SENSIBLE CACHE CONGESTION MANAGEMENT MECHANISM FOR IOT-ENABLED WIRELESS MESH NETWORK

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ABSTRACT

The rapid growth of Internet of Things (IoT) devices has led to increased data traffic, resulting in congestion in wireless mesh networks (WMNs). This project introduces a Sensible Cache Congestion Management Mechanism designed to alleviate congestion in IoT-enabled WMNs. By utilizing an Energy Efficient Selective Opportunistic Routing (EESOR) protocol, the proposed system reduces energy consumption, minimizes delay, and enhances network lifetime. The EESOR protocol dynamically selects the next hop node based on its proximity to the destination and energy efficiency, ensuring optimal data transmission. This study demonstrates the effectiveness of the proposed mechanism through extensive simulations, highlighting improvements in network performance metrics such as end-to-end delay, packet delivery ratio, and energy efficiency.

Keywords: IoT, Wireless Mesh Networks, Cache Congestion, Energy Efficient Selective Opportunistic Routing, Network Performance

1. INTRODUCTION

The proliferation of IoT devices has revolutionized various domains, including healthcare, agriculture, and smart cities. These devices generate substantial amounts of data, necessitating efficient data transmission and management mechanisms. Wireless mesh networks (WMNs) provide a robust infrastructure for IoT deployments, offering flexibility, scalability, and reliability. However, the increased data traffic can lead to congestion, affecting network performance and longevity. Therefore, developing efficient congestion management mechanisms is critical for sustaining IoT-enabled WMNs.

Routing protocols in WMNs are pivotal for ensuring efficient data transmission. They are broadly classified into proactive, reactive, and hybrid protocols. Proactive protocols, such as Destination Sequenced Distance Vector (DSDV), maintain consistent routing information by periodically updating routing tables. Reactive protocols, such as Ad hoc On-Demand Distance Vector (AODV), establish routes on-demand, reducing overhead but potentially increasing latency. Hybrid protocols, like the Zone Routing Protocol (ZRP), combine features of both proactive and reactive protocols to balance overhead and latency.

MANETs, a subset of WMNs, are employed in diverse applications due to their self-organizing and infrastructure-less nature. Key applications include military operations, disaster relief, industrial monitoring, and environmental monitoring. These networks facilitate real-time data collection and transmission, critical for mission-critical applications where timely information is paramount.

MANETs face several challenges, including limited energy resources, dynamic network topology, security vulnerabilities, and fault tolerance. Energy efficiency is a significant concern as nodes operate on battery power, necessitating protocols that minimize energy consumption to extend network lifetime. Additionally, ensuring reliable data transmission in the presence of node mobility and varying network conditions is crucial for maintaining network performance.

MANETs consist of mobile nodes that communicate wirelessly without fixed infrastructure. Each node acts as both a host and a router, forwarding data to other nodes. The network topology is dynamic, with nodes joining and leaving the network frequently. MANETs use routing protocols to discover and maintain routes, ensuring data packets reach their destinations efficiently. Energy-efficient routing protocols are essential to conserve battery power and prolong network operation.

2. LITERATURE REVIEW

2.1 Opportunistic Routing

Opportunistic routing protocols dynamically select the next hop for data packets based on the current network conditions. These protocols exploit the broadcast nature of wireless communication to improve throughput and reliability. Key studies have demonstrated the advantages of opportunistic routing in multi-hop wireless networks, highlighting its potential for enhancing network performance.

2.2 Problem Description

Existing congestion management mechanisms in WMNs often fail to address the unique challenges posed by IoT deployments, such as heterogeneous data traffic and varying QoS requirements. The primary issues include high energy consumption, increased end-to-end delay, and reduced network lifetime. Addressing these challenges requires innovative routing protocols that optimize data transmission while minimizing energy usage and delay.

2.3 Overview of the Project

This project proposes an Energy Efficient Selective Opportunistic Routing (EESOR) protocol to manage cache congestion in IoT-enabled WMNs. The EESOR protocol reduces the forwarder list size by selecting nodes closer to the destination, thus minimizing energy consumption and delay. By opportunistically routing acknowledgment packets, the protocol balances energy expenditure between transmission and reception, enhancing network lifetime.

3. SYSTEM ANALYSIS

3.1 Existing System

Current opportunistic routing protocols, such as ExOR and MORE, focus on maximizing throughput but often overlook energy efficiency and congestion management. These protocols maintain extensive forwarder lists, leading to increased complexity and energy consumption. Additionally, they do not effectively balance energy usage between nodes, resulting in reduced network lifetime.

3.1.1 Drawbacks

- High energy consumption due to extensive forwarder lists.
- Increased end-to-end delay and packet loss.
- Inefficient handling of network congestion.
- Limited scalability in dense IoT deployments.

3.2 Proposed System

The proposed EESOR protocol addresses these drawbacks by optimizing the forwarder list and balancing energy usage. The protocol includes the following features:

- **Selective Forwarding**: Nodes closer to the destination are prioritized, reducing the forwarder list size and energy consumption.
- **Opportunistic Acknowledgment Routing**: Acknowledgment packets are routed through different paths to balance energy expenditure.
- **Dynamic Update Mechanism**: Routing tables are updated dynamically based on network conditions, ensuring optimal data transmission.

