A Study on Cloud based Internet of Things: CloudIoT

Shaik Masthan Babu
CSE, Sri Sai Educational Society's
Andhra Pradesh, India
masthan.klu14@gmail.com

A. Jaya Lakshmi
CSE, MIC College of Technology
Andhra Pradesh, India
jvallabhaneni@hotmail.com

B. Thirumala Rao
CSE, KL University
Andhra Pradesh, India
thirumail@yahoo.com

***Abstract*—The Next Revolution in the era of computing will be changing in comparison to traditional desktop. Many objects surrounds the human users will be on the network in one form or in another form in the Cloud Computing and Internet of Things framework. Cloud Computing and Internet of Things are two different technologies, these are into our daily life. Most of the surveys discussed the literature work on Internet of Things and Cloud separately. This paper presents the need for integration of Cloud and Internet of Things, an agent-oriented and Cloud assisted on Cloud IoT paradigm which based upon the layered reference architecture. Reference architecture for agent-oriented vision and Cloud -assisted is proposed, a Cloud based IoT paradigm applications scenario is described that have been presented in the literature, and Finally identified and discussed about open issues and future directions.**

Keywords— Internet of Things (IoT), Cloud Computing, Fog Computing, Cloud assisted reference architecture, agent oriented architecture

I. INTRODUCTION

In view of Cloud Computing and Internet of Things (IoT) paradigm, Internet of Things (IoT) paradigm is both Dynamic and Global Networked Infrastructure oriented, Manages self configuring nodes (things) with high Intelligence. It generally contains small objects (things) with a limited Memory storage and Computing capacity, and is characterized by real world with consequential issues regarding Privacy, Performance, Scalability and Reliability. Whereas Cloud Computing is a vast with unlimited capabilities virtually considering storage and computation power globally. This technology solved most of the IoT issues partially. IoT and Cloud are two comparative challenging technologies are been merged together to change current and future of the Internetworking services [14] [13]. Most of the papers proposed about Cloud and IoT separately, this shows the interest on the trend since 2008, and there are more publications between 2008 and 2013 regarding integration of Cloud and IoT proposed on our review. Now the recent and coming trend is with integration of Cloud and IoT (Cloud based IoT). This new model called as Cloud IoT.

Cloud Computing is a business model to empower omnipresent, on-demand network access to a collection of configurable computing resources such as storage, services, networks, servers, and applications that can quickly provided and released with minimal management effort or service provider interaction. The Cloud Computing model consists of five essential characteristics such as a Resource pooling, broad network access, Metered Service, on-demand self service and Rapid Elasticity. The Cloud Model contains service models such as Infrastructure as a Service, Software as a Service and Platform as a Service. Cloud Computing has deployment models such as public Cloud, private Cloud, community Cloud and Hybrid Cloud [1].

II. THE NEED FOR INTEGRATING IOT AND CLOUD

As IoT has limited capabilities of processing power and storage also consequential issues like Performance, Security, Reliability, Privacy, Integration of IoT with Cloud is more beneficial for undergoing unlimited capabilities like Storage, and Processing power. Cloud can even benefit from IoT that it can extend its limits with real world things in more dynamic and distributed manner, and deliver massive number of services in real time. The characteristics of IoT and Cloud from different schemes which inspiring the Cloud IoT paradigm are plotted in the Table-1. Cloud will act as intermediate layer between the applications and the things conceal all the functionalities and complexities required for processing later [15]. The framework affects future application development, where information gathering process and transmission will deliver new challenges to be addressed in a multi-Cloud environment [17]. The following are the advantages gained in adopting the Cloud IoT paradigm [15].

A. Storage Resources:

IoT includes by differentiating huge sum of information sources (i.e., the things), which creates an immense measure of semi-structured or non-structured [17], having the three attributes regular of Big Data [20]: velocity (i.e., data generation frequency), volume (i.e., data size), variety (i.e., data type), and. Hence further it implies accessing, collecting, processing, visualizing, achieving, sharing and searching large volume of data [19]. The data is treated in homogeneous way through API standard [18], and can be protected by applying top-level security [21], and visually accessed directly from anywhere [19].

