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To Enhance the Performance of the WSN Using Software Defined Network and Gaussian Filter

S. LIGI[1], P.RENUKA[2] ,E.RAJESWARI[3]

[1]*Assistant Professor, Department of Electronics & Communication Engineering, Annai Vailankanni College of Engineering,Kanyakumari.*
ligi-ec@avce.edu.in

[2] *Assistant Professor, Department of Electronics & Communication Engineering, Annai Vailankanni College of Engineering,Kanyakumari.*
renuka-ec@avce.edu.in

[3]*Assistant Professor, Department of Electronics & Communication Engineering, Annai Vailankanni College of Engineering,Kanyakumari.*
rajeswari-ec@avce.edu.in

ABSTRACT

In this paper, we analyze the effectiveness of Software Defined Network (SDN) control in Wireless Sensor Networks (WSN) to estimate packet flow, utilizing a Gaussian filter to filter the transmitted signal. A Wireless Sensor Network is a wireless network consisting of independent sensors that communicate with each other in a distributed fashion to monitor the environment. Sensors are typically attached to microcontrollers and powered by batteries. The goal of a Wireless Sensor Network is to achieve a long lifetime and high reliability with maximum coverage. The practical aim of this method is to predict the next step of packet flow in advance, helping to reduce congestion if it occurs. The proposed method (SDN-WSN with Gaussian filter) enhances signal transmission, thereby reducing data errors and network congestion, which further minimizes data overflow. In the proposed method, nodes are first distributed randomly, then K-means clustering is applied to select the optimal position of the head cluster node, and finally, the network is connected using the LEACH protocol. Routing techniques are crucial for networks with limited resources. LEACH is one of the first hierarchical routing approaches for sensor networks. The Wireless Sensor Network (WSN) plays an important role in the Cell-LEACH based approach, where WSN refers to Wireless Sensor Network. In such a network, which has a large number of nodes and sensors, Software Defined Network with a Gaussian filter is proposed to control the network and minimize data errors. This is achieved by adding buffer memory to each node to store data. The data transmission process is controlled by SDN, and a Gaussian filter is applied before transmitting data to minimize errors.

Keywords: Wireless Sensor Network, Network Lifetime, LEACH, Cell-LEACH.

INTRODUCTION

WSN is a network composed of numerous sensor nodes, which are highly deployed in specific areas. The base station determines the data sensed and sends it to the committed nodes, which

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gather sensor node data and forward it to end-users. WSN requires network protocols for data transmission, and routing protocols are used to manage data paths. Various routing protocols, such as LEACH (Low-Energy Adaptive Clustering Hierarchy), PEGASIS (Power-Efficient Gathering in Sensor Information Systems), TBS (Tree-Based Clustering), and GSTEB (General Self-Organization Tree-Based Energy-Balance), are employed in WSNs. WSNs typically face challenges related to storage capacity, battery utilization, and resource limitations.

Currently, WSNs are used in real-time applications including intrusion detection, military tracking, domain monitoring, earthquake motion observation, health practice monitoring, and traffic analysis. The network comprises three types of sensor nodes: (i) Sensor Subsystem: includes numerous sensors for environmental parameter sensing such as humidity, temperature, and sound; (ii) Processing Subsystem: includes microcontrollers for local data computation and internal memory data storage; (iii) Communication Subsystem: responsible for transmitting sensed data to sink nodes. Figure 1 illustrates the internal structure of a sensor node.

WIRELESS SENSOR NETWORK (WSN)

This paper briefly explains the main concepts of WSN, including network structure, standards, research challenges, and applications. A Wireless Sensor Network consists of tiny sensor nodes that monitor physical or environmental conditions such as temperature, pressure, sound, and humidity. The network must have self-configuration capabilities since the positions of individual sensor nodes are not predetermined. Routing strategies and security issues are significant research challenges in WSNs; however, this paper emphasizes routing protocols. Several routing protocols have been proposed for WSNs, with hierarchical protocols like LEACH being among the most well-known. Table 1 illustrates some commonly used systems or technologies developed for critical applications.

Table 1: Application of WSN

Application	Condition	Parameters	Technologies
Infrastructure	Surveillance, Control, and Maintenance	Temperature, Motion, Vibration, Strain, Stress, Air-Flow	Camera Systems, Sensor Node, VIBCODE Transducer, etc.
Transportation	Asset Tracking, Presence, Logistics	Radio Frequency, Accelerometer, etc.	Trackers, RFIe, Smart Logistics, etc.
Water Quality	Observation and Control	pH, Iron, Nutrients, Color	Libelium Smart Water, etc.

