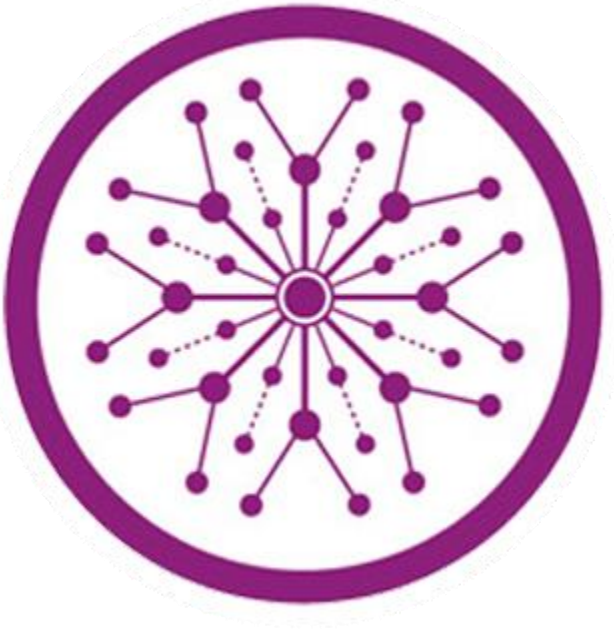
Proactive threat detection Honeypot

Final Year Project

Session 2021-2024

A project submitted in partial fulfillment of the degree of

BS in Cyber Security



Department of Information Technology

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Design and Implementation of real time honeypot

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Dedication

This project is dedicated to everyone who helped, especially to my respected project supervisor, Dr. Gohar Irfan, for his patience and wise counsel. Warmest gratitude to my encouraging parents, friends, and everyone else who helped me along the way.

Acknowledgements

I am sincerely grateful to all those who have contributed to the successful completion of my final year project. Foremost, I would like to express my deepest appreciation to my project supervisor, Sir Nasser Ahmed, whose expertise, understanding, and patience added considerably to my experience. His willingness to give his time so generously has been very much appreciated. I am also thankful for the support provided by the faculty and technical staff in the BSIT department, whose insights and assistance proved invaluable throughout this project. Additionally, I owe a heartfelt thank you to my peers and friends who provided feedback and moral support when it was most needed. Finally, my family deserves my deepest gratitude; their endless encouragement and unwavering faith in my abilities have been a constant source of strength. This project would not have been possible without the collective support and encouragement of all mentioned, for which I am eternally grateful.

Executive Summary

This project, titled "Design and Implementation of a Real-Time Honeypot System for the Detection and Prevention of Systems Attacks," aims to enhance cybersecurity by deploying an advanced honeypot system. Developed by IT students at The Superior University Lahore, it seeks to proactively detect and analyze cyber threats, mitigating risks to actual systems. With cyber-attacks becoming increasingly sophisticated, traditional security measures often fall short. Honeypots serve as decoys to attract attackers, allowing security experts to study their methods without jeopardizing real systems.

Key objectives include utilizing open-source technologies to create a cost-effective honeypot solution, analyzing attack patterns, and devising counter-strategies. The project's unique approach lies in its scalability and customization, catering to diverse organizational needs with low, medium, and high-interaction honeypots. Implementation follows an incremental model with stages like planning, design, risk assessment, and integration of monitoring tools.

By capturing and analyzing network traffic, the system offers real-time threat detection and prevention, providing a valuable tool to protect critical information systems.

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Chapter 1

Introduction

Chapter 1: Introduction

A honeypot is a security system that acts as a decoy to attract and analyze cyber threats. It is strategically positioned alongside production systems and mimics real environments by running similar processes and containing dummy files that appear relevant to attackers. Over the past three decades, cyber-attacks have surged in frequency and sophistication, with ransomware alone affecting victims every 11 seconds. This highlights the need for advanced defense mechanisms. Our honeypot project leverages open-source technologies to simulate vulnerable environments, engaging attackers to study their techniques, identify threats, and protect real systems without risking actual data.

1.1. Motivations and Challenges

The development of the honeypot system is motivated by a profound commitment to improving system security from internet threats designed to deceive and trap attackers by masquerading as vulnerable systems. The goal is to strengthen the system by threat detection and prevention, intelligence gathering, and reducing false positives. Challenges of using the honeypots may result in a risk of misuse, legal and ethical issues, maintenance and complexity, and resource intensity.

1.2. Goals and Objectives

The goals of this experiment include:

1) utilizing free and open-source technologies and techniques to minimize manual efforts required for updating and maintaining a high-interaction honeypot system designed for academic research.

2) identifying attack patterns on services and developing strategies to counteract these attacks.

1.3. Literature Review/Existing Solutions

A literature review of honeypot reveals a comprehensive landscape of existing solutions, highlighting both advancements and challenges relating honeypot existing solutions.

1. Stockman, Rein, & Heile (2015) conducted a 25-day study using an open-source honeynet system to examine the impact of system banner messages on hackers. The research collected data from nearly 200,000 events.

2. According to Stockman et al. (2015), out of 510 instances where logins were enabled through password spoofing, 280 received a warning banner while 230 did not receive any banner. The average duration of login attempts for those who saw the warning banner was 15.29 seconds, compared to 23.45 seconds for those who did not see any banner. The median duration was 9 seconds for users who received the banner and 11 seconds for those who did not. Furthermore, the intruders performed minimal actions once logged in, as the system recorded only a few commands. The researchers noted that the study's restriction against logging in as root may have reduced the level of activity observed.

3. Stockman et al.'s (2015) research involved manual setup of the honeynet. However, this study investigated methods to create more appealing targets for hackers by presenting services like web or database servers as valuable resources, thereby enticing attackers.

4. Döring (2005) suggested five distinct test scenarios for deploying honeypots in various environments, each with unique characteristics. His research indicated that the frequency of attacks in a secured environment tends to be lower compared to an unprotected one, as it ideally should be. Consequently, any subsequent analysis must emphasize the differences in the environments when comparing outcomes.

1.4. Gap Analysis

Since our project is made from opensource resource therefore it will be much cheaper than the existing competition, we expect security experts and organization to jump on board quickly. However, because there will be a significant price difference between our software and the other software, some organizations may be skeptical about the quality of the software, so to resolve this, we may need to adjust our prices to match the existing software.

1.5. Proposed Solution

This solution is quite simple, but it will necessitate the cooperation of the organizations and individuals where the software will be implemented. Because this is the IT industry, each client will have different requirements, so generalized software will not work, so all expected clients will be given a list of options from which to choose. For example: low interaction honeypots, high-interaction honeypots and decoy database. Each has different capabilities and works on different parameters.

1.6. Project Plan

Our plan for executing the project was based on an incremental model, which involves a step-by-step development process. Initially phase is planning phase a well-planned project gets swiftly done, taking in view all the possible scenarios and problem that may arise during development. Planning phase includes Identify Objectives, Determine Honeypot Type, Risk Assessment, Project Timeline Establishment. Second phase is Designing phase which includes Architectural Design, Selecting Technologies, Protocol Simulation Plan, Develop Interaction Scripts, Set up Virtual Environment. Third phase is implementation which include Develop Interaction Scripts, setting up Virtual Environment and Integrate Detection Mechanisms. Fourth phase is deployment phase having sub phase which are final setup in production, monitoring tools integration, documentation and ongoing maintenance plan

1.6.1. Work Breakdown Structure

1.6.2. Roles & Responsibility Matrix

WBS	WBS Deliverable	Activity #	Activity to Complete the Deliverable	Responsibility of a team member
1	Planning	1.1	Identify Objectives	All of us
1	Planning	1.2	Determine Honeypot Type	All of us
1	Planning	1.3	Risk Assessment	All of us
1	Planning	1.4	Project Timeline Establishment	All of us
2	Design	2.1	Architectural Design	All of us
2	Design	2.2	Select Technologies	All of us
2	Design	2.3	Protocol Simulation Plan	All of us
3	Implementation	3.1	Develop Interaction Scripts	All of us
3	Implementation	3.2	Set up Virtual Environment	All of us
3	Implementation	3.3	Integrate Detection Mechanisms	All of us
4	Testing	4.1	Unit Testing	All of us
4	Testing	4.2	System Testing	All of us
4	Testing	4.3	Security Testing	All of us
4	Testing	4.4	Performance Testing	All of us
5	Deployment	5.1	Final Setup in Production	All of us
5	Deployment	5.2	Monitoring Tools Integration	All of us
5	Deployment	5.3	Documentation	All of us
5	Deployment	5.4	Ongoing Maintenance Plan	All of us

1.6.3. Gantt Chart

	Jan 2024	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec 2024
Planning												
Designing												
Implementation												
Testing												
Validation												
evolution												

The provided Gantt chart outlines the timeline for a project in 2024, broken down into different phases: Planning, Designing, Implementation, Testing, Validation, and Evolution. Here is a detailed explanation of each phase and its duration:

1. Planning Duration: January 2024 Explanation: This is the initial phase where the project goals, requirements, and milestones are established. Activities might include defining the project scope, setting objectives, resource planning, and scheduling.

