A Survey on VSN: Applications, Challenges and Opportunities

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***Abstract*—Wireless Sensor Networks (WSNs) are achieving a lot of popularity as they can be used in broad range of commercial applications such as in industrial automation, health-care and home automation. Multi-vendor and heterogeneous sensor nodes are deployed in these applications. There are very hard administrative control over the various WSN domains, also communication barriers, and there are opposing objectives & gainful engrossments among different vendors of sensor node in WSN. Hence it makes very demanding to introduce a large scale confederate WSN. But if heterogeneous WSN can be allowed to coexist on a shared physical metonym, Virtualization is a technology that can potentially enable this sharing. Virtualization in sensor network (VSN) may provide essential required characteristics. These may include flexibility, promote diversity, ensure security and increase manageability. In this paper a survey on WSN virtualization is being discussed. A comprehensive review of the state-of-the-art and an in-depth discussion of the research issues. We will enlighten the concepts of WSN virtualization and stimulate its congruous. Existing works are discussed in detail and evaluated using a set of requirements derived from the various scenarios. In this paper, various challenges, opportunities and applications have been discussed.**

***Keywords*— WSN, VSN(Virtualization in WSN), 6LoWPAN, SVNSP, SInP .**

I. INTRODUCTION

The basic elements of IOT- Wireless Sensor Networks (WSN) deliberately help users to interact and react to real world events. The nodes in WSN are capable of sensing, communications, and computations; and are getting more powerful day-to-day. Though WSN nodes are domain-specific and task-oriented, which means they are designed to serve one particular application and it not possible to reuse them for another application. This leads us to duplicate deployment of WSN infrastructure in a particular area for multiple similar related applications. Recent advances in wireless communications and electronics have enabled the development of low-cost, low-power, multifunctional sensor nodes that are small in size and communicate untethered in short distances. A sensor network consists of a large number of sensor nodes that are densely deployed either inside the phenomenon or very close to it [1-5]. Due to the rapid advancement of electronics tiny sensor nodes are capable of supporting IP protocol stack. 6LoWPAN ensures the IPv6 communication over low power and low cost sensor nodes [5-7]. IP enabled sensor node has opened the door for further research to the advanced and distributed applications in sensor network [5]. The concept of WSN virtualization has also attracted a great deal of attention from industry and academia [7] [10]. WSN virtualization renaissance has been originated mainly from the realization that it can provide a common platform upon which novel federated sensor network architectures can be built, experimented and evaluated, freed from legacy technology constraints[13][15][16]. In addition, virtualization in WSN is expected to provide a separation of services and infrastructure and facilitate new ways of doing business by allowing the trading of network resources among multiple service providers and customers [18-19]. Depending upon the roles of the traditional WSN, Virtualization on sensor network (VSN) service can be discussed in two parts- sensor infrastructure provider (SInP), and sensor virtualization network service provider (SVNSP), This type of virtual environment can ensure the coexisting heterogeneous WSN at the physical level that are free from the limitations of existing multi-vendor sensor networks [19]. Depending upon the roles of the traditional WSN, Virtualization of WSNs is an emerging research area. With the expected expansion in its business model, many research domains expect a huge growing interest of application developers in this area like Virtual node/network embedding algorithms, Service composition in the virtualized environments, Resource allocation,VSWN for cloud applications/services, Energy efficient virtual solutions, Bandwidth allocation and load-balancing. It is widely held belief that virtualization in sensor network (VSN) provide flexibility, also it ensures security and hence increases manageability as well as operability. WSN implies various challenges in design and operations as major fact that sensor nodes run out of energy.So for energy consumption, better and improved clustering routing protocols are required as well.

Objectives of this Paper:
We have discussed virtual sensor network. We pointed out various challenges, opportunities and various applications of VSN in this survey paper. Section 2 proposes the virtual sensor network. Section 3 describes related works. Section 4 presents the challenges of the protocol architecture. Section 5 discusses opportunities. Section 6 depicts the various applications related to VSN. Section 7 shows the future research scope and conclusion.

II. VIRTUAL SENSOR NETWORK

A virtual sensor network (VSN) is an emerging form of collaborative wireless sensor networks.[1] In contrast to early wireless sensor networks that were dedicated to a specific application (e.g., target tracking), VSNs enable multi-purpose, collaborative, and resource efficient WSNs. The key idea difference of VSNs is the collaboration and resource sharing. By doing so nodes achieve application objectives in a more resource efficient way. These networks may further involve dynamically varying subset of sensor nodes (e.g., when the phenomenon migrates sensors that detect the phenomenon changes with time) and/or users (users that are accessing the network changes with time).

