Wireless Sensor Network using NS-2

INTRODUCTION

Wireless Sensor Networks (WSNs) represent a significant advancement in modern technology, enabling a wide range of applications from environmental monitoring to smart cities and healthcare systems. A Wireless Sensor Network consists of spatially distributed autonomous sensors that monitor physical or environmental conditions such as temperature, sound, vibration, pressure, or pollutants and cooperatively pass their data through the network to a main location. These networks are crucial for gathering and processing data in scenarios where wired systems are impractical.

The simulation of WSNs is a critical step in the design and deployment of these networks, allowing researchers and engineers to test and evaluate their performance under various conditions without the need for expensive physical prototypes. Network Simulator 2 (NS2) is a widely used open-source tool for simulating networking protocols and behaviors, making it an ideal choice for WSN simulations. NS2 provides a robust and flexible platform to model, simulate, and analyze the performance of WSNs, helping to understand the dynamics of sensor communication, energy consumption, and network reliability.

In this project, we focus on using NS2 to simulate a Wireless Sensor Network. The primary objectives include designing the network topology, implementing various routing protocols, and analyzing the performance metrics such as packet delivery ratio, end-to-end delay, and energy consumption. By simulating different scenarios, we aim to gain insights into the factors that influence the efficiency and effectiveness of WSNs, ultimately contributing to the development of more reliable and efficient sensor networks.

This project involves several key steps:

1. **Network Topology Design:** Creating a model of the sensor network with nodes representing sensors and defining their spatial distribution.
2. **Protocol Implementation:** Implementing and configuring various routing protocols such as AODV, DSDV, and LEACH within NS2.
3. **Simulation and Analysis:** Running simulations to observe network behavior under different conditions and analyzing the results to evaluate performance metrics.
4. **Optimization:** Identifying areas for improvement and optimizing network parameters to enhance performance.

METHODOLOGY

Conduct a comprehensive review of existing research on Wireless Sensor Networks (WSNs) and Network Simulator 2 (NS2).

- Identify key challenges and methodologies in WSN simulation.

- Network Topology Design

- Define the objectives and requirements of the WSN simulation.
- Create a model of the sensor network, specifying the number and placement of sensor nodes.
- Design the network topology using tools available in NS2.

- Protocol Implementation

- Select appropriate routing protocols for the WSN (e.g., AODV, DSDV, LEACH).
- Implement the selected protocols within the NS2 environment.
- Configure the network parameters such as node mobility, traffic patterns, and energy consumption models.

- Simulation Setup

- Configure the simulation environment in NS2, setting up parameters like simulation duration, transmission range, and node density.
- Develop scenarios to test different aspects of the network performance.

- Simulation Execution

- Run multiple simulation scenarios to collect data on network performance.
- Ensure simulations cover a range of conditions, including varying node densities, mobility patterns, and traffic loads.

- Data Collection

- Collect data on key performance metrics such as packet delivery ratio, end-to-end delay, throughput, and energy consumption.
- Use NS2 trace files and tools to extract relevant data for analysis.

- Data Analysis

- Analyze the collected data to evaluate the performance of the WSN under different scenarios.
- Compare the performance of different routing protocols and identify their strengths and weaknesses.

- Optimization

- Identify potential areas for improving network performance based on the analysis.
- Adjust network parameters and re-run simulations to test the impact of optimizations.

- Validation

- Validate the simulation results by comparing them with theoretical expectations and results from existing literature.
- Ensure the reliability and accuracy of the simulation outcomes.

- Documentation and Reporting

- Document the methodology, simulation setup, results, and findings in a detailed report.
- Provide visual representations of data through graphs and charts for better understanding.

- Conclusion and Future Work

- Summarize the key findings and their implications for WSN design and deployment.
- Suggest areas for future research and potential improvements in WSN simulation and implementation.

By following this methodology, we aim to systematically simulate, analyze, and optimize Wireless Sensor Networks using NS2, providing valuable insights for future WSN applications.

