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Research Methodology (22IM21T) EL Report On

Implementation of Wi-Fi Handoff using NS2 (Network Simulator 2)

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RV COLLEGE OF ENGINEERING®,

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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

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CERTIFICATE

Certified that the EL work titled **“Implementation of Wi-Fi Handoff using NS2(Network Simulator 2)”** carried out by **Pavankumar Patil, 1RV23CN10** and **Sathwik M S, 1RV23SCN14**, a bonafide students, submitted in partial fulfilment for the award of **Master of Technology** in **Computer Network Engineering** of **RV College of Engineering®, Bengaluru, affiliated to Visvesvaraya Technological University, Belagavi,** during the year **2023-24.** It is certified that all corrections/suggestions indicated for internal assessment have been incorporated in the report deposited in the departmental library. The EL report has been approved as it satisfies the academic requirement in respect of project work prescribed for the said degree.

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ABSTRACT

Today there's little recollection of life without wireless networks constantly at our disposal for universal connectivity. The rise of wireless technologies has led to more and more heterogeneous networks of Wi-Fi. QoS should be high and the user should be pleased in such cases and that's why there should be a gap less transition between networks called Handoff. In order to simulate this objective, the NS2 (Network Simulator 2) is used. The goal this project is to mimic real-world scenarios and experiment with various handovers between different Wi-Fi Access points. This work could lead to results that improve the user experience by designing better handoffs for coverage.

To accomplish the goals of this project initially, a detailed analysis of Wi-Fi performance parameters was conducted. This analysis served as the foundation for designing and implementing the handoff mechanism within the NS2 simulation environment. The topology for the wireless network is created. Later the nodes were configured for simulating the mobility. The UDP connection is setup. A constant bit rate of data communication is established between the access point and user equipment. Then using NS2 built-in protocol the handoffs are carried out. There is total 10 node in the topology, out of which 2 are considered for Wi-Fi access points. Rest all the nodes are assigned to be user equipment. 3 nodes were given mobility.

The simulation shows the real-world Wi-Fi handoffs. It is observed that the handoff occurs when the node is out of coverage area and the routing of packets should be calculated from base station. There are many background process should be done in order to complete the handoff. Since the users tend to move in the topology, user equipment should be tracked in real-time and assigned to another access point.

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Chapter 1

1.1 Introduction to Handoff

Handoff, in the context of technology and communication, refers to the seamless transfer of tasks, data, or control from one device, system, or user to another without disruption or loss of continuity. This concept is prevalent in various domains, including telecommunications, computing, healthcare, and manufacturing, where the ability to switch between different states or locations while maintaining a consistent experience is crucial.

Handoff mechanisms are designed to enhance user experiences and operational efficiency by ensuring that transitions between devices or systems are smooth and uninterrupted. This can involve transferring an ongoing phone call from a cellular network to a Wi-Fi network, shifting control of a robotic system from manual to autonomous mode, or passing patient information between healthcare providers during a hospital stay.

The key goals of handoff include:

- Continuity: Handoff ensures that users can seamlessly continue their tasks or activities as they move between different environments or devices. This is especially important in mobile computing, where users switch between cellular networks, Wi-Fi, and other wireless technologies.

- Reliability: Handoff mechanisms are engineered to be reliable and robust, minimizing the risk of data loss, dropped connections, or service interruptions during the transition.

- Efficiency: Handoff processes are designed to optimize resource usage, such as bandwidth or computing power, and minimize delays during the handover.

- Flexibility: Handoff can be used in a wide range of applications, from internet browsing on smartphones to the transfer of control in industrial automation. It adapts to the specific requirements of each use case.

- User Experience: A successful handoff should be transparent to the user, providing a consistent and intuitive experience across devices or systems.

Overall, handoff plays a critical role in modern technology ecosystems, enabling users to stay connected and productive while seamlessly transitioning between different contexts, devices, or networks. Its application continues to evolve with the advancement of technology and the growing interconnectedness of our digital world.

