Improving the Performance of Wireless Sensor Networks over Congestions and Transmission Errors by Cluster Based Filtering

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Abstract-Wireless sensor networks (WSNs) are becoming increasingly popular with the advent of the Internet of things (IoT). Various real-world applications of WSNs such as in smart grids, smart farming and smart health would require a potential deployment of thousands or maybe hundreds of thousands of sensor nodes/actuators. To ensure proper working order and network efficiency of such a network of sensor nodes, an effective WSN management system has to be integrated. This difficulty in management increases as the WSN becomes larger. Software Defined Networking (SDN) provides a promising solution in flexible management WSNs by allowing the separation of the control logic from the sensor nodes/actuators. The advantage with this SDN-based management in WSNs is that it enables centralized control of the entire WSN making it simpler to deploy network-wide management protocols and applications on demand. This paper highlights some of the recent work on traditional WSN management in brief and reviews SDN-based management techniques for WSNs in greater detail while drawing attention to the advantages that SDN brings to traditional WSN management.This paper also investigates open research challenges in coming up with mechanisms for flexible and easier SDN-based WSN configuration and management. The methodology of the proposed work can be explained as follows: first: distributing nodes randomly; second: Applying the K-mean cluster to choose to select the optimum position of the head cluster node; third: connecting the network using LEACH protocol. Moreover. In this work, SDN with a Gaussian filter is proposed to control the network and minimize data error. It is possible to achieve that by adding buffer memory for each node to store data. The data transmission process is controlled by SDN, and a Gaussian filter is applied before transmitting data to minimize error data.

Keywords: Software Defined Networking, -Wireless sensor networks, LEACH protocol

1. Introduction

It is estimated that by 2030, the number of connected devices in cellular networks will reach 100 billion [16]. Furthermore, the majority of network occupancy is due to the demand for high-definition video data, which leads to massive data traffic [17], [18]. Hence, many existing algorithms cannot process traffic flows, resulting in a loss of information. Moreover, algorithms are incapable of offering optimum system performance when the network environment is dynamic and random. Therefore, these algorithms are unable to meet the requirements of the 6G cellular networks. To overcome these problems and achieve better performance, researchers have developed optimization methods to attain effective solutions to get closer to optimal and suboptimal performance. However, many studies presume a static network environment rather than considering the random nature of networks [2], [1]. Additionally, traditional centralized algorithms for network management and simultaneous collection of global data are affected as the number of connected devices increases [3]. Consequently, one viable solution is to use KDN to automatically optimize, diagnose, and troubleshoot the network [4]. To enable KDN, a centralized controller with ML capabilities must collect information from the network to create knowledge via an appropriate ML algorithm. The centralized controller for collecting telemetry data must have SDN functionalities.

Software-defined networking (SDN) is a new networking paradigm for decoupling data and control planes [12]. Decoupling these two planes enables SDN to operate as a centralized controller to manage the network. The global view of the SDN controller provides advantages such as network flexibility, programmability, and efficient management over the traditional network. In the conventional network architecture, network administrators are required to manually configure and troubleshoot switches and routers within their organization [13]. From Fig. 4, the difference between traditional network architecture and SDN can be seen. SDN provides network programmability within the control plane, whereas traditional networks do not offer any flexibility. Traditional networks rely only on the physical infrastructure to create connections and run the network. On the other hand, SDN enables users to use software programs instead of physical infrastructure to provision new devices [14].

In addition to network softwarization, adequate data collection is required in KDN to make appropriate and accurate decisions. With the new advancements in data plane elements, routers and switches are capable of computation and storage, which makes the network monitoring and network telemetry accessible [15]. Network telemetry provides flow information, real-time packet information, and other critical packet-level data, as well as network state monitoring and organization with centralized network analytics. Hence, network telemetry and network analytics present a richer view of network performance metrics, providing an extra advantage over conventional network management techniques. The incorporation of SDN and network analytics provides essential elements required by the KP. However, the last piece of the puzzle to make the KDN fully functional is to integrate ML. ML uses network telemetry and historical data to process and find valuable information about the network, where this information is stored as knowledge to improve network performance.

