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A Survey on Virtual Sensor Networks Framework

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Abstract

Due to recent advancement in wireless sensor technology and extensive requirement of scalable applications, researchers are designing models of sensor network that can support wide multiplicity of services in a single heterogeneous sensor network infrastructure. In this work, we survey the virtual sensor networks (VSNs) design architecture, principles, service provisioning, sensor cloud architecture, and various applications that are widely used in different areas of VSNs. We propose a new framework for VSNs that can support multiple services and can give a new direction to Wireless Sensor Network (WSN) community.

Keywords: *Network Virtualization, Virtual Sensor Network, Wireless Sensor Network, Overlay network, Service provisioning*

1. Introduction

Wireless Sensor Network (WSN) is one of the emerging technologies in the research community. But due to limited computing power, cost, and limited storage capacity, sensors are densely deployed throughout the target area. WSN infrastructure provides single service to the end users, which is a limitation in the WSN. As a result cost of the service is increased while deploying the sensors in the target regions. To overcome this problem, researchers developed a framework called VSN, which provide multiple services in a single WSN infrastructure.

The recent history of research in WSN discovered few stuffs of WSN which has an additional direction of its conventional use [1]. Different computing devices can be operated by using efficient resource utilization, low cost, increased flexibility, manageability, improved administration, and interoperability through virtualization. WSN has been embellishes with aspects of virtualization leads to the execution of Internet of Things [2]. Some research work [3-4] adds value to virtualization with the following aspects such as OS Virtualization, Sensor Node Virtualization, Link Virtualization, and Network Virtualization. Focusing on algorithms and protocol with a shared physical infrastructure where, the formation usage, adaptation, and maintenance of possibly dynamically varying subset of sensors collaborating on specific tasks are supported and being organized as a VSN using resources of a shared physical infrastructure.

A VSN can be constructed by having a set of WSN nodes, with the set dedicated to a certain task or an application at a given time. Conventional design of WSN suggests that all the nodes do participate to obtain the end result, whereas, VSN suggests that a subset of nodes collaborates to carry out a given application. Multiple VSNs may exist simultaneously on a

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physical WSN. The membership of a VSN may change over time. The nodes in a VSN may be able to communicate directly with each other as they are distributed over the physical network.

The rest of the paper is structured as follows: Section 2 depicts the overview and related work of sensor network. The design principle and service provisioning in VSN is provided in Section 3. In Section 4 we provide the basic principle of cloud sensor architecture. Section 5 depicts the major application areas of VSN. Section 6 concludes the paper.

2. Overview of Sensor Network

In this section, we describe different models of sensor networks as well as types of sensor networks.

2.1. Sensor Networks

Due to advancement in wireless technology and sensor networks, the development of low-cost, low-power, multifunctional sensor nodes which can communicate over a small distance are widely used currently to solve the real life problems such as health-care, military, industrial automation, agriculture, critical infrastructure monitoring, environment monitoring, gaming, manufacturing and smart home applications.

