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Improved Energy Consumption and Resource Utilization through Sensor Virtualization in Smart home

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ABSTRACT
Wireless sensor networks have tremendous importance in our daily life style. Recently in the fields of WSN, the concept Virtualization of wireless sensor network i.e. VSN is a new promising research approach. The state of the art technology can provide the opportunity to build an economic business model for application area such as smart home, health care, because of the involved infrastructure cost. In this paper we propose an agent based approach of sensor virtualization concept in Smart home by efficiently utilizing the available resources for multiple Smart home applications through scheduling sensing activity and reduce Energy Consumption. We have implemented and evaluated the sensor virtualization scheme in real time environment. The evaluation method shows that the virtualization of s ensor network technology reduces the overall cost and complexity significantly for the implementation of smart home.

General Terms
Wireless sensor network ,Virtualization, Resource allocation, Sensor node.

Keywords
Cost, Virtual instance, Application, ACM(AC Monitoring Application)

1. INTRODUCTION
Advances in new technology in wireless communications and electronics have enabled the development of low cost, low power sensor node and that multifunctional sensor nodes are small in size and they can communicate untethered over short distances. A sensor network consists of a large number of sensor nodes that are d inside of the sensor network field . The position of sensor nodes need not be determined before the operation. This allows random deployment in inaccessible terrains or disaster relief operations. On the other hand, this also means that sensor network protocols and algorithms must possess self-organizing capabilities. Another unique feature of sensor networks is the cooperative effort of sensor nodes. Sensor nodes are fitted with an onboard processor. Instead of sending the raw data to the nodes responsible for the fusion, they use their processing abilities to locally carry out simple computations and transmit only the required and partially processed data.

Due to the rapid advancement of microelectronics, tiny sensor nodes are capable of supporting IP protocol stack. So that mentioned features we ensure that can use for the wide range of applications for the sensor networks. Some of the application areas are health, military, and home. In military, the rapid deployment, self organization, and fault tolerance are the characteristics of WSN that have sensing technique for the Military Command, Control and communication ,computing, intelligence, surveillance, reconnaissance, and targeting systems. In health, sensor nodes can also be deployed to monitor patients and assist disabled patients. And Some other commercial applications include managing inventory, monitoring product quality, and monitoring disaster areas. And other sensor network applications require wireless ad hoc networking technology. Though many protocols and algorithms have been proposed for traditional wireless ad hoc networks, but that are not provided unique features and application requirements for the sensor networks.

In the past, applications of sensor networks were thought to be very specific. The communication protocols of sensor networks were also very simple and straightforward. Some researchers were even against the use of the compatible internetworking protocol architecture in WSNs. There were different reasons behind that such as the resource constraints for layered architecture, the problems of configuring large no of devices, But with the growth of Internet of thing and advances in microelectronics we are going to achieve small sensor devices hold compatible TCP/IP protocol stack.

Now new generation of sensor node are come into the market to support multiple concurrent application through the new field Sensor virtualization. So this sensor virtualization has great deal of attention from industry as well from many academic institution

The rest of the paper is organized as follows. Related work is presented in Section II. Problem definition explained in Section III, Proposed Agent based approach of sensor virtualization is presented in Section IV. Mathematical Model presented in Section V, Resource allocation algorithm presented in Section VI, Implementation details is presented in section VII , Result and

Analysis are discussed in Section VIII and Section IX Concludes the paper.

2.RELATED WORK

In this section, we present literature survey of virtualization in smart home .The key objective is to highlight key strengths and limitations to these techniques.

I.F.Akyildiz [1] has done a lot of research of wireless sensor that focuses on the virtual and overlay sensor network rather than the traditional view of VSN. It demonstrates the modern research directions in the field of the virtualization of sensor network in general and highlighted the constraints like hardware cost, scalability, topology change, power consumption.

Fresnel[2] proposed to build a large scale sensor framework. The main goal of this project is to offer an environment that can support multiple applications running on each sensor node. It provides an execution environment that hides the system beneath from the application running on it. The system operates in a shared environment. The key characteristics of this approach are a virtualization layer that runs on each sensor node and provides abstracts access to the sensor resources which enables the management of these resources through policies defined by the infrastructure owner. A runtime environment on each node allows multiple applications to run inside the sensor node. Few of the challenges designing Fresnel are secure and safe sharing of resource, support for legacy networks, Flexible network partitioning etc.