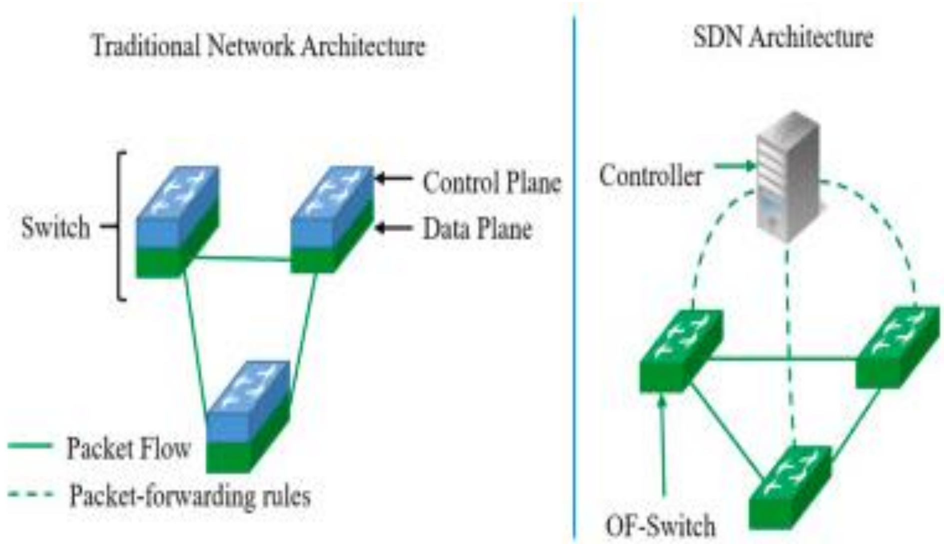

Fig 1: SDN Architecture

As part of the management of a large-scale WSN, mechanisms need to be employed to allow for maintainability and system self-healing. The system should be able to change parameters based on the conditions for example reducing service quality when the energy resource becomes scarce [5]. This is a challenge with the current configuration of WSNs where the control packets and data packets are all routed through an already constrained network band. Developing a network management system for such a distributed WSN especially on a large-scale is a demanding task and is usually considered as a second phase in project planning.

The above problems are inherent to WSNs simply because each node is made to have all the functionalities from the physical layer to the application layer behaving like an autonomous system that performs both the data forwarding and network control [11]. Much as this works well especially with small-scale short range WSNs due to well-developed algorithms,it lacks simplicity and flexibility making it hard to manage when trying to implement a long range and low power WSN at a large-scale.

Management of WSN should allow for definition of a set of functions that promote productivity and integration in an organized manner of the configuration, maintenance, operation and administration of the components and services of the WSN [1]. Several management methods have been proposed to manage functionality in the architecture of WSNs [3]. These methods take into account WSN metrics such as energy consumption, system lifespan, data latency, system tolerance to faults, accuracy in data acquisition or the Quality of Service and security.

WSN management should be simple and adhere to network dynamic behaviour, as well as provide efficiency in use of resources as proposed by Ruiz et al. in the MANNA (A management architecture for wireless sensor networks) architecture. The MANNA architecture considers management policies for WSN services, functions and models by looking at management of WSNs in three dimensions defining functionality abstractions:

WSN functionalities which include maintenance, configuration, sensor node operation (Sensing, processing, communication). Management levels which include application services and management of network elements (node clusters, data aggregation, network connectivity).. Management of functional areas such as security, fault monitoring, performance and configuration. Although there exist centralized algorithms and techniques for optimization that can achieve the objectives of various performance criteria, the lack of global network knowledge and intelligence has been recognized by researchers . For instance, the baseline technique to achieve load balancing and backhaul management in requires complete information about the traffic load and content popularity of users before execution of cache content, which is challenging to acquire precise information in advance. Therefore, we suggest prior knowledge for decision-making. Moreover, using a TL algorithm, the past experience in cache content can be utilized by BSs to guide cache management even without knowing any information about the current traffic information. In data aggregation problems, supervised learning approaches can differentiate between data communication after a thorough training procedure. On the other hand, having knowledge about the network and the information that is being transmitted or received can help improve network performance and add intelligence. Furthermore, in BS sleep-mode control problems, complete information of the network environment is required in advance, which is difficult to obtain. The authors of [8] used TL to adapt past information about BS switching to guide the current decision making for BS switching even without the knowledge of traffic loads in the network. In handover management, one solution is to use a fuzzy logic controller with a set of predefined rules, and each state of the system determines a specific action. However, the setting of each action mainly relies on the knowledge and information about the network environment, which might be unknown for the new state of the communication system. Overall, the main reason for adapting ML algorithms is to acquire knowledge from any particular system for optimization, self-organization, and self-healing. The majority of the papers surveyed in this study can be used as a prior processing technique to build a knowledge plane and provide intelligence for networks.

