, et al. "oneM2M architecture based IoT framework for mobile crowd sensing in smart cities." Networks and Communications (EuCNC), 2016 European Conference on. IEEE, 2016.

[12] Dlodlo, Nomusa, et al. "The state of affairs in internet of things research." Electronic Journal of Information Systems Evaluation 15.3 (2012): 244-259

[13] Guest Editorial, "Special Issue on Internet of Things (IoT): Architecture, Protocols and Services" in IEEE Sensors Journal, vol. 13, no. 10, October 2013

[14] Joseph Boman et al., "Flexible IoT Middleware for Integration of Things and Applications" in 10th IEEE International Conference on Collaborative Computing: Networking, Applications and Worksharing, 2014

[15] Jovanovic, Philipp, and Samuel Neves. "Practical cryptanalysis of the open smart grid protocol." International Workshop on Fast Software Encryption. Springer, Berlin, Heidelberg, 2015.

[16] Kursawe, Klaus, and Christiane Peters. "Structural weaknesses in the open smart grid protocol." Availability, Reliability and Security (ARES), 2015 10th International Conference on. IEEE, 2015.

[17] Laubhan, Kevin, et al. "A low-power IoT framework: From sensors to the cloud." Electro Information Technology (EIT), 2016 IEEE International Conference on. IEEE, 2016.

[18] Lloret, Jaime, et al. "An integrated iot architecture for smart metering." IEEE Communications Magazine 54.12 (2016): 50-57.

[19] Miorandi, Daniele, et al. "Internet of things: Vision, applications and research challenges." Ad Hoc Networks 10.7 (2012): 1497-1516

[20] Mudumbe, Mduduzi John, and Adnan M. Abu-Mahfouz. "Smart water meter system for user-centric consumption measurement." Industrial Informatics (INDIN), 2015 IEEE 13th International Conference IEEE, 2015.

[21] Nimmermark, Erik, and Alexander Larsson. "Comparison of IoT frameworks for the smart home." (2016)

[22] Park, Kil-Sung, and Sun-Hyung Kim. "Design of Mainframe for IoT Framework." 2015 8th International Conference on u-and e-Service, Science and Technology (UNESST). IEEE, 2015

[23] Ray, P. P. "A survey on Internet of Things architectures." Journal of King Saud University-Computer and Information Sciences (2016).

[24] Sanchez, Tomas, et al. "Adding sense to the internet of things—an architecture framework for smart object systems." Pers Ubiquitous Comput 16.3 (2012): 291-308

[25] Shahanas, K. Mohammed, and P. Bagavathi Sivakumar. "Framework for a Smart Water Management System in the Context of Smart City Initiatives in India." Procedia Computer Science 92 (2016): 142-147

[26] Sliwa, Jan. "A Generalized Framework for Multi-party Data Exchange for IoT Systems." 2016 30th International Conference on Advanced Information Networking and Applications Workshops (WAINA). IEEE, 2016

[27] Stankovic, John A. "Research directions for the internet of things." IEEE Internet of Things Journal 1.1 (2014): 3-9
[28] Wesnarat, Akekaluck, and Yodyium Tipsuwan. "A power efficient algorithm for data gathering from wireless water meter networks." Industrial Informatics, 2006 IEEE International Conference IEEE, 2006.
[29] White paper by Sierra Wireless, Inc. – "Cellular Communications and the Future of Smart Metering", September, 2010. 2 2010
[30] http://www.iotleague.com/list-of-10-iot-frameworks-and-platforms/ Accessed on 4th Dec 2016
[31] https://developer.ibm.com/architecture/webapp, Accessed on 3rd Jan 2017
[32] https://blog.persistent.com/index.php/2015/08/21/an-end-to-end-iot-platform-the-parts-that-make-the-whole-whole/, Accessed on 3rd Jan 2017
[33] http://www.oracle.com/technetwork/articles/entarch/shrivastava-automated-frameworks-1692936.html, Accessed on 4th Dec 2016
[34] http://spectrum.ieee.org/tech-talk/telecom/internet/popular-internet-of-things-forecast-of-50-billion-devices-by-2020-is-outdated. Accessed on 8th Jan 2017
[35] https://www.tizen.org/.../ballroom1_31st_1100-1200_iotivity_-_connecting_things-in-iot-ashok-subash.html
[36] www.http://events.linuxfoundation.org/sites/events/files/slides/IoTivityCoreFramework.pdf
[37] www.oracle.com/us/industries/utilities/046596.pdf
[38] https://dzone.com/articles/iot-software-platform-comparison
[39] www.mavensystems.com/monitormymeter/index.html
[40] https://sensus.com/smart-water-network/
[41] www.connit.com/en/
[42] www.connit.com/en/iot-smart-water-metering-sigfox-lora-water-management-solution/
[43] www.iotsens.com/smart-water-metering/
[44] https://www.webnms.com/iot/smart-metering.html
[45] https://smarterhomes.com/