B. Computational Resources:

IoT does not allow on-site data processing as it have limited processing capabilities which is not allowed. Scalability is challenging in IoT due to improper infrastructure. its on-demand paradigm allows the bound less processing capabilities of Cloud . Most of the processing needs of IoT are satisfied and empowered analysis of extraordinary complexities. Predictive algorithms and data driven decisions making can be integrated in IoT with less

978-1-4799-8553-1/15/$31.00 © 2015 IEEE

cost and will provide increasing revenue and risk is reduced [25]. Other tasks can be performed real-time processing [19], [21], to apply sensor-centric applications scalability, [18], to handle huge tasks [19], and to execute tasks offloading for power saving [24].

TABLE 1: Characteristics of IoT and Cloud

IoT	Cloud
IoT is Pervasive (things placed everywhere)	Cloud is Ubiquitous (resources usable from everywhere)
These are real world things	It is virtual resources
This has limited computational capabilities	It is virtually unlimited computational capabilities
Consists of limited storage or no storage capabilities	Cloud is virtually unlimited storage capabilities
This uses Internet as a point of convergence	It uses Internet for service delivery
This is big data source	It means to manage big data

C. Computational Resources

IoT does not allow on-site data processing as it have limited processing capabilities which is not allowed. Scalability is challenging in IoT due to improper infrastructure. its on-demand paradigm allows the bound less processing capabilities of Cloud . Most of the processing needs of IoT are satisfied and empowered analysis of extraordinary complexities. Predictive algorithms and data driven decisions making can be integrated in IoT with less cost and will provide increasing revenue and risk is reduced [25]. Other tasks can be performed real-time processing [19], [21], to apply sensor-centric applications scalability, [18], to handle huge tasks[19], and to execute tasks offloading for power saving [24].

C. Communication Resources:

Generally to identify the objects (things) IoT is IP-enabled hardware for communicating with the things which is most expensive. Cloud solves this issue, which offers cheap and effective solution to connect, manage and track anything from anywhere and at any time using customized portals and applications and allows real-time access to the produced data [19]. Remote objects or things are been monitored and is controlled [22].

D. New abilities:

IoT is characterized as a very high heterogeneity of devices, protocols and technologies. Therefore reliability, interoperability, scalability, security, availability, efficiency, and can be very difficult to obtain. Integration with the Cloud solves most of these problems [23], [18], [21], also provides additional features such as ease-of-access, ease of-use and reduced deployment costs [21].

E. New Models:

Cloud IoT model integration empowers a new scenario for smart services, smart objects and application based on the enhancement of Cloud through the things [19], [23]:

- SaaS (Sensing as a Service) [19], [25], [21], provides ubiquitous access to sensor data.
- EaaS (Ethernet as a Service) [25], its activity is to provide ubiquitous layer-2 connectivity to remote devices;
- SAaaS (Sensing and Actuation as a Service) [19], automatic control logics implemented in the Cloud in this service.
- IPMaaS (Identity and Policy Management as a Service) [25], ubiquitous access to policy and identity management functionalities are provided in this service.
- VSaaS (Video Surveillance as a Service) [26], it provides omnipresent access to recorded video and implementation of complex analyses in the Cloud.
- DBaaS (Database as a Service) [25], empowers ubiquitous database management;
- SEaaS (Sensor Event as a Service) [19], [21], it dispatches messaging services triggered by sensor events;
- SenaaS (Sensor as a Service) [25], this empowers ubiquitous management of remote sensors;
- DaaS (Data as a Service) [25], it provides ubiquitary access to any kind of data;

As mentioned above IoT have limited processing and storage capabilities as more it delivers large data through powerful nodes which does not have efficient infrastructure to do on integrating things with Cloud and its storage resources gives IoT processing solutions. With this cloud even enlarges its network and have effective resource sharing.