2. Related Survey

Many researchers work to enhance the performance of wirless sensor network, in this paper introduce some of researcher in WSN, Amit Dvir et al, 2019, introduces a new strategy for addressing the problem of controller placement, which provides protection to potential link failure, latency and transparency regarding a wireless southbound interfacing. The modeled the problem the wireless controllers placement in SDN. Zifu Fan et al, 2019 introduces the problem related to Software-defined networking controller placing such as delay and the number of control path rerouting occurring among the switches and the controllers and in every condition of link failure, and formulated that as a problem of multi-criteria optimization. The results have shown the proposed algorithm's effectiveness and the strategy proposed are capable of ensuring the control layer's delay and reliability in most cases of link failures. Biao Han et al, 2019, presented Multi-controller Based Software-Defined Networking for reducing the average time to respond with an event of the switches.

Shirin Tahmasebi et al, 2020, proposed the algorithm of Cuckoo Controllers Placement. This algorithm functions on the basis of Cuckoo optimization algorithm that is a (MhAs), taking inspiration from the life style of a family of birds called cuckoo. This algorithm aims at finding a globally optimal solution through the simulation process to cuckoo birds' brood parasite. For evaluating this algorithm's performance, A comparison is made between the proposed approach and two modern methods, (1) quantitative softening (QA) (2) simulated annealing (SA).

The integration of the KP in SDN is a new concept called knowledge-defined networking (KDN). The concept of KP is to add one more plane to the traditional two planes of SDN. This new paradigm incorporates SDN, data analytics, and ML. The KDN paradigm has several advantages: first, it has a global view of the network, and second, it enables telemetry data to be collected by the management plane to transform the data into knowledge via ML. The knowledge will later turn into decisions by nodes to achieve efficient network operations [10], [11]. The benefit of having the KDN over traditional networks is that it automatically operates based on the knowledge obtained from the network. Fig 2 illustrates the KDN architecture, including the data plane, control plane, management plane, and KP.