A VSN can be formed by providing logical connectivity among collaborative sensors. Nodes can be grouped into different VSNs based on the phenomenon they track (e.g., rock slides vs. animal crossing) or the task they perform. VSNs are expected to provide the protocol support for formation, usage, adaptation, and maintenance of subset of sensors collaborating on a specific task(s). Even the nodes that do not sense the particular event/phenomenon could be part of a VSN as far as they are willing to allow sensing nodes to communicate through them. Thus, VSNs make use of intermediate nodes, networks, or other VSNs to efficiently deliver messages across members of a VSN.

III. RELATED WORKS

In the recent past the research community mostly paid attention to issues of sensor networks, such as energy efficient routing issues, security and reliable transmission and data aggregation[1-2]. But recently a numbers of related researches have been performed on the virtualization of sensor network [7] [10] [13]. Table I addresses many research projects that are going on in this field and the respective research areas. Among the related researches most of them have two approaches. Few researchers focused on gateway based and overlay based concepts. In VIP Bridge based ubiquitous sensor network [7], the authors propose an approach of using bridge to integrate several different sensor networks into one virtual sensor network. Gateway based sensor-grid application is also discussed in [7-8]. In [10] authors.proposed a tiny virtual machine for a Sensor Network called Maté. Its code is broken up into small capsules of 24 instructions allowing complex program to be under 100 bytes. In [11] [12] authors discussed dynamic resource discovery and programming WSN with logical neighborhood in details.

In [18] authors proposed a system called Melete which is based on Maté virtual machine. Melete system enables reliable storage and execution of concurrent applications on a single sensor node. In [22] proposes the concepts of sensor virtualization for heterogeneous sensor network platforms. In [17] [25] authors propose a simple and robust virtual infrastructure for massively deployed wireless sensor networks that is simple and can be leveraged by a number of different protocols. In [9] virtual position based geographic routing has been addressed to take over the problem of the existing geographic routing. Table I summarizes research directions of sensor network virtualization in different contemporary projects.

IV. CHALLENGES in VSN

- High bandwidth demand: Bandwidth depends on the amount of data you take from sensors. A typical WSN would need at least 250KBps. Zigbee would be an ideal solution. However if your WSN require more bandwidth, if you are reading heavy data, it would be better to use wifi or other technologies.
- Energy consumption. Energy consumption means the total energy consumed by the network to perform transmission, reception and data aggregation. The comparisons performed among the different approaches based on the energy consumption in both cluster head sensor nodes and cluster member sensor nodes.
- Quality of service (QoS) provisioning: The growing demand of usage of wireless sensors applications in different aspects makes the quality-of-service (QoS) to be one of paramount issues in wireless sensors applications. Quality of service guarantee in wireless sensor networks (WSNs) is difficult and more challenging due to the fact that the resources available of sensors and the various applications running over these networks have different constraints in their nature and requirements.
- Data processing and compressing techniques: The advancement in the wireless technologies and digital integrated circuits led to the development of Wireless Sensor Networks (WSN). WSN consists of various sensor nodes and relays capable of computing, sensing, and communicating wirelessly. Nodes in WSNs have very limited resources such as memory, energy and processing capabilities.
- Cross-layer design: Cross-layer design refers to sharing information among layers for efficient use of network resources and achieving high adaptivity. In cross-layer design, each layer is characterized by a few key parameters and control knobs.
- Resource Allocation Resource allocation in a sensor network virtualization environment refers to static or dynamic allocation of virtual sensor gateway router nodes and links on physical nodes and paths, respectively. It may be known as the virtual sensor network embedding. Embedding of virtual sensor networks, with constraints on nodes and links, can be reduced to the NP-hard problem even all virtual network requests are known in advance. The embedding problem has been discussed in different way for the virtual networking environment.