Leontiadis[3] has suggested another platform that addresses the technical challenge of supporting multiple co running applications in the sensor node. Each application operates in an isolated environment consisting of an in node hardware abstraction layer and a dedicated overlay sensor network. Instead of using virtual machine, here hardware abstraction layer serves the purpose. It is a set of routine in software that emulates platform specific details, giving programs direct access to the hardware.

E.Felemban[4] has proposed a novel packet delivery mechanism. It provides QoS differentiation on two quality parameters such as timeliness and reliability. This approach is based on multiple logical speed layers over a physical sensor network which is based on conventional virtual sensor network. Based on the speed, it considers different virtual overlay. For virtual layering, it creates virtual isolation among the speed layers. It is achieved by classifying incoming packets according to their speed classes and placing them into the appropriate priority queue. Though this approach helps reduce the energy consumption by efficient routing mechanism it does not address the key challenges like multi vendor and heterogeneous protocol stacks.

The Y.Yu,V. Bhandari[5] proposed concurrent Application supporting system called Melete which is based on the Mate virtual machine which enables reliable storage and execution of concurrent applications on a single sensor node. VSN approach proposed in this paper is based on Mate and Melete systems and named as VSNware. As VSNware runs on the node itself memory, CPU, and communication capabilities remains the concern for high usage applications.

Bosheng Zhou[6] presented a novel concept of Virtual Wireless Wire (Viwiwire). It is the set of consecutive high bandwidth wireless links over which concurrent transmission and reception can operate without interference. Using this concept a number of specific mesh networking architectures are proposed for future smart home networking. The most popular solution for wireless home networking is to set up Wi-Fi based WLAN(s) due to its low cost. But at the same time there are some disadvantages in this solution. An obvious problem is the proximity of the access point (AP). The convenient location is usually not the best location which should be determined through an expensive and yet inconvenient site survey. For the full coverage of a house, it usually requires several APs to be deployed throughout the house and each AP needs to be wired to the home gateway, which is inconvenient and expensive as well. In addition to this all traffic will go through the AP(s), which is inefficient. In a smart home network, there will be many types of traffic such as audio, video, data, signalling, and sensor information where each type of traffic has different requirements.

Imran Khan, Roch Glitho[7] suggests the Multi-Layer Architecture for Wireless Sensor Network Virtualization. Multi Layer architecture uses CoAP Signalling framework for resource reservation and session management. But CoAP is still not matured as an attractive option and has many issues that are not solved yet.

Xin Dai, [8]Department of Computer Science, Guiyang University research focused on the home gateway. The Open Services Gateway Initiative (OSGi) is one solution of them ,which aims to create a platform and infrastructure to enable the deployment of services over wide area network to local network and device. In the OSGi architecture smart home, residential service gateway connects various appliances together inside-of-house and bridges the external network such as the Internet into the house network outside of house. This paper presents work on combining Clouds and smart home together so that appliances can benefit from Clouds and Cloud providers can have more potential users. In order to realize mechanism, they discussed the Peer-to-Peer and Web Service technologies to the Cloud Computing and modify the Service Layer of current Cloud architecture. With the purpose of combining Cloud and smart home which can enable Cloud to achieve more special functionality for smart home.

Bosheng Zhou, Alan Marshall, Tsung-Han Lee[9]
presented a novel concept of Virtual Wireless Wire (Viwiwire), which is a set of consecutive high bandwidth wireless links over which concurrent transmission and reception can operate without interference. Based on this concept, a number of specific mesh networking architectures are proposed for future smart home networking. These include wireless bus line mesh, wireless ring mesh, and general multi-path mesh. here Author also proposed networking architectures. There are mainly two types of wireless networks used in the home: Wireless LANs (WLANs) and Wireless Mesh Networks (WMNs). Current home wireless networks are mainly for broadband networking access Internet through a home gateway such as an ADSL/cable modem. The most popular solution for wireless home networking is to set up WiFi based WLAN(s) due to its low cost.

