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Effective resource virtualization for dynamic IoT devices in road network

Padmanabhan P, Sampath Kumar K, John A
School of Computing Science and Engineering, Galgotias University, Greater Noida, India

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ABSTRACT

Internet of things (IoT), which is considerably innovating and generating a large volume of processes in every field worldwide, is one of the recent and next disruptive technologies. As a result, IoT devices and others are increasing network connections in the relevant field. It is essential to maximize and process these kinds of resources. The effective usage of resources is one of the most important and very difficult to manage the resource in the dynamic environments. Many studies are performed in the effective usage of resource in the static and dynamic environments. However, the dynamic environments have still different issues and have to solve different dynamic networking issues. In this work, present a mechanism for managing different connecting devices in the dynamic environments. Especially this system is concentrating on road network device management in dynamic environments. The proposed system called dynamic road sensing (DyRSen) connectivity is support to different continuous connectivity. The DyRSen provides: i) continuous connectivity using available resources and provide virtual environment for computing, ii) temporary data storage in dynamic environment for effective resource sharing, and iii) reduce the energy utilization and network overhead and the effective resource management is compared to the other works.

Corresponding Author:

Padmanabhan P
School of Computing Science and Engineering, Galgotias University
Greater Noida, Uttar Pradesh, India
Email: padmanabhan5312@gmail.com

1. INTRODUCTION

The internet of things (IoT) provides a concept of connectivity of anything from anywhere at any time so that the interaction of physical objects connected to the network can be done autonomously. The applications of IoT are closely coupled with different technologies and different application environments. In the IoT, virtualization is used to effectively utilize the resources and reduced the cost of implementation. Virtualization is the procedure of running various virtual resources as instance, hardware and software. The main features of virtualization are dynamic, flexibility, on-demand service, and economic and high reliability [1]. The application of IoT and virtualizations are smart devices, road network, surveillance system, farming, wearable devices and other similar applications. The road networks are connected various cities using junctions and connecting points. The dynamic moving objects are changing the locations in each time interval and based on the changing the information transmission and retrieval also has been changed. So, dynamic management different resources are needed to store the transmitting and receiving data. But in the remote sense road network, very difficult to store and transmit the data, due to unavailability of resources. In this work proposed, a new model to manage the remote sense road network data using virtualization concepts. The system proposed a network function virtualization for long road network and this work applied into the telecommunication system. But the main issues in the long-term road networks are machine to machine communication, machine to person communication, device reliability, availability of resources, and management of available resource are still open in the dynamic road environments. In this work, addressing the mentioned issues using dynamic resource management with virtualization in road network [2].

2. RELATED WORKS

The proposed system a network function virtualization model for long term road network and using this method, different services are provided. The outcome of this method is reduced the deployment and resource cost [2]. The model represented to global connectivity and enabling various applications in the IoT environments and introduced sensor virtualization module (SVM) to utilize the IoT resource using external IoT external objects. But this model is performed the deployments in application level [3]. The paper presented various software definition and functions of virtualization techniques in IoT. Also various hardware architecture solution and network function virtualizations are summarized [4]. The DEVMAN methodology for managing and monitoring the physical device network in the IoT environments [5]. The system is provided the sensing and controlling policy for IoT environments using ARM Trust Zone based virtual sensing system.

In this work the applications are sense the needed application, but the resources are not utilized properly [6]. The model for connecting near future network devices using abstract device properties and virtual objects. In this work combined different network services for various applications [7]. The model for network virtualization for dynamic connectivity using various connected devices. This mechanism having various virtual networks among IoT devices and corresponding objects in the cloud environments [8].

The OMNeT++ is used to simulate this work. The proposed a model for effective utilization of resources in smart cities using IoT environment. Using this work the different resources are utilized and managed in the IoT environments [9]. The proposed a method for edge computing and network function utilization for service providing in the physical customer premises environments. Using this method, the resources are shared and reduced the number of resources also [10]. The method for virtualization using software defined networking (SDN) and network function virtualization (NFV) with the help of this work the energy cost is reduced and it is applied into 4G technologies [11]. The method described for service and connectivity based on the location. Also using this method, customer service selection, matching scenarios and device virtualization are performed [12]. IoT devices identification and virtualization processed by randomized and asynchronous distributed virtualiation (RADV) methods [13].