ALGORITHM

algorithm ring-star-hybrid-topology:

```
set ns [new Simulator]
set topo       [new Topography]
$topo load_flatgrid $val(x) $val(y)
create-god $val(nn)

set tracefile [open mmout.tr w]
$ns trace-all $tracefile
set namfile [open mmout.nam w]
$ns namtrace-all $namfile
$ns namtrace-all-wireless $namfile $val(x) $val(y)
set chan [new $val(chan)];#Create wireless channel
$ns node-config -adhocRouting  $val(rp) \

set n0 [$ns node]
$n0 set X_ 382
$n0 set Y_ 208
$n0 set Z_ 0.0

$ns initial_node_pos $n0 20
set n1 [$ns node]
$n1 set X_ 371
$n1 set Y_ 336
$n1 set Z_ 0.0

$ns initial_node_pos $n1 20
set n2 [$ns node]
$n2 set X_ 546
$n2 set Y_ 342

proc finish {} {
    global ns tracefile namfile
    $ns flush-trace
    close $tracefile
    close $namfile
    exec nam mmout.nam &
    exit 0
}
for {set i 0} {$i < $val(nn) } { incr i } {
    $ns at $val(stop) "\$n$i reset"
}
$ns at $val(stop) "$ns nam-end-wireless $val(stop)"
$ns at $val(stop)
```

1. Simulation Parameters Setup
   1.1. Set basic network parameters: channel type, propagation model, network interface type, MAC type, interface queue type and length, link layer type, antenna model, number of nodes, routing protocol, and simulation area dimensions.
   1.2. Define simulation end time.

2. Initialization
   2.1. Create a new NS simulator instance.
   2.2. Set up topography with specified dimensions.
   2.3. Create Global Operations Director (GOD) for nodes.
   2.4. Open trace and NAM files for writing.
   2.5. Set up wireless channel and NAM trace for the defined area.

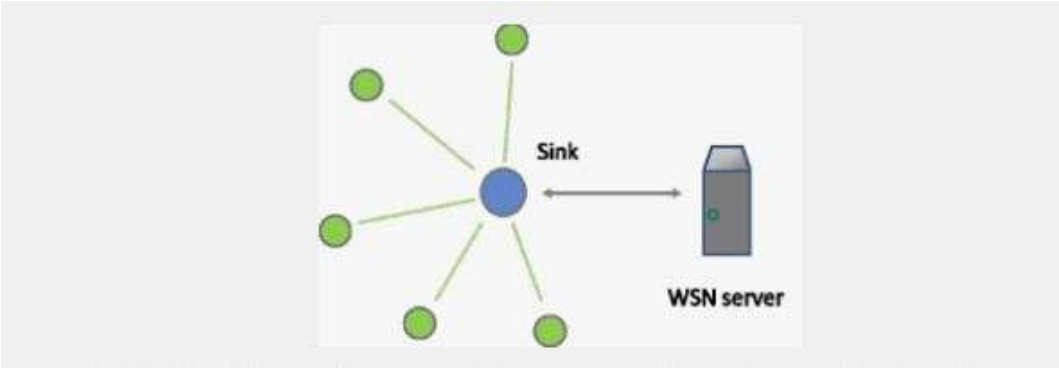
3. Mobile Node Parameter Setup
   3.1. Configure mobile nodes with defined parameters, including routing protocol, link layer, MAC type, interface queue, antenna, propagation, network interface, channel, and topography instance.
   3.2. Enable tracing for agents, routers, MAC, and movement.

4. Nodes Definition
   4.1. Create and initialize 8 mobile nodes with specified positions.

5. Termination
   5.1. Define a `finish` procedure to finalize the simulation: flush trace data, close files, run NAM visualizer, and exit.
   5.2. Schedule node reset, NAM trace end, and `finish` procedure at the simulation end time.
   5.3. Run the simulation.