III. CLOUD BASED IOT FRAMEWORK

Internet of Things is becoming the next Cloud Revolution. Internet of Things (IoT) interconnects the variety of devices. Instead of multimedia streaming and filtering data, Internet of Things devices will exchange the control data and real time sensor data in various messages. Data can be managed by cloud services from a huge number of devices and extremely to support massive scale Internet of Things Applications. Architecture of IoT Cloud services based on the Constrained Application Protocol (CoAP) is used to resource constrained IoT devices, less cost systems. With the system architecture, performance of web Protocol systematically is evaluated in Cloud environments. With state of the art for classic Cloud services, Californium (CF) CoAP framework shows 33 to 64 times higher throughput than high-performance HTTP Web servers. The results are low overhead of CoAP, it does not only enable Web technology for low- cost its devices, but also it significantly improves backend service scalability for massive numbers of connected devices [4]. IoT Cloud Services have three decoupled stages with individual thread pools. In the second stage, CoAP protocol is executed

Reliability Layer: The Reliability Layer retransmits the timeouts.

Block wise Layer: Blockwise layer divides the requests and responses for blockwise transfers in an atomic manner [5].

Token Layer: Token Layer ensures the matching of responses to open requests.

Observe Layer: Observe Layer handles the orders notifications and observe relationships.

CoAP-based out Cloud services system architecture is existing work for concurrent internet services such as pipelined architecture [6] and Staged Event Driven Architecture [7].

978-1-4799-8553-1/15/$31.00 © 2015 IEEE

All things in the Internet of Things (smart devices, sensors, etc.) have their own identity. They are combined into the information network and they will become actively participating in business whenever required. It is a complex challenge, at different levels of abstractions, distributed heterogeneous IoT components need to be assist between themselves with human users and with traditional IT infrastructures. To manage this issue, two paradigms proposed for massive scale distributed computing, such as Cloud Computing paradigm and agent-oriented paradigm [9].

Agent-oriented Computing Model: In terms of multi-tenant systems (MAS) agent–oriented computing model is a distributed software system. Agents are networked as software programs, these software programs performs tasks for a user , permits them to perform parts of their tasks autonomously and to interact with their environment in a useful way.

Cloud Computing Model: Cloud computing paradigm provides flexible, robust, computing resources and powerful storage, which enable dynamic data integration from various data sources [10]. Cloud -based approach offer adaptability, flexibility in the deployment and management of data analysis workflows. Cloud services eliminate the necessity of new client applications, these new client applications needs to be deployed whenever the user requirements change. Cloud service provides the competitive environment for the development of better services. Cloud Computing has service models and software components. To assist a distributed real-time system for the analysis of IoT objects. Cloud Computing Service models such as Platform as a service, infrastructure as a service and software as a service.

A. Layered Architecture For The Smart Object-Oriented IoT

IoT is defined as a world-wide network of interconnected things, which are uniquely addressable and based on standard communication protocols [11]. Smart object-oriented IoT contains three layers such as Internet layer, Middleware layer, Application layer and Smart Object layer.

a. *Application Layer:* It contains the applications based upon the IT infrastructure and smart objects.
b. *Middleware Layer:* This Layer provides the set of mechanisms for discovery, high-level interaction and the naming and state management of smart objectives.
c. Internet Layer: internet layer contains the network protocols, transport and application to support the communication through smart objectives among the smart objectives.

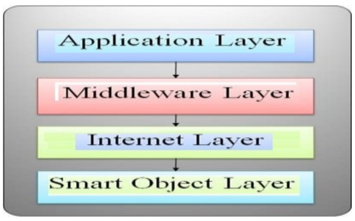

Fig. 1. Smart Object Oriented IoT Architecture

d. *Smart Object Layer:* It provides the tools and programming paradigms which enable the implementation of Smart Objects (SOs).

