A New Framework to Integrate Wireless Sensor Networks with Cloud Computing

Sajjad Hussain Shah, Fazle Kabeer Khan, Wajid Ali, Jamshed Khan
Department of Computer Science
Bahria University & ZSABIST, Islamabad, Pakistan.
Email: sajjadmcse@gmail.com, fazlekabeer@gmail.com, Wajid_6@yahoo.com, jamshedkhan380@gmail.com

***Abstract*—Wireless sensors networks have several applications of their own. These applications can further enhanced by integrating a local wireless sensor network to internet, which can be used in real time applications where the results of sensors are stored on the cloud. We propose an architecture that integrates a wireless sensor network to the internet using cloud technology. The resultant system is proved to be reliable, available and extensible. In this paper a new framework is proposed for WSN integration with Cloud computing model, existing WSN will be connected to the proposed framework. Three deployment layer are used to serve user request (IaaS, PaaS, SaaS) either from the library which is made from data collected from data centric DC by WSN periodically. The integration controller unit of the proposed framework integrates the sensor network and cloud computing technology which offers reliability, availability and extensibility.**

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1. INTRODUCTION

The idea of wireless networks was developed by sending messages through fire and smoke. It was a sign of presence of people in specific territory. In 80's researches came up with the idea of TNC (Terminal Node Controller). The aim of this invention was to communicate between a computer and radio, but desired performance was not achieved. Later on in 1985 FCC (Federal Communication Commission) allocated ISM bands for different applications. The assigned ISM bands were 902 MHz and 5.85 GHz. As these bands did not require any kind of registration, most of the vendors were using these bands. In 1997 some standards were set by IEEE (Institute of Electrical and Electronics Engineers) and access was limited to licensed users. Wireless Sensor Network (WSN) consists of distributed nodes with the capability of sensing, computation and wireless communications. The nodes are connected in ad-hoc fashion, operating independently of other nodes. There are various factors associated with the performance of WSN such power management, data dissemination and routing of information. A lot of work has been undergoing in these areas where energy awareness of essential design issue; routing and data dissemination is application dependent. WSN architecture could be either centralized or distributed. In centralized architecture the central node is the weak point of the network. If it fails, whole network collapse. However, distributed architecture provides failure resistant sensor network [1]. Comprehensive architecture and various wireless sensor applications emergence is represented and discussed as we can see in the Figure 1.

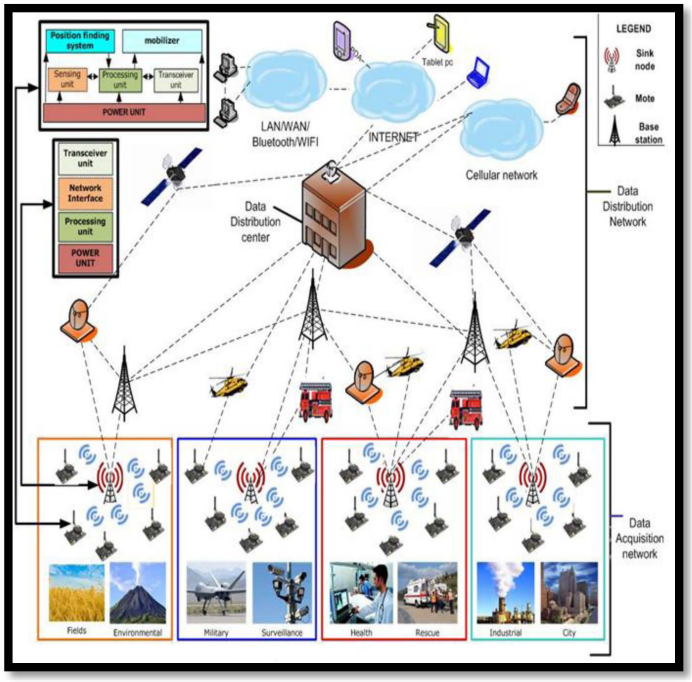

Figure 1: Emergence of Wireless Sensor Network in Various Applications

Issues in Wireless Sensor Network

Ad hoc network inherited some of the tribulations of wireless communication networks like lossy links, unreliable time in-