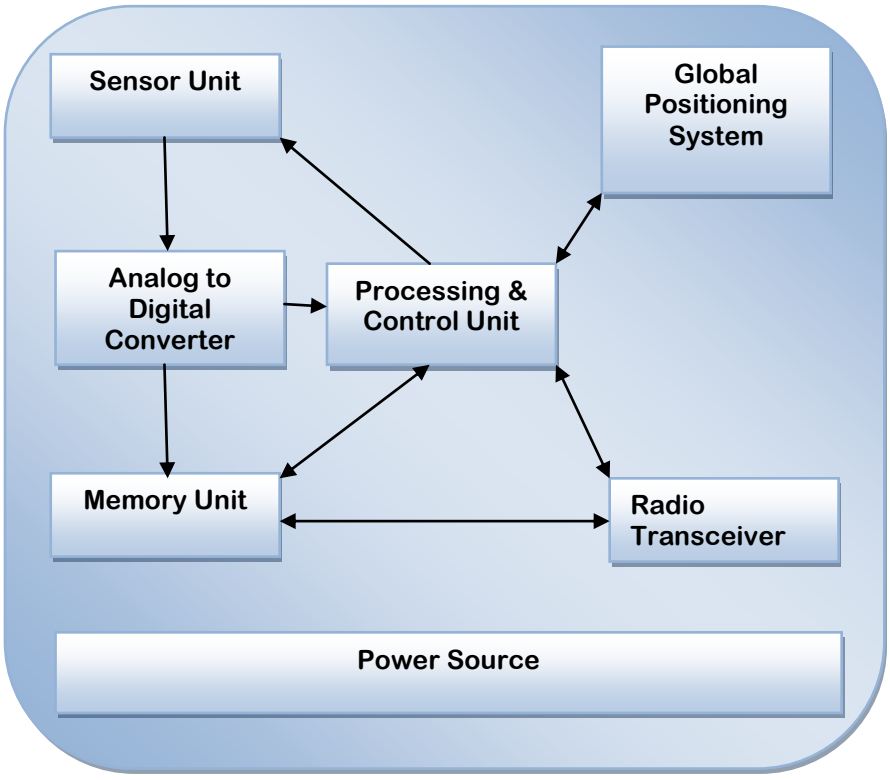

Figure 1. The Block Diagram of a Sensor Node

These tiny sensor nodes have the intelligence to do the operations such as sensing, processing and data communication among each other. Each node can process raw data locally to carryout simple computations to transmit only the required and partially processed

data. The sensor nodes are densely deployed in scattered manner randomly throughout the sensor field. A sensor network consists of a large number of sensor nodes that are densely deployed either inside the phenomenon or very close to it. WSN is a collection of micro electro mechanical systems that sense, compute and communicate. Each sensor nodes [14] has the capability to collect data, partially process it and transmit it to the sink node. These sink nodes can communicate with the end user through Internet or satellite. A sensor node consists of different components such as sensing unit, processing unit, power unit, and transceiver unit. The block diagram of a sensor node is shown in Figure 1. Sensor network has different protocol stack like physical layer, data link layer, network layer, transport layer, application layer, power management, and mobility management and are responsible for data communication, mobility management and so forth [1]. The major limitations of WSNs are low memory capacity, sources of power supply, and low computation and communication facilities. A sensor network may consist of number of sensor nodes communicate with each other to monitor a region and fetch data about their surroundings. A WSN contain self regulated sensors that can cooperatively operate on the environmental monitoring conditions such as sound, pressure, motion, temperature, vibration, and pollution. The most common sensor devices deployed in WSN as sensor nodes are camera sensor, accelerometer sensor, thermal sensor, and microphone sensor *etc.* [6].

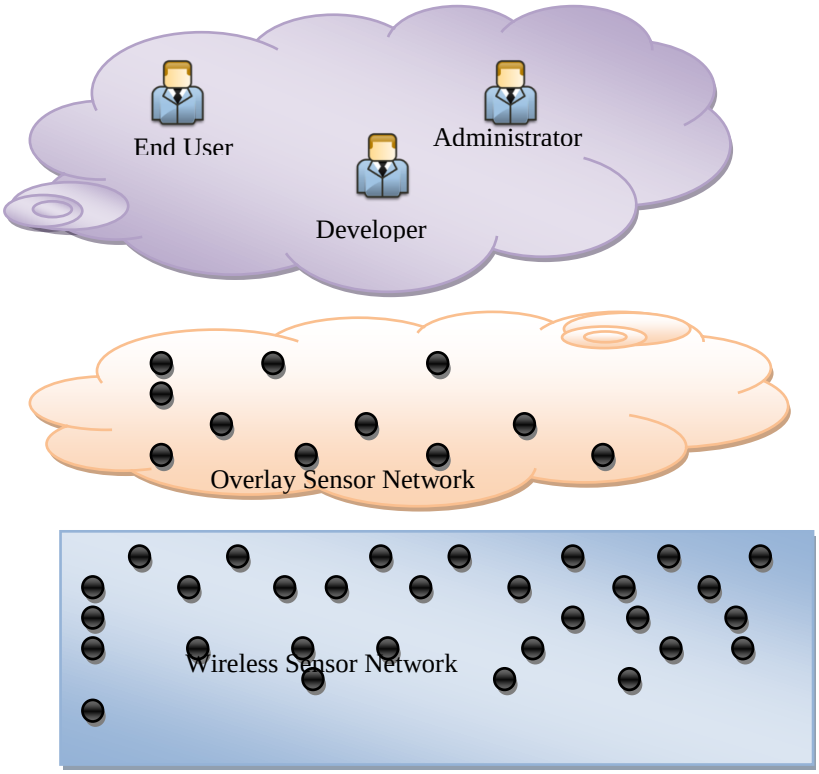

Figure 2. Overlay Sensor Network Architecture

2.2. Overlay Sensor Networks (OSNs)

An OSN is a network of different sensors which is built on the top of another physical sensor network. This network creates virtual topology on the top of the physical topology of a WSN. Nodes in an OSN are connected through virtual links corresponding to the physical paths in a WSN and are implemented in the application layers. Different distributed networks

such as cloud computing supports OSN as they run on top of the Internet [7]. The architecture of OSN is shown in Figure 2.