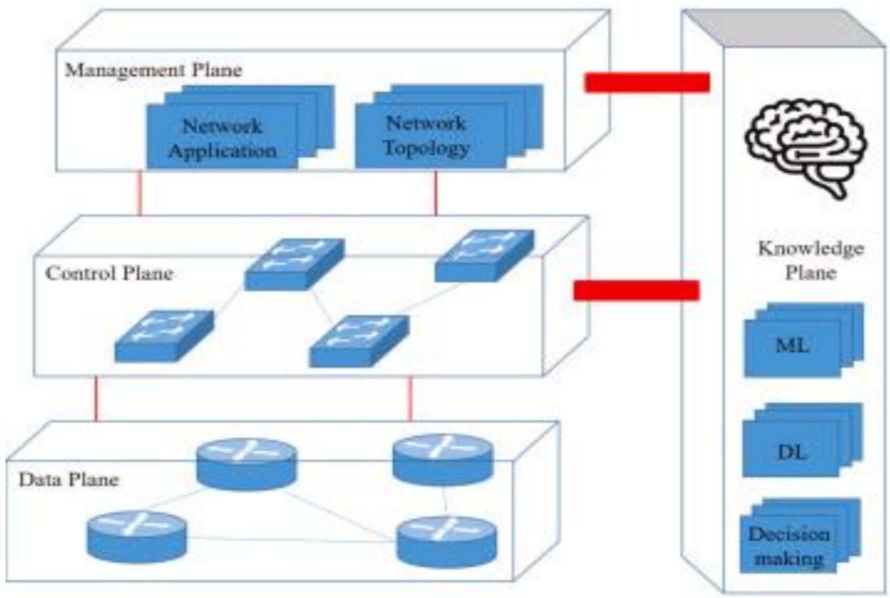

Fig 2: KDN Process

The development of the SDN paradigm in 2008 and the separation of the control and data planes from the individual network devices solved many previous problems in traditional networks. Furthermore, the programmability functionality of SDN in network simplified network management and enabled innovation [14]. The SDN controller interacts between the switches via the OF protocol API, where OF switches contain flow tables, including rules for handling packets with specific actions [5]. With the arrival of OF, the term SDN was born and used by the research community as early as 2009 [6]. However, it did not have much impact on networking vendors until 2011, when OF eliminated the configuration complexity and automated network management. The development of OF started in 2011, and the latest version was released in 2016. The summary of each version is as follows.

The first OF version was released in March of 2008. However, it was not until December 2009 that OF Version 1.0 reshaped large enterprises and service provider networks.

Version 1.1 enables innovation by adding multiple flow tables and multiprotocol label switching (MPLS), including modifying packets, complex forwarding actions, and updating an action. This version was introduced in February 2011.

In December 2011, Version 1.2 added flexibility by authorizing communication between a switch and multiple controllers and supporting IPv6 for the matching process.

In June 2012, OF Version 1.3 was released, which addressed backbone bridging, per-flow traffic meters, and tunneling.
Version 1.4 appeared in August 2013 and offered more accessible ways to add new features to the protocol, including type-length-value (TLV) formatting to match fields, role status events, flow monitoring, etc.

OF Version 1.5 was released in December 2014, enabled fast synchronization among multiple switches and processing and matching ingress packets by adding an egress table. Finally, the latest version of OF Version 1.6 was approved, but it was only available to the open network foundation (ONF) group.

Overlay networking was the first deployment of the SDN concept and has been used in data centers before the popularity of the SDN paradigm. In the overlay network architecture, a network layer is added above the basic transport layer (physical layer). Overlay networks use virtual links to create a virtual network on top of an underlying physical platform. A virtual connection between the two nodes at the end of the network is created using tags/labels to create a virtual tunnel (overlay link) from one end to another. The network is programmed to manage the tunnels between the network switches and hypervisors (an intermediate layer between the SDN controller and the associated virtual SDN network). Nodes in overlay networks act based on an overlay topology, which consists of certain behaviors: cooperative or selfish. In cooperative mode, each node creates an overlay link to allow other nodes to route their traffic through different nodes. In the selfish mode, nodes create overlay links to make connections in the network to maximize their benefit. Overlay networks aim to improve QoS by optimum routing decisions. Overlay networks can be deployed by overlay protocol software without the involvement of Internet service providers (ISPs). However, there are some drawbacks to this technique, such as increasing latency, slow-spreading data, and duplicate packets. Moreover, the overlay has no control over routing packets; it only knows the message trajectory before it reaches its destination.
Wireless sensor networks are able to integrate various sensing capabilities thus providing support for various real-world applications. This flexibility is accompanied by several research challenges in providing effective management for the application considering the resource constrained nature of WSNs. The various benefits that SDN introduces to these management challenges allows it to be utilized in several applications such as in environmental applications, health care, military and in home networks. We shall briefly discuss these application scenarios and bring to light the benefits of SDN-based management in these areas.

3. Filtering with SDN

3.1 Management of WSNs Based on SDN

WSNs are composed of a network of sensors that are deployed to measure parameters such as temperature, pressure and air quality. The sensor network may exist as hundreds or even thousands of resource constrained nodes. Also taking into account the inherent challenges of WSNs in terms of energy requirement which is directly linked to network lifetime, the application specific nature with vertical integration [17] where manufacturers and vendors control the end products of the devices as well as the software and hardware of their infrastructure . Another challenge introduced as the nodes are deployed in the field is the management of the network topology [7] where we have to consider the coverage of the network and Quality of Service in an environment with varying conditions at a limited energy supply. Integration of SDN in WSN has been proposed [14] to mitigate these challenges. Integration of SDN would require consideration of how the network will be managed to ensure efficient performance and resource allocation. The WSN architecture based on SDN can be divided into managerial entities similar to the management functionality abstractions as mentioned by Ruiz et al. Fig 3 shows this architecture adapted with a further focus on the management entities we will consider in our review and evaluation of SDN-based management for WSNs. The architecture shown depicts an SDN-based WSN with a centralized controller thus providing a global view of the entire network resulting in efficient management. Management of the network topology, energy, configuration, QoS and security are done centrally in the control plane while management of enabling technologies can be implemented at all levels of the architecture. In the data plane enabling hardware such as SDN-enabled sensor nodes with multiple sensing capabilities and hardware capabilities can be installed while programming of the nodes for various applications can be done and managed centrally in the control plane.