4. REQUIREMENT SPECIFICATION

4.1 Hardware Requirements

- **Processor**: Intel Core i5 or higher
- **Memory**: 4GB RAM
- **Storage**: 500GB HDD
- **Network Interface**: Wireless LAN adapter

4.2 Software Requirements

- **Operating System**: Windows 10 or Linux
- **Simulation Tools**: NS2 or NS3
- **Programming Languages**: Java, Python

4.3 Software Tool Description

The project utilizes NS2 for simulating the proposed EESOR protocol. NS2 provides a flexible environment for modelling and analyzing network protocols, allowing detailed performance evaluation.

5. SYSTEM DESIGN

5.1 File Design

The system's file structure includes modules for routing table creation, updating, and packet transmission. Each module is designed to handle specific tasks, ensuring modular and scalable implementation.

5.2 Input Design

The input design focuses on capturing network parameters such as node positions, energy levels, and data packet characteristics. Input validation ensures accurate and consistent data for simulation and analysis.

5.3 Output Design

The output includes performance metrics such as end-to-end delay, packet delivery ratio, and energy consumption. These metrics are presented in graphical and tabular formats for easy analysis.

5.4 Database Design

The database stores information about network nodes, routing tables, and performance metrics. Efficient indexing and querying mechanisms ensure quick data retrieval and analysis.

5.5 Architecture Diagram

The architecture diagram illustrates the system's components and their interactions, highlighting the flow of data from input to output.

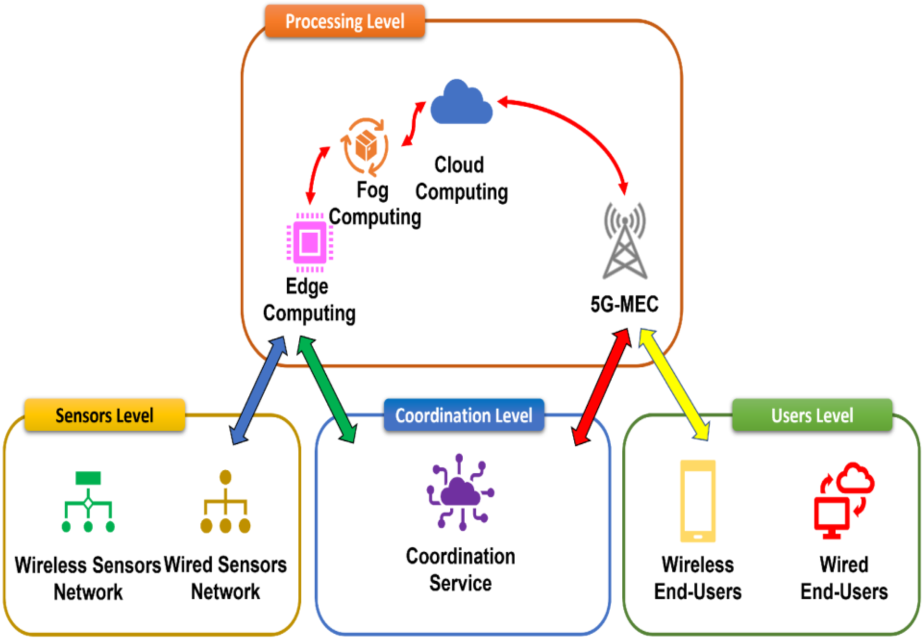

Figure 5.5: Architecture Diagram for Representation of Cloud , Fog and Edge Computing.

5.6 Data Flow Diagram

The data flow diagram provides a detailed view of the data processing steps, from initial input to final output, ensuring clarity in the system's operations.