1.2 Objective of the Project

The objective of the project are as follows:

- To simulate a wireless network using NS2(Network Simulator 2)
- To demonstrate Wi-Fi handoff in the wireless network topology.

1.3 Problem Statement

Simulation of Wi-Fi network using NS2(Network Simulator 2) and demonstration of the Wi-Fi handoff in the topology of Wi-Fi network using NS-2.

1.4 Organization of the report

This report is organized as follows. The discussions in each chapter are as follows.

- Chapter 2 discusses Theory and Fundamentals, which briefly describes working of each component and the hardware and software that is used in the implementation of the project.
- Chapter 3 discusses Design and methodology of the project that describes in detail the software component of the project, from designing to implementation, using tables and flow diagrams for each of understanding.
- Chapter 4 discusses the implementation of the project and the detailed functioning of the project.
- Chapter 5 Results and discussions gives the practical analysis of the project, with visualization of the project output.
- Chapter 6 discusses Future scope and conclusion that gives final remarks regarding the project and explains project limitations.

Chapter 2
Theory and Concepts of Wi-Fi Handoff

1.1 Wi-Fi Architecture

Wi-Fi architecture encompasses the foundational components and principles that underpin wireless local area networks (WLANs), enabling wireless communication between devices. At its core, Wi-Fi relies on access points (APs), which are connected to a wired network infrastructure. These APs act as hubs for wireless devices to connect to the network. Each AP broadcasts a Wi-Fi signal, and when a device comes within range, it can associate with the nearest AP, establishing a wireless link. This network architecture is highly scalable, making it suitable for a wide range of environments, from small homes to large corporate campuses.

In more complex Wi-Fi architectures, multiple APs are strategically deployed to provide seamless coverage across a given area. These APs often communicate with a centralized controller, which helps manage and optimize network performance. Additionally, advanced security measures, such as encryption protocols and authentication mechanisms, are employed to protect data transmitted over the wireless network. Wi-Fi architecture has evolved over the years to accommodate the growing demand for wireless connectivity, offering various standards and frequency bands to cater to different use cases and ensure interoperability between devices from different manufacturers. Overall, Wi-Fi architecture forms the backbone of modern wireless communication, enabling ubiquitous internet access and connectivity for a collection different of devices.

1.2 Wi-Fi Handoff

Wi-Fi handoff, also known as Wi-Fi roaming, is a critical functionality within wireless networks that ensures uninterrupted connectivity as mobile devices move from one access point (AP) to another. This seamless transition is essential for maintaining a consistent and reliable wireless experience, especially in environments with multiple APs, such as office buildings, airports, and large public venues. During a Wi-Fi handoff, a mobile device detects a stronger signal from a different AP and decides to switch its connection to that AP. The handoff process involves disassociating from the current AP and associating with the new one, all while maintaining the ongoing network session, such as an internet browsing session or a VoIP call. Effective Wi-Fi handoff mechanisms prioritize a smooth and swift transition to prevent disruptions, packet loss, or dropped connections.

The success of Wi-Fi handoff relies on several factors, including the efficiency of handoff algorithms, signal strength and quality, load balancing among APs, and the quality of service (QoS) mechanisms in place. Handoff algorithms play a crucial role in determining when and how a device should switch between APs. They consider factors like signal strength, latency, and the AP's capacity to ensure optimal handoff decisions. Load balancing helps distribute the connected devices evenly across available APs, preventing network congestion and maximizing performance. QoS mechanisms prioritize critical applications during handoff to maintain a high-quality user experience. Wi-Fi handoff is fundamental in providing uninterrupted wireless connectivity, making it a key component in modern wireless network design and optimization.