3. PROBLEM DEFINATION

Although WSN virtualization provides efficient method to utilize individual sensor for multiple application and achieve better resource utilization, it still does not help much to improve Energy utilization

4.PROPOSED AGENT BASED MODEL

We propose use of Sensor virtualization and sensor scheduling to achieve efficient resource utilization and less energy consumption, which in turn will make smart home solution more cost effective.

4.1 System Architecture.

Here, we briefly describe the detailed system architecture sensor virtualization in smart home application. The system architecture consists of four major layers such as Physical layer, Virtual layer, Agent Layer and Application layer. To develop this architecture, we have referred some models which are useful herein[10][11][12]
Proposed architecture behaves like a stack of layer where each layer has its specific functionality.
The functionality of the each layer of system architecture are discussed are as follows:-

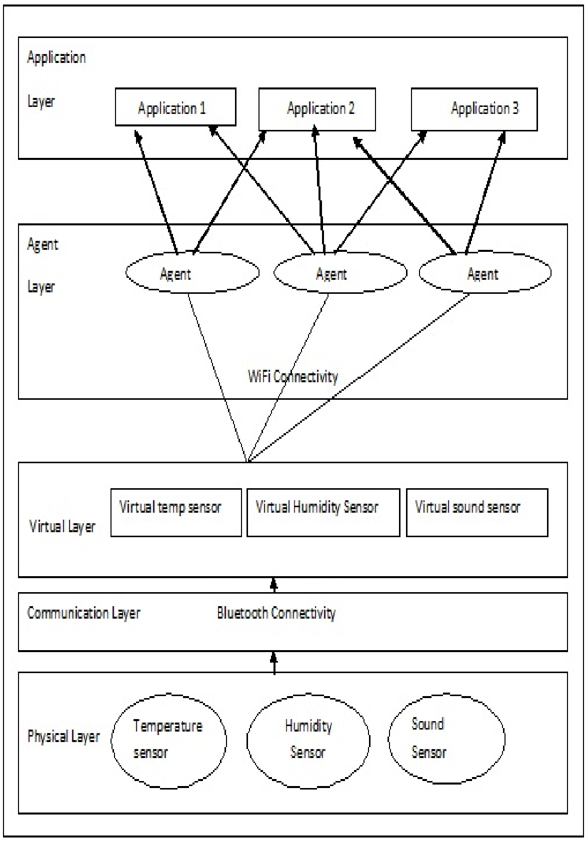


Figure 1. Proposed Agent Based approach

1.Physical layer

In this layer we have three types of sensor Temperature sensor, Humidity sensor and Sound Sensor. The main role of the temperature sensor is to sense real time environment data, humidity sensor is used to measure moisture in the air and sound sensor is used for detecting sound signal.

2.Virtual layer
The main role of this layer is to create the virtual copies of the underlined physical sensors like Temperature, Humidity and Sound and pass it on to Agent Layer. Number of Virtual copies created are dependent of the capacity of physical sensors to support thorough its hardware and software
.
3.Agent layer
This layer creates and manages Agents created for particular task. It addresses requirements coming from Application layer and crate agent to perform specified task. I t will monitor and Manage Agent though its lifecycle. It is closely work with Virtual layer and Application Layer to understand Application requirement and expected output.

4.Application Layer
This Layer manages all the Application overlay targeted at Agent layer. Applications at Application layer are top of the entity in architecture which are being served by Virtual Layer through multiple Agents. Applications will be supported on the basis of their priority and criticality in the defined system.

