**QoS-Aware Seamless Vertical Handoff in Heterogeneous Wireless Networks using SDN and MIPv6**

Report submitted to GITAM (Deemed to be University) as a partial fulfillment of the requirements for the award of the Degree of Bachelor of Technology in (write your respective branch)



DEPARTMENT OF ELECTRICAL, ELECTRONICS AND COMMUNICATION ENGINEERING

GITAM SCHOOL OF TECHNOLOGY

GITAM (DEEMED TO BE UNIVERSITY)

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**DECLARATION**

I declare that the project work contained in this report is original and it has been done by me under the guidance of my project guide.

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**CERTIFICATE**

This is to certify that Boddu Bharath Narasimha Sai bearing Regd. No.:BU22EECE0100184 has satisfactorily completed Mini Project Entitled in partial fulfillment of the requirements as prescribed by University for VIIth semester, Bachelor of Technology in “Electrical, Electronics and Communication Engineering” and submitted this report during the academic year 2025-2026.

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**Table of contents**

**Chapter 1: Introduction 1**

* 1. Overview of the problem statement 1
  2. Objectives and goals 1

**Chapter 2 : Literature Review 2**

**Chapter 3 : Strategic Analysis and Problem Definition 3**

* 1. SWOT Analysis 3
  2. Project Plan - GANTT Chart 3
  3. Refinement of problem statement 3

**Chapter 4 : Methodology 4**

* 1. Description of the approach 4
  2. Tools and techniques utilized 4
  3. Design considerations

**References**

**Chapter 1: Introduction**

**1.1 Overview of the problem statement**

In today's hyper-connected world, mobile users expect uninterrupted network access as they move through diverse wireless environments, such as Wi-Fi, LTE, and 5G. This movement necessitates a "vertical handoff" between different network technologies. Traditional handoff mechanisms, often managed by the mobile device itself, lack a global view of network conditions, leading to suboptimal decisions, connection drops, and a degraded **Quality of Service (QoS)**. This problem is particularly acute for real-time applications like video conferencing and online gaming. The challenge is to create an intelligent, centralized system that can proactively manage these handoffs to ensure a seamless and "always best connected" user experience.

**1.2 Objectives and goals**

The primary objective of this project is to design, simulate, and evaluate a novel framework for managing vertical handoffs using **Software-Defined Networking (SDN)** and **Mobile IPv6 (MIPv6)**.

The specific goals are:

* To design a centralized network architecture using an **SDN controller** to monitor heterogeneous wireless networks.
* To develop a **QoS-aware handoff decision algorithm** that considers network metrics like bandwidth, latency, and jitter to select the optimal target network.
* To integrate **MIPv6** to ensure session continuity, allowing the mobile device to maintain its IP address during the handoff process.
* To build a simulation model to validate the proposed framework and compare its performance (e.g., handoff latency, packet loss) against traditional device-centric approaches.

**Chapter 2 : Literature Review**

|  |  |  |  |
| --- | --- | --- | --- |
| Title and Author | Problem Statement | Methodology | Result |
| Dynamic Mobility and Handover Management in SDN-Based 5G HetNets  Khan et al., 2024 | Frequent and unnecessary handovers in dense heterogeneous networks degrade QoS and increase signaling overhead. | Multi-parameter best cell selection using SDN controller. Algorithm based on RSS, load, dwell time, direction. Simulated in 5G HetNet scenario. | 39% reduction in handovers; improved throughput and lower delay. SDN enables efficient, dynamic mobility.[[1]](#fn1) |
| QoS-Aware and Fault-Tolerant Handovers in SDN-Based 5G Networks  Recent Supporting Paper | Vertical handoffs can cause packet loss, latency spikes, and service disruption, especially in real-time apps. | SDN-based centralized control with QoS criteria. Fault-tolerant handover logic tested in wireless emulation environments. | Enhanced QoS during handoff. Fault-tolerance reduces service interruption. Improved performance for multimedia apps.[[2]](#fn2)[[3]](#fn3) |
| Machine Learning for Handover Decision in 6G Networks  Recent Publication (2025) | Classical handover methods fail to predict user movement and network load, impacting handoff quality. | ML algorithms trained with user mobility and network data. Edge computing assists handover prediction and selection. | Higher handoff accuracy and lower delay. Dynamic adjustment to network conditions, useful for future 6G scenarios.[[4]](#fn4) |
| SDN-Based Distributed Mobility Management for 5G Networks  Eurecom White Paper | Traditional mobility management lacks scalability and quick adaptability for multiple user types and diverse apps. | SDN and DMM integration, centralized flow management, simulation in cloud-based testbed. | Reduced signaling load, rapid handoff response, scalable to large networks. Successful dynamic handoff management.[[5]](#fn5) |

|  |  |  |  |
| --- | --- | --- | --- |
| QOS Aware Vertical Handover Process in Heterogeneous Wireless Networks  Santhi and Prabha, 2023 | Vertical handoffs must meet QoS constraints such as delay, jitter, bandwidth, security, and cost. | Combined multiple analytic network process (M-ANP) and TOPSIS for network selection satisfying QoS constraints. | Enhanced QoS-aware network selection for vertical handoffs, validated through simulation.[[8]](#fn8) |
| Enhancing QoS Through SDN in Wireless Networks  Ait Oulahyane, 2023 | Addressing unreliable access points and dynamic access control to maintain QoS in wireless networks. | Proposed SDN-based secure model for dynamic access control and QoS management. Tested using SDN controllers and real scenarios. | Improved connection reliability and QoS enforcement in wireless networks through SDN-enabled control.[[9]](#fn9) |