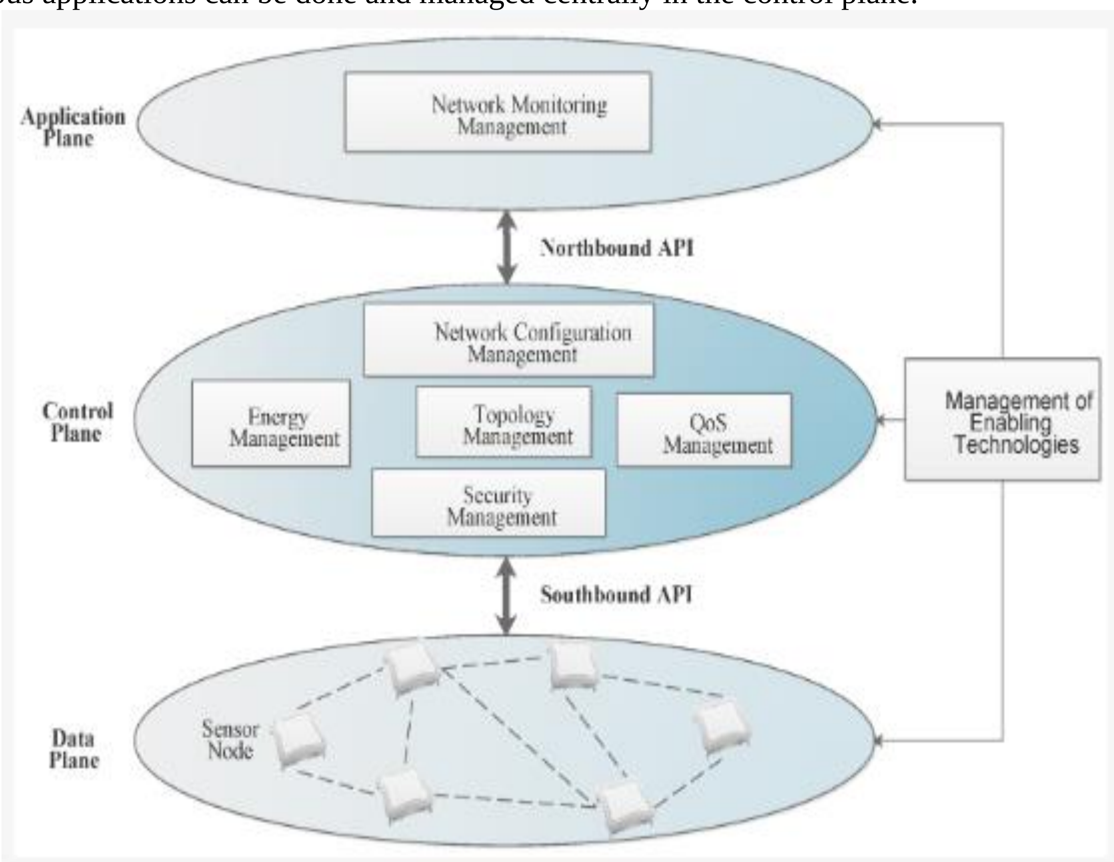

Fig 3: SDN-based wireless sensor network management architecture

A hierarchical architecture called Software Defined Clustered Sensor Networks (SDCSN) has been proposed to use multiple base stations as controllers that also play the role of cluster heads. A large-scale group of nodes is divided into clusters and there is a cluster head for each. The cluster head controls and coordinates the sensor nodes in each cluster and all the information processed in each cluster is routed to the cluster head. Management of such an architecture requires enabling the sensor nodes to function as controllers effectively enabling multiple controllers in the network. Oliveira et al. design and implement an architecture based on multiple controllers within a WSN in a framework called TinySDN based on Tiny-OS with a design structure that consists of SDN-enabled sensor nodes and an SDN controller node. This addresses issues such as in-band control, higher communication latency, and limited energy supply. The downside to this management approach is that the cluster head can also become vulnerable