The method represented to software defined network for virtualization, resource management, dynamic, and resource optimization in the IoT environments [14]. The summarized methods and applications for various virtualizations are shown in Table 1. The IEEE 802.15.4 used in the physical layer and act as low rate WPA network. And it is designed for machine-to-machine communication and provides the maximum energy life [15], [16]. The mesh topology used in this standard and used for long distance communication and multiple pathway communication. The Wi-Fi used for local communication between two or more resources and using low bandwidth for data communication [17]. The system described various networking devices, corresponding layers, virtualization, and functionalities of each device [15]-[22]. The Bluetooth, 6LowPAN and 5G are used for transfer the data in short distance, small devices and speedup data transmission. The most of the methods from previous research represented only service virtualizations in cloud not in resource virtualization [17]-[19], [22], [23]. This approach, virtual nodes and links in a dynamic network are created and destroyed with traffic magnitude, service requests, and high level objectives [24]. The federation of IoT systems that offer scalable and interoperable smart city applications that make use of microservice sharing and dynamic resource scaling [25].

Table 1. Methods and applications

Methods	Applications
NFV model for long term road network [2]	Reduce the resource cost
Sensor virtualization module (SVM) [3]	Enabled application development
DEVMAN methodology [5]	IoT device monitoring and management in physical network
Virtsense [6]	Provide the Sensing and Controlling Policy in IoT environments
Service and virtual objects management (SVOM) [7]	Monitor the physical resources using virtual objects and services
Dynamic connectivity in network devices [8]	Dynamic end to end connectivity in IoT devices
Effective resource utilization in IoT platform [9]	Docker, Kubernetes and Apache Kafka prototype used for resource sharing and utilization
SDN and NFV [11]	Energy reduced using SDN and NFV
Virtualization based service matching [12]	Identified the services based on the geographic area
RADV [13]	IoT devices identification and virtualization

3. PROBLEM AND PROPOSED WORK

3.1. Problem

The dynamic environments resource connectivity is one of the important issues in the IoT because the objects are changing the location each and every second. So, connectivity in the IoT environments is very challenging task. The number of the resources and energy utilization are very high. Especially, in the dynamic road network the number of moving objects is changing each and every second. In the dynamic changing road network then T is the trajectory moving path, L is the length, S is the segments in the dynamic environments, N is the number of segments in the moving environments and MO is the moving objects. The dynamic environments consist of sequence of segments (S) and connecting nodes. The dynamic nodes and distance (D) is denoted in the ordered list such as$(MO_1, \dots, MO_n)$, where N is the number of nodes in (T). The representation of the problem shown in the (1).

$$\{T_1 \dots \dots T_n\} = \{ MO_1, \dots, MO_n\}, \{D_O \dots D_n\}, \{t_1 \dots t_n\} \quad (1)$$

The trajectory of road network (T) is connected to various moving objects (MO) with distance (D) and time (t). In the dynamic environments each and every object are interconnected and each connecting node have set of communication devices. Moving objects and network connectivity scenarios with network management functions is shown in the Figure 1. The representation of the problem is shown in the (1).

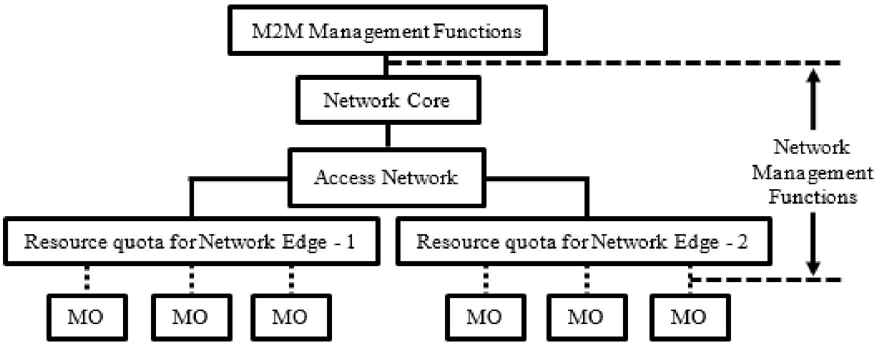

Figure 1. Moving objects and network connectivity scenarios

3.2. Dynamic road sensing (DyRSen)

The entire dynamic road network devices are connected using dynamic road sensing (DyRSen). The communication physical devices and connectivity of DyRSen layers are represented in the Figure 2. The proposed method consists of communication layers and working process. The communication layer consists of DyRSen having three layers such as physical layer, virtual object layers, and dynamic objects layers. The functionalities of each layer and connecting components are represented in the physical, virtual and dynamic layers.