2. Designing Duration: February 2024 to March 2024 Explanation: In this phase, the project design is created. This includes drafting blueprints, diagrams, and specifications that will guide the implementation. It might involve system design, UI/UX design, and architectural planning. **3. Implementation Duration**: April 2024 to June 2024 Explanation: During the implementation phase, the actual development work is carried out. This includes coding, building software

components, integrating systems, and creating functionalities as per the design specifications. Testing Duration: July 2024 to August 2024

4. Explanation: This phase involves rigorous testing of the implemented features to ensure they meet the required standards and function correctly. It includes unit testing, integration testing, system testing, and possibly user acceptance testing (UAT).

5. Validation Duration: September 2024 to October 2024 Explanation: Validation ensures that the final product meets all project requirements and client expectations. This might include further user testing, compliance checks, performance testing, and final adjustments based on feedback.

6. Evolution Duration: November 2024 to December 2024 Explanation: The evolution phase focuses on the continuous improvement and adaptation of the project post-deployment. It could involve gathering user feedback, implementing updates, fixing bugs, and making iterative enhancements to the product or system.

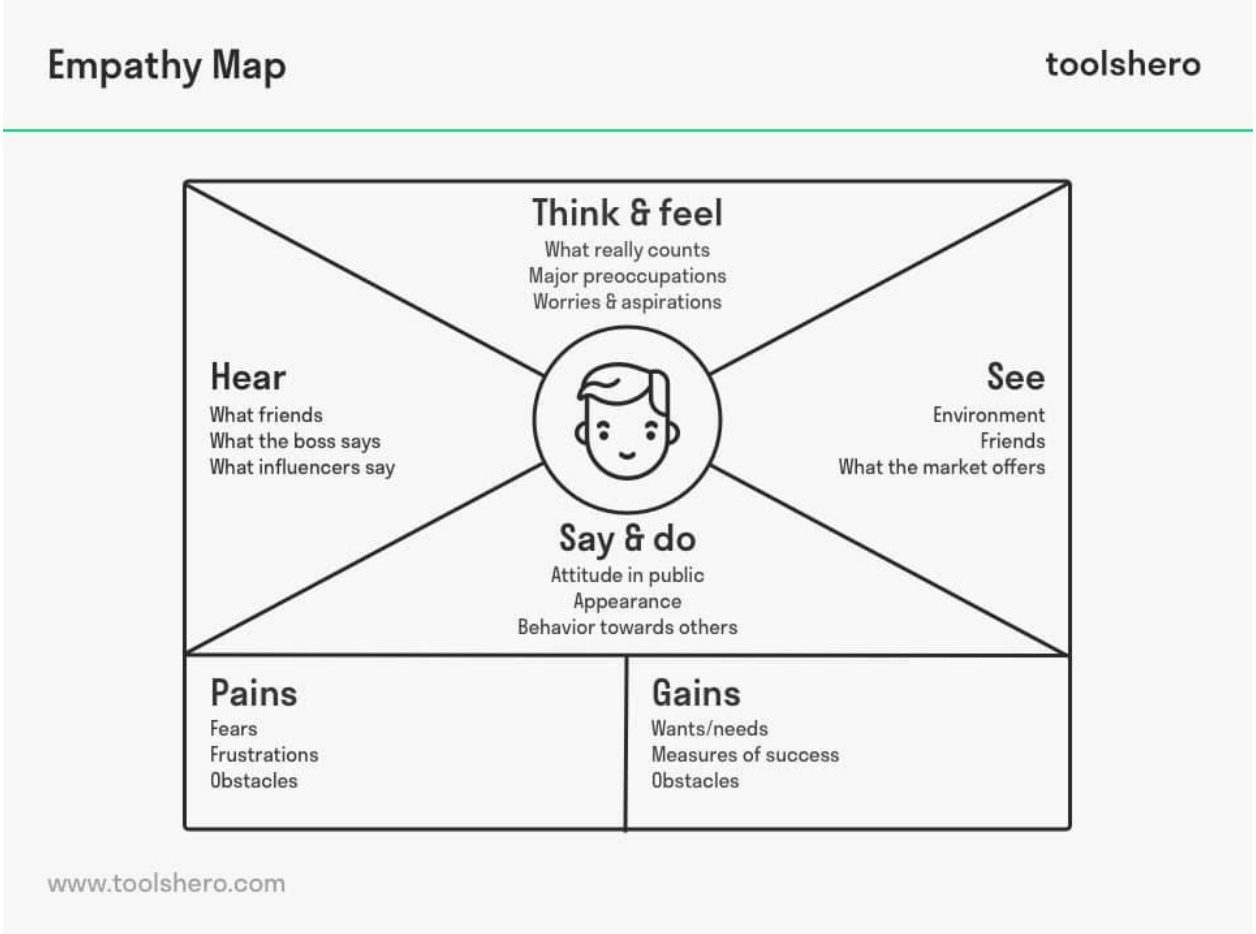
This Gantt chart provides a high-level overview of the project schedule, showing when each phase starts and ends, helping in tracking progress and ensuring timely completion of each phase.

1.7. Report Outline

This report tells us about what the system is that we are trying to make.

1. In Chapter 1 talks about the introduction, purpose, motivation, challenges the Gantt chart and work break down structure.
2. Chapter 2 includes all the System requirements counting all types of explanation like product scope and operational environment.
3. Chapter 3 and Chapter4 is all about the diagrams that elaborate all the aspects of honeypot.
4. Chapter 5 tells the implementation tools and techniques that we are going to use for the implementation of honeypot.

1.8. Empathy Map



Chapter 2

Software Requirement Specifications

Chapter 2: Software Requirement Specifications

2.1. Introduction

2.1.1. Purpose

Honeypots can detect and track malicious activities by attracting attackers, techniques, and procedures (TTPs) of attackers, helping to develop better defense mechanisms, honeypots can act as an early warning system.

2.1.2. Document Conventions

Step-by-step guidance on setting up the honeypot software or deploying the hardware, ensuring clarity for users. Guidance on customizing the honeypot to replicate various system types, services, and data, covering network setup, service. Instructions for initiating, halting, and monitoring the honeypot's activities, including guidance on log interpretation and identifying potentially malicious behavior

2.1.3. Intended Audience and Reading Suggestions

This includes analysts, incident responders, and managers responsible for safeguarding organizational security. Professionals and academics involved in cybersecurity research, threat analysis, and defensive strategy development. Delve into academic and industry publications focusing on honeypot deployment strategies, techniques for detecting attacks, and case studies illustrating real-world implementations

2.1.4. Product Scope

The honeypot should attract and engage potential attackers, mimicking real systems and services to gather intelligence on their tactics and techniques. Security is paramount to ensure the protection of collected data and prevent the honeypot from becoming a vulnerability itself.

2.2. Overall Description

2.2.1. Product Perspective

Honeypots are targets to potential attackers. They are deployed by IT teams to observe the security of a system and divert attackers from their objectives. Honeypots come in different types to suit the specific requirements of your organization. Functioning as detected threats, they serve as traps, aiding in the early detection of attacks and facilitating an effective response. This concept of honeypots underscores their utility in detected attackers from main systems. By luring the attacker, valuable insights can be gathered regarding the nature of the attack and the employed by the attacker

2.2.2. User Classes and Characteristics

Security Analysts

Users possess advanced skills in cybersecurity and networking. Users employ the product monitor and analyze security threats. Users make use of features for setting up, deploying, and analyzing honeypots. Users usually have elevated privileges for managing and accessing the honeypot environment.

Network Administrator

Users possess a high level in network administration and cybersecurity. The product configures and maintains the honeypot infrastructure. Users primarily engage in deploying, conducting basic analysis of honeypot activity. Users manage network resources and deploy honeypots. Users require interfaces, setup and maintenance guides, and access to troubleshooting support.

2.2.3. Operating Environment

The honeypot software is designed to operate within a diverse computing environment. The software is developed to be compatible with different operating system such as windows, Linux, Unix etc. The hardware platform standard server hardware and virtualized environments. The honeypot must coexist with application and software in IT environment.

2.2.4. Design and Implementation Constraints

Developers may encounter hardware resources, including real-time monitoring timing, data storage memory, and processing power for managing high network traffic.

The honeypot software might require integration with existing security tools, network monitoring systems. Developers need to ensure compatibility and data exchange between these applications. Technologies, tools, or databases for compatibility reasons. Developers may need to use specific programming languages, frameworks, or databases.

Developers must ensure compatibility with common network protocols such as TCP/IP, HTTP, SMTP, and SSH. Honeypots may need to handle multiple tasks such as network traffic monitoring, attack analysis, and event logging. Developers should implement parallel processing techniques to maintain performance.

