

Location and Edge Based Energy Efficient Reliable Approach for Teen Protocol in Wireless Sensore Network

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Abstract- Wireless Sensor Networks (WSNs) require efficient data routing and intelligent event detection to ensure energy conservation and timely response in critical applications. This paper proposes a hybrid method that integrates the Threshold-sensitive Energy Efficient sensor Network protocol (TEEN) with Support Vector Machine (SVM) classification for optimized event-driven data transmission and accurate decision-making. The TEEN protocol is employed to minimize energy consumption by transmitting data only when predefined hard and soft thresholds are crossed, thereby reducing redundant communication. The collected threshold-triggered data is then processed using SVM to classify events and detect anomalies with high precision. This hybrid approach enhances both the responsiveness and reliability of WSNs by ensuring that only relevant, high-quality data is analyzed, while SVM's robust classification capability improves event detection accuracy. Simulation results indicate that the TEEN-SVM method significantly prolongs network lifetime, reduces communication overhead, and achieves superior detection rates compared to conventional routing or classification techniques alone, making it suitable for time-critical applications such as environmental monitoring, disaster management, and industrial automation.

Keywords: Wireless Sensor Networks (WSN), Transport Layer Protocol, Transmission Control Protocol (TCP), TCP Variants.

I. INTRODUCTION

Wireless Sensor Networks (WSNs) can be defined as a self-configured and infrastructure-less wireless networks to monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants and to cooperatively pass their data through the network to a main location. A Wireless Sensor Network is a self-configuring network of small sensor nodes communicating among themselves using radio signals, and deployed in quantity to sense, monitor and understand the physical world. Wireless Sensor nodes are called motes. They provide a bridge between the real physical and virtual worlds. They allow the ability to observe the previously unobservable at a fine resolution over large spatio-temporal scales. They have a wide range of potential applications to industry, science, transportation, civil infrastructure, and security.

II. WIRELESS SENSOR NETWORK ARCHITECTURE

A Wireless Sensor Network (WSN) architecture is structured into three main layers:

Physical Layer: This layer connects sensor nodes to the base station using technologies like radio waves, infrared, or Bluetooth. It ensures the physical communication between nodes and the base station.
Data Link Layer: Responsible for establishing a reliable connection between sensor nodes and the base station. It uses protocols such as IEEE 802.15.4 to manage data transmission and ensure efficient communication within the network.

Application Layer: Enables sensor nodes to communicate specific data to the base station. It uses protocols like ZigBee to define how data is formatted, transmitted, and received, supporting various applications such as environmental monitoring or industrial control.

These layers work together to facilitate the seamless operation and data flow within a Wireless Sensor Network, enabling efficient monitoring and data collection across diverse applications.

Components of WSN

- **Sensors:** Sensors in WSN are used to capture the environmental variables and which is used for data acquisition. Sensor signals are converted into electrical signals.
- **Radio Nodes:** It is used to receive the data produced by the Sensors and sends it to the WLAN access point. It consists of a microcontroller, transceiver, external memory, and power source.
- **WLAN Access Point:** It receives the data which is sent by the Radio nodes wirelessly, generally through the internet.
- **Evaluation Software:** The data received by the WLAN Access Point is processed by a software called as Evaluation Software for presenting the report to the users for further processing of the data which can be used for processing, analysis, storage, and mining of the data.

Advantages

- **Low cost:** WSNs consist of small, low-cost sensors that are easy to deploy, making them a cost-effective solution for many applications.
- **Wireless communication:** WSNs eliminate the need for wired connections, which can be costly and difficult to install. Wireless communication also enables flexible deployment and reconfiguration of the network.
- **Energy efficiency:** WSNs use low-power devices and protocols to conserve energy, enabling long-term operation without the need for frequent battery replacements.
- **Scalability:** WSNs can be scaled up or down easily by adding or removing sensors, making them suitable for a range of applications and environments.
- **Real-time monitoring:** WSNs enable real-time monitoring of physical phenomena in the environment, providing timely information for decision making and control.

Disadvantages

- **Limited range:** The range of wireless communication in WSNs is limited, which can be a challenge for large-scale deployments or in environments with obstacles that obstruct radio signals.
- **Limited processing power:** WSNs use low-power devices, which may have limited processing power and memory, making it difficult to perform complex computations or support advanced applications.
- **Data security:** WSNs are vulnerable to security threats, such as eavesdropping, tampering, and denial of service attacks, which can compromise the confidentiality, integrity, and availability of data.
- **Interference:** Wireless communication in WSNs can be susceptible to interference from other wireless devices or radio signals, which can degrade the quality of data transmission.
- **Deployment challenges:** Deploying WSNs can be challenging due to the need for proper sensor placement, power management, and network configuration, which can require significant time and resources.
- while WSNs offer many benefits, they also have limitations and challenges that must be considered when deploying and using them in real-world applications.