1.3 NS-2(Network Simulator 2)

NS2, or Network Simulator 2, is a widely used open-source discrete event simulation tool primarily utilized for simulating computer networks and communication systems. It is a valuable resource in the fields of network research, development, and education. NS2 allows researchers and network engineers to model, analyze, and evaluate the behavior and performance of various network protocols, algorithms, and technologies in a controlled and repeatable environment. It provides a platform for studying a wide range of network types, including wired and wireless networks, ad-hoc networks, sensor networks, and more.

NS2 is particularly popular among academics and researchers because of its flexibility and extensibility. Users can develop custom network models and protocols, making it a versatile tool for exploring novel networking concepts and conducting experiments. NS2 also offers visualization capabilities to help users understand the dynamics of network behavior and the impact of different parameters and configurations. NS2 continues to be a valuable resource for network simulation and research in various academic and industrial settings. The detailed architecture of the NS-2 is shown in Fig.2.1

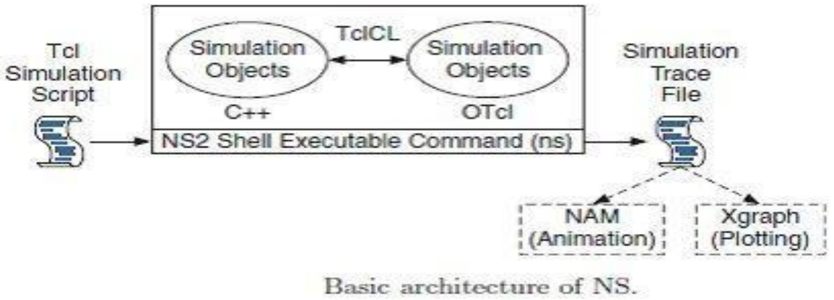

Fig 2.1: Architecture of NS-2

1.4 Software and Hardware Requirements

Software requirement:

Table 2.1 Software requirements

Operating System	Ubuntu
Tools	NS-2
System Architecture	64-bits

Hardware Requirement

Table 2.2 Hardware requirements

Processor	Intel i5
RAM	8GB
Storage	500GB

1.5 Summary

In this section, fundamental concepts related to Wi-Fi technology, Handoff in Wi-Fi and the ns-2 simulation framework are explained. It serves as the theoretical foundation for the project. The tool used NS-2(Network Simulator 2) and the hardware and software requirements are also discussed. It clarifies key terms and ideas that will be applied in the simulation.

Chapter 3
Methodology for the Simulation

The methodology section outlines the steps taken to set up and execute the Wi-Fi handoff simulation. It includes details on configuration, node creation, mobility modelling, device installation, and simulation execution. It also covers the setup, configuration, simulation execution, and any specific steps or considerations that were crucial to the project.

3.1 Class Diagram for the model

A class diagram is a type of diagram used in software engineering and object-oriented modeling to visually represent the structure and relationships of classes within a system or application. Class diagrams are part of the Unified Modeling Language (UML), a standardized notation for modeling software systems.

