

# MACHINE LEARNING BASED NETWORK MONITORING SYSTEM

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# ML – Based Network Monitoring System

## Revision History:

<i>Revision History</i>	<i>Date</i>	<i>Comments</i>
1.00	November 18, 2025	Draft SRS Document and submit it for review to supervisor and Co-Supervisors
2.00	November 19, 2025	Finalize the documents, make changes suggested by our Supervisors.

## Document Approval:

The following document has been accepted and approved by the following:

<i>Signature</i>	<i>Date</i>	<i>Name</i>
	November 19, 2025	Dr. Muhammad Zain Siddiqi
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## Disclaimer:

This document outlines the functional and non-functional requirements for the "Machine Learning-based Network Monitoring System" a Final Year Project (FYP) developed by the project team members: Muhammad Umar Maqsood, Shamina Durrani and Muhammad Younas, at the Ghulam Ishaq Khan Institute of Engineering Sciences and Technology.

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# **ML – Based Network Monitoring System**

## **1 INTRODUCTION**

The Machine Learning-based Network Monitoring System is a FYP being developed at the Ghulam Ishaq Khan Institute of Engineering Sciences and Technology (GIKI). Aims to provide real-time anomaly detection within a LAN to enhance network security and assist network administrators in identifying and responding to cyber threats.

The platform will serve as a prototype for advanced network intrusion detection, demonstrating the application of machine learning techniques to network traffic analysis for security purposes.

### **1.1. PURPOSE**

The purpose of this Software Requirements Specification (SRS) is to define the functional and non-functional requirements for the **Machine Learning-Based Network Monitoring System**. This system is a Final Year Project (FYP) designed to enhance network security by detecting anomalies in network traffic behavior. Unlike traditional signature-based systems, this project leverages machine learning to identify novel and polymorphic threats in real-time within a Local Area Network (LAN). This document serves as the roadmap for development, testing, and validation.

### **1.2. PRODUCT SCOPE**

The Machine Learning-based Network Monitoring System is a FYP being developed at the Ghulam Ishaq Khan Institute of Engineering Sciences and Technology (GIKI). The system aims to provide real-time anomaly detection within a LAN to enhance network security and assist network administrators in identifying and responding to cyber threats.

The platform will serve as a prototype for advanced network intrusion detection, demonstrating the application of machine learning techniques to network traffic analysis for security purposes.

**Table 1: Terms used in this document and their description**

Name	Description
SRS	(Software Requirements Specification). A document that describes the nature of a project, software or application.
ML-NMS	Machine Learning-Based Network Monitoring System.
ML	Machine Learning: algorithms that enable systems to learn from data.
SPAN	Switched Port Analyzer: a method to copy network

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	traffic to a monitoring device.
CLI	Command-Line Interface
RBAC	Role-Based Access Control
SRS	Software Requirement Specification
METADATA	High level data (e.g., packet size, flow duration etc) used for analysis, protecting privacy by ignoring payloads.
IDS	Intrusion Detection System
FYP	(Final Year Project). A substantial project undertaken by university students in their final year of study.
AI	(Artificial Intelligence). The simulation of human intelligence processes by machines, especially computer systems.
IPS	(Intrusion Prevention System). A network security device that monitors network and/or system activities for malicious or unwanted behavior and can react to block or prevent those activities.
PCAP	(Packet Capture Format). A file format for recording network traffic.
TLS	(Transport Layer Security). A cryptographic protocol designed to provide communications security over a computer network
FPR	(False Positive Rate). The proportion of actual negatives that are incorrectly identified as positives.
FNR	(False Negative Rate). The proportion of actual positives that are incorrectly identified as negatives.
TPR	(True Positive Rate). The proportion of actual positives that are correctly identified as positives.
TNR	(True Negative Rate). The proportion of actual negatives that are correctly identified as negatives.
IT	(Information Technology). The use of computers, storage, networking, and other physical devices, infrastructure, and processes to create, process, store, secure, and exchange all forms of electronic data.
SIEM	(Security Information and Event Management). A software solution that aggregates and analyzes security alerts and log data from various sources across an IT infrastructure.
LAN	(Local Area Network). A computer network that interconnects computers within a limited area such as a home, school, computer laboratory, or office building.
Client	In a network context, typically refers to a device (e.g., workstation, server, IoT device) that requests resources or services from another device (the server).
Server	A computer program or device that provides functionality or services for other programs or devices (clients) over a network.
SPAN	(Switched Port Analyzer). A feature on network switches