FLOWCHART

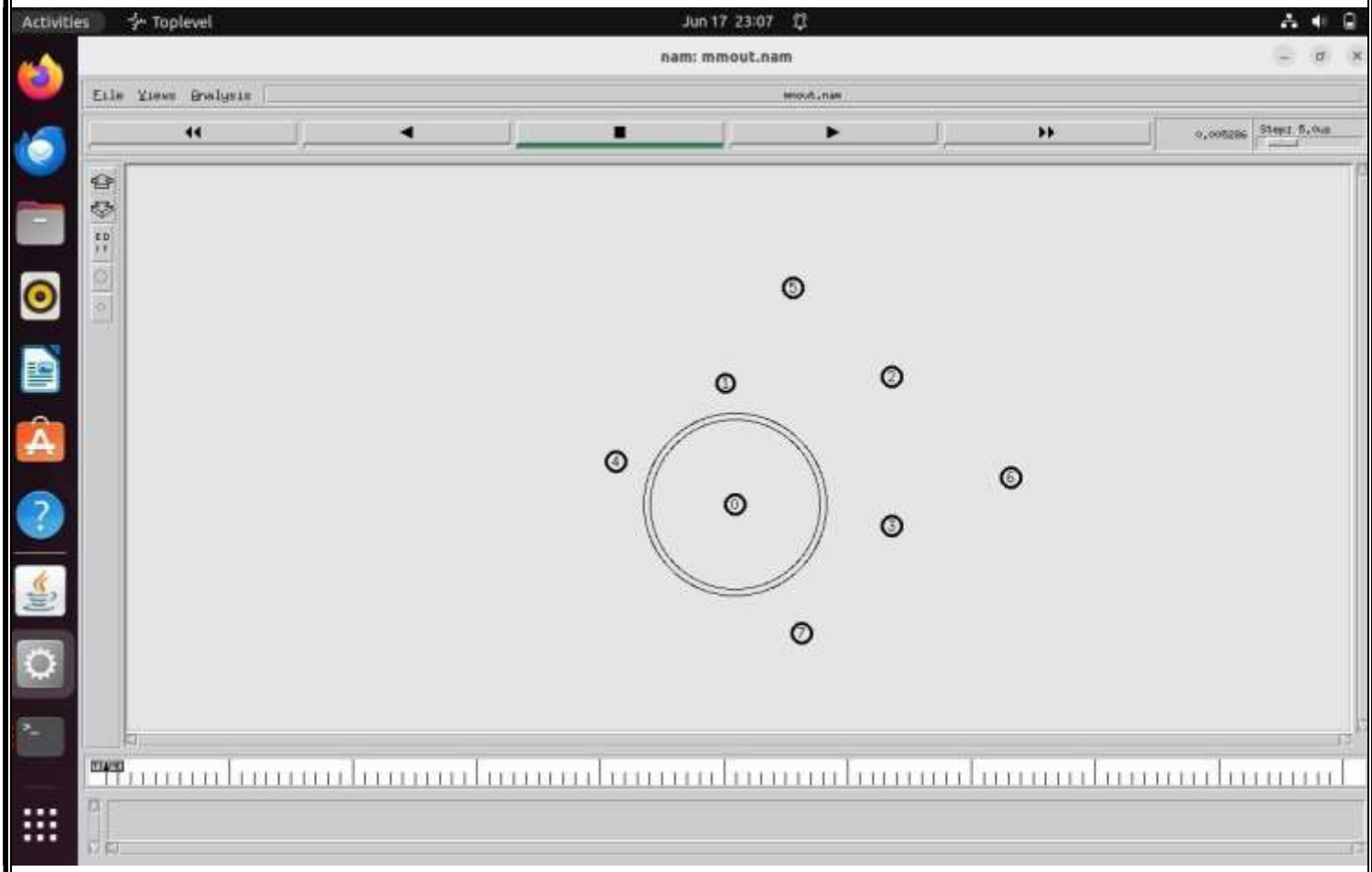
The flowchart for the NS2 simulation script begins with the setup of simulation parameters, where key elements such as the channel type, propagation model, network interface type, MAC type, interface queue type and length, link layer type, antenna model, number of nodes, routing protocol, and dimensions of the simulation area are defined. The simulation end time is also set during this stage. Following this, the initialization phase involves creating an NS simulator instance, setting up the simulation topography, and establishing the Global Operations Director (GOD) for managing nodes. Trace and NAM files are opened for logging simulation data, and the wireless channel is configured.