4.2 Agent Based approach

An agent is an entity that is able to act without the intervention of humans or other systems: that agents have control both over their own internal state and over their behavior [3]. Therefore, each agent is self-content and acts autonomously to enable autonomous decision making, agents observe their environment with sensors, act upon it, and communicate with other agents. Consequently, agents react on changing environmental influences by continuously sensing their environment.
An agent is characterized by the architecture part, or the agents behavior - the action performed after any given sequence of perceptions and the program part, or the agents built in part , the internal functionality of the agent. An intelligent agent should be endowed with an initial (built in) knowledge and with the capability of learning. The learning capability ensures the agents autonomy, i.e., the capability of deducing his behavior from its own experience.
Multi-agent systems (MAS) are computational systems in which several agents cooperate to achieve some task that would otherwise be difficult or impossible for a single agent to achieve.
The multi-agent-oriented approach is the proper approach for our proposed work due to the flexibility of the agents as autonomous and intelligent components in decisions support actions. The agents of the model have capabilities for semantic interpretation of events/measurements provided by physical components. The multi-agent model supports an event-driven architecture that addresses complex
Systems composed of components with distinct functions, and therefore the communication between the different smart home application is based on simple and complex events. The decision model of the smart home, an event-driven multi-agent model using the data detected by the physical entities and the interpreted semantics by means of the behavior based on the defined ontology.

4.3Hardware characterization

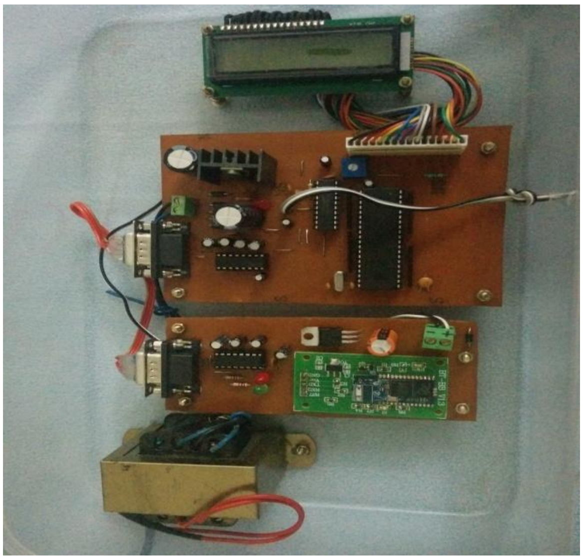


Figure 2: Hardware unit

Hardware component are described are as follows**.**

4.1.1. Temperature Sensor :

LM35 series are precision integrated circuit temperature sensors, whose output voltage is linearly proportional to the Celsius temperature. The LM35 does not require any external calibration or trimming to provide typical accuracies of 14C at room temperature and 34C over a full 55 to +150C temperature range. Low cost is assured by trimming and calibration at the wafer level. The LM35s low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. Total power consumed by the sensor 0.1KW.

Features of Temperature sensor are:

1. Calibrated directly in Celsius
2. Suitable for remote applications
3. Operates from 4 to 30 volts
4. Less than 60 A current drain

4.1.2. 16 x 2 Character LCD:

Features are as follows:

1) 5 x 8 dots with cursor.

2) Built-in controller (KS 0066 or Equivalent).

3) + 5V power supply (Also available for + 3V).

5) N.V. optional for + 3V power supply

4.1.3. 8-bit Microcontroller with 8K bytes In-System Programmable Flash AT89S52:

The AT89S52 is a low-power ,high-performance CMOS 8-bit microcontroller with 8K bytes of in-system programmable Flash memory. The on-chip Flash allows the program memory to be reprogrammed in system or by a conventional nonvolatile memory programmer.

The AT89S52 provides the following standard features:

1) 8K bytes of Flash

2) 256 bytes of RAM

3) 32 I/O lines, Watchdog timer, two data pointers, three 16-bit timer/counters.

4) A six-vector two level interrupt architecture, a full duplex serial port.

5) On-chip oscillator and clock circuitry.

5. MATHEMATICAL MODEL

5.1 Resource allocation in sensor virtualization

Let S be the system that describes input to system with Preprocessing of temperature sensor data, virtual copies creation, grouping of virtual copies , passing it to the application, So this all function gives the output as a allocation of resources in sensor Virtualization.