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	that allows traffic from one or more source ports to be copied and sent to a designated destination port for monitoring.
Mirror Port	A common alternative term for a SPAN port, used to describe the capability of duplicating network traffic to another port for analysis.
Data Collectors	Components (software agents or dedicated hardware) deployed within a network responsible for gathering various types of telemetry data (e.g., metrics, logs, network flows) for monitoring and analysis.
Telemetry Data	Data collected from various sources (e.g., network devices, servers, applications) that provides information about the performance, health, and activity of a system.
MFA	(Multi-Factor Authentication). An authentication method that requires users to provide two or more verification factors to gain access to a resource.
OAuth	(Open Authorization). An open standard for access delegation, commonly used as a way for Internet users to grant websites or applications access to their information on other websites without giving them their passwords.
METADATA	High-level descriptive information about network traffic (e.g., packet size, timestamps, source/destination IPs, ports)
FLOW	A unidirectional sequence of packets sharing common attributes such as IP addresses, ports, and protocol
FEATURE VECTOR	A structured representation of extracted attributes used as input for ML models
SUPERVISED LEARNING	ML approach using labeled data to train classification algorithms
UNSUPERVISED LEARNING	ML approach used to identify patterns or anomalies in unlabeled data
ANOMALY DETECTION	ML-based identification of unusual patterns or deviations from normal traffic behavior
ALERT	A system generated notification indicating detected anomalous or suspicious activity
JSON	(JavaScript Object Notation). A lightweight data-interchange format that is easy for humans to read and write and easy for machines to parse and generate.
REAL-TIME PROCESSING	Data analysis and detection performed with minimal latency
IT Teams	Information Technology teams (which could be internal to an SMB or a managed service provider supporting SMBs)
DATASET	A structured collection of network samples used for training and testing ML models
MODEL DRIFT	Degradation of ML performance when input data characteristics change over time
CLASS IMBALANCE	Unequal representation of classes within the dataset
PREPROCESSING	Transformation steps applied to raw data before model

# ML – Based Network Monitoring System

training

## 1.1.1 Document Conventions

Table 2: Conventional terms used in this document and their description

Term	Description
<b>SHALL</b>	Referring to a mandatory requirement that must be fulfilled as part of the core project scope for this Final Year Project. This feature is essential for the system's successful completion.
<b>SHOULD</b>	Indicates a desirable requirement that, if feasible, ought to be implemented to enhance the system. It is a high-priority consideration for inclusion.
<b>MAY</b>	Refers to an optional requirement that could be considered for future enhancements or if time and resources permit beyond the core scope. The developer is encouraged to consider this requirement generally.
<b>TBD</b>	To Be Determined, indicates information that is not yet available but will be provided in future iterations or updates of this document.
<b>Note</b>	Provides additional information or clarification relevant to the preceding text.

Requirements are categorized as follows:

Table 3: Conventional terms used in this document

Requirement Number	Description
<b>FR-XX</b>	Functional Requirements
<b>NFR-XX</b>	Non-Functional Requirements
<b>UC-XX</b>	Use Case

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## 2 OVERVIEW

### 2.1 THE OVERALL DESCRIPTION

The Machine Learning-Based Network Monitoring System is a standalone security solution designed to address the limitations of traditional signature-based IDSs. As we outlined in our project scope (FYP-Presentation -1), traditional systems often struggle with **unknown attack patterns** and high-volume traffic. This system employs behavioral analysis and machine learning algorithms to identify irregular patterns in real-time.

The system captures network packets, extracts flow-based features, and compares them against a dynamic baseline. If the "anomaly score" exceeds a threshold, the system alerts the network administrator. The primary goal is to provide a scalable, adaptive system that enhances security in high-traffic environments while minimizing false positives.

### 2.2 PRODUCT PERSPECTIVE

The system operates as an independent monitoring node within a LAN. It interfaces with:

- **Network Infrastructure:** Captures traffic via a Switched Port Analyzer (SPAN/Mirror) port or a direct network interface.
- **System Administrator:** Interacts with the system via a Web Dashboard and Command Line Interface (CLI) to view alerts and configure settings.
- **Local Storage:** Stores trained ML models, traffic feature datasets, and anomaly logs.

### 2.2. PRODUCT FUNCTIONS

To ensure the project is achievable within the FYP timeline, the system focuses on these 7 core functions:

1. **Network Traffic Capture:** Real-time ingestion of packets from a designated LAN interface.
2. **Feature Extraction:** Processing raw packet data into ML-ready metadata (e.g., packet size, timestamp, protocol) to reduce dimensionality.
3. **ML Anomaly Detection:** Using unsupervised learning algorithms to detect novel threats and assign anomaly scores.
4. **Basic Data Storage:** Persisting extracted features and anomaly logs in a structured database.
5. **Alerting Mechanism:** Generating email and dashboard notifications for high-severity anomalies.
6. **Web Dashboard:** A visualization interface for monitoring "Network Health" and viewing active incidents.
7. **User Management & RBAC:** Secure authentication with "Administrator" and "Observer" roles.

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### 2.3. USER CHARACTERISTICS

- **Network Administrator:** Technical user responsible for setting up the capture interface, managing ML models, and investigating alerts.
- **Observer:** Non-technical or junior staff who view the dashboard for status updates but cannot modify configurations.

### 2.3. CONSTRAINTS

- **Timeframe:** Core development must be completed within 2-3 months (Simplified Scope).
- **Computational Resources:** Must run on standard commodity hardware (e.g., a high-spec laptop or standard server).
- **Privacy:** Analysis is performed strictly on metadata; packet payloads are not inspected or stored.
- **Connectivity:** The system requires a specific network configuration (e.g., Port Mirroring) to see LAN traffic.