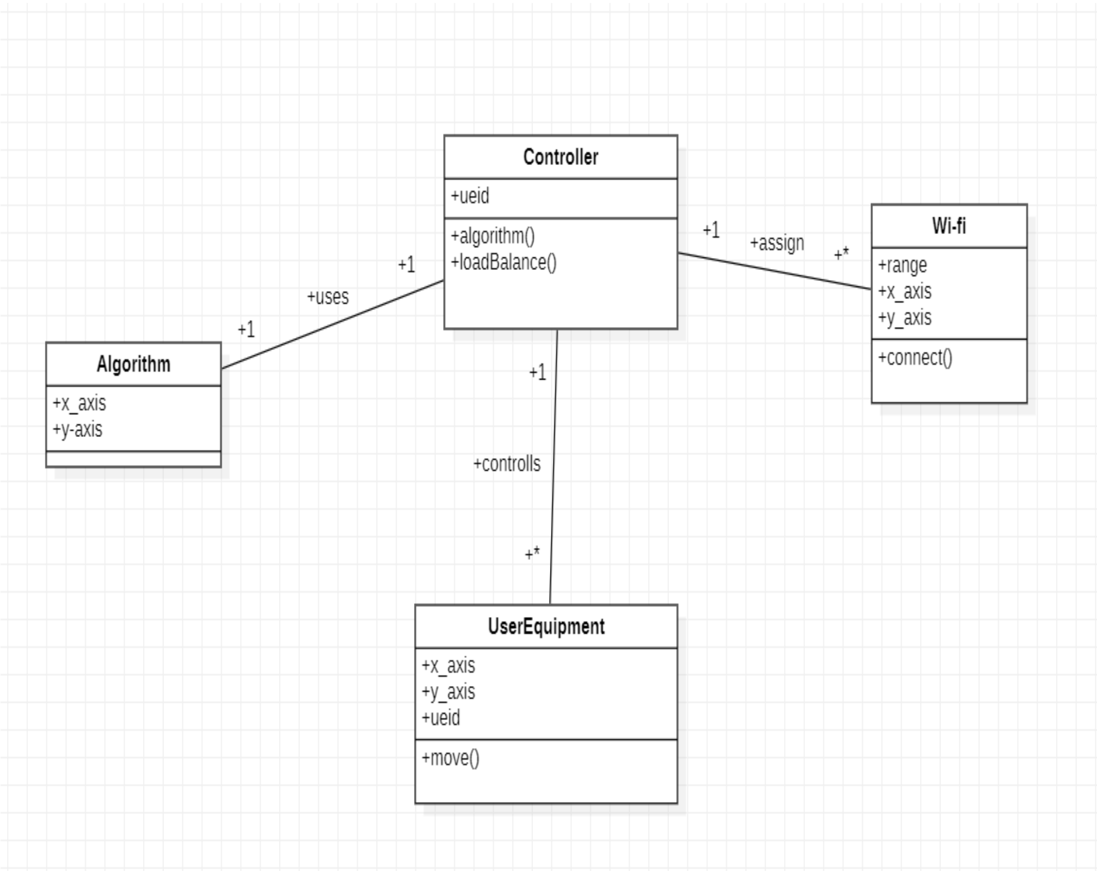

Fig 3.1 Class Diagram for the Wi-Fi Handoff

In the Fig 3.1, “Controller” represents the main program used to control all the handoffs and Wi-Fi Access points. The “UserEquipment” is the mobile nodes in the topology and many objects can be created for this class. The “Algorithm” is the algorithm class for Handoff of the nodes. The “Wi-fi” represents class of all Access points in the topology.

3.2 Setup And Configuration

For configuring and simulating a wireless network handoff scenario using the Network Simulator 2 (NS2). Steps discussed below sets up a basic wireless network with multiple nodes and wireless communication between them.

Step 1. Variable Definitions:

- Several variables are defined at the beginning of the script to configure various aspects of the network. These include channel type, propagation model, network interface type, MAC type, queue type, link layer type, antenna model, and more.

Step 2. Creating NS2 Simulator Instance and Creating Trace Files:

- An NS2 simulator instance is created to manage the simulation.
- Trace file and Nam files are created to log simulation events and for visualization.

Step 3. Creating Topography Object and God Object:

- A topography object is created to define the physical layout of the network.
- A GOD (General Operations Director) object is created. This is used for various network management tasks.

Step 4. Node Configuration Loop:

- A loop is used to configure each node in the network. It sets various parameters such as ad-hoc routing protocol, MAC type, queue type, and more.

Step 5. Node Positions, Labels and Markers:

- The script sets the positions of each node in the simulated area.
- Labels and markers are added to nodes for identification and visualization in the simulation.

Step 6. Traffic Generation:

- Traffic is generated using CBR (Constant Bit Rate) traffic sources for nodes. Packets are generated at specified rates.

Step 7. Node Motion:

- Some nodes have their positions updated at specific times to simulate node mobility.