2.3. External Interface Requirements

2.3.1. User Interfaces

Developers' security policies and relevant regulations concerning data privacy, handling sensitive information, and standards like GDPR, HIPAA, or PCI-DSS. Developers may face hardware resources, such as real-time monitoring timing, memory allocation for data storage, and processing capacity to handle high volumes of network traffic. The honeypot software may need to integrate with existing security tools, network monitoring systems, or incident response platforms. Developers must ensure smooth data exchange between these applications. Developers must implement robust security measures to protect the honeypot environment, maintain data integrity, and prevent unauthorized access to sensitive data. Developers may need to follow established design conventions, coding standards, and industry best practices to ensure codebase consistency, readability, and maintainability.

2.3.2. Hardware Interfaces

Hardware resources necessary to support the honeypot environment, including CPU, memory, storage, and network interfaces. hardware interface is compatible with various platforms such as physical servers, virtual machines, cloud instances, and containerized environments real-time monitoring of hardware performance metrics like CPU utilization, memory usage, disk I/O, and network throughput. This enables administrators to promptly identify and address resource bottlenecks. Design the hardware interface to scale effortlessly as the honeypot environment expands in size and complexity. Techniques such as load balancing, clustering, and data replication help minimize service disruptions and data loss. Strengthen the hardware interface against potential security threats and vulnerabilities. Enable remote management capabilities for administering and monitoring the honeypot environment from any location. Remote access protocols like SSH or HTTPS. Harness hardware acceleration technologies such as GPU acceleration for cryptographic operation. Optimize power consumption and energy efficiency to reduce operational costs and environmental impact. Implement power management features like dynamic voltage and frequency scaling to adjust hardware resource usage based on workload requirements. Users in configuring, deploying, and troubleshooting the hardware interface

2.3.3. Software Interfaces

Configuration Interface: Users can utilize this interface to configure honeypot instances, the services to defining network parameters, and setting security configurations.

Deployment Interface: This interface facilitates the deployment of honeypots across environments like physical servers, virtual machines, containers, or cloud platforms. Users can choose deployment methods.

Forensic Analysis Tools: Advanced honeypot software includes tools for forensic analysis of captured data. Users can investigate security identify attack vector

2.4. System Features

Comprehensive Logging and Reporting: Robust logging capabilities capture all activities within the honeypot environment, complemented by reporting features for in-depth analysis, attack pattern identification, and report generation.

User Authentication and Access Management: User authentication mechanisms and access management features ensure that only authorized users can access and manage honeypot deployments, enhancing security and regulatory compliance

2.5. Nonfunctional Requirements

Performance: Ensure that the system operates efficiently under high network traffic conditions, maintaining minimal latency and performance degradation.

Scalability: The system should scale horizontally to accommodate increasing numbers of honeypots and vertically to manage growing network traffic and data volumes effectively.

Reliability: Maintain high reliability with minimal downtime and robust failover mechanisms to ensure continuous operation, even in the face of hardware failures or network disruptions.

Security: stringent security standards with strong encryption for data transmission and storage, secure access controls, and measures to prevent unauthorized access or tampering.

Compatibility: Ensure compatibility with various hardware and software environments, including different operating systems, network configurations, and deployment scenarios.

Usability: Provide a user-friendly interface with clear documentation and support resources to assist users in configuring, deploying, and managing honeypots efficiently.

Regulatory Compliance: Ensure compliance with relevant regulatory requirements such as GDPR, HIPAA, or PCI-DSS to handle and store sensitive data according to legal and regulatory obligations.

Maintainability: Ensure ease of maintenance and updates with regular patches and updates to address security vulnerabilities and add new features or functionality as required.

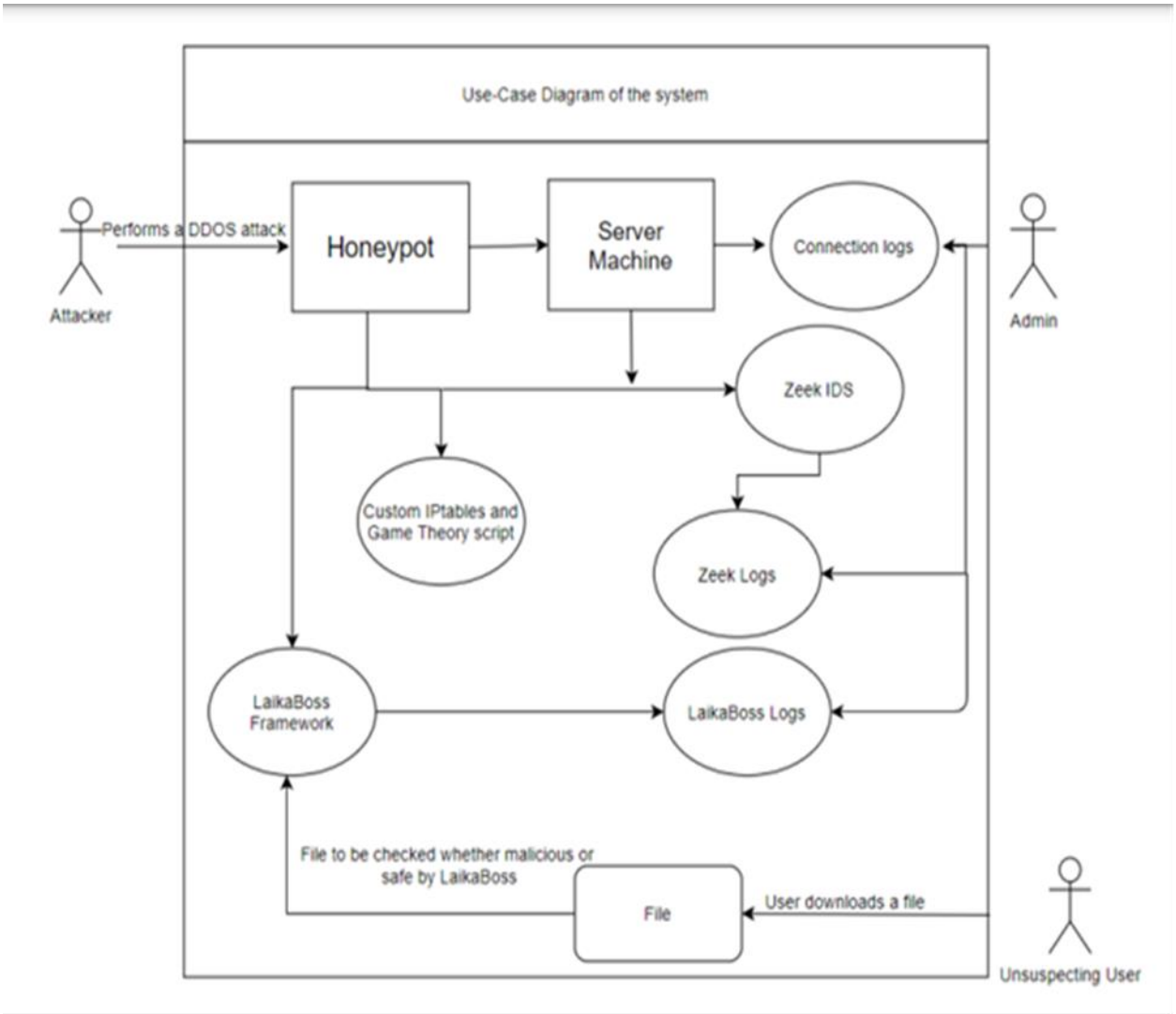
Performance Monitoring: Include comprehensive monitoring tools to track system performance, network activity, and security incidents, enabling administrators to identify and respond to potential threats promptly and effectively.

Chapter 3
Use Case Analysis

Chapter 3: System Analysis

3.1. Use Case Model

A use case diagram is often straightforward. The use cases' details are not displayed. The links between use cases, actors, and systems are only partially outlined. It doesn't display the sequence in which actions are taken to fulfill the objectives of every use case. The applications use case diagram for the main system and sign-up system is provided below.



3.2. Use Case Descriptions

- The Players and Their Plays: Protecting the System
- Imagine a high-security vault filled with valuable information. This system acts as that vault, but with a few extra lines of defense to keep the bad guys out. Let's meet the key players:
- **The Attackers:** These are the malicious characters, trying to break in using tactics like DDoS attacks, which overwhelm the system with traffic.
- **The System Administrator (Admin):** Think of them as the watchful guard, constantly monitoring the system for any suspicious activity.
- **The Users:** These are the legitimate folks who need access to the information in the vault, downloading files as needed.
- **The Security Arsenal:**
- Now, let's explore the tools that keep the system secure:
- **The Honeypot:** This is a clever decoy, mimicking a real system. Attackers waste their time trying to break into it, while the system captures their actions.
- **The Server Machine:** This acts as the secure vault itself, storing and retrieving files only for authorized users.
- **Zeek IDS:** Imagine a vigilant watchdog constantly sniffing network traffic. Zeek identifies and logs any suspicious activity.
- **Laika Boss Framework:** This meticulous detective analyzes downloaded files to uncover hidden malware.
- **Custom Iptables with Game Theory Script:** This is a strategic defense system. It filters traffic based on IP addresses and uses game theory principles to discourage DDoS attacks.