2.3 Virtual Local Area Networks (VLANs)

A VLAN is a group of logically connected networks that hosts with a single broadcast domain regardless of their connectivity. VLAN is based on logical connections instead of physical connections [3].

2.4 Virtual Private Networks (VPNs)

A VPN[5] is a dedicated network connected to multiple sites using private and secured tunnels over shared or public networks such as Internet. VPN connects geographically distributed sites in a single organization.

3. Virtual Sensor Networks (VSNs)

A VSN consist of different subset of sensor network and each subset is dedicated to a certain task or an application. In WSN, service provider and infrastructure provider is the same vendor. The rapid development of technology makes it possible to separate the service from the infrastructure to provide the multiple services in sensor network infrastructure. VSN is the collection of multiple heterogeneous sensor networks from different sensor infrastructure provider (SIP). Each service provider use resources from one or more SIP to form VSN and deploys services over the hired VSN resources [2, 9]. The architecture of VSN is shown in Figure 3.

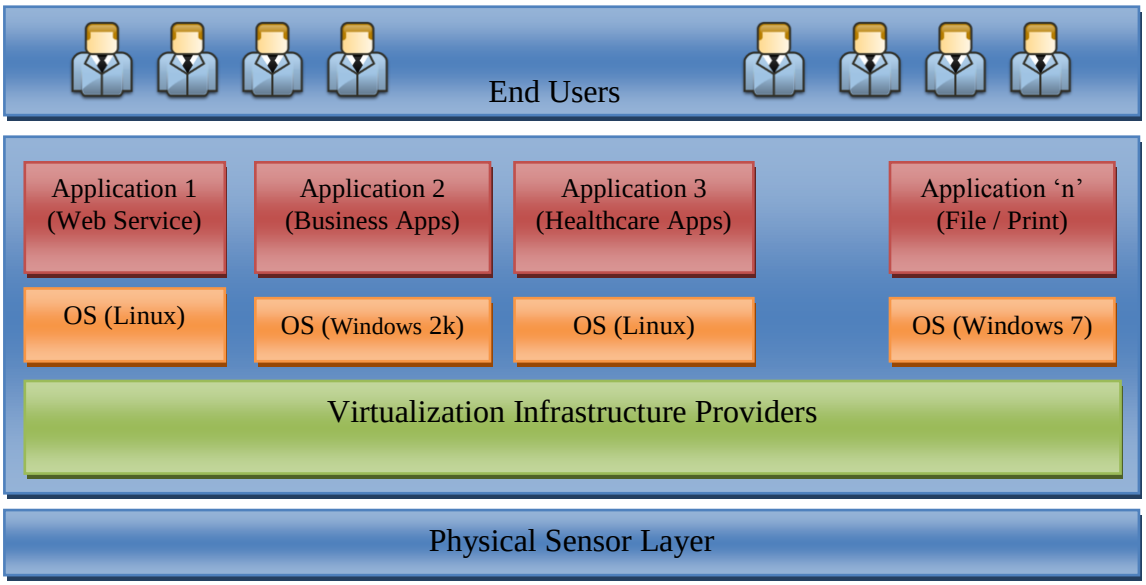

Figure 3. Virtualization Sensor Network Architecture

VSN is likely to provide a separation of services from sensor network infrastructure. Virtualization on sensor network can be used to separate the roles of traditional WSN service provider into two parts such as SIP, who manages the physical sensor infrastructure and

sensor virtualization network service provider (SVNSP), which provides multiple services [2].

VSN is an emerging technology that separates the physical sensor deployment from the applications running on it and provides several services or applications to the end users. VSN supports multiple logical networks over a single physical network infrastructure [4]. Virtualization is a technique that presents physical resources logically over a physical sensor network infrastructure for sharing and efficient use.