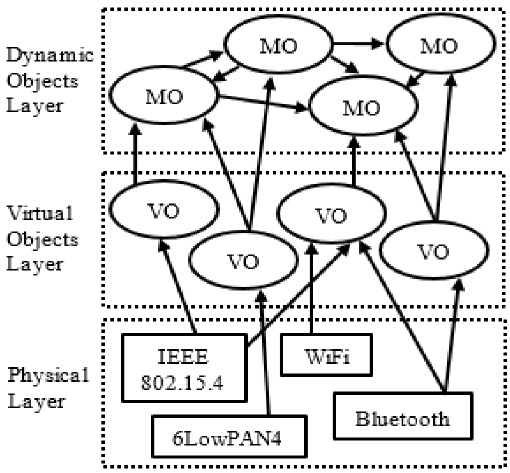

Figure 2. Layers and connectivity devices of dynamic environments

3.2.1. Physical layers

The Figure 2 shows the physical, virtual objects and dynamic objects layer and connectivity devices of dynamic environments. The physical composed three types of devices used for data acquire and control the devices. (a) sensors are the electromechanical or electronic devices which acquire surrounding moving objects data; (b) actuators used to control the moving nodes on the dynamic environments. In the Figure 2, things represent both set of sensing and actuating things. The some of the physical sensing and activating devices are Wi-Fi, IEEE 802.15.4, Bluetooth, car sensors, and other moving objects devices.

3.2.2. Virtual objects layers

The virtual object (VO) used to manage the moving objects from the one location to other locations of the moving in the physical IoT environments. The physical IoT system encapsulates the various physical system associated with its. The users, storage, virtual device and manager, transmission and receiving are also performed in the layer. The virtual objects are connected and make a service form one object layer to multiple object layers and transmit from one layer to multiple layers. The virtual device and managers combine the multiple object devices to coordination, transmission and receiving. The virtual object managers connected to the various service compositions to provide service to various virtual objects. The service composition and virtual objects combine the various functionalities and stored the collected data in the different places of dynamic environments such as road side unit, car storage units, smart phone in the IoT environments and other computing devices. Beyond this, the VO devices are connected to the various sensors in the car, and moving objects. All the computing and storage devices are interconnected each other, while static and dynamic environment of IoT.

The DyRSen two layers such as physical and virtualization have interconnected and it connected in the limited registered devices. The limited connected devices are added, remove and manage the moving objects in the surrounding dynamic IoT environments. The same device, connected more devices in the same location, then complexity of the next connecting device is increased. But in the DyRSen having included the object management system to resolve the multi-connectivity issues. The based the two moving objects speed, the devices are released from the same objects. Similarly, the multiple virtual objects are managed in the dynamic environments.

3.2.3. Dynamic objects layers

The top layer of the proposed system used to manage the moving objects and config the moving objects to dynamic virtual device to another virtual device or multi-virtual device. Using the dynamic objects layers, the virtualization of the moving objects is interconnected each other. This layers consists of location based, moving object configuration, operational, and fault management:

- Location based management: This is used to enable multiple virtual devices in the particular selected IoT environments. The selected dynamic road environments sense the various devices in the particular area using road side unit, Li-Fi and other physical devices. If the moving objects are changing the position in the dynamic environments, immediately sense the corresponding next objects in the multi-dynamic locations.
- Moving object configuration management: The configuration management select and config using various multiple parameters such as moving objects virtual type, location of the dynamic objects, speed, nearest next dynamic moving objects and ranges of dynamic objects. Using the DyRSen every second the dynamic objects are sensing based on the location and check the multiple parameters and based on each parameter its config the objects in the dynamic environments.
- Operational management: The operational management is used to manage the dynamic activities of the moving objects in the dynamic road network. Each activity of the moving objects is stored in the road side unit or nearest connecting point base stations.
- Fault management: The fault management is used to check the various activities in the continuous connectivity of devices. It checks the strength of the signal to connectivity, find the optimal route of the connectivity and correct the malfunctions of dynamic connectivity.