to attack posing a network security risk however self-stabilisation techniques for re-selecting a new cluster head upon such an event have been proposed. To manage the network with more flexibility for integration of various functions an architecture based on network virtualisation has been proposed. Basically, a virtual overlay topology can be built to certain specifications based on an actual physical WSN based on SDN.

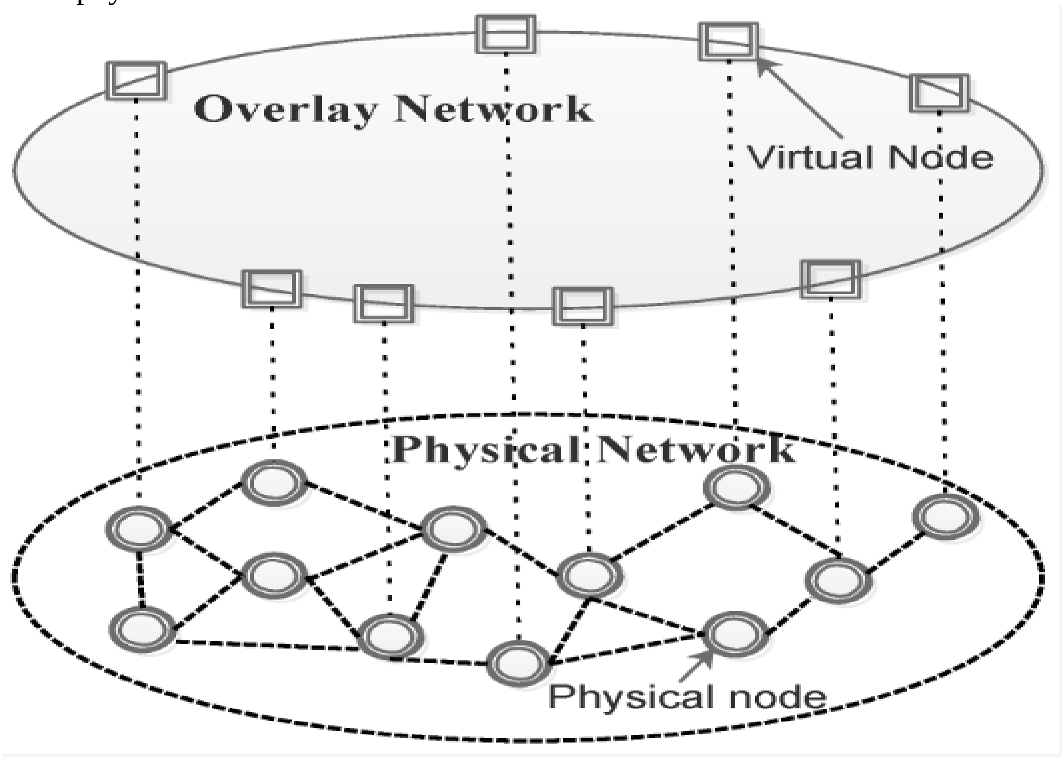

Fig 4: Topology based on virtual overlay

Sensor nodes in an SDN-based WSN are susceptible to movement and this can cause variation in packet transmission and execution of tasks making it necessary to monitor and manage the movement of nodes in the network. The challenges to consider when integrating a mobility management scheme includes handling the effect of nodes entering the network and the nodes leaving the network on QoS, execution of functions and other network attributes. A few solutions and processing steps that the SDN controller can provide to prevent problems associated with nodes entering and leaving the WSN have been outlined by Zhou et al.