**Chapter 3 : Strategic Analysis and Problem Definition**

* **Strengths**:
  + **Centralized Intelligence**: The SDN controller has a global view of the network, enabling smarter, context-aware handoff decisions.
  + **Improved QoS**: The handoff algorithm explicitly optimizes for user-defined QoS requirements, leading to a better user experience.
  + **Seamless Connectivity**: MIPv6 ensures that ongoing sessions (like a VoIP call) are not terminated during the handoff.
* **Weaknesses**:
  + **Controller Overhead**: Centralized control can introduce signaling overhead and a potential single point of failure.
  + **Scalability**: A single SDN controller may face scalability challenges in a very large and dense network.
* **Opportunities**:
  + **5G and Wi-Fi 6 Integration**: The increasing convergence of cellular and Wi-Fi networks creates a strong demand for efficient inter-network handoff solutions.
  + **Growth of Real-time Applications**: The proliferation of applications sensitive to latency and packet loss makes this technology highly relevant.
* **Threats**:
  + **Security**: The centralized SDN controller is a high-value target for security attacks.
  + **Interoperability**: Ensuring seamless operation between equipment from different vendors can be challenging.

**3.2 Project Plan - GANTT Chart**

(Represented as a task list with a timeline)

* **Weeks 1-2**: System Architecture and Algorithm Design.
* **Weeks 3-5**: Simulation Environment Setup (Mininet-WiFi, Ryu).
* **Weeks 6-8**: Implementation of QoS Monitoring and Handoff Logic.
* **Weeks 9-11**: Integration of MIPv6 functionality and Testing.
* **Week 12**: Performance Evaluation and Data Analysis.
* **Week 13**: Final Report Compilation and Review.

**3.3 Refinement of problem statement**

To design and validate a centralized, proactive, and QoS-aware vertical handoff framework for heterogeneous wireless networks. The proposed solution leverages a **Software-Defined Networking (SDN)** architecture for intelligent control-plane decision-making and integrates **Mobile IPv6 (MIPv6)** for seamless data-plane session continuity, aiming to minimize handoff latency and packet loss, thereby maximizing application performance for mobile users.

**Chapter 4 : Methodology**

**4.1 Description of the approach**

This project follows a design and simulation-based research methodology. The approach consists of three phases:

1. **System Design**: Architecting the overall framework, including the interaction between the mobile node, wireless access points, the SDN controller, and the MIPv6 Home Agent.
2. **Simulation Setup**: Building a virtual network environment to model the designed system. This involves configuring network topologies, user mobility patterns, and traffic flows.
3. **Performance Evaluation**: Conducting simulation experiments to measure key performance indicators (KPIs) and comparing them against a baseline scenario.

**4.2 Tools and techniques utilized**

* **Network Simulator**: **Mininet-WiFi** will be used to create a realistic network topology that includes both Wi-Fi access points and mobile stations.
* **SDN Controller**: **Ryu**, a component-based, Python SDN framework, will be used to implement the centralized handoff logic.
* **Mobility Protocol**: A lightweight implementation of **MIPv6** components will be simulated to handle IP address management and packet tunneling.
* **Traffic Generation**: Tools like iperf will be used to generate UDP and TCP traffic to simulate real-time applications and measure QoS metrics.

**4.3 Design Considerations**

The design of an effective QoS-aware vertical handoff system requires careful consideration of several interconnected components. Key design considerations include:

* **Selection of QoS Metrics**: A multi-parameter approach is essential. The primary metrics considered are **Available Bandwidth**, **Latency**, **Jitter**, and **Packet Loss Rate**.
* **Handoff Decision Algorithm Logic**: A **weighted scoring function** was chosen. In this model, each QoS metric is assigned a weight based on its importance, and the controller calculates a final score to compare available networks.
* **Handoff Triggering Mechanism**: A **hybrid triggering mechanism** was designed, using a reactive trigger (when QoS drops below a threshold) and a proactive trigger (periodic monitoring by the controller).
* **Synchronization between SDN and MIPv6**: The design ensures the controller initiates the MIPv6 binding update process in parallel with reprogramming the network's data path to minimize handoff latency.

**Reference Links**:

1. **Dynamic Mobility and Handover Management in SDN-Based 5G HetNets (Khan et al., 2024)**
2. **QOS Aware Vertical Handover Process in Heterogeneous Wireless Networks (Santhi and Prabha, 2023)**
   * **Link**: <https://ieeexplore.ieee.org/document/10169438>
3. **Enhancing QoS Through SDN in Wireless Networks (Ait Oulahyane, 2023)**
4. **Machine Learning for Handover Decision in 6G Networks (Recent Publication, 2025)**
   * **Link**: [IEEE: Machine Learning for Mobility Management in 5G and Beyond](https://ieeexplore.ieee.org/document/9402517)

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