3.2.4. Working process of DyRSen

The working procedure of the proposed work is based on the moving objects in the dynamic environments. In the Figure 3 shown the various objects and representation of various nodes in the limitations. For example, in the Figure 3 contains the X and Y are the limitations of the network in the moving environments. In the limited network, the upcoming networks are not available to store and connect, it will search the availability of upcoming objects and perform the connectivity of the objects.

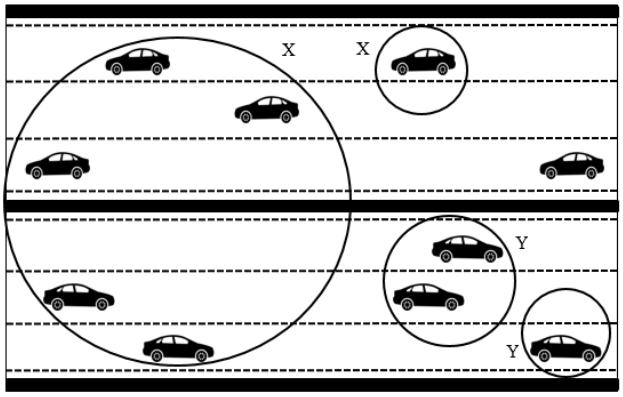

Figure 3. Transmission and limitations of various moving objects and nodes

Similarly, the Y network also search and finding the upcoming objects and make a continuous connectivity in the dynamic road network. The distance between the network and nodes measured using Euclidean Distance (C, S) as in (2),

$$\text{Euclidean Distance } (C, S) = \sqrt{\sum_{i=1}^{n}(S_i - C_i)^2} \quad (2)$$

where C and S are represents two points such as network and nodes in Euclidean n – space, S_i and C_i are Euclidean vectors, starting from the origin of the space (initial point), n is represents n – space.

The MDL concepts consists of $L(D/H)$ and $L(H)$ components. Here D denoted data and H denote Hypothetic. Based on the $L(H)$ and $L(D/H)$ partitions the network is formulated as $\{S_{1,\dots,}S_n\}$ and the nodes segment points are $\{S_{1,\dots,}S_n\}$. So, the parallel node segmentation and partitions is (3) and (4).

$$L(H) = \sum_{j=1}^{S-1} log_2(D(S_i, \dots . S_i + 1) \quad (3)$$

$$L(H) = \sum_{j=1}^{S-1} +\{log_2(S_i, \dots . S_i)\} + \{log_2(D(S_i, \dots . S_i + 1)\} \quad (4)$$

The $L(H)$ used to increase the nodes in the partitions continuously based on the availability of network. So, the optimal partitions and segmentations reduces $L(H) + L(D/H)$. The algorithm of DyRSen has shown the proposed work with various conditions of the moving nodes.

3.2.5. Algorithm of DyRSen

The overall processing of the proposed work is presented in Algorithm 1. The number of nodes, network segments and resource availability are taken into account for the simulation of the work in the proposed work. Initially, the sensors are checked and used for availability of resources with its distance which calculated using Euclidean distance. Based on the distance and searching the availability of the resources are incremented and the nearest node is selected for processing the continuous transmission in the dynamic road network.

Algorithm 1: DyRSen algorithm

```
Input: Number of Nodes, Network Segments, Available Resources
Output: Continuous Transmission
            Start
            Initialize the network;
            Initialize the nodes:
            Initialize the available resources
            If (Network Resources > 0) then
                   {
                   Do the transmission
                   }
            If ((Network Resources < 0) then
                  {
                   Search the Availability of resources;
                   Find the distances // Euclidean Distance
                   }
            Increase the distance of moving nodes:
```

```
            Min Distance (D) +1
If (Find the availability of network resources >0)
Then
Increment + 1;
Else
Search the continues nearest node;
End
```

The proposed work algorithm continuously searches the resources in the dynamic environments and continuously searches the upcoming nodes. If the nodes are available nearest, it performs the transmission and otherwise search the nearest upcoming node resources for transmission and availability of data.

4. IMPLEMENTATION

The simulation of the proposed work performed using OMNeT++. The simulation of the proposed work performed using OMNeT++. The basic simulation setup of the proposed work virtual objects setup in Table 2. The simulation analysis requirements server shown the growing network size because the size of the moving node counts to gateway count and it is in the increasing order.