3.3 Summary

This section outlines the steps to sets up a basic wireless network scenario with mobility, traffic generation, and node configuration. The Wi-Fi handoff can be implemented using the steps discussed above and visualized. The simulation is run, and the results can be visualized using the Nam visualizer.

Chapter 4
Implementation of Wi-Fi Handoff using NS-2

This section discusses the practical implementation of the project using tcl script and network simulator-2. It highlights key components of the code, the flow chart, configuration, and the simulation execution process.

4.1 Flow chart

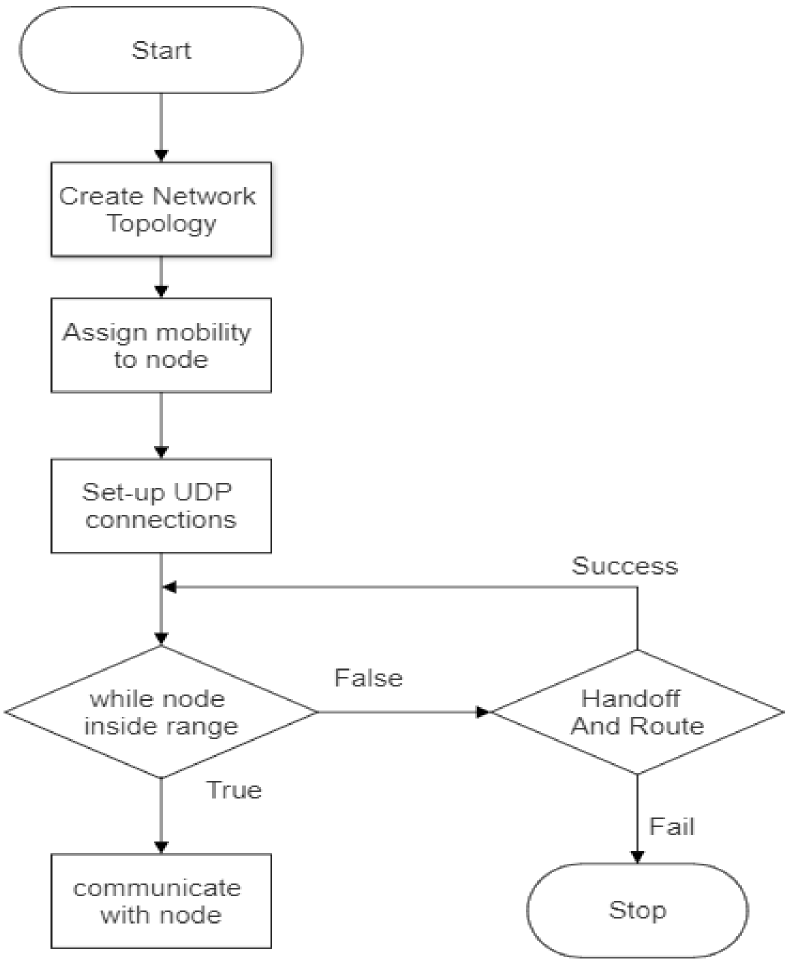

Fig 4.1: Flowchart of the implementation of Wi-Fi Handoff

4.2 Source code

The Tcl script configures and conducts a wireless network simulation using the Network Simulator 2 (NS2). It establishes a wireless network environment with multiple mobile nodes, access points, and various network parameters. The script defines essential settings such as channel type, propagation model, routing protocol, and mobility patterns. Additionally, it generates network traffic using Constant Bit Rate (CBR) sources and simulates node mobility within a defined area. The simulation records events in trace files and visualizes the network topology using the Nam tool.