SOFTWARE-DEFINED NETWORKING (SDN)

Software-defined networking (SDN) is a new network structural design technique that addresses the deficiencies of traditional network designs. It separates the data plane (DP) and control plane (CP) of the network, allowing the controller to configure forwarding elements (FEs) using precise forwarding processes for data packets of different flows. The controller gathers sample information to perform its tasks, so control protocols are distributed and not

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required among FEs. Moreover, the controller can interact with applications to enhance the performance of the wireless sensor network. Table 2 compares SDN networks to traditional networks.

Table 2: SDN Network versus Traditional Network

Potential	**SDN**	**Traditional (Non-SDN) Network**
Operating Features	Separation of control and data forwarding planes. Easily controlled and deployed.	Hard-structured and logically coupled operations. Very complex control.
Configuration	Configuration can be largely done remotely. Software monitoring and operations are centralized.	Network devices need to be configured directly and individually.
Management	Easily managed using APIs. Can be modified based on network demand.	Difficult to manage as network devices are proprietary and hard to access.
Maintenance	Easily maintained. New services or network upgrades can be implemented without affecting the whole network.	Difficult to maintain. Small changes in the network may affect the entire system.

GAUSSIAN FILTER

The Gaussian filter is a linear type filter used to smooth, blur, and eliminate noise in signals, thereby enhancing the performance of wireless sensor networks. The Gaussian function determines the weight value of each group. The filter mechanism involves moving the filter mask center from one point to another. At each pixel (x, y), the filter result is the sum of the products of the filter's coefficients and the corresponding neighboring filter mask range. This process is defined as obtaining values based on their values, adjacent pixels, and kernel matrices, as represented in equation 1.

$$G(x) = \frac{1}{\sqrt{2\pi\sigma}} exp\left(\frac{-x^2}{2\sigma^2}\right) \text{ ------ } (1)$$

THE PROPOSED MODEL

In this system, controllers are suggested using the SDN platform. The function of the controllers is to manage the data flow in the physical area. Within the sensing zone, the SDN controllers can select Cluster Heads (CH) and Cluster Members (CMs). Results demonstrate that this approach improves service quality. The proposed model computes the data rate of data flow and coordinates buffer capacity with a set of active sensor nodes in the network to prevent buffer overflow. The proposed system is composed of three layers:

- **Layer 1:** Composed of various types of WSN devices.
- **Layer 2:** Composed of several edge servers deployed in WSN devices and SDN controllers.

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- **Layer 3:** The cloud data center (DC), which is assumed to have substantial resources.

SDN is employed in WSN to verify node activation in real-time to meet application requirements. The controller, considered the brain of the SDN control layer, manages the data flow effectively. This work proposes an SDN controller with a Gaussian filter to manage the WSN, enhancing both data management and overall performance.

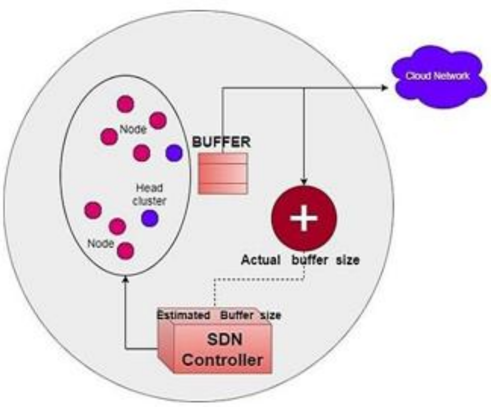

Figure 1: Proposed model

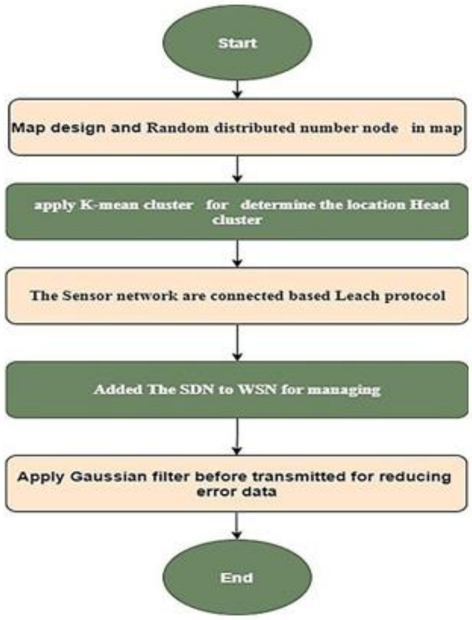

Figure 2: THE FLOWCHART

RESULT

This paper proposes an intelligent Software Defined Network (SDN) control with a Gaussian filter, simulated using MATLAB. The network is based on five key assumptions:

1. **Stationary Nodes:** All sensing nodes create a stationary flow per unit of time.
2. **Activities:** There are two activities in sensing: the first activity generates traffic flow, and the second involves forwarding the traffic by the Forwarding Cluster Head (CH).
3. **Connectivity:** The connections between the Forwarding Cluster Head, cloud, and member nodes utilize single-hop wireless links with an OpenFlow software-defined network switch.
4. **Authentication:** Sensing nodes authenticate their mode based on density and CH buffering capacity.
5. **Flow Proportion:** The flow quantity transmitted by sensing nodes must be proportional to the network channel capacity.

The work integrates the Gaussian filter with SDN to manage data transmission and reception among nodes and CHs, or between CHs and routers. This approach aims to minimize overflow,

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reduce memory usage, and extend the sensor network's lifetime, thereby enhancing WSN effectiveness as shown in Figure 4.

Figure 4 presents two scenarios:

- Applying a Gaussian filter in a Wireless Sensor Network (WSN).
- Using WSN with a Gaussian filter.

It was observed that the Gaussian filter reduces data errors by approximately 5% compared to traditional methods. Additionally, when comparing WSN with and without SDN in terms of memory capacity, memory density, and node energy, as illustrated in **Figure 5**, the following results were noted:

- The QoS of the SDN-WSN network extends the network lifetime by nearly 30% more rounds than traditional WSN.
- It reduces the average memory density by 20% compared to traditional WSN.
- It increases the average memory capacity by 20% compared to traditional WSN.

Table 3 summarizes the benefits of SD-WSN over traditional WSN technologies. In traditional WSNs, sensor nodes have various structures, including normal nodes, routers, and coordinators, with application types matching function types. In contrast, SD-WSN nodes exhibit minimal structural differences.

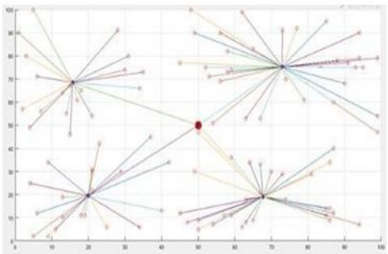

Figure 3: Show the connection of node and CH based on Leach protocol

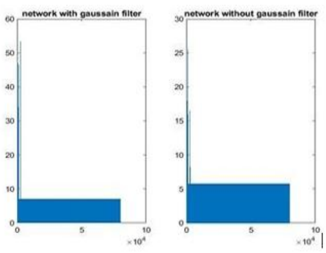

Figure 4: The compute the data error in the dissimilarscenario (a) the scenario Gaussian filter in WSN
b. The scenario without Gaussian filter in WSN

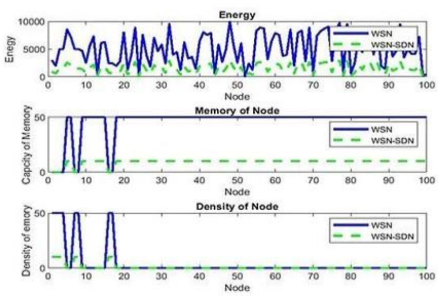

Figure 5: The QoS the SDN-WSN and WSN form Energy, Memory of node, density

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Table 3: Comparison of Traditional WSN and SDN-WSN

Traditional WSN	SDN-WSN
Broadcasting messages periodically	Service response and more flexible
Variety of node structures	Minimal difference in node structures and a smaller network structure
Data transfer from all directions	Pathfinding based on node direction; more adaptive for IoT

CONCLUSION

This paper presents a Software Defined Network (SDN) model for Wireless Sensor Networks (WSNs), featuring controllers in the SDN queue to estimate packet flow in the sensor zone. One of the controllers works proactively with a Gaussian filter to evaluate sensor packet flow. Simulation results indicate that QoS was optimized with the Gaussian filter integrated with SDN in WSNs. The K-means clustering algorithm effectively selected cluster heads and their members in the sensing zone, as evidenced by the QoS results. This model enhances packet flow estimation and overall performance in wireless sensor networks.

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