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varying and asymmetric channel, hidden node and exposed node and improperly defined coverage boundary. Ad hoc network puts a messy contribution in this knotted portfolio in the form of multi hop environment, location awareness, and node mobility, dynamically changing topology, vulnerability of channel and nodes and different aspects in QoS. Specifically in WSN, in addition to most of the aforementioned issues, network partitioning, localization, calibration, data fusion, aggregation and dissemination, coverage issues, self-organizing and self-administration, scalability, load balancing, node clustering, topology management, end-to-end delay constraint routing, security and privacy, heterogeneity, and other energy, memory, power and bandwidth constraints are the active challenges. In the closer view, node scheduling, whole problem, avoiding and coping with void node areas, node failure and QoS relating factors are under great concentration of researchers where QoS is a level of service in achieving the target with sufficient resources by fulfilling the requested QoS parameters. End-to-End performance, delay, bandwidth, energy consumption, transmission power, memory usage, probability of packet loss, jitter, bit error rate, miss ratio, packet over-head and packet success delivery are considered under the umbrella of QoS parameters. Real-time routing has the core importance in QoS-aware network layer issues which ensures catching the destination within a limited required time and resources.

Table 1: Wireless Sensor Network Applications

Application Area	Usage
Military	Military situation awareness [3]. Logistics in urban warfare [4]. Battlefield surveillance [5]. Computing, intelligence, surveillance, reconnaissance, and targeting systems [6].
Mobile wireless low-rate networks for precision location	Including industrial, retail, hospital, residential, and office environments, while maintaining low-rate data communications for monitoring, messaging, and control [7].
Airports	Smart badges and tags [7,3] Wireless luggage tags [7] Passive mobility (e.g., attached to a moving object not under the control of the sensor node) [8]
Medical/Health	Monitoring people's locations and health conditions [5]. Sensors for: blood flow, respiratory rate, ECG (Electrocardiogram [9] Monitor patients and assist disabled patients [6]
Ocean	Monitoring Fish [5]

2. CLOUD COMPUTING

Cloud Computing is internet based computing, where resources allocations are shared, software and information are provided to computer and all other devices on demand as requested. It is considered as an alternative to traditional server or web hosting servers. Cloud provides much more services then that, having different layer to provide application based services. [2].

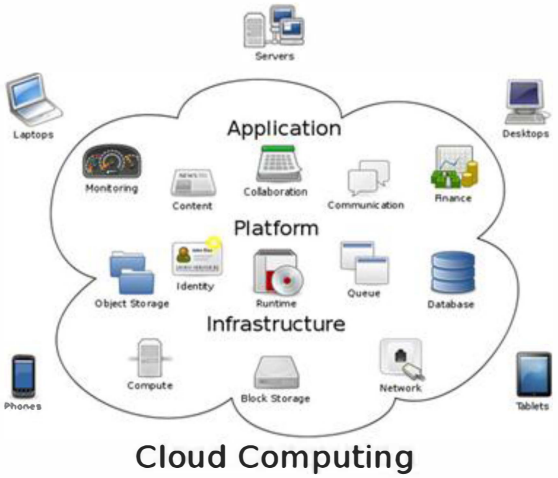

Figure 2: Overview of Cloud Computing

IBM report stated that "*Cloud is a new consumption and deliver model for many IT-based services, in which the user sees only the service, and has no need to know anything about the technology or implementation"* [10]. NIST classify the cloud computing as *"Cloud computing is a model for enabling convenient, on demand network access to shared pool of configurable computing resources"* [11].

Cloud Computing Architecture Layers

a) SaaS (Software as a Service)
b) PaaS (Platform as a Service)
c) IaaS (Infrastructure as a Service).

General overview of cloud computing architecture layers as we can see in the Figure 3.