Table 2. Experimental parameters

S. No	Parameters	IoT devices/values/ranges
1	Node counts	900–250 dynamic devices
2	Gateway nodes	3 to 5
3	Application layers	IoT application layers
4	Packet rate	200-1000 P/Sec
5	Protocols	TCP/IP and UDP
6	Environments	IEEE802.11
7	Areas size	10,000 m×1,000 m
8	Communication range	Min: 100 m–2,000 m, Max:100 m-10,000 m
9	Mobility type	Dynamic
10	Memory range	128 KB to 32 GB
11	Simulation time	50 Sec

As per the virtual objects and moving managements the IoT environments are created and virtualized using device management applications. The proposed work is simulated in the different environments based on the objects or gateway node transferring from one direction to another direction and multi-gateway node. The gateway nodes are: single gateway node, multiple gateway nodes and analysis of control overhead. The basic requirements of memory, connectivity and record registrations are change as per depends on structure and properties of the IoT environments. In the simulation environments setup, consider the different types of devices such as road side unit, camera, various sensors, basic memory of each device, and virtual objects properties. The basic memory capacity has been used for connecting and storing the devices between 128 KB to 32 GB. The memory capacities of devices are changing dynamically in the IoT and simulation environments. The testing and verifications of data, multiple simulations are performed. In each simulation the types of communication and corresponding types of distribution is created. Each communication, the memory requirements, usage and remaining memory space and required memory for further communications are recorded with the help of configuration managements. Based on the direction and objects movements, the types of gateway decided and managed.

4.1. Single gateway node

The moving objects are connected to different upcoming sources of network. The single gateway connected using 200 to 2,000 m connectivity range. The connectivity ranges are changing accordingly to the availability of upcoming moving objects or availability of connecting resources. The MAC layers or physical layer check the packet size and availability of type of resources. In the single gateway node, all the incoming packets and objects are managed using configuration management and location-based management. The performance of the single node measured using distance of the node, number of nodes, and average response time. The Figure 4 has shown the performance of connectivity and timing single gateway nodes connectivity. If the distance and node is increased, the response time also increased.

4.2. Multiple gateway nodes

The next, the experiments are conducted using multiple gateway node and connected to 4 upcoming devices. The source nodes are placed in the dynamic location and upcoming nodes also placed in the dynamic locations. The experimental performed using 30 devices and the networking size from 60 to 150 nodes. The performance calculated using distance and node parameters. The response time and network response have been illustrated in Figure 5. In the Figure 5(a) the number of the node increased, the average response time also increased because the searching and connecting of multiple devices take more time to check the exact connecting node. Similarly, the number of the nodes are less, the response time also less, because the connecting time and seeking time of devices are less. The discussion can be made in several sub-sections.

4.3. Control overhead analysis

The overhead issues are raised due to central grouping of various nodes in the dynamic road network. The experiment conducted various times using several sets of parameters, mentioned in the Table 2. The experiment monitoring using different parameters such as dynamic network size, data transfer rate, number of nodes, and availability of upcoming resources. The proposed model sometime raised the centralized connectivity, if the upcoming node is not available. If the dynamic registration of IoT devices, maintained in the long time in a particular device, automatically overhead issues will raise.

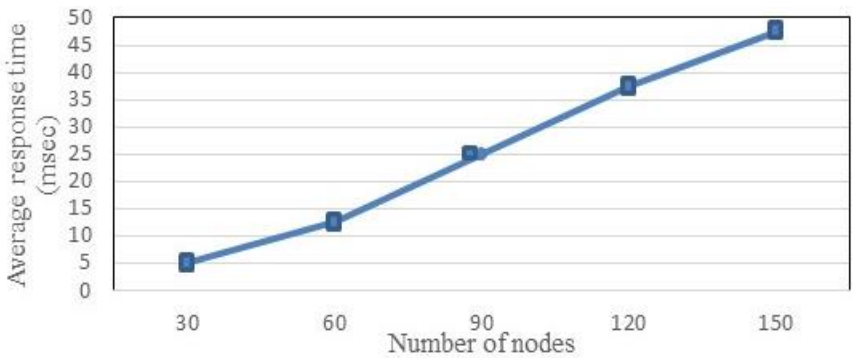

Figure 4. Response time of IoT network nodes in dynamic network for single gateway nodes

If IoT device registration changes dynamically from one node to another node, automatically network overhead reduced. The network overhead flow represented for various devices shown in the Figure 5(b). The network size increased automatically control overhead issues also increased simultaneously, because the managing of devices and selecting the exact node take more time.