V. OPPORTUNITIES IN VSN

The concept of the sensor network virtualization may be interesting from the technical point of view, but it will only become a reality in commercial environments if there are enough business opportunities for SInP and SVNSP. Some opportunities in which an infrastructure provider can benefit from implementing sensor network virtualization are discussed below:

- Sharing Sensor Network: The most important opportunity behind sensor network virtualization is the sharing of substrate physical infrastructure. Along with a cost-reduction strategy, network operators are steadily exploring the deployment of common infrastructures to share capital investments. Especially in the time of economic recession, VSN can save a lot in terms of money and human labor in different critical situation like natural disaster management, battlefield surveillance and collecting resources form mine, building sky scrapers and large bridge.
- Reducing complexity and cost of Overlay proliferations: For a variety of reasons like organizational issues, security, scalability, and quality of experience guarantees providers are forced to deploy sensor network. Deployment of separate sensor nodes in target area for specific purposes is not cost effective. If a single sensor network can serve multiple purposes then it becomes very cost effective. Virtualization of sensor network satisfies this purpose by providing the options to use a

single physical infrastructure for different application level users through virtualization. In this way virtualization in sensor network can reduce complexity and cost sensor overlay proliferations.

- Managed services: Large scale WSN operators are increasingly focusing their growth strategies toward services delivery, customer orientation and product marketing. In this context, a potential approach would be the externalization of infrastructure to better focus on their core service oriented business. A third party could in this context become an infrastructure provider, and could therefore benefit from virtualization techniques to better capitalize its investments in new network deployments. The same approach could be followed by governments or public entities aiming at deploying federated WSN infrastructure, to promote the development of the digital society.
- Simplified architecture: VSN allows a simplified architecture that serves all of the applications and networks such as sensing sound, temperature, motion, object monitoring, monitoring the environment etc that previously required individual dedicated sensor networks and unnecessary duplication. So VSN provide a simplified heterogeneous architecture of sensor network.

VI. Applications

VSNs are useful in three major classes of applications:

A single WSN is deployed to monitor rock sliding and animal crossing in a mountainous retain (two applications). Each application use nodes from the other application to relay its data to the signaling systems and/or to its members.

- Geographically overlapped applications
- E.g., monitoring rock slides and animal crossing within a mountainous terrain. Different types of devices that detect these phenomena can relay each other for data transfer without having to deploy separate networks. Here the advantage is saving in hardware cost.
- While logically separating multi-purpose sensor networks
- E.g., smart neighborhood systems with multifunctional sensor nodes. Instead of traditional WSNs that runs one single applications, VSN enabled nodes run multiple applications
- In certain dedicated but dynamic applications
- E.g., To enhance efficiency of a system that track dynamic phenomena such as subsurface chemical plumes that migrate, split, or merge. Such networks may involve dynamically varying subsets of sensors. Here the advantage is the ability to connect right set of nodes at the right time.

VII. FUTURE RESEARCH SCOPE AND CONCLUSION

Virtualization on sensor network (VSN) service can be discussed in two parts- sensor infrastructure provider (SInP), and sensor virtualization network service provider (SVNSP), depending upon the roles of the traditional WSN. This type of virtual environment can ensure the coexisting heterogeneous WSN at the physical level that are free from the limitations of existing multi-vendor sensor networks. Virtualization of WSNs is an emerging research area where there is a lot of scope for the researchers. There is expected expansion in its business model, hence many research domains expect a huge growing interest of application developers in this area like Virtual node/network embedding algorithms, Service composition in the virtualized environments, Resource allocation,VSWN for cloud applications/services,Energy efficient virtual solutions, Bandwidth allocation and load-balancing. Many applications of Virtual wireless sensor networks can be deployed to attain different services. Virtualization has opened a new dimension in different research fields especially in WSN. The whole world is facing economic recession. So virtualization in sensor network can be a promising research issue in the field of wireless sensor network. Among the future research scopes few of them may be developing convenient operating system for tiny sensor which can support virtualization in sensor network. Managing resources, scheduling the sensing activities, minimizing energy consumption are few of the future research area in sensor network virtualization. Large scale federated sensor network framework with multiple applications sharing the same physical resources has already attracted the researchers.

In this paper we present a survey of virtualization in sensor network. Virtualization in sensor network can be effective in home automation, patient monitoring, battlefield surveillance, rock sliding and animal crossing in a mountainous retain. Multi vendor sensor network architecture can be deployed for efficient utilization of physical sensor infrastructure. However, communication barrier, conflicting goal & economic interest of individual vendor and the gradual ossification problem of WSN make it difficult to introduce a large scale federated WSN. By allowing multiple heterogeneous wireless sensor network architecture to coexist on a shared physical substrate, virtualization in sensor network may provide flexibility, promote diversity, ensure security and increase manageability. Here we discuss different challenges and opportunities of using the large scale federated WSN resources in a sensor virtualization environment. Our future interest is to emphasize on building a large scale federated sensor network framework with multiple applications sharing the same physical resources.

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