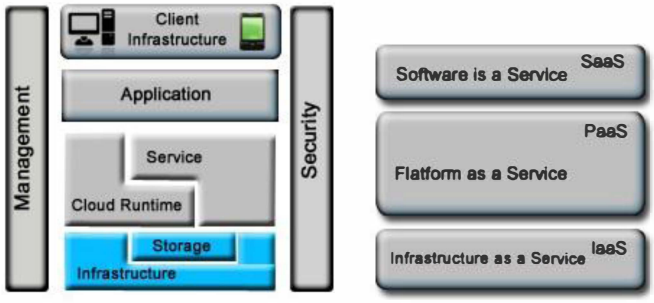

Figure 3: Cloud Computing Architecture

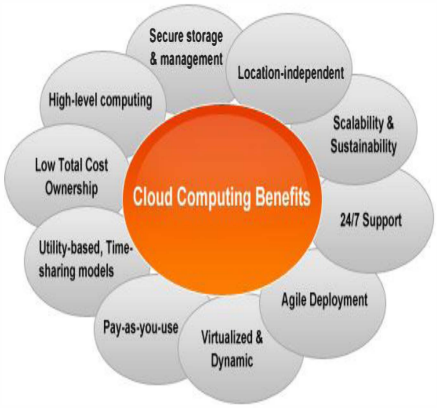

Figure 4: Cloud Computing Application Domain

SaaS provides board market solutions where the vendor provides access to hardware and software products through portal interface [12]. PaaS allows the consumer to run the specified application on the platform. In these type of services, consumer have no control over the infrastructure as well as the on the installed applications [13], [14]. IaaS provides consumers with the benefit to consume the infrastructure that includes processing power, data storage, and network etc. The consumer can run multiple applications without worrying about maintenance of underlying infrastructure [15]. Sensor network is used in many fields such as health, environment and battle field. They monitor the situation and give you report to help you. The Application is even wider. In this era we are looking to integrate Wireless Sensor Network with Cloud computing. In order to support huge amounts of data, today solutions are based on cloud computing. Accordingly, it seems obvious to bring cloud computing to the wireless sensor networks. The cloud provides scalable processing power and several kinds of connectable services. This distributed architecture has many similarities with a typical wireless sensor network, where multiple motes responsible for sensing and local preprocessing, are interconnected with wireless connections. Since wireless sensor networks are limited in their processing power, battery life and communication speed, cloud computing usually offers the opposite, which makes it attractive for long term observations, analysis and use in different kinds of environments and projects, since the basic infrastructure remains the same. Wireless Sensor Networks are designed to gather data from different sources in real-time and distribute it to the nodes which require that data for further processing. However the distribution is not uniform. Cloud computing, on the other hand, aimed to provide data centric solution where multiple consumers connects and consumes the data from cloud. The data collected from WSN can be uploaded over some time interval on the cloud. Such data would be available to all the nodes, in present and in future for further processing. Natural question arises, why we need to store data that is no longer required. There are various possible reasons for storing data i.e. historical mining, analysis to predict in future etc.

3. PROPOSED FRAME WORK OVERVIEW

Figure 5 shows the proposed integration framework of cloud computing and WSN. The major components of the framework are Data Processing Unit (DPU), Publisher/Subscriber Broker, Request Subscriber, Identity and Access Management Unit (IAMU) and Data Repository (DR). The data gathered from WSN is passed through gateway to DPU, which process data and add it to DR. In order to access the stored data from cloud services, user connects through secured IAMU; on successful connection establishment user will be given the access according to the account policies. User data request is forwarded to RS which creates a request subscription and forward the subscription to the Pub/Sub Broker. When DPU receives the data from gateway, it forwards the data to Pub/Sub Broker. When the event matches the subscription, data is made available to the respective user. There has to be effective way for user to access the data sensed by the sensors. The idea of connecting a standalone wireless network to internet is comparatively new and still is an open research area [16]. The sensor networks are known to be pervasive and ubiquitous. It is impossible to connect each and every node to internet, as we are constrained by the IP addresses. This article proposes architecture as a solution where industrial sensor networks can be integrated with internet through cloud technology and Service Oriented Architecture (SOA). The system proposed main modules as application server, integrated controller, and a register agent. The role of integrated controller is to provide the storage as well as the recovery mechanism to the sensed data. This has been achieved by uploading the sensed data to internet using cloud services. The user can access the data from any location in the world. The sensor networks are ideally considered to be energy efficient and it's the major criticality of the network that must be answered. In addition to that, short range hop communications is preferred in order to communicate with a long range destination. Therefore, the information from source is distributed across intermediate nodes in the path towards destination node. The intermediate nodes must process the received data, aggregate it to remove duplication and to minimize the network traffic [17].