### 2.4. ASSUMPTIONS AND DEPENDENCIES

- **Assumption:** The network switch/router supports SPAN or Port Mirroring.
- **Assumption:** A dataset of "normal" network traffic is available or can be captured to train the initial baseline.
- **Dependency:** Availability of Python libraries (Scikit-learn, Pandas) and stable network drivers for packet capture.

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## 3 STATE OF THE ART

### • LITERATURE REVIEW

The project builds upon research into ML-based intrusion detection.

- *Sommer & Paxson (2010)* highlighted the challenges of applying ML to network intrusion detection, emphasizing the need for generalization.
- *Ahmad et al. (2021)* reviewed ML/DL techniques, confirming their potential for encrypted traffic analysis.
- *J. Dromard et al. (2018)* demonstrated the efficacy of unsupervised learning (Autoencoders) for online attack detection.

### • EXISTING SYSTEMS

The following table outlines well-known commercial platforms that utilize machine learning for network anomaly detection, security event monitoring, and intelligent alerting. These systems represent the current methodology in the industry that validates the approach taken by this project.

Table 4: Existing Systems

System Name	Key Features & Methodology
1. Darktrace	Uses AI and machine learning for real-time network threat detection and autonomous response. It learns the "pattern of life" of devices and users, identifying anomalous behavior and security breaches without relying only on signatures. It provides continuous learning and adapts to network changes automatically.
2. Dynatrace	Employs the "Davis" AI engine for root cause analysis, anomaly detection, and predictive insights. It discovers application, service, and infrastructure dependencies automatically, mapping network topology in real-time. It forecasts performance issues and can auto-remediate common problems using ML.
3. LogicMonitor	Uses machine learning to reduce false positives and alert noise. It forecasts resource utilization, adjusts monitoring thresholds based on historical data, and detects anomalies before they escalate into critical failures.
4. Juniper Mist AI & Marvis	Automates network troubleshooting, detecting anomalies and root causes using ML. It provides natural language chatbot support to answer network questions and simulate user connections to preemptively identify problems.

## 4 USER/SYSTEM REQUIREMENTS

### 4.1 External Interface Requirements

#### 4.1.1 User Interfaces

- **Web Dashboard:** A clean, responsive interface displaying a list of recent anomalies, a traffic volume graph, and system status.
- **CLI:** A terminal-based interface for initial configuration (e.g., selecting the network interface).

#### 4.1.2 Hardware Interfaces

- **Network Interface Card (NIC):** Must support promiscuous mode for packet capture.
- **Storage:** Minimum 256GB SSD recommended for efficient database read/write operations.

#### 4.1.3 Software Interfaces

- **Backend Framework:** Python (Flask or Django).
- **Frontend Framework:** HTML, CSS, JavaScript/ React, Vue.js, and Angular
- **ML Engine:** Scikit-learn / ML Algorithms.
- **Database:** SQLite (for prototype) or PostgreSQL.

#### 4.1.4 Communication Interfaces

- **HTTP/HTTPS:** For accessing the Web Dashboard.
- **SMTP:** For sending email alerts to administrators.

## 5 Functional Requirements

This section details the functional requirements of the ML-Based Network Monitoring System, organized by major system features. Each requirement is identified with a unique ID (FR-XX) for traceability and reference.

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## 5.1 Functional Requirements with Traceability information

### 5.1.1 Feature 1: Network Traffic Capture & Processing

Core Capability to ingest and parse raw network data.

Table 5: First FR OF Feature 1.

Requirement ID	FR-01		Requirement Type		Functional		Use Case #		UC-01						
Status	New		Agreed-to	-	Baselined	-	Rejected	-							
Parent Requirement #	N/A														
Description	The system <b>SHALL</b> captures real-time network packets from a designated Local Area Network (LAN) interface.														
Rationale	Without packet capture, the system has no data to analyze for security monitoring.														
Source	Project Scope			Source Document		SRS									
Acceptance/Fit Criteria	The system successfully binds to the network interface and begins ingesting packets without errors														
Dependencies	N/A														
Priority	Essential		Conditional	-	Optional	-									
Change History	v1.0														

Table 6: FR-02 OF Feature 1

Requirement ID	FR-02		Requirement Type		Functional		Use Case #		UC-01
Status	New		Agreed-to	-	Baselined	-	Rejected	-	
Parent Requirement #	FR-01								
Description	The system <b>SHALL</b> support "Promiscuous Mode" on the network interface card to capture all traffic on the segment, not just traffic addressed to the host.								
Rationale	Essential for an IDS to monitor the entire network segment, not just the monitoring device itself.								
Source	Technical Requirement			Source Document		SRS			

# ML – Based Network Monitoring System

Table 7: FR-03 OF Feature 1

**Table 8: FR-04 OF Feature 1**

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### 5.1.2 Feature 2: ML Anomaly Detection Engine

The brain of the system using ML Algorithms

Table 9: FR-05 OF Feature 2

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**Table 10: FR-06 OF Feature 2**

**Table 11: FR-07 OF Feature 2**

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<b>Priority</b>	<i>Essential</i>		<i>Conditional</i>	-	<i>Optional</i>	-	
<b>Change History</b>	v1.0						

**Table 12: FR-08 OF Feature 3**

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### 5.1.3 Feature 3: Data Storage & Management

Persistence layer for logs and training data.