Code:

```
# Define simulation parameters
set val(chan) Channel/WirelessChannel ;# Channel Type
set val(prop) Propagation/TwoRayGround ;# Propagation model
set val(netif) Phy/WirelessPhy ;# PHY layer
set val(mac) Mac/802_11 ;# MAC layer
set val(ifq) Queue/DropTail/PriQueue ;# Queue type
set val(ll) LL ;# Link layer
set val(ant) Antenna/OmniAntenna ;# Antenna type
set val(ifqlen) 50 ;# Queue length
set val(nn) 10 ;# Number of nodes
set val(rp) DumbAgent ;# Routing protocol
set val(x) 600 ;# Area width
set val(y) 600 ;# Area height

# Initialize the simulator
set ns_ [new Simulator]
set tracefd [open project1.tr w]
$ns_ trace-all $tracefd
set namtrace [open project1.nam w]
$ns_ namtrace-all-wireless $namtrace $val(x) $val(y)

# Set up the topography
set topo [new Topography]
$topo load_flatgrid $val(x) $val(y)

# Create the 'God' (God object for node positioning)
create-god $val(nn)

# Create and configure the channel
set chan_1_ [new $val(chan)]
$ns_ node-config -adhocRouting $val(rp) \
-llType $val(ll) \
```

```
-macType $val(mac) \
-ifqType $val(ifq) \
-ifqLen $val(ifqlen) \
-antType $val(ant) \
-propType $val(prop) \
-phyType $val(netif) \
-topoInstance $topo \
-agentTrace OFF \
-routerTrace OFF \
-macTrace ON \
-movementTrace ON \
-channel $chan_1_

# Create nodes and configure their properties
for {set i 0} {$i < $val(nn)} {incr i} {
    set node_($i) [$ns_ node]
    $node_($i) random-motion 0
    set mac_($i) [$node_($i) getMac 0]
    $mac_($i) set RTSThreshold_ 3000
}

# Set initial positions and labels for nodes
set positions {
    {200.0 360.0} {100.0 100.0} {400.0 400.0} {280.0 140.0}
    {100.0 320.0} {70.0 210.0} {440.0 310.0} {490.0 320.0}
    {520.0 280.0} {560.0 360.0}
}
set labels {AP1 N1 MN1 MN2 MN3 MN4 MN5 MN6 MN7 AP2}

set colors {green red yellow blue purple pink orange cyan brown grey}
for {set i 0} {$i < $val(nn)} {incr i} {
    # Set position and label
    set pos [lindex $positions $i]
    $node_($i) set X_ [lindex $pos 0]
    $node_($i) set Y_ [lindex $pos 1]
    $node_($i) set Z_ 0.0
    $ns_ at 0.0 "$node_($i) label [lindex $labels $i]"
```

```
    # Set color mark
    set color [lindex $colors $i]
    $ns_ at 0.0 "$node_($i) add-mark m1 $color circle"
}

# Configure the access points (APs)
set AP_ADDR1 [$mac_(0) id]
$mac_(0) ap $AP_ADDR1
set AP_ADDR2 [$mac_([expr $val(nn) - 1]) id]
$mac_([expr $val(nn) - 1]) ap $AP_ADDR2

# Set scan types for nodes
$mac_(1) ScanType ACTIVE
for {set i 3} {$i < [expr $val(nn) - 1]} {incr i} {
    $mac_($i) ScanType PASSIVE
}
$ns_ at 1.0 "$mac_(2) ScanType ACTIVE"

# Set up CBR traffic and UDP agents
Application/Traffic/CBR set packetSize_ 1023
Application/Traffic/CBR set rate_ 256Kb
for {set i 1} {$i < [expr $val(nn) - 1]} {incr i} {
    set udp1($i) [new Agent/UDP]
    $ns_ attach-agent $node_($i) $udp1($i)
    set cbr1($i) [new Application/Traffic/CBR]
    $cbr1($i) attach-agent $udp1($i)
}

# Attach Null agents and configure connections
set nulls [list]
for {set i 0} {$i < 7} {incr i} {
    lappend nulls [new Agent/Null]
}
for {set i 2} {$i < 9} {incr i} {
    $ns_ attach-agent $node_(1) [lindex $nulls [expr $i - 2]]
    $ns_ connect $udp1($i) [lindex $nulls [expr $i - 2]]
}
```

```
# Set initial node positions and movement
for {set i 0} {$i < $val(nn)} {incr i} {
    $ns_ initial_node_pos $node_($i) 30
}
$ns_ at 8.0 "$cbr1(2) start"
$ns_ at 2.0 "$cbr1(3) start"
$ns_ at 3.0 "$cbr1(4) start"
$ns_ at 4.0 "$cbr1(5) start"
$ns_ at 5.0 "$cbr1(6) start"
$ns_ at 6.0 "$cbr1(7) start"
$ns_ at 7.0 "$cbr1(8) start"

# Define node movements
$ns_ at 10.0 "$node_(4) setdest 590.0 350.0 1000.0"
$ns_ at 35.0 "$node_(5) setdest 460.0 360.0 1000.0"
$ns_ at 50.0 "$node_(3) setdest 590.0 350.0 1000.0"
$ns_ at 52.0 "$node_(3) setdest 100.0 360.0 1000.0"

# End the simulation
$ns_ at 100.0 "stop"
$ns_ at 100.0 "puts \"NS EXITING...\" ; $ns_ halt"

proc stop {} {
    global ns_ tracefd
    $ns_ flush-trace
    close $tracefd
    exec nam project1.nam
    exit 0
}
puts "Starting Simulation..."
$ns_ run
```