B. Cloud -Assisted and Agent - Oriented for Internet of Things (IoT) Reference Architecture

High level architecture based upon the agent-oriented and Cloud Assisted Computing is pro-posed to manage the complexity of smart Object based Internet of Things

The Cloud assisted and Agent-based IoT as architecture contains components such as Smart Interface agent, Smart User Agent and Smart Object Agent.

Smart Interface Agent: The Smart Agent Interface defines an interfacing agent are as follows mediators, brokers and wrappers. Smart Interface agents are interacting with external IT Systems.

Smart User Agent: which users can request the services and specific service request are formalized through Graphical User Interface features. It Models the users in the context of specific smart systems.

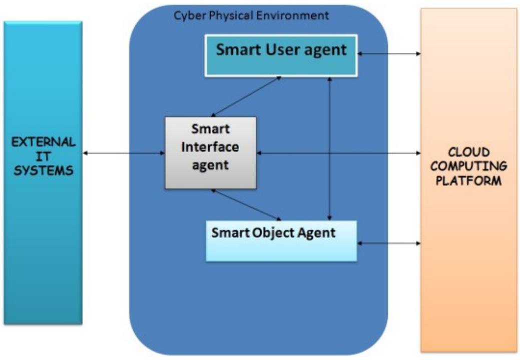

Fig. 2. Architecture of CA-IoT (Cloud assisted and Agent-based IoT)

Smart object Agent: Smart Object agent models the Cyber, Physical Environment; agents are embedded in physical and logical components. According to the specific coordination model Agents will interact. Cloud Computing Platform provides the support for smart agents.

C. Cloud Platform for Massive IoT Systems Management and Integration of Smart Object Middleware

Agent-oriented smart objects and, Cloud-assisted objects are used to develop the massive scale Internet of Things (IoT) applications and systems. Cloud assisted and Agent-based IoT as architecture can be implemented in the adoption and integration of an efficient Cloud platform and smart object middleware. To achieve a massive-scale distributed platform for smart object-based IoT development, they are integrated according to the specific defined requirements [12].

Cloud based architectures as discussed above enhances the computing and processing capabilities for example consider

GPS sensor which is an group of Indianna Lab which registers with cloud for sending and receiving information. Weather forecast sensors produce continuous data streams in a regular time intervals which has to be stored for record or for analysis of weather conditions CloudIoT architectures are the intermediates for connecting to the sensors, will send and receive information using interfaces.

IV. APPLICATIONS

This session gives a description of wide set of applications which are significantly improved in Cloud IoT paradigm. Integration of two technologies makes sense for large number of application [16], which is defined with characteristics, open issues and challenges. Some applications Cloud IoT are explained below:

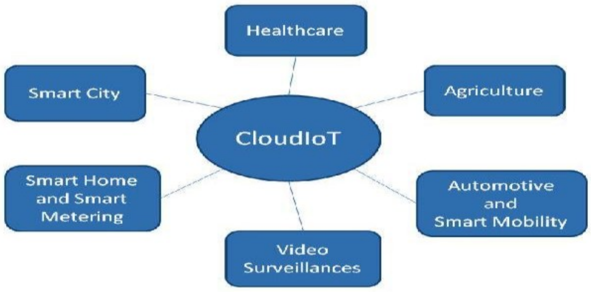

Fig.3. CloudIoT Application Scenario

Agriculture

IoT as a role: IoT in agriculture is doing more adventure. In result, the most efficient crops with low cost in production. Contribution of IoT in Agriculture, machinery of agriculture, agricultural products (pesticides, fertilizers etc), all these are incorporated including broad band network, data base systems this collectively gives a class new “agricultural infrastructure”. The benefits of agriculture with IoT includes, tracing the food using RFID, monitoring the plants and soil, monitoring and controlling (greenhouse environment) , animal monitoring, monitoring safety needs of food etc. the inputs used for agriculture like water, soil, pesticides, fertilizers etc are being managed, means the quantity and quality required for the crop is used. Cloud computing as a role: In provincial areas, it is not financially practical for farmers to manage administration suppliers on an individual premise. They require extensive and financial administration suppliers with various administrations. The one such dare to take care of the rustic business sector demand is MBR Consumer Services Pvt. Ltd. Founded in 2005 by Rama Krishna. It started as a super bazaar based out of Eluru, Andhra Pradesh initial setup was approximately 10 and increase up to 55 villages. This MBR is the one who gave ground level end-to-end support more for the rural farmers in India for the rural customers (farmers) MBR empowered more things and do provide some essential services like Products Sales, Fast moving consumer goods, Promotion etc. With the Internet of Things, individual farmer may have the capacity of crop delivery straightforward to the customers not just in a little locale like in direct promoting or shops yet in a more extensive region. This advancement results to better crop and effective sales of the food product and production of food products which is beneficial to the real world.

Healthcare

Patient physiological data is been maintained by some of the modernized hospitals using sensor networks, for monitoring the hospital, doctors and patients also to control drug administration track[16]. The first contribution in Healthcare field is IoT and Multimedia services [27]. To empower, cost effective and high-quality ubiquitous medical services, efficient, mobile internet, smart devices, and Cloud services are contributing for continuous and systematic innovation in health care [28]. Being such a vast area Healthcare area encounters some of the applications i.e., hospital and physician networks, laboratories, health insurance companies pharmacies, patients and other entities [8]. This healthcare applications are generating a large amount of data (sensor data), which is to be maintained in proper manner for future processing and analysis [29]. Mobile devises can make the services more efficient for health information delivery in future for access and communication [15]. Common issues investigated in this field are system security; streaming quality of service (QoS), interoperability and dynamic increasing storage are commonly considered obstacles [28].

Smart city

Typical middleware for future oriented smart city can be given through IoT [23], obtaining information from sensing infrastructure, IoT technology (RFID sensors and Geo-tagging) and putting information in consistent manner. From the recent proposals it has been suggested to empower the discovery, connection and integration of actuators and sensors. This makes easy to real-time applications for smart cities and pervasive connectivity. This makes easier to the third parties to develop IoT plug-in to be connected to Cloud [30]. The common issues are related to security, real-time interaction and resilience.

Smart Home and Smart Metering

To empower the automation of regular in home activities IoT have large applications for home atmosphere, where in this embedded devises are been used. To build flexible applications with less code lines, to handle complex tasks also, Cloud is the best source which can manage even huge data [15]. When the single family Smart home accessing reusable service is to be accessed through online with the internet, some of the requirements should be satisfied: Automation (home based application should be attached to service provider like smart home based Cloud), Internal Network Interconnection(each intelligent digital thing (application) in the home should interact with each other), Intelligent Remote Control(Smart home devises or objects can be managed or intelligently operated from anywhere). Most of the literatures proposed are involved and implement metered solutions to provide recognition of appliances [3], wireless sensor networks and intelligent management of energy consumption [3], heating, lighting, and air conditioning [15]. More issues should be solved to get better service, the home devises must be connected to internet, thus identification and service description should be standardized, and with uniform interaction. To handle tasks and to interact with IoT and Cloud there should be provided powerful computing devises that has to be developed.

Video Surveillance

Video Surveillance is the most important intelligent thing as a part of security related issue as it works as a monitoring and self management system. The complex video analysis required Cloud based solutions [26], as to satisfy the requirement of storage and processing. The proposed solution is, identifying storing and managing the video information from camera and data delivery efficiency to the number of users through internet, load-balancing and fault tolerance fashions.