There is a virtual sensor layer that consists of logical instances of sensors that deploy multiple applications or services. E.g. if VSN allows n number of applications, then it should have at least n number of virtual sensor layers each layer dedicated to a single application or services. The number of virtual sensors supported by a sensor node depends on its resources [5].

3.1. Design Principle of VSNs

Sensors are deployed by some organizations but it can be used by other organizations in terms of services or applications. By taking this into consideration, researchers designed an infrastructure that supports multiple services or applications. We proposed an architecture of VSN that may provide multiple services in single physical infrastructure.

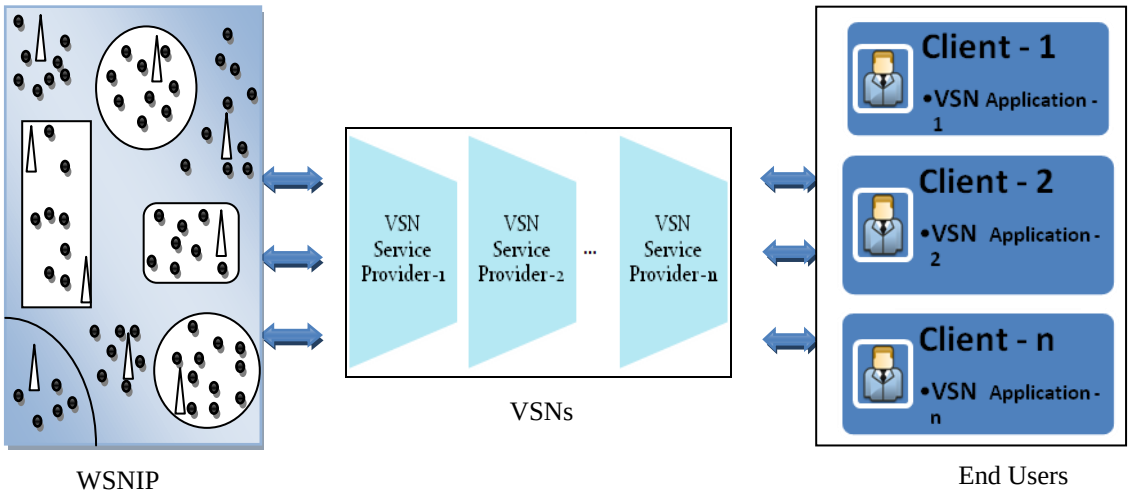

Figure 4. Proposed Architecture of VSN System

The proposed architecture is broadly categorized into three layers and is shown in Figure 4.

Wireless Sensor Network Infrastructure Provider (WSNIP): It will manage the physical infrastructure of sensor nodes. It can be possible by deploying the sensors through helicopter from air randomly. It will form a set of wireless sensor islands (WSI) which consists of group of sensor nodes that are isolated from the rest of the network. Each WSI is an autonomous administrative domain that offers at least one service or application to the end user.

Virtual Sensor Network (VSN): It is the logical extension grouping of sensor nodes from the physical sensor nodes is called VSN. Each logical grouping of sensor nodes called Virtual Sensor Islands (VSI) which is dedicated to provide a single service to the end user. More than one VSI services are combined to offer new VSN services.

End users (EU): End users are the clients and their relevant applications. Several users want to access the services from different clients. This layer provides users of different platform to access and utilize the sensor services without facing any problem.

3.2 Service Provisioning in VSN

Sensors are very limited and specific applications or services when they are deployed in sensor networks [9]. Therefore, fewer number of service provider organizations can provide the sensor services are very limited. A number of services can be provided to the users for different applications such as battlefield surveillance, industrial automation, environmental monitoring, and so forth.

In VSN infrastructure, infrastructure provider initiates to establish the sensor infrastructure, subsequently service templates are created by the service provider and end users can request by creating new sensor services by means of service templates with the exiting sensors by using service instances. End users can use the services[6] according to their requirements. Then end users should unregister from the services by deleting the service templates. The layered architecture for service provisioning is shown in Figure 5.

4. Sensor-Cloud Architecture

The sensor-cloud infrastructure[8] deal with huge amount of data analysis and having high computational power, mass storage unit and software as service in a virtualized and scalable manner at low cost.