4.3 Summary

In this section the flowchart and the implementation code are discussed. The source code is a tcl script which is used to create and simulate the Wi-Fi topology and handoff scenario. The source code generates a trace file for logging the process. Nam file is formed after the successful execution of the project which has the visualization details.

Chapter 5

Results and Discussion

The expected results of the project include a simulation of the Wi-Fi handoff, trace file generation for logging of the process and real-time handoff messages in the command line interface.

Fig 5.1: Network topology

The provided script sets up a wireless network simulation using NS2 (Network Simulator 2). It configures various parameters and conducts a simulation scenario with 10 mobile nodes in a specified area. The key parameters include channel type, propagation model, network interface type, MAC type, interface queue type, link layer type, antenna model, and others. The simulation scenario also involves node mobility, routing protocols, and the generation of network traffic using CBR (Constant Bit Rate) sources.

After running the simulation, the script outputs trace files and uses the Nam tool to visualize the network topology. To analyze these trace files and visualization outputs to obtain a result summary specific to the simulation scenario.

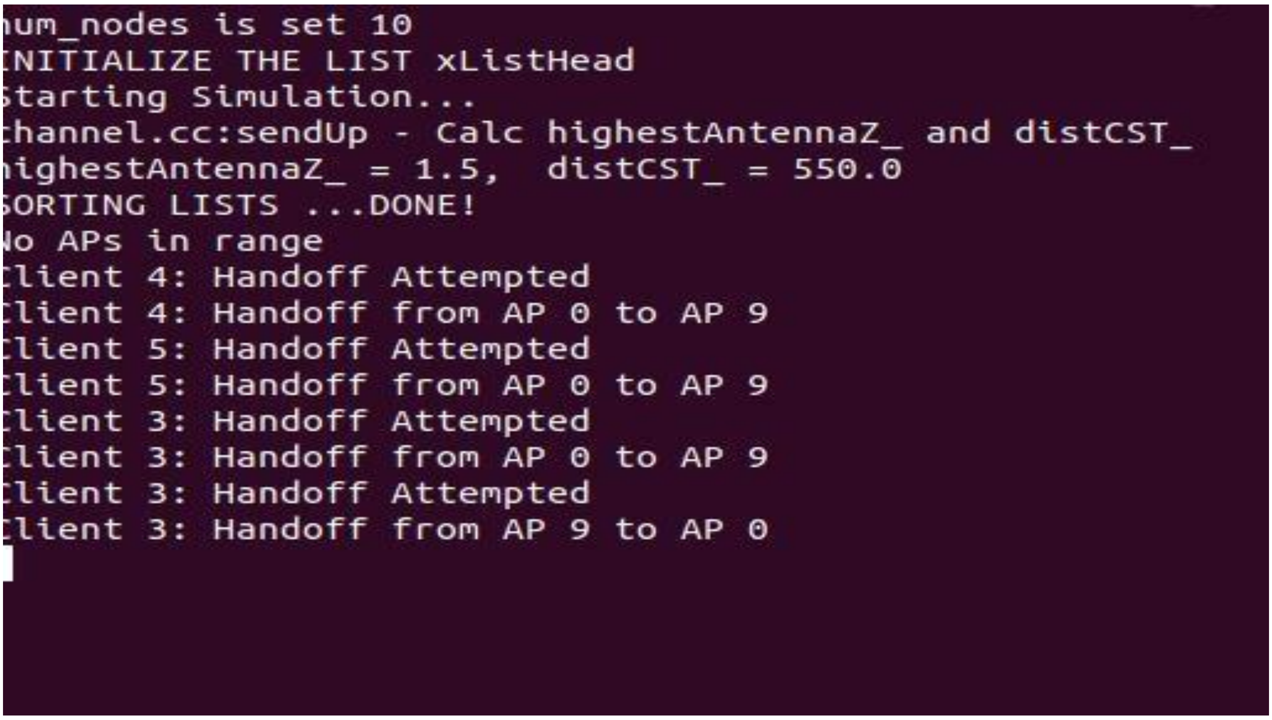

Fig 5.2: Command line output

In Figure 5.1, the topology of the Wi-Fi network is shown. The nodes MN3, MN4 and MN5 are given motion in the scenario. After the given interval the node starts moving and accordingly handoff occurs.

In the Figure 5.2, the output on the command line is shown. Whenever the mobile node attempts for a handoff the output is given to standard output. The access point from and access point to is also displayed. As the Fig 5.2 shows the real time movement of the node MN4, MN5 and MN3 triggered handoff between access point AP0 to access point AP9.

Chapter 6

Conclusion

6.1 Conclusion