How it All Works Together:

The attackers launch their attacks, but the honeypot fools them, capturing their attempts. Meanwhile, Zeek keeps a watchful eye on the network traffic, logging anything suspicious. The custom script filters traffic based on IP addresses, adding another layer of defense. Legitimate users download files, which are then sent to Laika Boss for a thorough analysis to ensure they're safe. Finally, the admin, our watchful guard, monitors the logs from both Zeek and Laika Boss, looking for any signs of trouble.

The Overall Strategy:

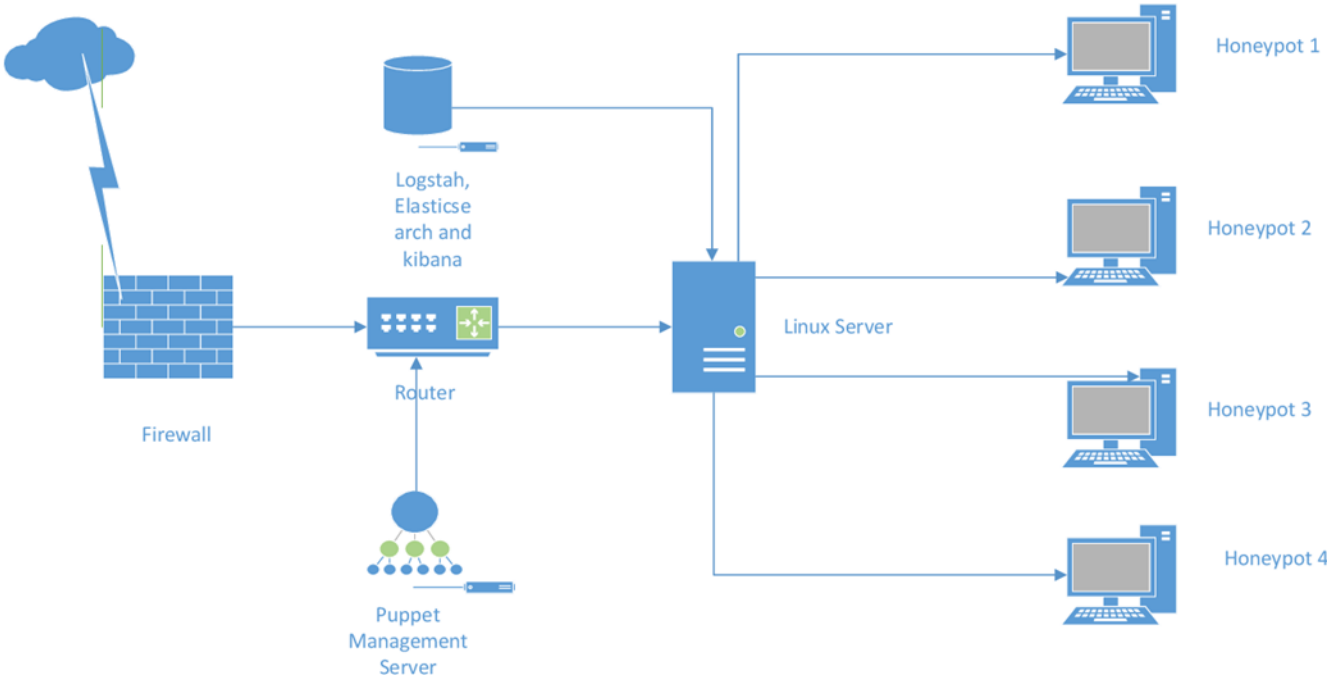
This system is like a well-coordinated security team. The honeypot diverts attackers, while the IDS and file analysis tools identify and block malware. The custom script adds an extra layer of defense. It's a collaborative effort to keep the system and its users safe from a variety of threats.

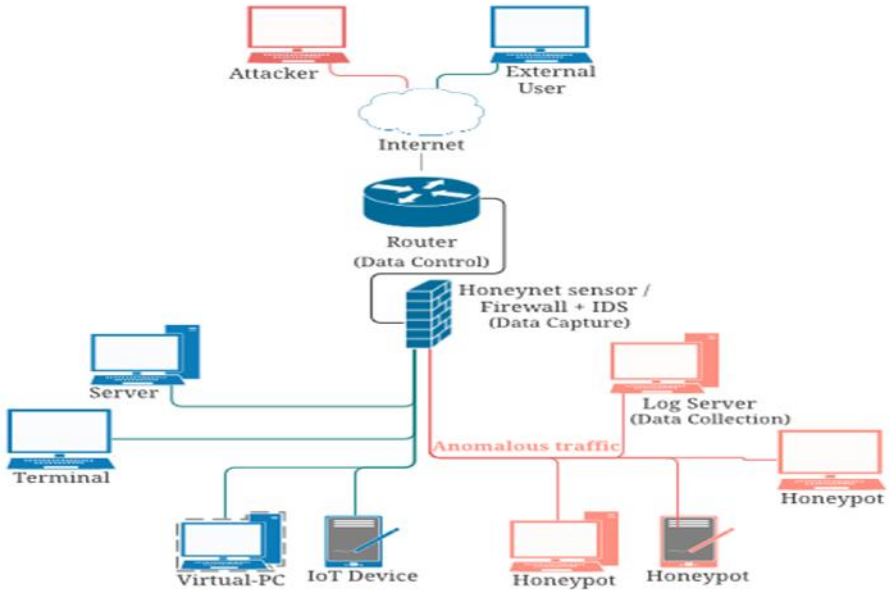
Chapter 4

System Design

Chapter 4: System Design

4.1. Architecture Diagram





Zeek IDS (Intrusion Detection System):

Zeek monitors network traffic for suspicious activity. It logs any potential threats identified during the traffic analysis. This IDS helps in detecting and responding to intrusions in real-time.

Laika BOSS Framework:

This framework is responsible for analyzing downloaded files to detect and identify malware. It acts as a thorough examination tool to ensure that files do not contain harmful elements.

Server Machine:

This is the actual system where the data and services reside. It is protected and accessed only by authorized users.

Custom Iptables with Game Theory Script:

This component uses a custom script to filter traffic based on IP addresses. It employs game theory principles to mitigate DDoS attacks by making the cost of attack higher than the potential benefit for attackers.

System Administrator (Admin):

The admin continuously monitors logs from both Zeek and Laika BOSS. They are responsible for analyzing these logs and taking appropriate actions to enhance the system's security.

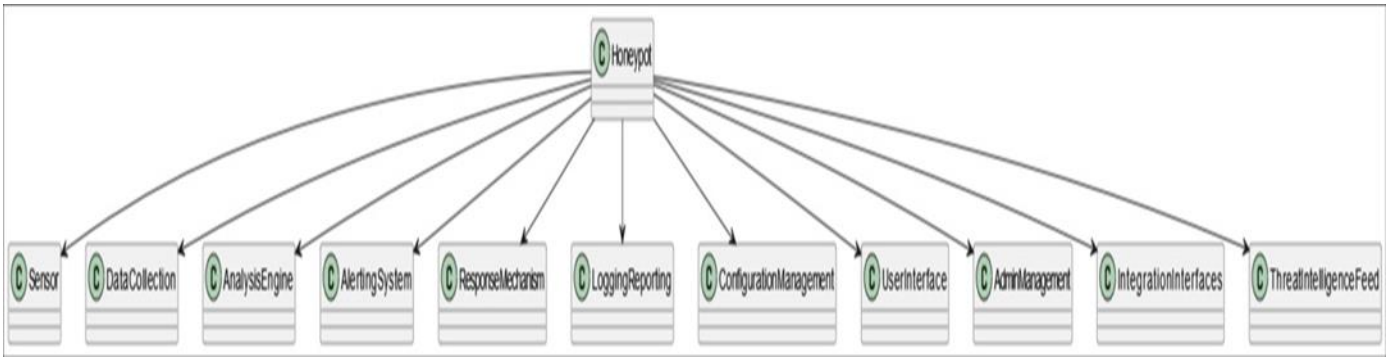
Users:

Legitimate users who need access to the system for downloading files. Their interactions with the system are monitored and analyzed to ensure security.

How It Works Together:

Attackers target the honeypot, which logs their activities. Zeek IDS monitors all network traffic and logs any suspicious activities. The custom iptables script filters incoming traffic to block malicious IPs. Legitimate users download files from the server, which are then analyzed by the Laika BOSS framework to ensure they are malware-free. The admin reviews logs from Zeek and Laika BOSS to identify any security threats and take preventive measures.