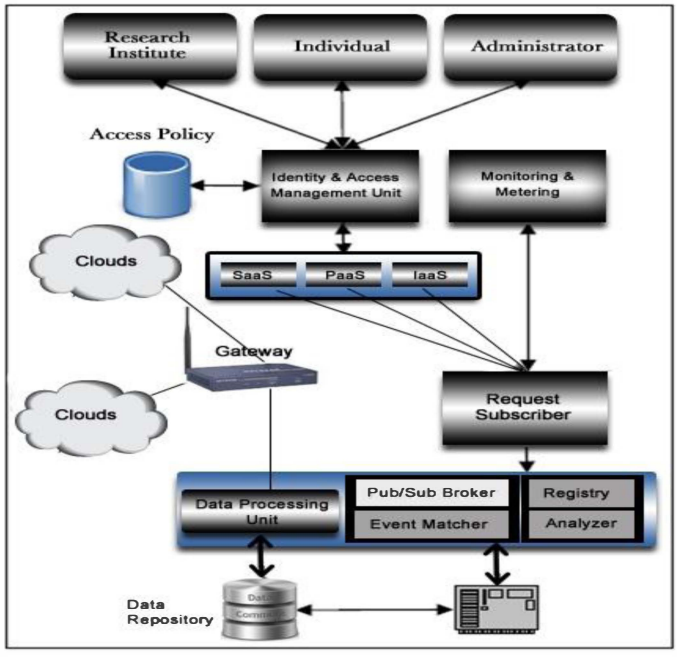

Figure 5: Proposed Architecture General Overview

This research article presents a framework which integrates cloud computing and WSN. The objective is to facilitate the shift of data from WSN to cloud computing storage so that it may be further utilized in scientific and economic analysis. The propose system suggests that sensor nodes and Integration Controller (IC) can interact through SOA. Sensor nodes are considered as service providers and sink nodes are consumers, they receive information through IC. The sensor nodes are deployed into the application server as service description. It has location information and provides a service end point, a target namespace and a transport name. These components exchange messages in xml format [17].

Access Control Enforcement Unit

ACEU is used to authenticate the user and it is consists of EN and three servers i.e. AS, TGS and SS. The request received by EN is sent to AS. EN implements Kerberos in order to authenticate the user with AS.

Access Control Decision Unit

ACDU is used to enforce the policy rules. It consists of RBAC processor and policy storage. It communicates with ACEU through SS. After successful authentication; user is given the access to the resources as constrained by the access policies.

Communication flow between User and IAMU

The description of different messages those have been exchanged among different servers and edge node (EN) are left out of the scope of this poster due to the space constraint [16].

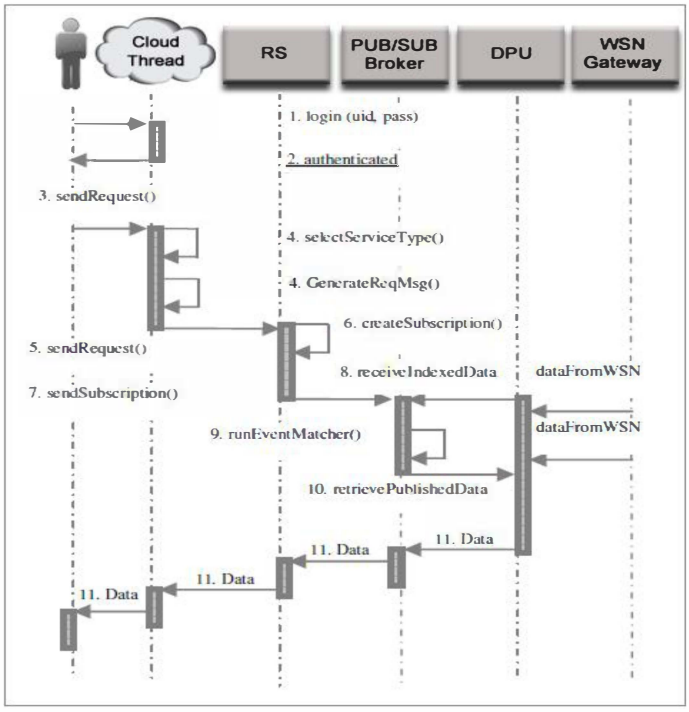

Figure 6: Communication among Framework Component

As programming sensor networks is complicated with existing programming languages and techniques, using XML in this case will optimize the way of getting information from the network [18]. Xml register agent (eb-xml-registry-repository) is used to facilitate orchestration and aggregation of service into processes and applications.