- S = { I, O, F, D ,F ,Su ,Constraint }

Where
I be the input to the system
O be the output
F be the function which is to be required
Fa Failure state
Su Success State

- D = { Vc , GVc , SVc , T(n), Cap (s) }

Where
D be data item for the system
Vc be Number of Virtual copies
GVc be Group of virtual copies
SVc be To store virtual copies
Cap (s) capacity of sensor node
T (n) sensor node senses the surrounding Temperature

- F = { Create Vc , Group Vc, Assignment Vc }

Where
Create Vc be function to create the virtual copies of the existing Physical Node
Group Vc Add Vc to Group
Assignment Vc is the function to assign the Virtual Copy to the Intended Application

- Constraint = sensor sense temperature should be non zero values.
- Fa - be the failure state

Where Resource not properly allocated according to original temperature

- Su - be the success state

Where resources properly allocated to the end user application

- O- be the output

Where Resource is allocated to the Application

5.2 Resource allocation

Residual resources management is performed by measuring the available remaining resources after utilization. We have given the mathematical formulation of the remaining resources of sensor node, corresponding virtual copies, and its storage . the residual capacity of the sensor nodes is defined as the total processing capacity of the sensor nodes which is given by

$$Rn = \{ cap(s) [Tn] \} - Un$$

Un – Utilization of sensor node

$$Un = \{ cap(s) \} * (Vc) \}$$

5.3 Energy consumption

Due to the wide diversity of sensors, the power consumption of sensors varies greatly. In general, a sensor, i, will have the following sensing energy consumption.

$$E = Vdc * Ii * T$$

Where $T = Ta + Ti$

where T is the time required for obtaining a data from the sensor (Active State + Idle state) and Ii is the current drawn of sensor i.

5.4 NP-hard and NP-Complete Analysis

The proposed work comes into the NP complete because in particular time it will give the result. In this case we assume that we have virtual sensors and every application uses one virtual sensor. Virtual sensors mean we have created multiple instance of the same physical sensor. So one sensor cannot process multiple applications at the same time. For that we are using Time Slots. A timeslot will be allotted to every newly created Virtual Instance.

No. of Virtual Sensor = No. of Application

So now during Time Period T only One Virtual Instance will be active and the same will utilize the energy of the physical sensor. After time T the second Instance now become active and the same will now utilize the energy of the sensor. This continues same for all the Virtual Instance. Now in Round Robin fashion the system continues the process from the first Virtual Instance. Its clear that at a time only one Application uses the physical senor. The time cycles move fast which gives an illustration of virtual instances. It looks like that we have multiple sensor for multiple application. But in practical we have only one sensor.

6. RESOURCE UTILIZATION AND SCHEDULING ALGORTHM

Algorithm

Step 1. Application requests virtual instance to main server.
Step 2. Authenticate incoming application Request R(Ai)
Step 3.Check the priority of the Application Request P(Ai)
Step 4. Main server checks if it can create instance copy for the application request.
Checks if count of current number of active instance Ci< 3
If Yes Continue else go to step 5
Step 4. Create virtual copy Vi and allocate it to application request R(Ai). Go to step 6.
Step 5. Check if priority of new the application request is greater than any of the existing application.
If P(Ai) >P(Ci)
Destroy instance from existing low priority application and allocate it to new Application request
R(Ai)and continue.
If Not Do nothing and Go to Step 8.
Step 6. Allocate time slot ti as per Priority of the Application request.
If High - 5 second, Low - 15 second.
Step 7. Destroy instance Vi as per predefined timeslot.
Step 8. Exit

7. IMPLEMENTATION DETAILS

In the proposed agent base model we worked on to serve multiple application with the help of single available resource. In our case we are using single temperature Sensor supporting multiple applications based on their system priority.

7.1Declaration Specification of the Physical Sensors

In our proposed model sensor is required to serve multiple application tasks. At the physical layer, we used temperature sensor. The main role of the temperature sensor is to capture surrounding temperature data within defined proximity. In our case we have taken hardware kit and on that board fitted one temperature sensor LM 35and the microcontroller is used to process the data .For the communication purpose used onboard Bluetooth device which has a range of 5- 10 meter. The LCD device also embedded on kit itself for displaying the real time temperature data. Data is displayed in degree.

7.2 Evaluation of the virtual sensor layer

Above the sensor hardware kit virtual sensor layer sits in between physical layer and the application layer. The main function of this layer is to Create logical copies as per the capacity of the sensor node. Here we are implementing priority based Scheduling algorithm which defines criteria to allocate available resources to Application overlays on its system priority. It also sets Idle or Active mode for Sensor helping it reduce energy consumption.