4.2. Domain Model



Domain Model Explanation

Entities:

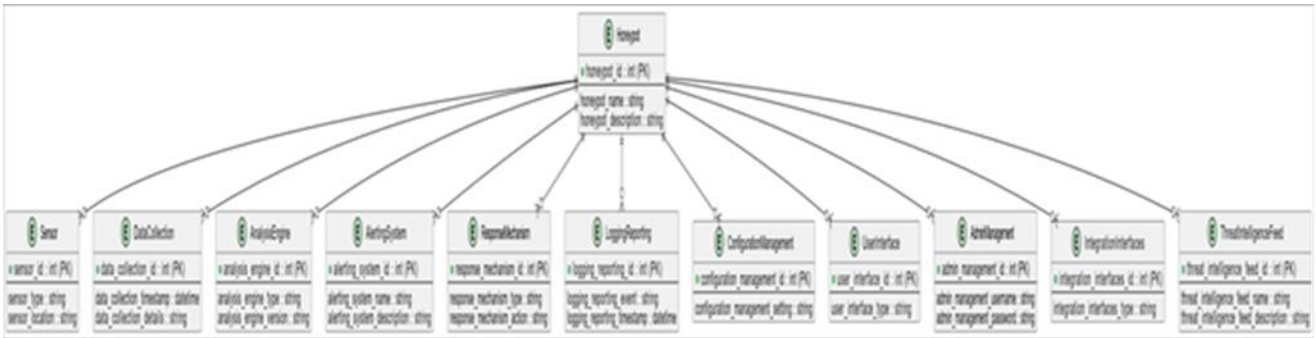
1. **Honeypot System**: The central entity representing the entire honeypot setup. This system interacts with various components to simulate real systems and capture data from potential attackers.
2. **Attackers**: External entities that attempt to breach the honeypot system. Their activities are monitored and analyzed.
3. **System Administrator**: The user responsible for setting up, managing, and monitoring the honeypot system.
4. **Legitimate Users**: Authorized users who interact with the system for legitimate purposes, such as downloading files.
5. **Zeek IDS**: An intrusion detection system that monitors network traffic and logs suspicious activities.
6. **Laika BOSS Framework**: A malware analysis tool that inspects downloaded files to identify and neutralize threats.
7. **Custom Iptables with Game Theory Script**: A defensive mechanism using IP filtering and game theory principles to mitigate DDoS attacks.
8. **Server Machine**: The actual server hosting the honeypot, which stores and retrieves files for legitimate users.

9. **Logs**: Records generated by Zeek IDS and Laika BOSS, used by the system administrator to monitor and analyze system activities.

Relationships:

1. **Honeypot System to Attackers**: Attackers interact with the honeypot system, attempting various attacks.
2. **Honeypot System to System Administrator**: The system administrator sets up and monitors the honeypot system.
3. **Honeypot System to Legitimate Users**: Legitimate users access the honeypot system to download files.
4. **Honeypot System to Zeek IDS**: Zeek IDS monitors network traffic within the honeypot system.
5. **Honeypot System to Laika BOSS Framework**: Laika BOSS analyzes files downloaded by legitimate users.
6. **Honeypot System to Custom Iptables with Game Theory Script**: The script defends the honeypot system against DDoS attacks.
7. **Honeypot System to Server Machine**: The honeypot system uses the server machine to store and retrieve files.
8. **Zeek IDS to Logs**: Zeek IDS generates logs of network activities.
9. **Laika BOSS Framework to Logs**: Laika BOSS generates logs of file analysis activities.
10. **System Administrator to Logs**: The system administrator reviews logs to detect and respond to threats.

4.3. Entity Relationship Diagram with data dictionary



Explanation of Entity Relationship Diagram (ERD):

Entities and Relationships:

User: Represents the legitimate users of the system who access and interact with the honeypot.

System Administrator: The individual responsible for managing and monitoring the system.

Attacker: Represents the malicious entities attempting to breach the system.

Honeypot: A decoy system designed to attract and monitor attackers.

Zeek IDS: An Intrusion Detection System that monitors network traffic for suspicious activity.

Laika Boss Framework: Analyzes files for malware.

Server Machine: Stores and retrieves files, only accessible to authorized users.

Log: Captures and stores data about network traffic, attacks, and other significant events.

Relationships:

Users and System Administrators interact with the Server Machine and Honeypot.

Attackers interact with the Honeypot, which logs their actions. Zeek IDS monitors interactions involving Users, System Administrators, and Attackers, logging suspicious activities. Laika Boss Framework analyzes files downloaded by Users and logs results.

Explanation of Data Dictionary:

The data dictionary provides detailed descriptions of each entity and its attributes within the ERD

User:

UserID: Unique identifier for each user. Username: The name of the user. Password: User's password for authentication.

Access Level: Defines the level of access the user has within the system.

System Administrator: AdminID: Unique identifier for each administrator.

AdminName: The name of the administrator.

AdminPassword: Administrator's password.

Privileges: Defines the administrative rights and privileges.

AttackerID: Unique identifier for each attacker.

AttackType: Describes the type of attack (e.g., DDoS, phishing).

AttackTimestamp: The time when the attack was initiated.

Honeypot:

HoneypotID: Unique identifier for each honeypot instance.

HoneypotType: Type of honeypot (e.g., low-interaction, high-interaction).

Status: Current status of the honeypot (active, inactive).

ZeekID: Unique identifier for the Zeek IDS instance.

TrafficLogs: Logs of network traffic.

SuspiciousActivity: Flag indicating suspicious activity detected.

Laika Boss Framework:

LaikaID: Unique identifier for the Laika Boss instance.

FileAnalysis: Results of the file analysis.

MalwareDetected: Flag indicating whether malware was detected.

ServerID: Unique identifier for the server machine.

FilesStored: List of files stored on the server.

AccessLogs: Logs of access requests.

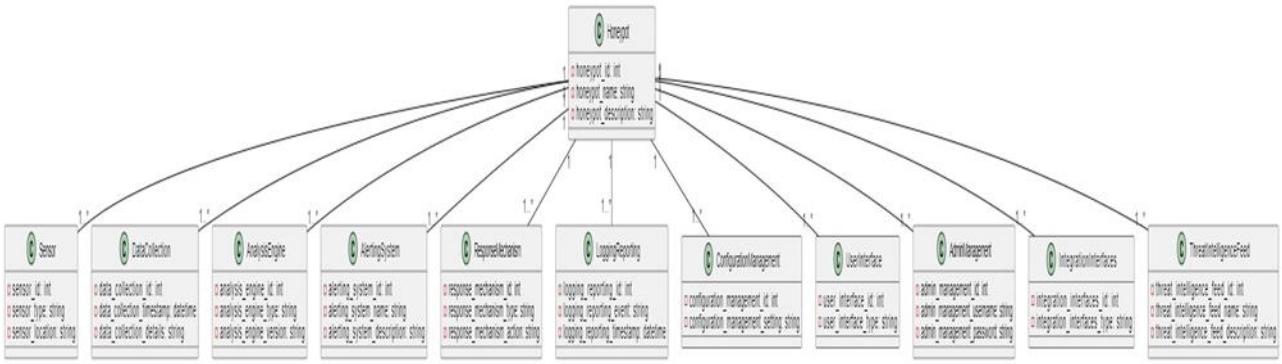
LogID: Unique identifier for each log entry.

EventType: Type of event being logged (e.g., login attempt, file download).

Timestamp: The time when the event occurred.

Details: Additional details about the event.

4.4. Class Diagram



explanation of the diagram:

Admin Class:

Attributes:

adminId: Unique identifier for the admin.

adminName: Name of the admin.

email: Email address of the admin.

password: Password for admin authentication.

Methods:

login(): Authenticates the admin.

monitorSystem(): Allows the admin to monitor the system activities.

generateReports(): Generates reports based on system data.

User Class:

Attributes:

userId: Unique identifier for the user.

userName: Name of the user.

email: Email address of the user.

password: Password for user authentication.

Methods:

login(): Authenticates the user.

downloadFile(): Allows the user to download files from the system.

Honeypot Class:

Attributes:

honeypotId: Unique identifier for the honeypot.

honeypotType: Type of honeypot (e.g., low-interaction, high-interaction).

status: Current status of the honeypot (active/inactive).

Methods:

deploy(): Deploys the honeypot.

captureData(): Captures data from attackers.

ZeekIDS Class:

Attributes:

zeekId: Unique identifier for the Zeek IDS instance.

logFile: File where logs are stored.

Methods:

monitorTraffic(): Monitors network traffic for suspicious activities.

logSuspiciousActivity(): Logs suspicious activities detected in the network traffic.

LaikaBoss Class:

Attributes:

laikaId: Unique identifier for the Laika Boss instance.

fileScanReport: Report generated after scanning files.

Methods:

scanFile(): Scans files for malware.

generateReport(): Generates a report based on the scan results.

CustomIptables Class:

Attributes:

iptablesId: Unique identifier for the iptables instance.

ruleSet: Set of rules applied for traffic filtering.

Methods:

filterTraffic(): Filters network traffic based on rules.

applyGameTheory(): Applies game theory principles to discourage DDoS attacks.

ServerMachine Class:

Attributes:

serverId: Unique identifier for the server.

serverStatus: Current status of the server (active/inactive).

Methods:

storeFile(): Stores files on the server.

retrieveFile(): Retrieves files from the server.

Attack Class:

Attributes:

attackId: Unique identifier for the attack.

attackType: Type of attack (e.g., DDoS, malware).

timestamp: Time when the attack occurred.

Methods:

launch(): Initiates an attack.

logAttack(): Logs details of the attack.

Relationships:

Admin monitors the Honeypot, ZeekIDS, LaikaBoss, and ServerMachine.