3.2 Kalman Filter

The Kalman filter was published in 1960 by R.E. Kalman, it is one of the most important estimating techniques for linear states with Gaussian distributions, and it provides estimates of states in the past, present, and future time domains. (Muhammad Ehatisham-ul-Haq, 2018, Pan, Ming, and Eric F. Wood, 2006). To compute the accurate guess position of an object by comparing the present state with the prior state of an object, the Kalman filter relies on guessing repeating prediction and correction cycle, and it is dependent on the history of guessing (Evensen, Geir, 2009). Kalman filter algorithm is simply mathematical model based on the recursive procedures. Eq (1) and (2) show the mathematical expression for this ‘time update step (2). The future state is represented in these equations.

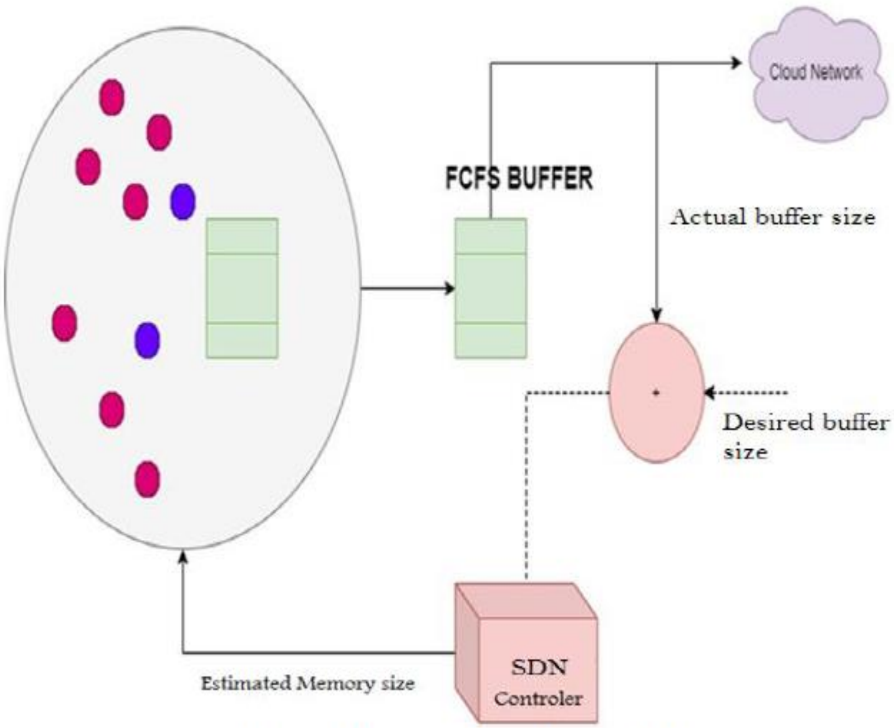

Fig 5:Working of Kalmn Filter

3.3 Gaussian filter

Gaussian filter is included in filter with linear type, which uses Gaussian function to determine the weight value of each group. Gaussian filter is commonly utilized to smooth, blur and eliminate noise in the signal. The filter's mechanism is to move the filter mask center from one point to another. In each pixel (x, y), the filter's result at that point is the multiplication sum of the filters' coefficients and the corresponding neighboring filter mask range. In contrast, it is defined as a process to get values depending upon their values, adjacent pixels, and kernel matrices, as represented in equation 1.

The model proposed (SDN with Kalman filter) is optimized using congestion controller, the methodology of proposed work, the first step random distributed of random node, the apply the Kmean cluster of select the head cluster node in, the connected the network based on LEACH protocol. in this work proposed SDN with Kalman filter for control on network and reduce error of data, where achieve by add buffer memory for each nodes and head cluster to store the data, and SDN control on transmit ion data and receiver data, before transmit apply the Kalman filter on data to reduce error data. The proposed technique, according to simulation findings, extends the network's lifetime by over 30% more than typical WSNs, the reduce the average density of memory to 20% than traditional WSN, and the increase the average capacity of memory to 20% than traditional WSN

4. Discussions

In this paper propose intelligent SDN control with Kalman filter using MATLAB® R2018b to simulation, in this work, scenarios are considered with N randomly placed sensors in sensing area of square shape, the Leach protocol connects the WSN network and organizes the networks into clusters. It separates the sensor nodes into clusters and delivers fusion cluster data to a cluster head, which is a representative node for one region. In the start of every scheduling period, sensor generates traffic, in other word, sensor(s) conducts low-flow to high- flow, after that, the traffic is directed to Forwarding Cluster Head. The controller of SDN reduces the level of congestion. However, Forwarding Cluster Heads can be categorized as congestion, when this ratio goes beyond the level of threshold where the Buffer size of CH equal by (250 packet), Buffer size of each node equal 50 packet, Initial energy E equal 0.5 J.