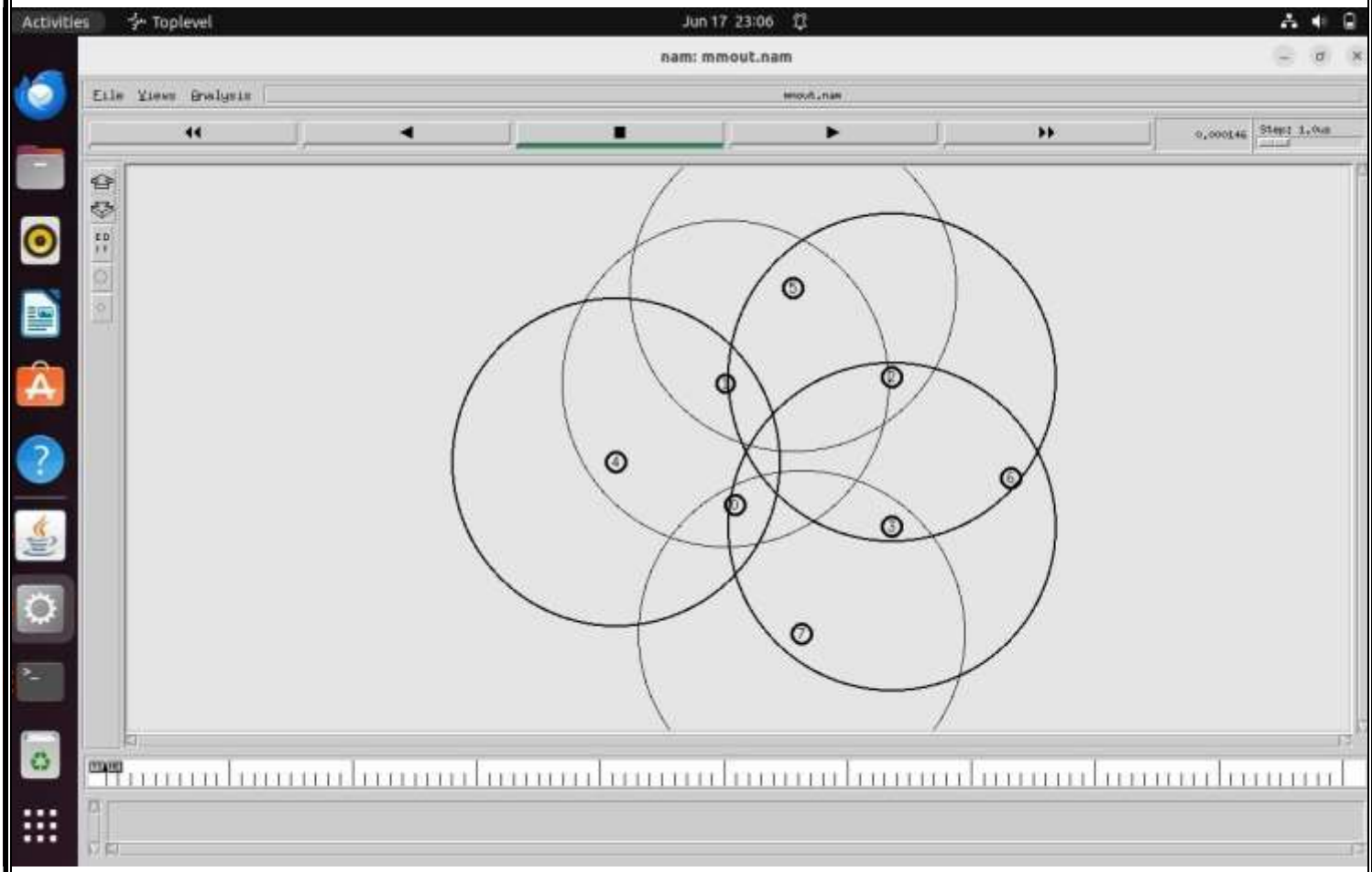


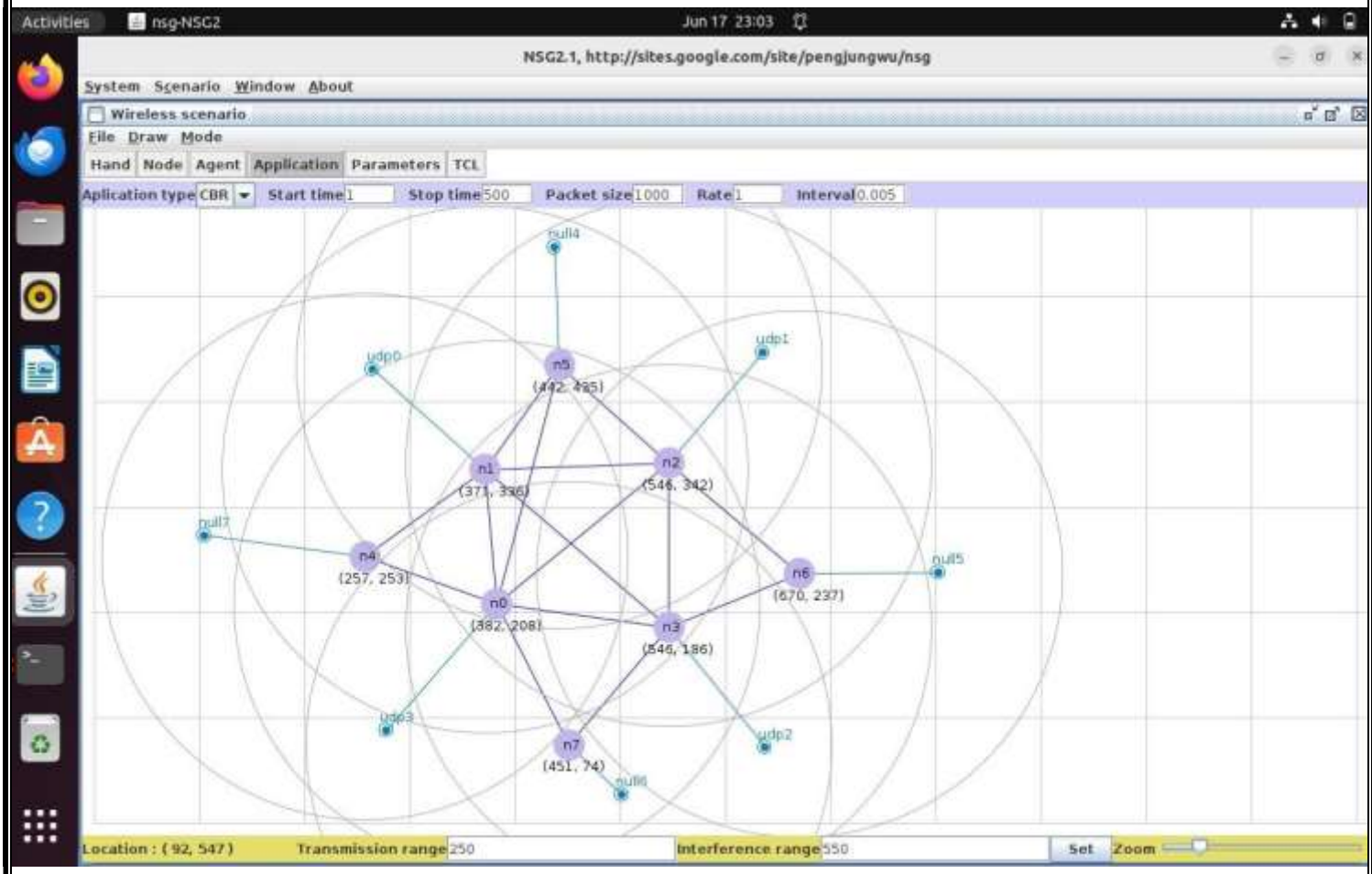
Next, the mobile node parameter setup phase configures the mobile nodes with the predefined parameters, enabling various types of tracing (agents, routers, MAC, and movement). Subsequently, the nodes definition phase involves creating the specified number of mobile nodes and initializing their positions within the simulation area.