Table 13: FR-09 OF Feature 3

Requirement ID	FR-09		Requirement Type		Functional		Use Case #		UC-03						
Status	New		Agreed-to	-	Baselined	-	Rejected	-							
Parent Requirement #	N/A														
Description	The system SHALL maintain a structured local database (e.g., SQLite/PostgreSQL) to store system data.														
Rationale	Data persistence is required for reporting and historical analysis.														
Source	System Design			Source Document		SRS									
Acceptance/Fit Criteria	Database file is created and accessible by the application. Database file is created and accessible by the application.														
Dependencies	N/A														
Priority	Essential		Conditional	-	Optional	-									
Change History	v1.0														

Table 14: FR-10 OF Feature 3

Requirement ID	FR-10		Requirement Type		Functional		Use Case #		UC-03
Status	New		Agreed-to	-	Baselined	-	Rejected	-	
Parent Requirement #	FR-04								
Description	The system SHALL store detailed records of all detected anomalies (Time, IP, Score) in a dedicated "Incidents" table.								
Rationale	Ensures a permanent record of security threats for the administrator to review later.								
Source	Project Scope			Source Document		SRS			

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Acceptance/Fit Criteria	"Anomalous" records are successfully written to the Incidents table.
Dependencies	FR-08, FR-09
Priority	<i>Essential</i> <input type="checkbox"/> <i>Conditional</i> - <i>Optional</i> -
Change History	v1.0

### **5.1.4 Feature 4: Alert Mechanism**

**Table 15: FR-11 OF Feature 4**

Table 16: FR-12 OF Feature 4

<b>Requirement ID</b>	FR-12	<b>Requirement Type</b>	Functional	<b>Use Case #</b>	UC-04
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# ML – Based Network Monitoring System

### 5.1.5 Feature 5: Web Dashboard & Visualization

## User (Administrator) interface for monitoring.

**Table 17: FR-13 OF Feature 5**

# ML – Based Network Monitoring System

Priority	<i>Essential</i>		<i>Conditional</i>	-	<i>Optional</i>	-	
<b>Change History</b>	v1.0						

**Table 18: FR-14 OF Feature 5**

### 5.1.6 Feature 6: User Management & RBAC

Security and Access Control.

Table 19: FR-15 OF Feature 6

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<b>Rationale</b>	Prevents unauthorized personnel from viewing sensitive network security data.									
<b>Source</b>	Security Requirement			<b>Source Document</b>	SRS					
<b>Acceptance/Fit Criteria</b>	Unauthenticated access redirects to a login page.									
<b>Dependencies</b>	N/A									
<b>Priority</b>	<i>Essential</i>		<i>Conditional</i>	-	<i>Optional</i>	-				
<b>Change History</b>	v1.0									

Table 20: FR-16 OF Feature 6

<b>Requirement ID</b>	FR-16		<b>Requirement Type</b>	Functional		<b>Use Case #</b>	UC-07					
<b>Status</b>	New		Agreed-to	-	Baselined	-	Rejected	-				
<b>Parent Requirement #</b>	FR-15											
<b>Description</b>	The system SHALL implement Role-Based Access Control (RBAC) supporting 'Administrator' and 'Observer' roles.											
<b>Rationale</b>	Different users require different levels of access (Full Control vs Read-Only).											
<b>Source</b>	Project Scope			<b>Source Document</b>	SRS							
<b>Acceptance/Fit Criteria</b>	Users are assigned a specific role upon account creation.											
<b>Dependencies</b>	FR-15											
<b>Priority</b>	<i>Essential</i>		<i>Conditional</i>	-	<i>Optional</i>	-						
<b>Change History</b>	v1.0											

Table 21: FR-17 OF Feature 6

<b>Requirement ID</b>	FR-17		<b>Requirement Type</b>	Functional		<b>Use Case #</b>	UC-07	
<b>Status</b>	New		Agreed-to	-	Baselined	-	Rejected	-

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<b>Parent Requirement #</b>	FR-16										
<b>Description</b>	The system SHALL hide configuration settings and user management options from users with the 'Observer' role.										
<b>Rationale</b>	Enforces the principle of least privilege; observers should not change system settings.										
<b>Source</b>	Security Requirement		<b>Source Document</b>	SRS							
<b>Acceptance/Fit Criteria</b>	"Settings" menu is invisible or disabled for Observer accounts.										
<b>Dependencies</b>	FR-16										
<b>Priority</b>	<i>Essential</i>		<i>Conditional</i>	-	<i>Optional</i>	-					
<b>Change History</b>	v1.0										

## 6 Nonfunctional Requirements & Software System Attributes

### 6.1 Performance Requirements

- **NFR-01:** Real-time anomaly scoring must complete within minimum time of data ingestion to ensure timely detection.
- **NFR-02:** Dashboard page load times should be minimum under normal load conditions.

### 6.2 Security Requirements

- **NFR-04:** All user passwords must be hashed before storage in the database.
- **NFR-05:** Access to the web dashboard must require valid authentication.
- **NFR-06:** Input validation must be implemented to prevent injection attacks.