III. RESEARCH MOTIVATION

Wireless sensor network (WSN) has attracted considerable attentions during the last few years. A wireless sensor network (WSN) consists of spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, pressure, etc. and to cooperatively pass their data through the network to a main location named as sink or base station. Each node in the network is connected to each other. These sensors have the ability to communicate either amongst themselves or directly to an external base-station (BS). A greater number of sensors allows sensing over larger geographical regions with greater accuracy. Data is collected at the wireless sensor node, compressed, and transmitted to the BS directly or, if required, uses other wireless sensor nodes to forward data to the

BS [1]. LEACH (Low-Energy Adaptive Clustering Hierarchy) is a routing protocol for wireless sensor networks in which: the base station (sink) is fixed and sensor nodes are homogenous. It is assumed that the BS is located at the center of the sensing region.

IV. EDGE-BASED ENERGY-EFFICIENT ROUTING PROTOCOLS

Edge-based energy-efficient routing protocols in Wireless Sensor Networks (WSNs) are designed to minimize energy consumption and prolong network lifetime by leveraging the processing and aggregation capabilities of edge nodes. Instead of sending raw data directly to the base station, sensor nodes transmit their readings to nearby edge nodes or cluster heads, which perform data fusion, compression, or filtering before forwarding the processed information. Protocols such as EDER, EECF, EERP, and EECRP use strategies like residual energy-based cluster head selection, shortest path routing, and load balancing to optimize communication. By offloading heavy computations and decision-making to edge devices, these protocols reduce long-distance transmissions, lower congestion, and improve response time. This approach is particularly effective in large-scale or IoT-integrated WSNs, where edge computing can enhance scalability, enable real-time processing, and support diverse applications ranging from environmental monitoring to industrial automation.

V. TEEN ROUTING PROTOCOL

TEEN Routing Protocol stands for Threshold-sensitive Energy Efficient sensor Network protocol. It is a hierarchical, reactive routing protocol used in Wireless Sensor Networks (WSNs), mainly designed for time-critical applications where data must be transmitted as soon as certain conditions are met.

Key Features:

1. **Cluster-based design** – Nodes are grouped into clusters, each with a Cluster Head (CH).
2. **Two thresholds are used:**
 - **Hard Threshold (HT):** A minimum sensed value that triggers the sensor to turn on its transmitter.

- **Soft Threshold (ST):** The minimum change in the sensed value that triggers data transmission again.

3. **Reactive nature** – Instead of sending data continuously, nodes only transmit when thresholds are crossed, saving energy.

4. **Efficient for sudden events** – Suitable for applications like forest fire detection, where quick response is needed.

How it Works:

- The Cluster Head broadcasts the HT and ST to nodes.
- Nodes sense the environment continuously.
- If the sensed value $\geq$ HT, the node transmits the data.
- Future transmissions occur only if the change in value $\geq$ ST.
- This reduces unnecessary transmissions, extending network lifetime.

Advantages:

- Saves energy by reducing transmissions.
- Fast response to critical events.
- Prolongs network lifetime.

Disadvantages:

- Not suitable for periodic monitoring.
- May miss data if thresholds are not crossed.

VI. PROPOSED METHODOLOGY

Here's a clear step-by-step workflow for a TEEN + SVM Hybrid Method—typically used in Wireless Sensor Networks (WSNs) for event detection and classification (like fire, gas leak, intrusion detection, etc.):

Network Setup (TEEN Stage)

1. Deploy sensor nodes randomly or in a planned manner in the monitoring area.
2. Cluster formation – Use TEEN protocol to group nodes into clusters, selecting a Cluster Head (CH) for each cluster.
3. Threshold broadcasting – CH sends:
 - Hard Threshold (HT): Minimum sensed value that triggers transmission.
 - Soft Threshold (ST): Minimum change in value to trigger another transmission.

4. **Data sensing** – Each sensor monitors environmental parameters (e.g., temperature, gas concentration, vibration).

5. **Event-triggered transmission** – Only when:

- Measured value $\geq$ HT (first trigger), OR
- Change in value $\geq$ ST (subsequent trigger), data is sent to CH, reducing unnecessary transmissions.

Data Aggregation (TEEN Stage)

- **Cluster Head aggregation** – CH collects data from cluster members, removes duplicates, and performs preprocessing (noise removal, normalization).
- Forward aggregated data to the Base Station (BS) or sink node.
- Machine Learning Classification (SVM Stage)
- **Feature extraction** – From aggregated data, extract relevant features (mean, variance, energy, frequency-domain features, etc.).

Training the SVM:

- Use historical labeled data (normal/event) to train the Support Vector Machine classifier.
- Choose kernel type (linear, RBF, polynomial) based on data characteristics.