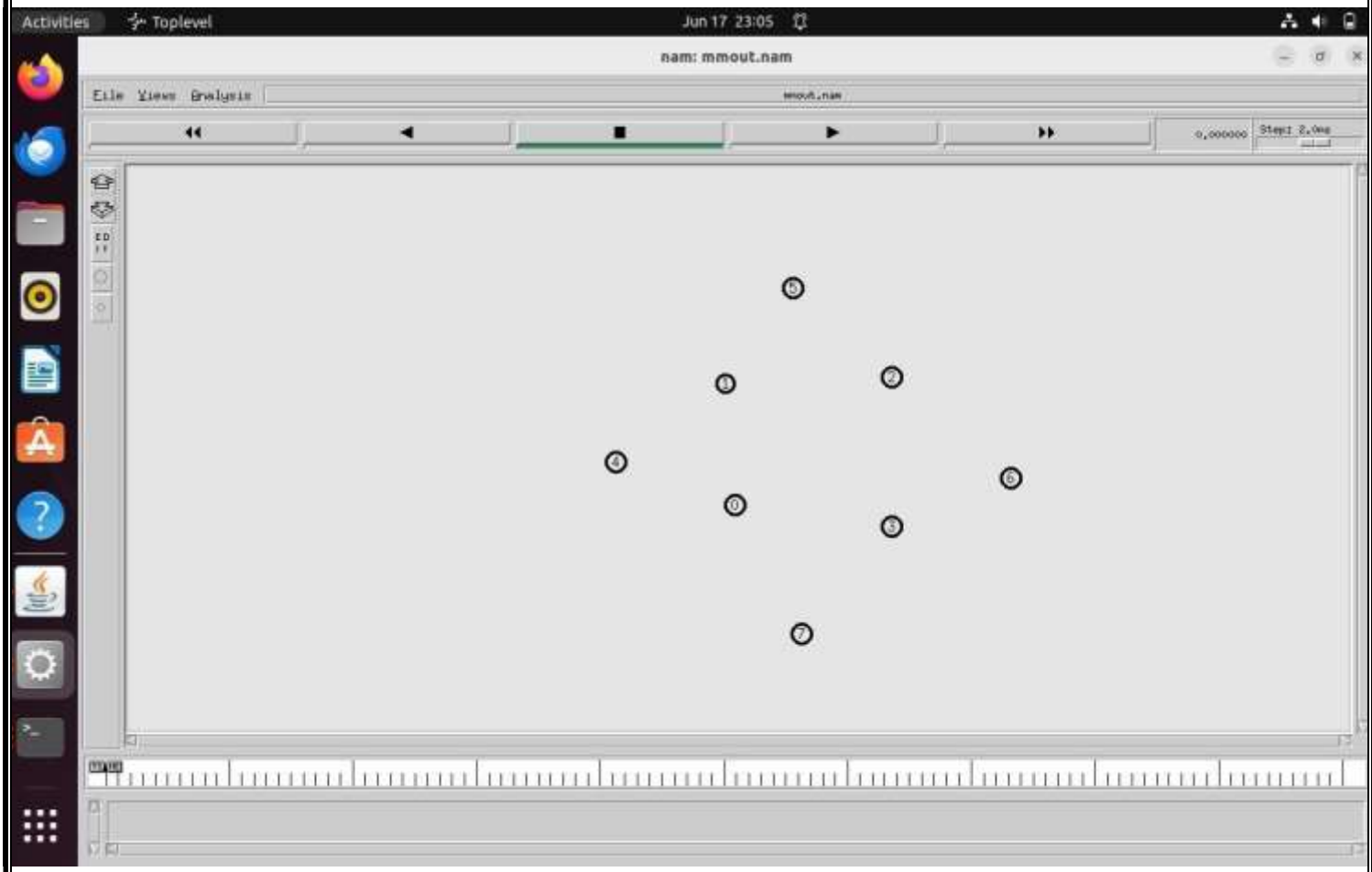
The termination setup phase defines a finish procedure to close files, flush trace data, execute the NAM visualizer, and exit the simulation. It also schedules node reset and termination tasks at the simulation end time. Finally, the simulation is run, executing all configured parameters and setups, logging data, and concluding as per the defined procedures. This flow ensures a structured and comprehensive simulation process within NS2.