Automotive and Smart Mobility

IoT is offering promising solution to automobile services and transportation systems. Loud computing integration technologies with satellite networks, wireless sensor networks represent an opportunity to deal with the main current challenges. IoT based vehicular data Cloud s is a new generation of technology that can be deployed to bring business benefits such as reducing road congestion, managing traffic [31], increasing road safety,. Cloud based vehicular data platform that controls Internet of Things and Cloud Computing technologies. The main purpose of these platforms provides less cost, real-time, on-demand, secure services to the customer. To extend the traditional Cloud, vehicular Clouds are designed to increase the storage capacities, processing, on-demand computing. Vehicular issues such as scalability, QoS, reliability, performance, IoT based vehicular Cloud s [31], [33]. It is difficult to implement authorization and authentication mechanisms with impact in privacy and security positions of infrastructure [32].

V. OPEN ISSUES AND FUTURE DIRECTIONS

This paper presented the need for integration with advantages, an agent oriented Cloud based IoT architecture, and applications if Cloud IoT in various fields with challenges. Wireless Sensor Network technologies (IoT) are enabled by Ubiquitous sensing which cuts through the modern day living of more areas, which offers the capability to understand the environmental indicators, infer and measure from natural resources to urban environments. To store and process the data Cloud environments are used. Cloud Computing offers the infrastructure, platform and applications over the internet. Sensors are placed in distributed fashion to monitor the environment changes and physical changes such as pressure, temperature with the help of, Wireless Sensor Network technology. On integrating the Cloud Computing and Internet of Thing (IoT), it helps to manage the remotely connected sensor nodes and the data generated by another sensor node globally. Now we discuss some of the open issues related to Cloud IoT still require research efforts pointing out the future directions. Now IoT6 which is an Europian research project deals with the use of IP-V6 and related standards (e.g., CORE, COAP) to enhance the IoT world more.

Need for Standards

In cloud IoT paradigm, necessary standard protocols, architectures, and APTs are being required though Scientific Community has given contribution for standardization and deployment of Cloud and IoT paradigm. This is for interconnection between the creation of enhanced services and heterogeneous smart objects, which realize CloudIoT paradigm [23]. The leading paradigm is Mobile-To-Mobile (M2M) with a little standard. Hence existing solutions uses standard web, internet, and cellular technologies. Most of the architectures are proposed at the primary phase of IoT either come from Cloud at the center or from Wireless Sensor Network perspectives.

Complex Data Mining

Big data complexity issues are not been solved by the present technologies. When large number of Big data is produced, the high frequency of data generated and the gap between data availability and organizing the data for processing is getting wider. More research efforts are required to meet the challenges of Big data, heterogeneous spatio-temporal (geo-related and sparsely distributed) data which has high-valued data mixed with erroneous data are not directly reality direct consumption using virtualization platform which are coming from IoT. In order to create attractive and easy to understand visualization [9], New schemes have to be developed (e.g. 3D, GIS).

Cloud Capabilities

In any a networked area or environment, security is the major issue for CloudIoT. There are more chances of number of attacks on both of IoT (i.e., RFID, WSN) and Cloud side. Integrity confidentiality and authenticity can be ensured with encryption in IoT and can address inside attacks, and is typical task to implement on processing or embedded devices. RFID component achieves high level security since it has high level intelligence. To meet QoS requirements of diverse users and seamless execution of applications and domain specific programming tools provided. in order to the deliver reliable services, Duplication should be made for the cloud scheduling algorithms in case of failure management, still QoS parameters are to be concentrated.

Fog Computing

Fog computing is a model; It extends Cloud computing and services to the edge of the network. Similar to Cloud, Fog provides compute, application Services to end-users, data, storage. It is an extension of Cloud Computing which is an intermediate between the edge of the network and Cloud and it deals with latency-sensitive applications require nodes in the vicinity to meet their delay requirements [2]. In Smart Grid, Future work will expand the Fog computing paradigm. Even Fog devises are been developed to interact directly to the

Cloud. Traffic light control can also be assisted by the Fog computing concept. Finally, mobility between Fog nodes, and between Fog and Cloud, can be investigated.