7.3 Application interacting with the Virtual layer through Agent

Here we have considered two applications Fire Alarm and AC Monitoring as they require temperature data for their functioning. Fire Alarm application will contact Virtual Layer for virtual copy in order to access Temperature data, virtual Layer will create an agent and will assign it to Fire Alarm application which will pass temperature data to it. Fire Alarm application will process the information received from agent and will display alert as per backend logic written for particular Fire situation. Same time SMS will be sent to registered user informing situation.

8. RESULT

Table 1: Comparison Table of Existing Vs Proposed Agent base Approach

Above table shows the comparison of proposed agent base and Existing model. We can show that proposed agent base approach help us achieve 300% more Resource utilization and utilizes 60%less energy than Existing Virtualization approach.

Here, we have plotted the graph for Energy consumption and Resource utilization with number of sensor nodes against multiple applications by using VSN approach and agent base approach with the help of scheduling and TDMA Scheme. In case of VSN we were able to use single sensor node for multiple application by using virtual instance of physical sensor, avoiding need of adding extra sensor for each newly added application to infrastructure and thus improve utilization available resource. In case of Agent Based approach we can use single sensor for multiple application and achieve optimum resource utilization through its active and idle state which also help us reduce energy consumption.

Approach	No of sensors	Application served	Resource utilization (%)	Energy Consumption (KW)
Existing approach	3	3	100%	1.4 KW
Proposed Agent Base approach	3	9	300%	0.577 KW

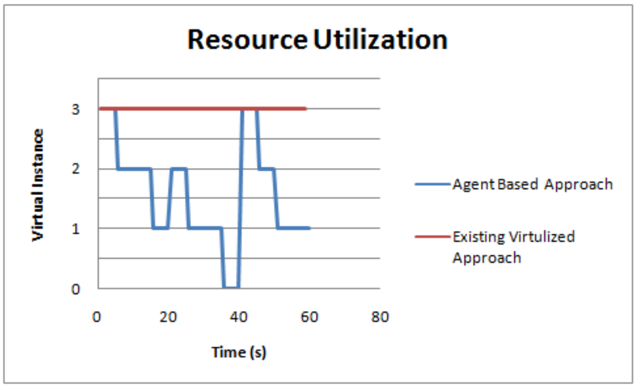
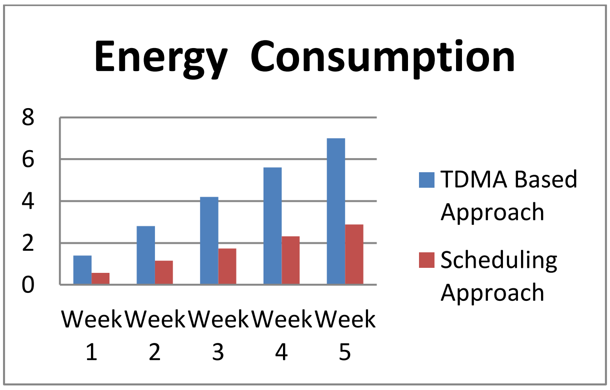


Figure 2: Resource Utilization

Figure 2 shows the comparison of Resource utilization in existing virtualized approach and agent base approach. Scheduling agent base approach shows 50% better utilization of sensor while serving same number of applications than the TDMA base approach.

Figure 3 shows the energy consumption graph with and without sensor scheduling. With the help of scheduling sensor showed less energy consumption than earlier TDMA Agent based approach serving same number of applications



9. CONCLUSION

In this paper, we presented Agent base virtualization approach in wireless sensor network concerning its application in smart home. By allowing multiple heterogeneous nodes in different sensor network architecture to coexist on a shared physical substrate, virtualization approach may provide flexibility, promote diversity, ensure security, and increase manageability for smart home applications. Here, we proposed a business model of smart home based on VSN, mathematical model for resource allocation and scheduling and measurement and evaluate the model for smart home implementation. With the help of virtualization and sensor scheduling we have to improved resource utilization as well to minimizing the energy consumption efficiently in smart home.

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