The simulation provides details of Wi-Fi handoff. Based on the result, there is a visual representation of the Wi-Fi handoff. The first phase of the project simulates the Wi-Fi topology and mobile nodes. The two nodes are assigned to be Wi-Fi access points and rest all are assigned to be mobile nodes. Nodes movements invokes the handoff between the access points and trace file and NAM files are generated. The objective of simulating a Wi-Fi topology and demonstrating Handoff is achieved in this project.

6.2 Limitations of the work

The project demonstrates a simple Wi-Fi handoff scenario. There are some limitations to the work done in this project.

- Performance Analysis: This project does not implement any criteria for the performance analysis of the nodes. The nodes and access points used here are of same characteristics and performance analysis is a limit.
- LTE Integration: The project does not include any LTE (Long Term Evolution) modules. The LTE vertical handoff can be achieved in the future scope
- Power efficiency: The power efficiency of the nodes and access points are not considered in this project. In the current situation the power efficient nodes are essential and thorough study should be done on the issue.

6.3 Future scope of the project

The limitations of the project open doors to new extended study and research of the project.

- Performance Analysis: The project can be expanded with addition of performance analysis of each mobile node and access points. This will help in analyzing the nodes in details. The drawback of algorithms and other major details.
- LTE integration: This can improve the project reachability and will solve some of the challenges faced during vertical handoff. In the scenario of vertical handoff, there will be different technology adopted at each node. So the handoff not only deals with the signal transfer but also the technology stack exchange. This will be a big

challenge in the future work

- Power efficiency: The project can be extended with power usage considerations. The power usage at each node can be monitored and tuning to the algorithms and handoff can be achieved.

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