VI. CONCLUSION

In view of Cloud Computing and Internet of Things (IoT) paradigm, Internet of Things (IoT) paradigm is both Dynamic and Global Networked Infrastructure oriented, Manages self configuring nodes (things) with high Intelligence. In Smart Grid, Future work will expand the Fog Computing paradigm. As IoT has limited capabilities of processing power and storage, also consequential issues like Performance, Security, Reliability, Privacy, Integration of IoT with Cloud is more beneficial for undergoing unlimited capabilities like Storage, and Processing power. A wide set of applications such as Healthcare, Smart city, Smart Home and Smart Metering, Video Surveillance, Automotive, Agriculture and Smart Mobility are significantly improved in CloudIoT paradigm. High level architecture based upon the agent-oriented and Cloud Assisted Computing is pro-posed to manage the complexity of smart Object based Internet of Things.

References

[1] Peter Mell, Timothy Grance, "The NIST Definition of Cloud Computing", NIST Special Publication 800-145.

[2] F. Bonomi, R. Milito, J. Zhu, and S. Addepalli. Fog Computing and its role in the internet of things. In Proceedings of the first edition of the MCC workshop on Mobile Cloud computing, pages 13–16. ACM, 2012.

[3] S.-Y. Chen, C.-F. Lai, Y.-M. Huang, and Y.-L. Jeng. Intelligent home-appliance recognition over IoT Cloud network. In Wireless Communications and Mobile Computing Conference (IWCMC), 2013 9th International, pages 639–643. IEEE, 2013.

[4] Matthias Kovatsch, Martin Lanter, Zach Shelby,"Californium: Scalable Cloud Services for the Internet of Things with CoAP".

[5] C. Bormann and Z. Shelby. Blockwise transfers in CoAP. Draft-ietf-core-block-14, 2013.

[6] G. S. Choi, J.-H. Kim, D. Ersoz, and C. R. Das. A Multi-threaded PIPELINED Web Server Architecture for SMP/SoC Machines. In Proc.WWW, Chiba, Japan, 2005

[7] M. Welsh, D. Culler, and E. Brewer. SEDA: An Architecture for Well-conditioned, Scalable Internet Services. In Proc. SOSP, Banff, Canada, 2001.

[8] Sanjay P. Ahuja, Sindhu Mani & Jesus Zambrano. A Survey of the State of Cloud Computing in Healthcare. URL: http://dx.doi.org/10.5539/nct.v1n2p12.

[9] Jayavardhana Gubbi, Rajkumar Buyya, Slaven Marusic , Marimuthu Palaniswami ,"Internet of Things (IoT): A vision, architectural elements, and future directions", Future Generation Computer Systems 29 (2013) 1645–1660, www.elsevier.com/locate/fgcs.

[10] R. Hill, L. Hirsch, P. Lake, S. Moshiri, "Guide to Cloud Computing.Principles and Practice," Computer Comm. and Networks, Springer, 2013.

[11] D. Bandyopadhyay and J. Sen, "The internet of things - applications and challenges in technology and Standardization," Springer International Journal of Wireless Personal Communications, 58(1), pp. 49-69, May 2011.

[12] Giancarlo Fortino and Wilma Russo,"Towards a Cloud -assisted and Agent-oriented Architecture for the Internet of Things".

[13] H.-C. Chao. Internet of things and Cloud Computing for future internet. In Ubiquitous Intelligence and Computing, Lecture Notes in Computer Science. 2011.

[14] J. Zhou, T. Leppanen, E. Harjula, M. Ylianttila, T. Ojala, C. Yu, and H. Jin. Cloud things: A common architecture for integrating the internet of things with Cloud computing. In CSCWD, 2013. IEEE.

[15] Alessio Botta, Walter de Donato, Valerio Persico, Antonio Pescap´e. "On the Integration of Cloud Computing and Internet of Things".

[16] Sanjit Kumar Dash, Subasish Mohapatra and Prasant Kumar Pattnaik, "A Survey on Applications of Wireless Sensor Network Using Cloud Computing", International Journal of Computer Science & Emerging Technologies (E-ISSN: 2044-6004) 50 Volume 1, Issue 4, December 2010.