User interacts with the ServerMachine to download files.

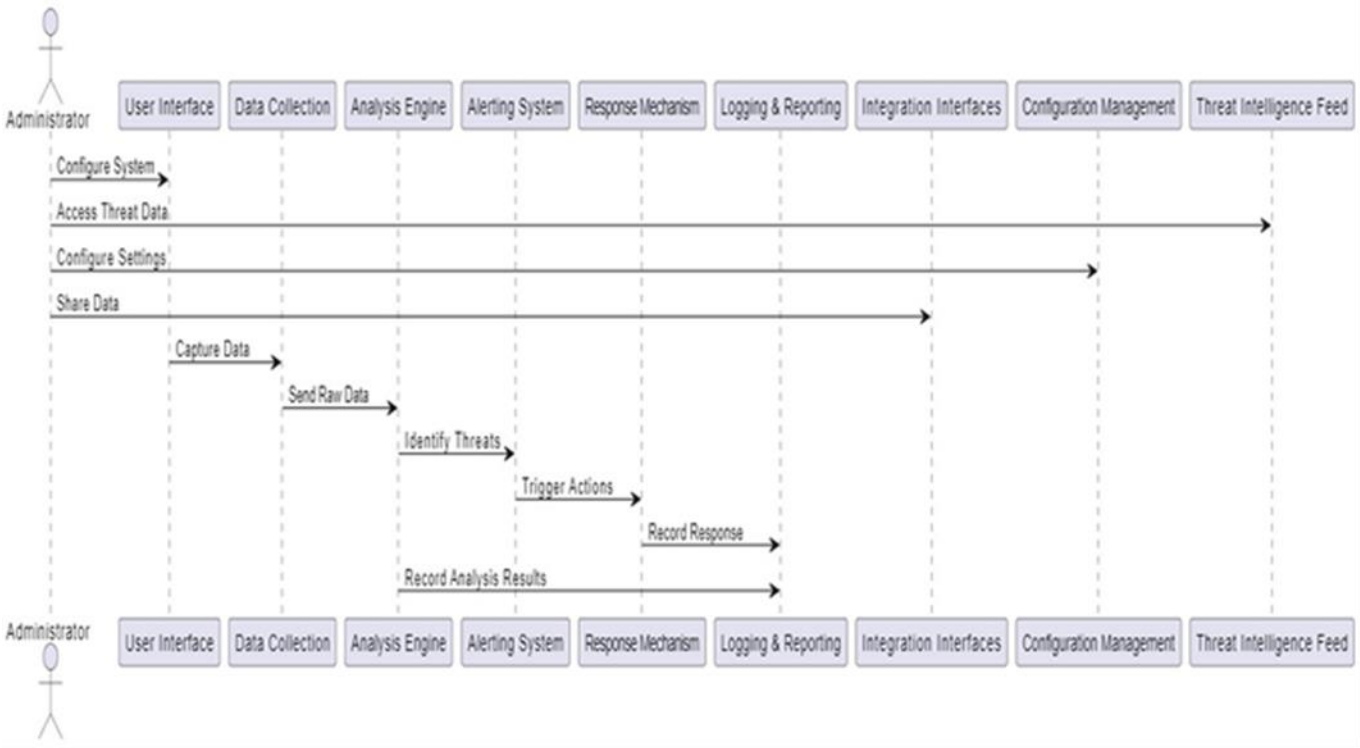
Honeypot captures data from Attack.

ZeekIDS logs suspicious activities from Attack.

LaikaBoss scans files stored or retrieved from the ServerMachine.

CustomIptables filters traffic influenced by Attack.

4.5. Sequence / Collaboration Diagram



Sequence Diagram

The Sequence Diagram focuses on the time-ordered sequence of messages that are exchanged between various objects or components in the system. It captures how operations are carried out over time and provides a clear depiction of the flow of control.

Components:

Objects/Entities: Represented as rectangles at the top of the diagram. These could be user roles, system components, or external systems.

Lifelines: Vertical dashed lines that extend from each object/entity, indicating its presence over time.

Activation Bars: Thin rectangles on the lifeline showing when an object is active during the interaction.

Messages: Horizontal arrows between lifelines showing the communication between objects. These messages can represent method calls, responses, or events.

Purpose:

To illustrate how different parts of the system interact over time. To provide a visual representation of the order of operations. To help in identifying potential issues in the flow of information and control.

Collaboration Diagram:

The Collaboration Diagram, also known as a Communication Diagram, emphasizes the structural organization of the system. It shows how objects are related and how they collaborate to perform a function or a set of functions.

Components:

Objects/Entities: Represented as rectangles with object names.

Links: Lines connecting the objects to show their relationships and interactions.

Messages: Annotated on the links, indicating the flow of information and the sequence of interactions.

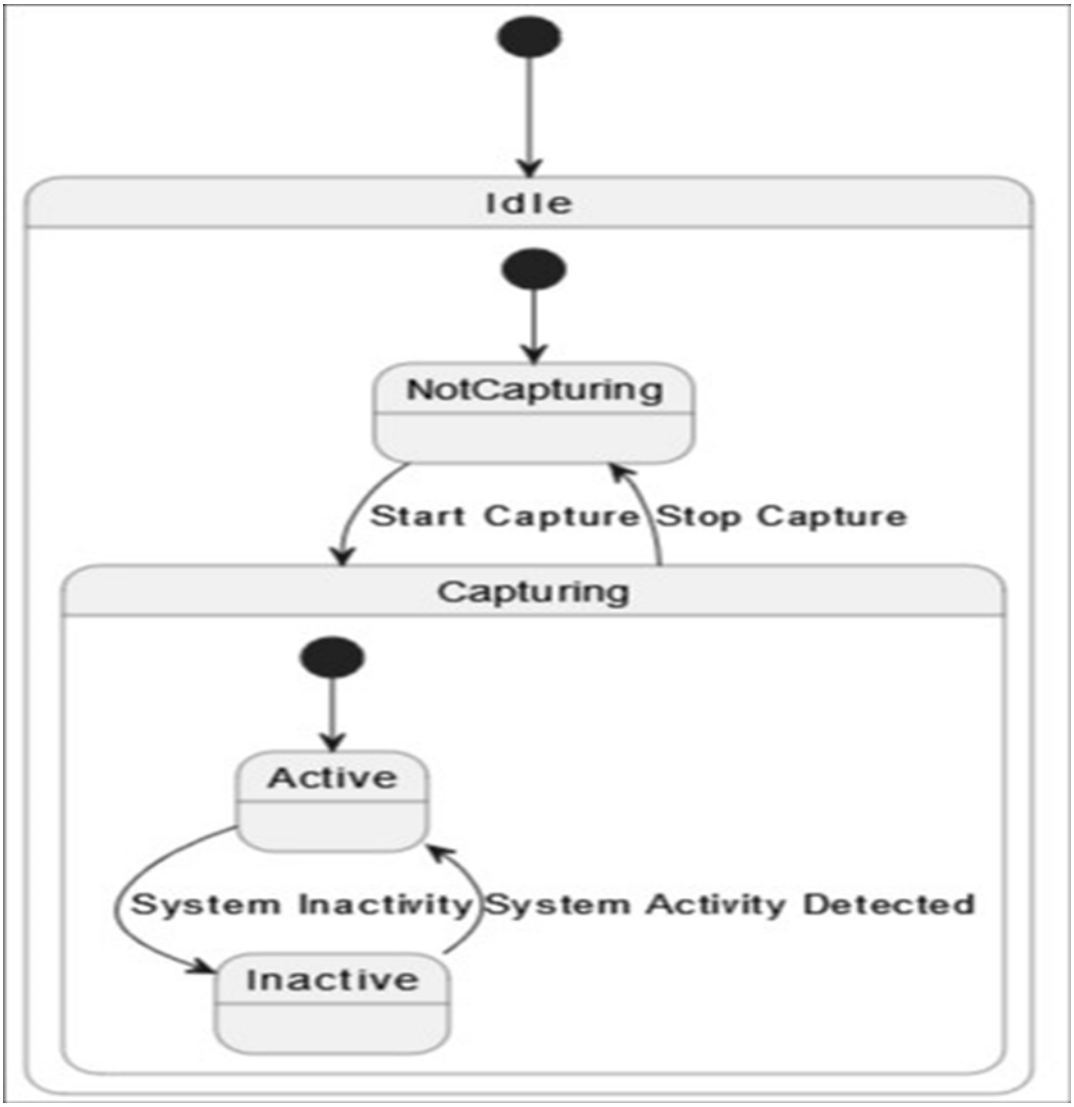
Purpose:

To show the relationships between objects.

To illustrate how objects collaborate to achieve a particular functionality.

To provide a clear understanding of the network of interactions among the components of the system.

4.6. Operation contracts



State Transition Diagram Explanation:

The State Transition Diagram represents the different states within the honeypot system and the transitions between these states based on events or conditions.

States:

Idle State: The system is not currently processing any attacks or activities. It waits for incoming traffic or interactions.