A sensor network consist of a number of sensor nodes acting together to monitor a region and fetch data about the surroundings. A sensor network consist of self regulated sensors [8] that can monitor the environmental conditions such as sound, pressure, temperature, vibration, motion etc. Design principle of sensor network depends on monitored environment from where network size is specified. To monitor a small area, few nodes are required where as to monitor the large area; a large number of sensors are deployed.

Cloud computing allows the users to use platform as a service (PaaS), infrastructure as a service (Iaas), and software as a service (SaaS) at low cost which are provided by several cloud providers like Google, Microsoft, Amazon and so forth on the basis of pay per use services. Cloud computing platform dynamically configures and reconfigures the servers when needed by the end user. These servers may be virtual machines or physical machine in the cloud. The major benefit of cloud computing are the end-users who need not worry about the location of servers and services provided by the servers. Sensors collect data from the environment and transmit it to the cloud computing infrastructure for monitoring the applications. Sensor-cloud infrastructure provides services automatically to the end user by using the concept of virtual sensors. These services and their associated sensor data can be used by the end users via user interface through web services.

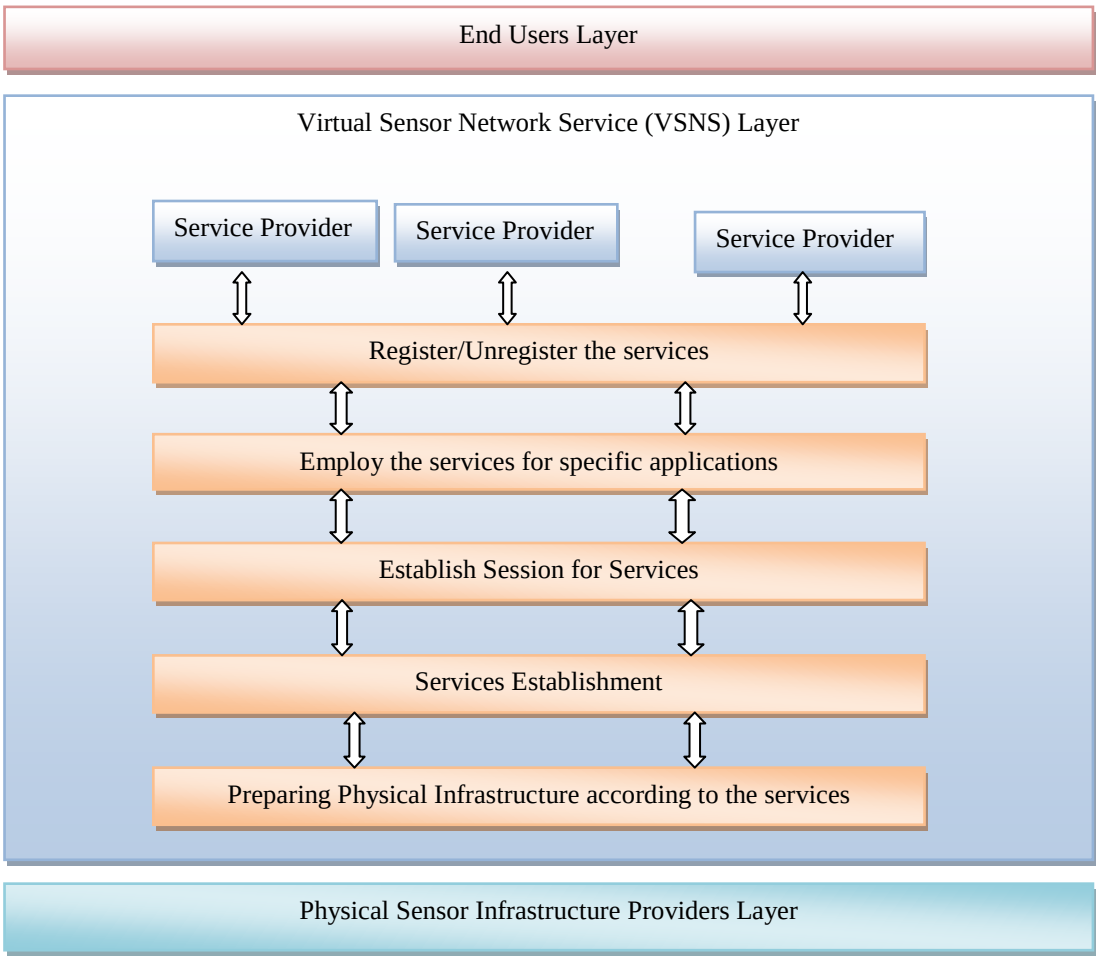

Figure 5. Layered Architecture for Service Provisioning

5. Applications of VSNs

Nowadays WSNs are used in many applications such as battlefield surveillance, environmental monitoring, healthcare applications, smart home, traffic control and so forth. In the following, we briefly explain the above applications in the field of VSNs.