[17] European Commission. Definition of a research and innovation policy leveraging Cloud Computing and IoT combination. Tender specifications, SMART 2013/0037, 2013.

[18] G. C. Fox, S. Kamburugamuve, and R. D. Hartman. Architecture and measured characteristics of a Cloud based internet of things. In Collaboration Technologies and Systems (CTS), 2012 International Conference on, pages 6–12. IEEE, 2012.

[19] B. P. Rao, P. Saluia, N. Sharma, A. Mittal, and S. V. Sharma. Cloud computing for Internet of Things & sensing based applications. In Sensing Technology (ICST), 2012 Sixth International Conference on, pages 374–380. IEEE, 2012.

[20] P. Zikopoulos, C. Eaton, et al. Understanding big data: Analytics for enterprise class hadoop and streaming data. McGraw-Hill Osborne Media, 2011.

[21] S. K. Dash, S. Mohapatra, and P. K. Pattnaik. A Survey on Application of Wireless Sensor Network Using Cloud Computing. International Journal of Computer science & Engineering Technologies (E-ISSN: 2044-6004), 1(4):50–55, 2010.

[22] P. Parwekar. From Internet of Things towards Cloud of things. In Computer and Communication Technology (ICCCT), 2011 2nd International Conference on, pages 329–333. IEEE, 2011.

[23] G. Suciu, A. Vulpe, S. Halunga, O. Fratu, G. Todoran, and V. Suciu. Smart Cities Built on Resilient Cloud Computing and Secure Internet of Things. In Control Systems and Computer Science (CSCS), 2013 19th International Conference on, pages 513–518. IEEE, 2013.

[24] D. Yao, C. Yu, H. Jin, and J. Zhou. Energy Efficient Task Scheduling in Mobile Cloud Computing. In Network and Parallel Computing, pages 344–355. Springer, 2013.

[25] A. Zaslavsky, C. Perera, and D. Georgakopoulos. Sensing as a service and big data. arXiv preprint arXiv:1301.0159, 2013.

[26] A. Prati, R. Vezzani, M. Fornaciari, and R. Cucchiara. Intelligent Video Surveillance as a Service. In Intelligent Multimedia Surveillance, pages 1–16. Springer, 2013.

[27] Q. Zhang, L. Cheng, and R. Boutaba. Cloud computing: state-of-the-art and research challenges. Journal of internet services and applications, 1(1):7–18, 2010.

[28] A. M.-H. Kuo. Opportunities and challenges of Cloud Computing to improve health care services. Journal of medical Internet research, 13(3), 2011.

[29] C. Doukas and I. Maglogiannis. Bringing iot and Cloud Computing towards pervasive healthcare. In Innovative Mobile and Internet Services in Ubiquitous Computing (IMIS), 2012 Sixth International Conference on, pages 922–926. IEEE, 2012.

[30] P. Ballon, J. Glidden, P. Kranas, A. Menychtas, S. Ruston, and S. Van Der Graaf. Is there a need for a Cloud platform for European smart cities? In eChallenges e-2011 Conference Proceedings, IIMC International Information Management Corporation, 2011.

[31] W. He, G. Yan, and L. Xu. Developing Vehicular Data Cloud Services in the IoT Environment. 2009.

[32] P. Marchetta, E. Natale, A. Salvi, A. Tirri, M. Tufo, and D. De Pasquale. Trusted information and security in smart mobility scenarios: The case of s2-move project. In Algorithms and Architectures for Parallel Processing, pages 185–192. Springer, 2013.

S. Bitam and A. Mellouk. ITS-Cloud: Cloud Computing for Intelligent transportation system. In Global Communications Conference (GLOBECOM), 2012 IEEE, pages 2054–2059. IEEE, 20

978-1-4799-8553-1/15/$31.00 © 2015 IEEE