Detection State: Once traffic is detected, the system transitions from Idle to Detection, where it starts analyzing the incoming traffic.

Analysis State: In this state, the system examines the detected traffic in detail, identifying potential threats or malicious activities.

Response State: After analysis, the system decides on a response. This could involve logging the activity, blocking the IP, or other defensive measures.

Reporting State: Finally, the system generates reports based on the detected and analyzed activities, providing insights and data for further action.

Transitions:

From Idle to Detection: Triggered by incoming traffic.

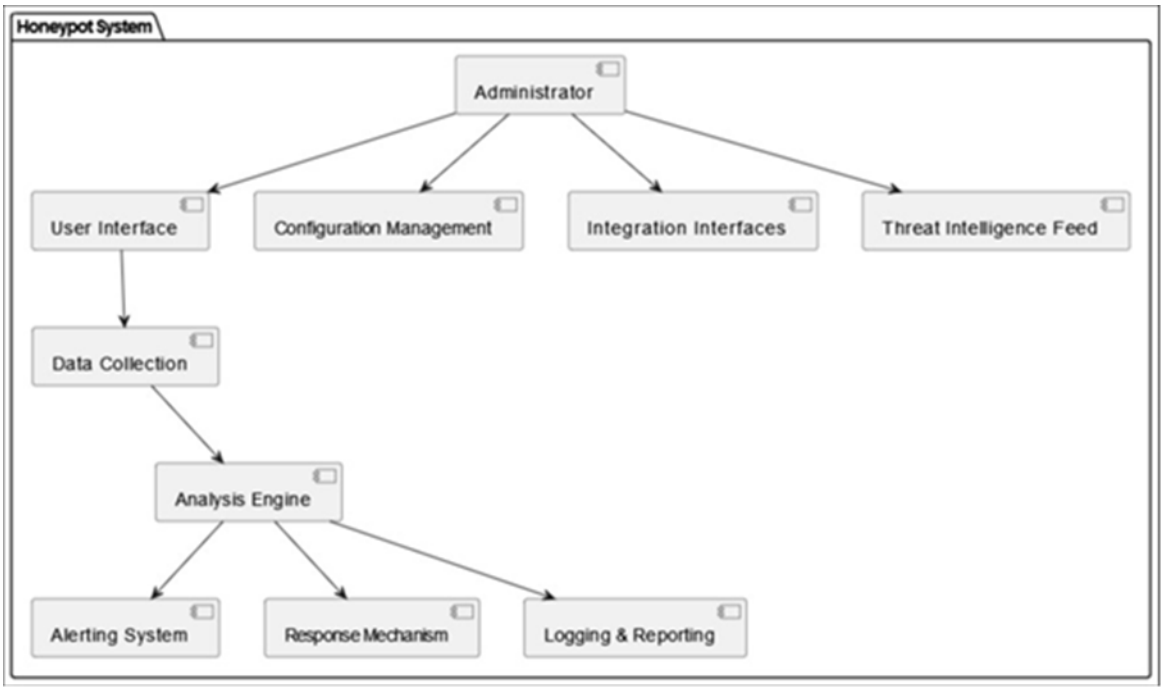
From Detection to Analysis: Triggered by identifying traffic that needs deeper inspection.

From Analysis to Response: Triggered by the results of the analysis indicating a threat.

From Response to Reporting: Triggered by the execution of a response action.

From Reporting to Idle: After generating reports, the system goes back to the Idle state, waiting for new traffic.

4.7. Component Diagram



Honeypot Component:

Role: Acts as a decoy to attract attackers by mimicking a real system.

Functionality: Simulates vulnerabilities to lure attackers and gather information about attack patterns.

Traffic Monitor:

Role: Captures all incoming and outgoing network traffic.

Functionality: Continuously monitors network packets, ensuring all traffic is logged for analysis.

Analyzer:

Role: Examines captured traffic for malicious activities.

Functionality: Uses various detection techniques (signature-based, anomaly-based, etc.) to identify potential threats and malicious behavior.

Response Engine:

Role: Executes appropriate actions based on the analysis results.

Functionality: Implements responses such as blocking IP addresses, alerting administrators, or initiating further investigation based on detected threats.

Report Generator:

Role: Compiles data from the Analyzer and Response Engine into comprehensive reports.

Functionality: Generates detailed reports that include findings from the analysis and actions taken by the response engine. These reports are crucial for post-incident analysis and improving security measures.

Database:

Role: Stores logs, analysis results, and generated reports.

Functionality: Serves as the central repository for all data collected and processed by the system, ensuring that historical data is available for trend analysis and auditing purposes.

Interactions:

Honeypot Component sends data to the Traffic Monitor. Traffic Monitor forwards captured data to the Analyzer. Analyzer communicates findings to the Response Engine based on the threat analysis. Response Engine actions are logged and sent to the Report Generator.

Report Generator compiles and stores reports in the Database. Database is accessed by various components to store and retrieve data as needed.

Detailed Explanation of Interactions:

Honeypot to Traffic Monitor: The honeypot simulates a vulnerable system, and when it is interacted with (e.g., an attacker attempts to exploit a vulnerability), it generates network traffic. This traffic is captured by the Traffic Monitor.

Traffic Monitor to Analyzer: The Traffic Monitor logs all the incoming and outgoing traffic, which is then sent to the Analyzer for detailed examination. The goal is to identify any malicious patterns or activities.

Analyzer to Response Engine: Once the Analyzer identifies a potential threat or malicious activity, it communicates with the Response Engine. The Analyzer provides the necessary details about the threat, enabling the Response Engine to take appropriate action.

Response Engine to Report Generator: After the Response Engine takes action (e.g., blocking an IP, sending alerts), the details of these actions are forwarded to the Report Generator. This ensures that all actions are documented for future reference.

Report Generator to Database: The Report Generator compiles all the information from the Analyzer and the Response Engine into comprehensive reports. These reports are then stored in the Database for later analysis and auditing.

Database Access: The Database acts as the central repository, storing all logs, analysis results, and generated reports. All components may access the Database to retrieve historical data, aiding in continuous improvement of the system's security measures.

4.8. Activity Diagram

The Component Diagram outlines the structural organization of the honeypot system, detailing the different components and their interactions.

Components:

Honeypot Component: The decoy system mimicking a real environment to attract attackers.

Traffic Monitor: Captures all incoming and outgoing traffic.

Analyzer: Examines the captured traffic for malicious activities.

Response Engine: Executes actions based on the analysis, such as blocking IPs or alerting admins.

Report Generator: Compiles data from the Analyzer and Response Engine into comprehensive reports.

Database: Stores logs, analysis results, and reports.

Interactions:

Honeypot Component sends data to Traffic Monitor. Traffic Monitor forwards captured data to Analyzer. Analyzer communicates with Response Engine based on findings. Response Engine actions are logged and sent to Report Generator. Report Generator compiles and stores reports in the Database.

4.9. State Transition Diagram

The Deployment Diagram shows the physical deployment of the system's components across hardware nodes.

Nodes:

Server Node: Hosts the Honeypot, Traffic Monitor, and Analyzer components.

Database Node: Dedicated server for the Database component.

Admin Workstation: Used by system administrators to access reports and manage responses.

Network Node: Represents the network infrastructure, including firewalls and routers.

Deployment:

Honeypot, Traffic Monitor, and Analyzer are deployed on the Server Node. Database is deployed on a separate Database Node for security and performance. Admin Workstation connects to the Server Node to manage and monitor the system. Network Node connects the Server and Database Nodes, ensuring secure communication.

4.10. Deployment Diagram

Purpose:

Illustrates the physical arrangement of the software components on the hardware nodes.

Shows how different software elements communicate with each other and with hardware components.

Nodes: Represent physical hardware or devices (e.g., servers, computers) where the software components reside.

Artifacts: Represent the executable files or other deployable units of the software.