When nodes are distributed, the K-mean cluster is applied to choose the optimum position of FCH, which will get all the nodes (100) to enter into k- mean cluster and cluster it into four groups, where each group belongs to the subset of nodes. The center point represents an HC position. When nodes are distributed, the node and the CH are determined, then the CH is connected with the node, the model is the LEACH protocol as illustrated in Figure 3. This figure shows the effect on the k - mean to determine HC, where there are the 4HCs, are in position (67,19),(20,19),(15,68), (72,75) in order The Intelligent the SDN controller to WSN, When WSN model is prepared.

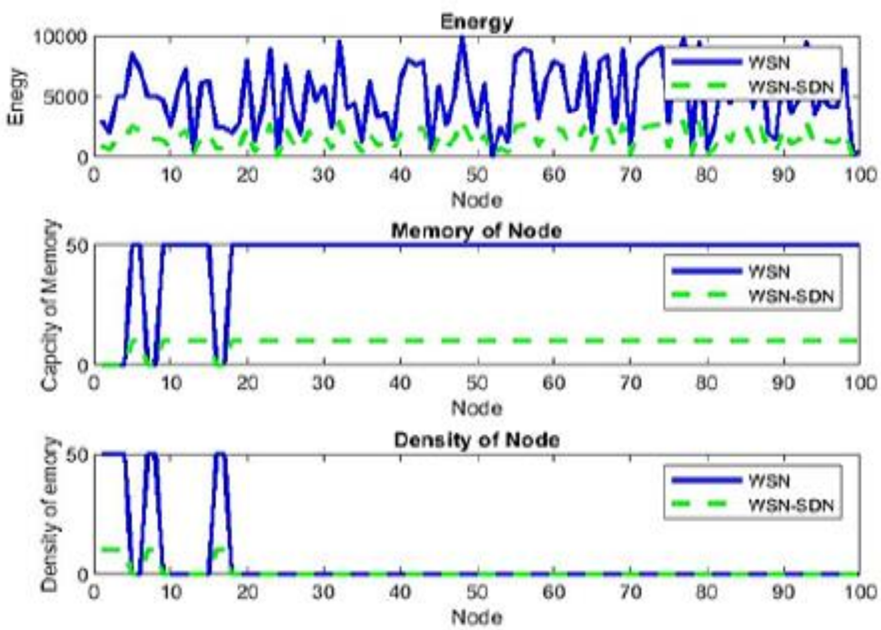

Fig 6: Qos the SDN-WSN and WSN form Energy, Memory of node, density

5. Conclusion

This paper reviewed the various contributions to managing WSNs and techniques available for SDN-based management of WSNs. The SDN paradigm has introduced flexibility and simplicity in managing wireless sensor networks, despite having different vendor specific hardware in the network. A highlight of the main real-world WSN applications and how SDN would improve the management of the applications was presented. However, the inherent properties of WSNs do not permit the easy integration of SDN as it was initially meant for traditional wired/wireless address-centric networks which are different from the data-centric WSNs. This paper also focused on the generic architecture of SDN-based WSNs and reviewed the management schemes available to ensure efficient functionality of the network. A review of the management classifications, namely management of the network configuration, topology, QoS, energy, security, network monitoring and enabling technologies with a further focus on SDN-enabled node hardware and software, was made. Furthermore, an attempt to define the overall management of WSNs based on SDN as abstractions of the north, south, east-west bound architecture of SDN had been presented. A discussion and summary was presented for the various proposals and work done necessary for management of WSNs based on SDN. We observed the Qos SDN-WSN network get result best than where increase the residual energy to 35 % when compere with traditional WSN, and the reduce the average density of memory to 25%, and the increase the average capacity of memory to 20%. The proposed strategy, when applied to a random distribution, extends the network's lifetime by about 30% more rounds than regular WSN.

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