5.1. Battlefield Surveillance

The application of battlefield surveillance [15] in VSN is to classify and detect the multiple targets to identify different categories like civilian, soldiers, enemies, wild animals, domestic animals. In such circumstances military operation is essential to identify the different categories and target to the enemies without upsetting the others. In this situation virtualization of sensor network plays an important role to sense the environment to identify civilian, soldiers, enemies, and animals. As a result, it only target to the enemies without affecting the others. To achieve this, VSN provide services to sense different environmental parameters such as sound, vibration, civilian *etc*., in a single sensor network deployment. Soldiers can supervise the battlefield to target the enemies by sensing sound, animal movement, and civilians by using different services of the VSNs.

5.2. Environmental Monitoring

Environment monitoring is required in emergency situations such as disaster, flood, to detect volcano explosion, earthquake, and cyclone. It requires continuous monitoring of the environment to get the prior information about disaster hazards. This can be achieved by deploying different sensors such as temperature, light, sound, camera sensors etc through the services of the VSNs.

5.3. Health Care Monitoring

Health care monitoring [9] can be achieved by using wearable sensors such as temperature sensors, and accelerometer sensors etc. These sensors are required to collect patient's health related data such as tracking body temperature, heartbeat count, pulse rate, and blood sugar control etc. A set of sensors are deployed in the home or hospital to monitor the movement of doctors, nurse and other people. It can also keep track of patient's details like body temperature, heartbeat count, pulse rate, and blood sugar control *etc.*, and also alert an alarm in case of any deflections in patient's health parameters.

5.4. Vehicle Monitoring

Vehicle monitoring is one of the challenging issues in VSNs to track the vehicles, and monitor the traffic signals. Tracking of vehicle is one of the challenging issues now-a-days to control the crimes. The main objective of vehicle monitoring is to keep the status of the vehicle like current location, speed, light status, pollution control, weight control, status of driver, fuel status, distance covered, and time of arrival etc. by using services of the VSN. As a result, traffic police can track the target vehicle to avoid crimes in the smart cities. It can be achieved by incorporating the sensors in the vehicle. It can also monitor the traffic control system by considering density of individuals and sound to avoid the traffic. Figure 6 shows the Vehicular sensor monitoring system

5.5. Smart Grid Monitoring

Power grid is a complex network [10-13] and is required to monitor and control the power system efficiently. Smart grid is one of the emerging technology which helps in taking smart decision for automatic monitoring and control of power grid. It can be achieved by deploying the sensors throughout the grid to keep track of different components such as generation unit, transmission unit and distribution unit. VSNs enable different services on the sensor infrastructure to keep track smart decision to monitor and control of power system. Figure 7 shows a smart grid monitoring system.

5.6. Smart Home Monitoring

VSNs provide services for smart home monitoring [9] and control either locally or remotely. It will monitor the humidity control of the room, temperature control, light control and status of the doors etc. It can also control the different electrical equipments such as light, and fan. To achieve this, sensors like light sensors, temperature sensors, humidity sensors, and sound sensors have to be implemented throughout the home. Automatic door, window control and also electrical equipment control can be done by taking smart decisions of the individual presence of detection sensors.

5.7. Industry Monitoring

VSNs provide services for monitoring of industry [9]. These services are responsible for different applications such as production, service, safety, and operation. In production unit different sensors are deployed to make the system autonomous and increase the production quantity and quality. Operation unit is also equipped with sensors to monitor the devices. If any hazards such as increase in speed or sound in any device occur, then it makes the workers alert by giving alarms.

6. Conclusion

In this review article we have surveyed on virtualization on wireless sensor network to provide a platform to serve the different applications in a single framework of sensor infrastructure to reduce the different parameters such as deployment cost, number of sensors etc of sensor infrastructure. In this work, we are trying to provide a model which will solve the problem of sensor network and provide the multiple services in deployed sensor infrastructure.

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