This allows a user to have a single view of all services. The sensor services are published in xml registry using wsdl. SOAP messages are used to discover and invoke the sensor application/client. The client communications are passed through IC; which also takes care of authentication of user and delivering required parameters using push interaction pattern. This can be triggered by multitude of events. Such as an audible event is triggered i.e. a message sent to client when the process parameters exceed some threshold. The IC and internet can communicate through cloud services. Cloud technology enables the development of scalable system where the capacity can be added the system on the fly and at any moment. The proposed system allows user to easily access the data. Furthermore, user can visualize, process, archive, share and search the stored data from various applications. Data life cycle is supported by architecture i.e. from data collection to decision support system. With the intervention of cloud architecture large amount of data can be processed, analyzed and stored using computational services of cloud [19].

IAMU includes Diffie-Hellman, Kerberos, Role Based Access Control and XML [16]. The main rationale of this model is first, to provide authentication between consumer and cloud provider. Second, to provide policy based access control over the cloud resources. Consumers directly communicate IAMU for authentication and access control. Access Control Enforcement Unit (ACEU) and Access Control Decision Unit (ACDU). Edge Node (EN) is used as replacement of Kerberos. It is actually based on Kerberos with slight modifications. It also implements Diffie-Hellman public key [20].

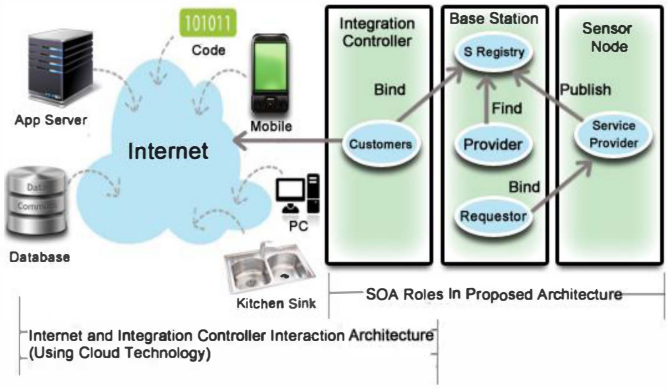

Figure 7: Composed Over view of Proposed Framework

4. TECHNICAL AND APPLICATION ANALYSIS

The above analysis and figure shows that all the sources of wireless sensor networks are heterogeneous. In order to process the data it is necessary to enforce standard abstraction on information on all sources. Moreover, data is communicated among intermediate nodes in path to reach the destination.

This may lead to a security flaw, and in security applications it becomes necessary to control the flow of information. Thus, there has to be data centric access control to ensure the forwarding of critical data only. Besides, context aware attribute of the system allows the user access to data anywhere and anytime. NPMS can benefit from the integration of wireless sensor networks. First, it allows a continuous monitoring of the critical parameters during the manufacturing process [21]. Second, NPMS can monitor in time delivery and product quality by mentoring detailed and electronically processed information by various manufacturing parties such as producers, freight carriers, suppliers etc. Third, monitoring of data from large sites leads to reduced manual maintenance inspection and thus leaving the manufacturing process automated. Figure 1 shows the information sharing mechanism from different wireless sensor networks.

5. CONCLUSION

Both wireless sensor network and Cloud Computing technologies along with their applications are discussed in this paper. We gave an overview of architectural extension to wireless sensor network. Application of cloud computing to enhance the reliability and availability of wireless sensor networks is discussed with special emphasis on its application in distributed manufacturing engineering. The proposed system is based on ideas taken from an in depth study and support of various technologies. The proposed system has its useful applications and important role in medical sciences field. It is supposed to help in efficient cure of Strokes and Parkinson. However the security issues involved in the integration process are of key importance and need critical focus.

Further efforts will help extend the applications to military and manufacturing services.

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BIOGRAPHY

Mr.Sajjad Hussain Shah *is Certified Network Engineer. He graduated from City University of Science & Information Technology Peshawar , Pakistan in 2006 and received his MS Degree in Telecommunication and Network from the Department of Computer Science Bahria University, Islamabad,Pakistan.*

Mr.Fazle Kabeer khan *was born in September, 1983. He completed his bachelor's degree BS-IT from Gomal University Dera-ismail khan, Pakistan in 2007.* Currently he is pursuing his *MS-IT from SZABIST, Islamabad, Pakistan.*

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Mr.Wajid Ali *was born in February, 1986. He received his Bachelor's degree in Computer Science from University of Peshawar, Pakistan and completed his MS in telecommunication and Network from Bahria University Islamabad, Pakistan.*

Mr.Jamshed Khan *is a Computer Information System Engineer. He graduated from NWFP University of Engineering & Technology Pakistan and did his M.Sc.*