### 6.3 Reliability

- **NFR-07:** The system should handle unexpected input data (e.g., malformed packets) gracefully without crashing.
- **NFR-08:** The system must automatically attempt to reconnect to the database if the connection is lost.

## 7 Project Design/Architecture

- 4+1 ARCHITECTURE VIEW MODEL (mandatory for Software Projects)
  - Use Case View

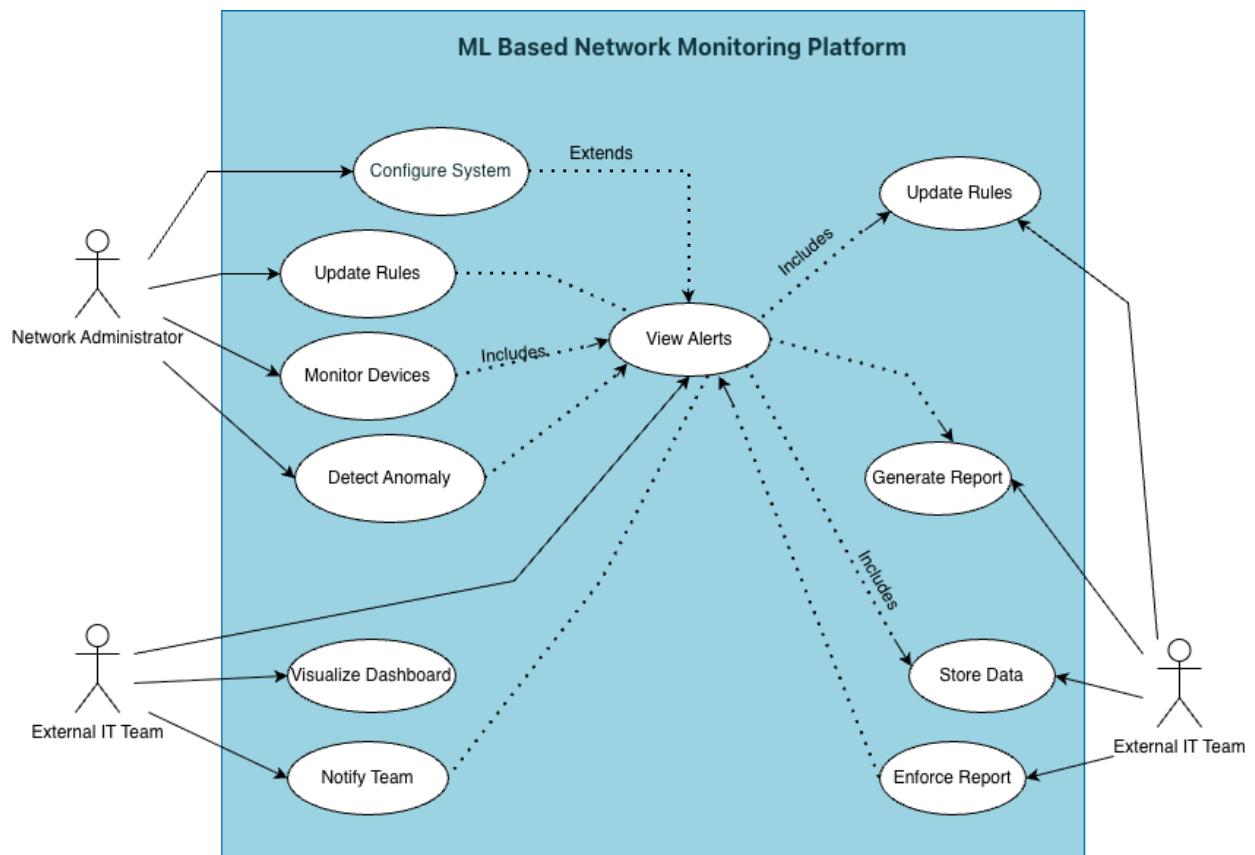


Figure 1: Use Case Diagram

## ML – Based Network Monitoring System

- Data Flow Diagram:

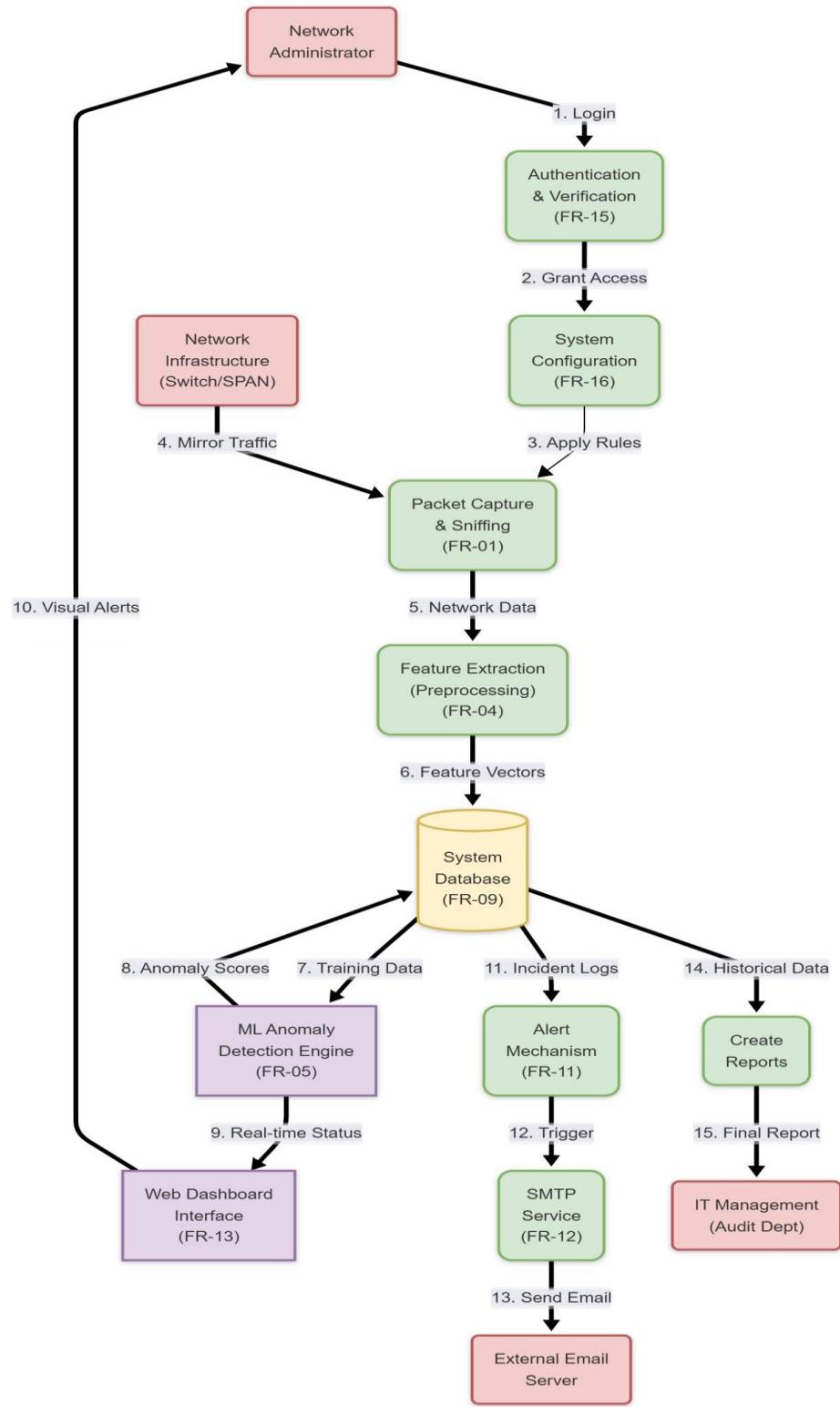


Figure 2: Data Flow Diagram

# ML – Based Network Monitoring System

- Development View

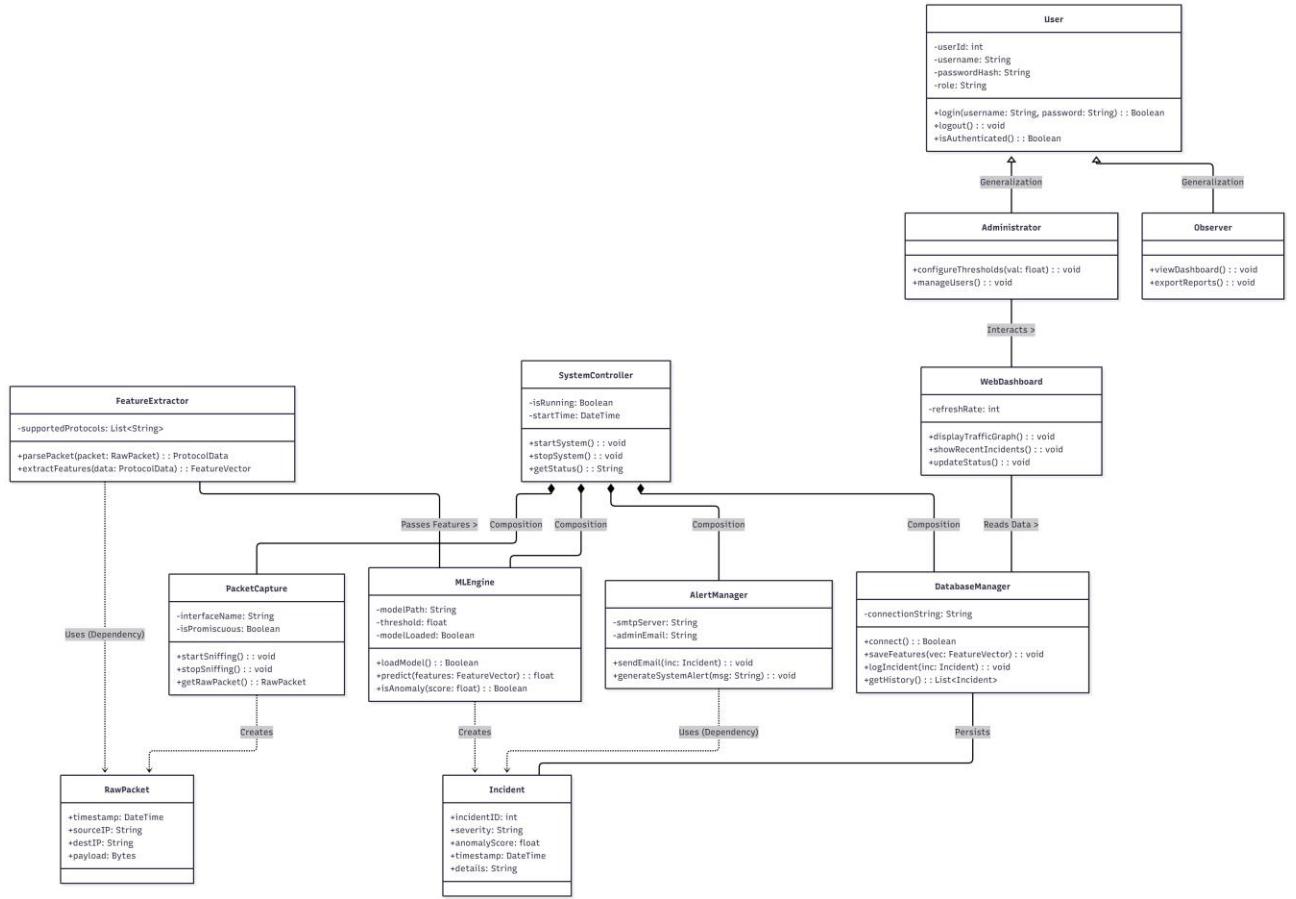


Figure 3: Development View Diagram

# ML – Based Network Monitoring System

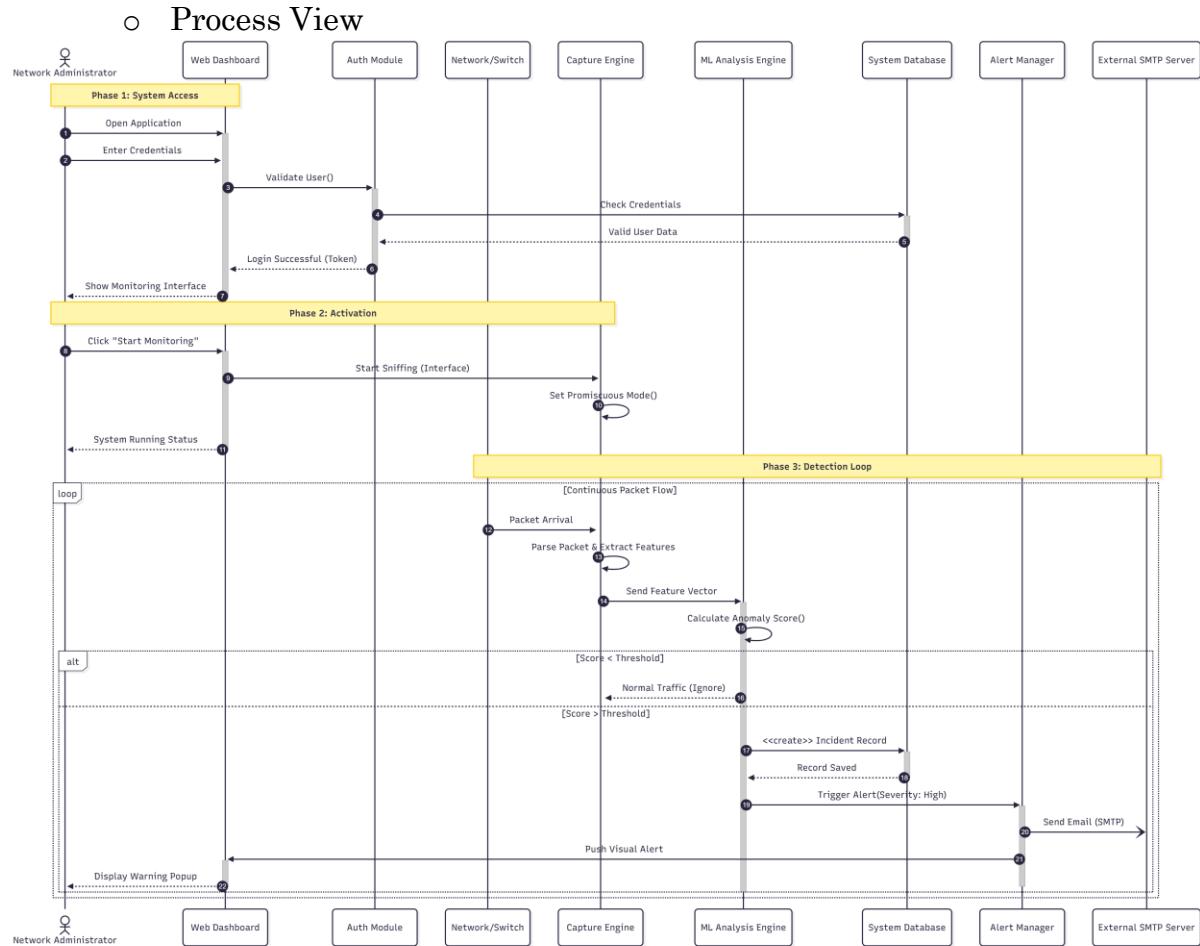


Figure 4: Process View Diagram

## ML – Based Network Monitoring System

- User Interface Design