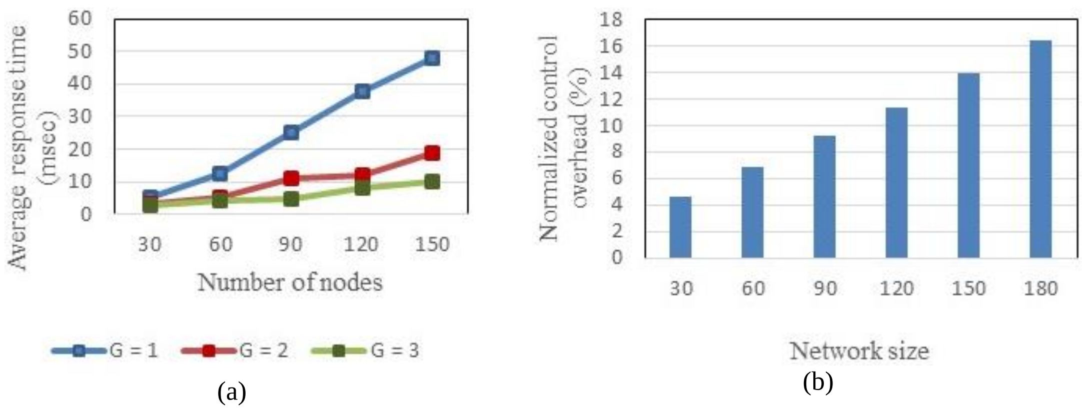

Figure 5. Analysis of response and control of dynamic network to (a) response time of IoT network nodes in dynamic network for multiple gateway nodes and (b) network overhead in dynamic nodes

5. CONCLUSION

One of the important and very challenging aspects of effective usage of resources in dynamic environments is their optimal use. The efficient use of resources in static and dynamic environments has been performed in the subject of numerous research. However, the dynamic environments have still different issues and have to solve different dynamic networking issues. In this work, present mechanism for managing different connecting devices in the dynamic environments. Especially this system is concentrating on road network device management in dynamic environments. The proposed system called DyRSen connectivity support to different continuous connectivity. The DyRSen providing: i) continuous connectivity using available resources and provide virtual environment for computing, ii) temporary data storage in dynamic environment, and iii) reduce the energy utilization. Response time and connectivity were improved as a result of effective resource management.

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BIOGRAPHIES OF AUTHORS

Padmanabhan P is working as an assistant professor in the school of computing science and engineering, Galgotias University, Greater Noida, UP, NCR-Delhi, India. He has completed his B.Sc., M.Sc. and M.Tech. degree from reputed institutions. His research areas and interests are resource management in WSN, internet of things, machine learning, artificial intelligence, big data, cloud technologies and blockchain. He can be contacted at email: padmanabhan5312@gmail.com.

Sampath Kumar K is working as a professor and Ph.D. coordinator in the school of computing science and engineering, Galgotias University, Greater Noida, UP, NCR-Delhi, India. He has completed his Ph.D. in big data mining from Anna University, Chennai and obtained his M.E. from Sathyabama University, Chennai. He has more than 21 years of experience in the field of teaching. He has published more than 60 research articles in the international journals and conferences also published more than 13 patents. He is expertise in big data, cloud, IoT and artificial intelligence. He can be contacted at email: ksampathkumara@gmail.com.

John A is working as an associate professor in the school of computing science and engineering, Galgotias University, Greater Noida, India. He received his Ph.D. in computer science and engineering from Manonmaniam Sundaranar University, Tirunelveli, India and master's degree in computer science and engineering from Pondicherry University, Puducherry, India. Bachelor's degree in computer science, from Puducherry, India. He has presented and published papers in various National and International Conferences and Journals. His fields of interest are data analysis and prediction, spatial and temporal data, machine learning, resource management in WSN and society technology interface. He can be contacted at email: johnmtech@gmail.com.