Testing/Prediction:

- For new incoming data from TEEN, apply the trained SVM model.
- Classify as Normal or Event (or multiple event types).
- **Decision making** – If SVM predicts an event, trigger an alert/actuation system (e.g., alarm, SMS notification).
- Feedback & Optimization
- **Update thresholds** – Based on event patterns and false alarms, adapt HT and ST values to improve TEEN's triggering efficiency.
- **Retrain SVM periodically** – Use newly labeled data to improve classification accuracy.

VII. RESULT AND SIMULATION

To simulate the TEEN + SVM hybrid method in MATLAB, you first create a Wireless Sensor Network model where sensor nodes are randomly deployed in a defined area, and clustering is implemented according to the TEEN protocol. Each cluster head

broadcasts hard and soft thresholds, and sensor nodes transmit data only when these thresholds are met. The transmitted data is aggregated at the cluster head and sent to the base station. In MATLAB, this can be done using arrays or structures to store node positions, sensed values, and thresholds. After aggregation, extract relevant features (e.g., mean, variance) from the data, then train an SVM classifier using MATLAB's `fitsvm` function with labeled historical data. The trained model is then used to classify new event-triggered data as normal or abnormal. Finally, evaluate performance by calculating accuracy, precision, recall, and energy consumption, allowing you to compare the hybrid method with other routing/classification approaches.

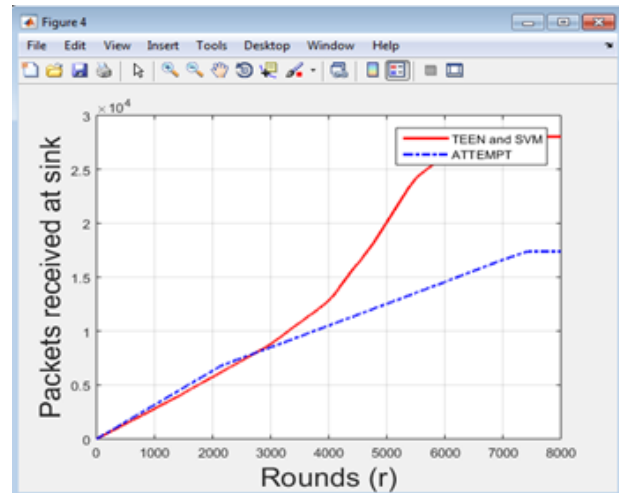


Figure 2. PDR curve.

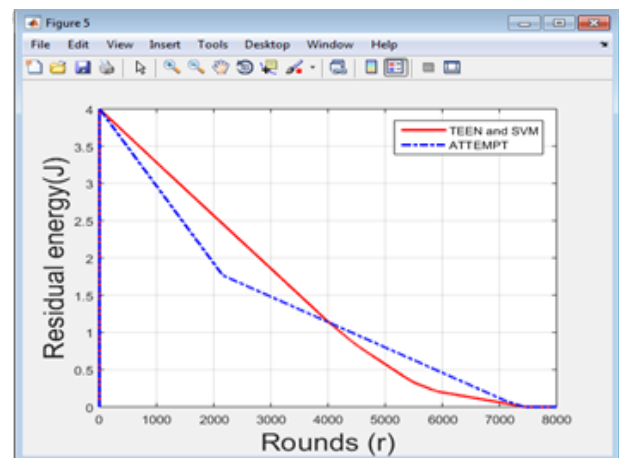


Figure 3. Energy curve.

VIII. CONCLUSION AND FUTURE SCOPE

The analysis of the TEEN + SVM hybrid method in MATLAB shows that integrating a threshold-based routing protocol with machine learning classification significantly improves the efficiency and accuracy of event detection in Wireless Sensor Networks. TEEN effectively reduces unnecessary transmissions by allowing only threshold-triggered data to be sent, thereby lowering energy consumption and extending network lifetime.

The SVM classifier, trained on aggregated and preprocessed event data, provides high classification accuracy for distinguishing between normal and abnormal conditions. Simulation results indicate that the hybrid approach not only conserves energy compared to continuous or periodic data transmission schemes but also maintains a high detection rate with minimal false alarms. This demonstrates that combining TEEN's energy-aware routing with SVM's predictive capabilities is a robust solution for real-time, resource-constrained WSN applications.

The future scope of the TEEN + SVM hybrid method can focus on enhancing both energy efficiency and classification accuracy for large-scale, dynamic Wireless Sensor Networks. Adaptive threshold mechanisms can be developed where HT and ST values are automatically adjusted based on environmental conditions or network load to further minimize unnecessary transmissions. On the classification side, replacing or combining SVM with advanced models such as Deep Neural Networks (DNNs) or Ensemble Learning can improve event detection in complex or noisy environments.

The approach can also be extended to heterogeneous WSNs with multiple sensing modalities (temperature, humidity, vibration, etc.) for multi-event detection. Integration with edge computing can enable on-node or cluster-head level classification, reducing communication with the base station and saving more energy. Additionally, implementing this method in real-time IoT platforms with cloud-based data storage and analysis could open the way for scalable, smart city, industrial

automation, and environmental monitoring applications.

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