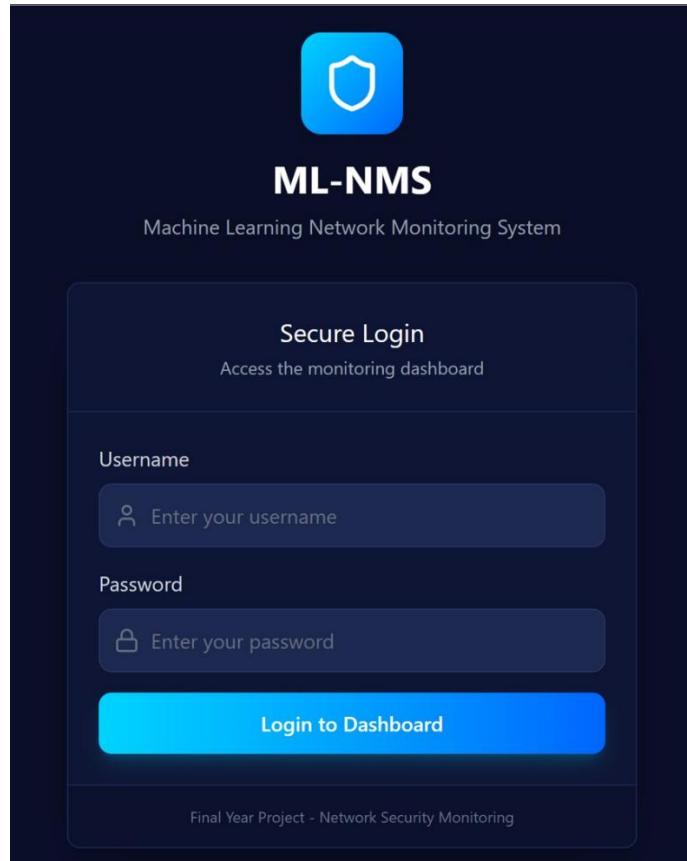


Figure 5: Dashboard Login Interface

## ML – Based Network Monitoring System

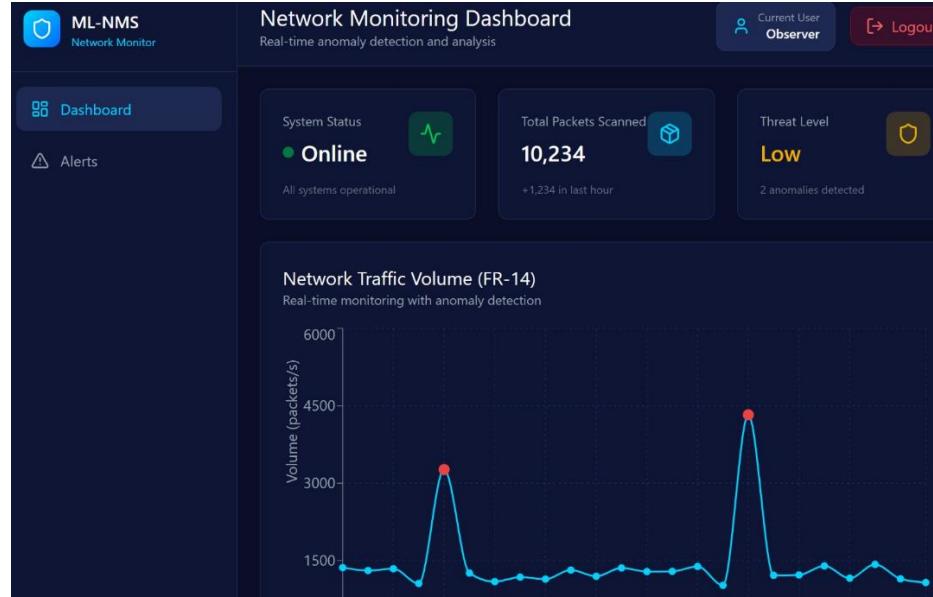


Figure 6: ML-NMS Dashboard Interface

Recent Network Incidents (FR-10)						
Anomaly detection alerts and events						
Timestamp	Source IP	Destination IP	Protocol	Anomaly Score	Severity	
2025-11-19 10:00:23	192.168.1.50	8.8.8.8	TCP	0.95	Critical	
2025-11-19 09:45:12	10.0.0.15	1.1.1.1	UDP	0.87	Critical	
2025-11-19 09:30:45	192.168.1.100	192.168.1.1	TCP	0.45	Medium	
2025-11-19 09:15:33	172.16.0.50	185.125.190.36	ICMP	0.23	Medium	
2025-11-19 09:00:18	192.168.1.75	208.67.222.222	UDP	0.12	Low	
2025-11-19 08:45:05	10.0.0.25	216.58.214.206	TCP	-0.15	Low	

Figure 7: ML -NMS Recent Incident Interface