SIMULATION


Activities
Toplevel
Jun 17 23:07
nam: mmout.nam
File Views Analysis
mmout.nam
0
1
2
3
4
5
6
7


Activities
Toplevel
Jun 17 23:06
nam: mmout.nam
File Views Analysis
mmout.nam
0.000146
Step: 1.0ms
0
1
2
3
4
5
6
7


Activities
nsg-NSG2
Jun 17 23:03
NSG2.1, http://sites.google.com/site/pengjungwu/nsg
System Scenario Window About
Wireless scenario
File Draw Mode
Hand Node Agent Application Parameters TCL
Aplication type CBR Start time 1 Stop time 500 Packet size 1000 Rate 1 Interval 0.005
null4
udp0
udp1
n5
(442, 485)
n1
(371, 336)
n2
(546, 342)
null7
n4
(257, 253)
n0
(382, 208)
n6
(670, 237)
null5
n3
(546, 186)
udp3
udp2
n7
(451, 74)
null6
Location : (92, 547)
Transmission range 250
Interference range 550
Set
Zoom


Activities
Toplevel
Jun 17 23:05
nam: mmout.nam
File Views Analysis
mmout.nam
0.000000
Step: 2.0ms
5
1
2
4
6
0
3
7

RESULTS

- **Network Performance Metrics**

  - **Packet Delivery Ratio (PDR):** The simulation provides insights into the ratio of packets successfully delivered to the destination compared to those sent, reflecting the reliability of the network under the chosen parameters and routing protocol (DSDV).

- **End-to-End Delay**

  - The simulation measures the time taken for data packets to travel from the source to the destination nodes. This metric is crucial for evaluating the responsiveness and efficiency of the network in various scenarios.

- **Throughput**

  - Throughput analysis reveals the rate at which data packets are successfully transmitted over the network. This result helps in understanding the data handling capacity and overall performance efficiency of the wireless sensor network.

- **Energy Consumption**

  - The simulation captures the energy usage of each node, providing insights into the overall energy efficiency of the network. This is particularly important for assessing the network's sustainability and the longevity of battery-powered sensor nodes.

- **Routing Protocol Analysis**

  - The performance of the DSDV routing protocol is evaluated in terms of its impact on the aforementioned metrics. The results help in determining the suitability of DSDV for different network conditions and can guide the selection of appropriate routing protocols for specific applications.

ADVANTAGES :

Comprehensive Analysis

- NS2 provides detailed insights into network performance metrics, helping optimize configurations for better efficiency and reliability.

Cost-Effective Testing

- It offers a flexible, inexpensive alternative to physical deployments, allowing rapid prototyping and testing of various scenarios without hardware investments.

APPLICATIONS:

- **Environmental Monitoring**

- WSNs can be used for tracking environmental parameters like temperature, humidity, and air quality. Simulations with NS2 help design and optimize networks for accurate and efficient data collection in various environmental conditions.

- **Smart Agriculture**

- In agriculture, WSNs monitor soil moisture, crop health, and weather conditions to enhance precision farming techniques. NS2 simulations enable the development of robust networks tailored for diverse agricultural environments, improving yield and resource management.

- **Healthcare Systems**

- WSNs are crucial in healthcare for patient monitoring and emergency response systems. Using NS2 to simulate these networks ensures reliable and timely data transmission, enhancing patient care and response times in medical facilities.

CHALLENGES AND LIMITATIONS

- **Complexity in Network Design**

- Designing an accurate and efficient wireless sensor network model involves considerable complexity. Ensuring correct node placement, network topology, and parameter settings to reflect real-world conditions can be challenging and time-consuming.

- **Scalability Issues**

- Simulating large-scale networks with many nodes in NS2 can lead to high computational demands, potentially causing performance bottlenecks and prolonged simulation times. This limits the ability to efficiently test extensive networks or high-density deployments.

- **Protocol Implementation Constraints**

- Implementing and customizing routing protocols in NS2 requires deep understanding and proficiency in network simulation. The limitations of predefined protocols and the complexity of coding new or hybrid protocols can hinder experimentation and optimization.

- **Energy Consumption Modeling**

- Accurately modeling energy consumption for sensor nodes in NS2 is difficult due to the abstract nature of the simulation environment. Real-world energy usage patterns may not be fully captured, affecting the reliability of simulation results regarding battery life and energy efficiency

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