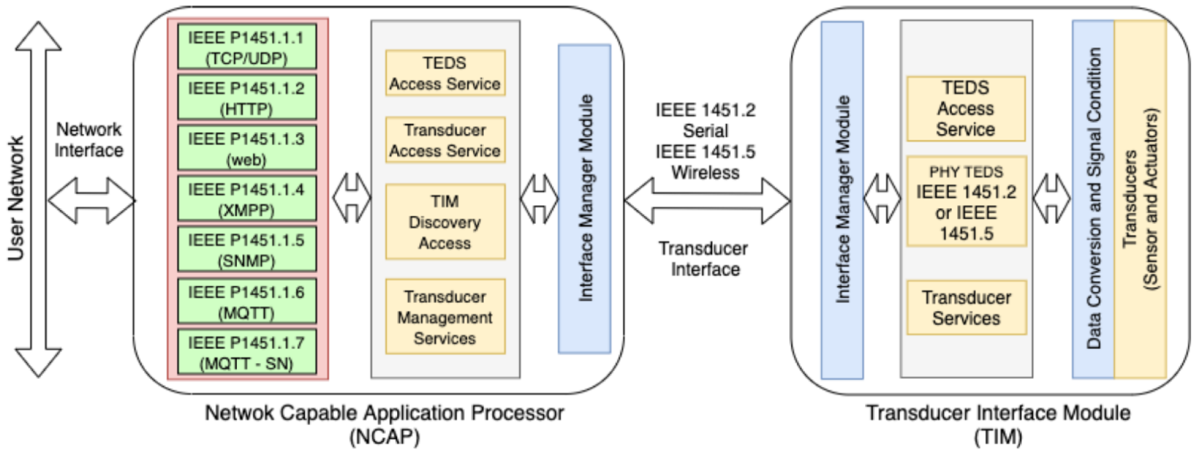

Figure 5.6: Data Flow Diagram

6. PROPOSED SYSTEM

6.1 Energy Efficient Selective Opportunistic Routing (EESOR)

The EESOR protocol optimizes data transmission by reducing the forwarder list size and opportunistically routing acknowledgment packets. This approach minimizes energy consumption and delay, enhancing network performance and lifetime.

6.2 MANET Routing Protocols

MANET routing protocols are classified into proactive, reactive, and hybrid protocols. The EESOR protocol combines features of reactive and opportunistic routing, providing a balance between overhead and latency.The Figure shows the output design for the proposed system for the Protocol stack and network architecture representation of an infrastructure handled with Thread protocol.

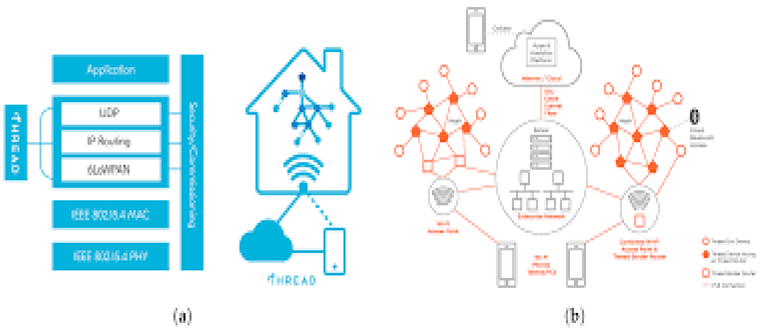

Figure 6.2.1 . Protocol stack and network architecture representation of an infrastructure handled with Thread protocol. (a) Thread networking protocol stack (b) Thread network architecture example .

6.3 Advantages

- Reduced energy consumption.
- Lower end-to-end delay.
- Enhanced network lifetime.
- Improved packet delivery ratio.

6.4 Simulation Setup

The simulation setup involves deploying 50 nodes in a 500m x 500m area, with each node having an initial energy of 50 Joules. Packets of 1000 bytes are transmitted between source-destination pairs, with performance metrics recorded for analysis.

6.5 Performance Evaluation

The performance evaluation demonstrates significant improvements in network metrics such as end-to-end delay, packet delivery ratio, and energy efficiency. The EESOR protocol outperforms existing protocols, providing a viable solution for IoT-enabled WMNs.

7. SYSTEM IMPLEMENTATION

7.1 Module Description

The system implementation includes modules for routing table creation, updating, and packet transmission. Each module is designed to handle specific tasks efficiently, ensuring robust and scalable implementation.

7.1.1 Creation of Routing Table

Routing tables are initialized with information about neighbouring nodes, including their distances and energy levels. HELLO packets are broadcasted to update routing tables dynamically.

7.1.2 Updating the Routing Table

Routing tables are updated based on current network conditions, ensuring optimal data transmission paths are selected.

7.1.3 Sending Acknowledgment

Acknowledgment packets are routed opportunistically, balancing energy expenditure and enhancing network lifetime.

7.2 Creation of Congestion Aware Routing Table

Congestion-aware routing tables are created by exchanging HELLO packets and updating entries based on network congestion levels.

7.3 Updating Congestion Aware Routing Table

Routing tables are updated dynamically to reflect current network conditions, ensuring efficient data transmission and congestion management.

8. SYSTEM TESTING AND MAINTENANCE

8.1 System Testing

Comprehensive testing is conducted to ensure system reliability and performance. Testing includes unit testing, integration testing, and validation testing.

8.1.1 Unit Testing

Individual modules are tested for functionality and correctness, ensuring each module performs as expected.

8.1.2 Integration Testing

Integrated modules are tested to ensure seamless interaction and data flow between components.

8.1.3 Validation Testing

The entire system is validated against user requirements and performance criteria, ensuring the system meets its objectives.

8.2 System Maintenance

Regular maintenance ensures the system remains operational and adapts to changing network conditions. Updates and enhancements are applied as needed to maintain optimal performance.

9. CONCLUSION AND FUTURE WORK

9.1 Major Findings

- The Random Space Perturbation method effectively protects data confidentiality while maintaining analysis utility.
- The KNN Query Management module provides accurate and efficient classification of encrypted health records.
- The integrated system demonstrates high performance, making it suitable for deployment in healthcare environments.

9.2 Future Scope

Future research could focus on:

- Enhancing the scalability of the system to handle larger datasets.
- Integrating additional machine learning algorithms to improve classification accuracy.
- Developing user-friendly interfaces for healthcare professionals to interact with the system.

10. REFERENCES

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