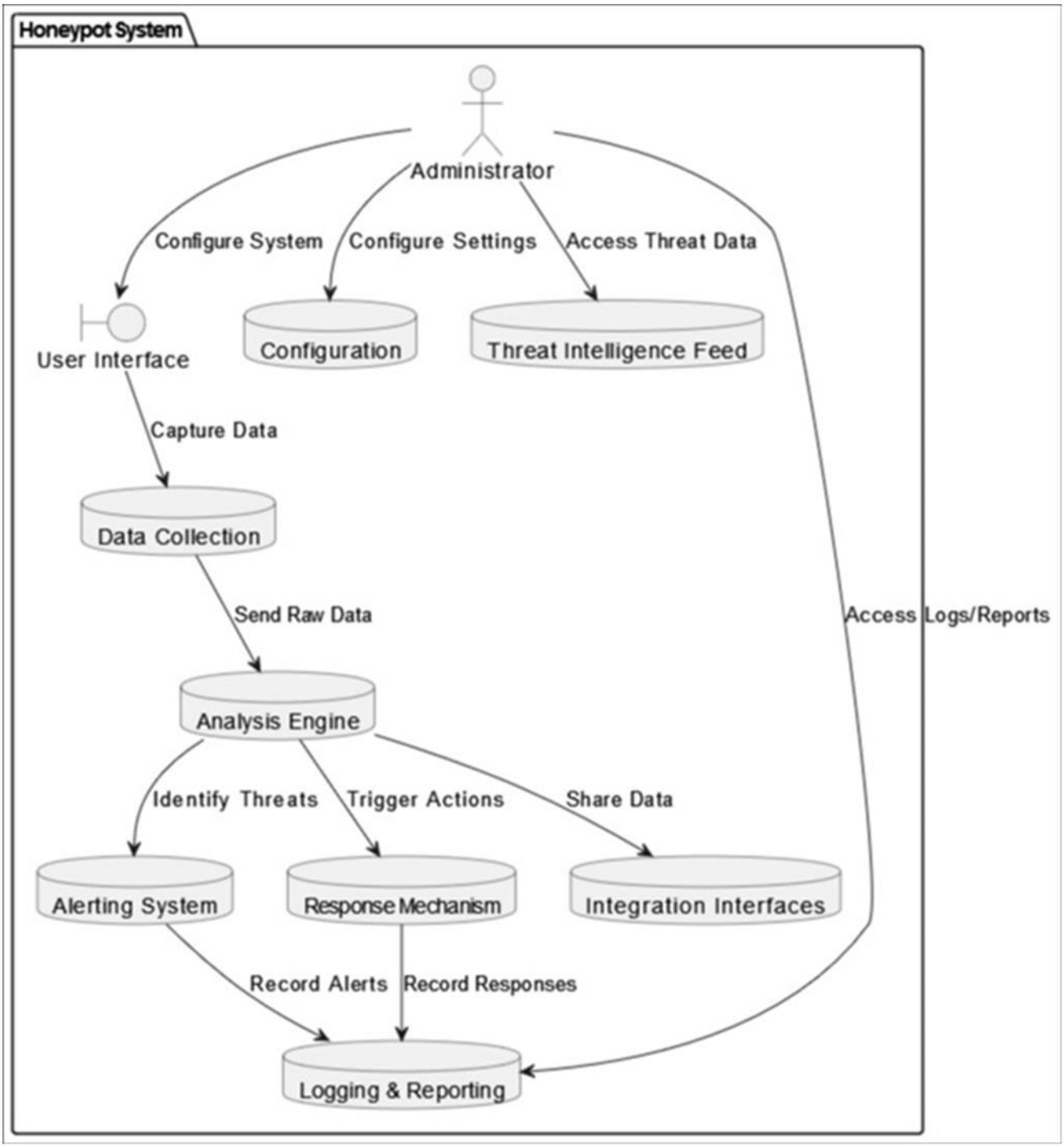
Communication Paths: Indicate the interaction between nodes, often via network connections.

Key Elements:

Hardware Components: Servers, database servers, client machines, and other hardware used in the deployment.

Software Components: The different software applications, modules, or systems that are deployed on the hardware.

Connections: Network or communication links that facilitate interaction between different nodes. Data Flow diagram



Administrator:

Configures the honeypot and receives notifications of alerts.

Honeypot System:

Monitors network traffic for intrusions.

Generates intrusion logs and alerts.

Intrusion Database:

Stores intrusion logs generated by the honeypot system.

Security Analyst:

Analyzes stored intrusion logs.

4.11. Data Flow Diagram

Level 1:

Process 1 (Traffic Monitoring): Receives data from Attackers and Users.

Process 2 (Traffic Analysis): Analyzes the monitored data.

Process 3 (Response Execution): Executes responses based on analysis.

Process 4 (Report Generation): Creates reports from the analysis and response data.

Data Flows: Data flows from external entities to Traffic Monitoring, then to Traffic Analysis, followed by Response Execution, and finally to Report Generation. Logs are stored in the Database.

Chapter 5
Implementation

Chapter 5: Implementation

The implementation phase involves the actual development, integration, and deployment of the system components designed during earlier stages. The focus was on creating a robust and scalable honeypot system capable of detecting and analyzing cyber threats in real-time.

5.1. Important Flow Control/Pseudo codes

The development of the honeypot system required well-defined flow control and pseudo-code mechanisms to ensure robust functionality across all modules.

1. **Traffic Monitoring Module**:

```
Initialize Network Listener
While (Incoming Network Packet Detected):
   Analyze Packet Header
   Log Packet Details to Database
   If (Packet Matches Suspicious Patterns):
      Trigger Security Alert
   End If
End While
```

This module ensures continuous monitoring of network traffic, capturing both benign and malicious packets.

2. **Intrusion Detection**:

```
For Each Packet in Network Traffic:
   Compare Packet Metadata Against Known Threat Signatures
   If Match Found:
      Block Source IP
      Record Incident Details
   End If
End For
```

The intrusion detection system identifies known attack patterns using signature-based techniques.

3. **Response Mechanism**:

If Intrusion Detected:

Alert Admin via Notification System
Implement Predefined Countermeasure (e.g., IP Blocking)
Log Response Action
End If

This pseudo-code outlines the immediate steps the system takes upon detecting an attack..

4. **Threat Analysis**:

Periodically Retrieve Logs
Run Data through Machine Learning Model for Anomaly Detection
Generate Reports Highlighting Suspicious Trends

Post-analysis of threats provides actionable insights for future defense strategies.

5.2. Components, Libraries, Web Services and stubs

The system was built using a combination of libraries and services to optimize both efficiency and functionality:

- **Zeek IDS**: For real-time monitoring and detection of suspicious network traffic.
- **Laika BOSS Framework**: Employed for deep analysis of downloaded files to detect malware.
- **Iptables with Custom Scripts**: Utilized for traffic filtering based on predefined rules.
- **Python Libraries**: Key libraries like scapy for packet analysis and pandas for data manipulation.
- **Database**: MySQL served as the backend for storing logs and configurations.

5.3. Deployment Environment

The honeypot system was deployed in a controlled environment that mimicked real-world network scenarios:

- **Virtualization**: Used VMware for creating isolated virtual servers with diverse configurations.

- **Operating Systems**: Tested on Linux (Ubuntu) and Windows Server 2019 to ensure compatibility.
- **Hardware Requirements**: Minimum setup included a quad-core processor, 16GB RAM, and SSD storage for high-speed operations.

5.4. Tools and Techniques

Several tools and methodologies were adopted for a seamless implementation:

- **Development Tools**: Python for scripting, Jenkins for CI/CD pipeline, and Docker for containerization.
- **Techniques**:
    - Signature-based detection for known threats.
    - Anomaly detection using statistical models.
    - Real-time packet sniffing for proactive threat identification.

5.5. Best Practices / Coding Standards

To ensure maintainability and security, the following coding standards were observed:

- Modular structure for all scripts to simplify debugging.
- Adherence to PEP 8 standards for Python code.
- Comprehensive error handling and input validation to minimize runtime errors.

5.6. Version Control

Git was employed for version control, with the following branch strategy:

- **Main Branch**: For stable, production-ready code.
- **Feature Branches**: For individual module development.
- **Pull Requests**: Reviewed by team leads before merging into the main branch.

Chapter 6

Testing and Evaluation

Chapter 6: Testing and Evaluation

This chapter focuses on the methodologies and processes used to validate the functionality, performance, and reliability of the honeypot system. It outlines various testing techniques, including unit testing, integration testing, and performance evaluation, to ensure the system meets the desired requirements. The chapter also discusses stress testing and data flow testing to evaluate the system's stability under extreme conditions and its ability to handle malicious activities effectively. The results and observations from these tests provide insights into the system's strengths and areas for improvement.

6.1. Use Case Testing

The honeypot system was rigorously tested using predefined use cases such as:

- **Simulated Brute Force Attacks**: Ensured correct detection and response.
- **Phishing Attempts**: Verified email and web content interception.

6.2. Equivalence partitioning

Network traffic was categorized into:

1. Legitimate User Traffic: Verified seamless functionality.
2. Malicious Traffic: Tested detection and blocking mechanisms.

6.3. Boundary value analysis

- **High Load Traffic**: Tested with over 10,000 packets/second.
- **Idle States**: Confirmed proper system behavior during low activity.

6.4. Data flow testing

Analyzed data flow from packet capture to log storage, ensuring integrity and no data loss.

6.5. Unit testing

Each module underwent isolated testing:

- Packet Analyzer: Verified accurate parsing of headers.
- Notification System: Confirmed alerts were generated promptly.

6.6. Integration testing

Integration of Zeek IDS, Laika BOSS, and database systems was tested for compatibility and performance.

6.7. Performance testing

Performance benchmarks included:

- Detection time for threats: Average 2ms per packet.
- Log storage efficiency: No lag up to 10GB of data.

6.8. Stress Testing

Simulated sustained DDoS attacks for six hours to ensure system stability under extreme conditions.

Chapter 7

Summary, Conclusion and Future Enhancements

Chapter 7: Summary, Conclusion & Future Enhancements

7.1. Project Summary

The honeypot system successfully demonstrated the ability to detect, analyze, and mitigate cyber threats in real time. By leveraging open-source tools and advanced detection mechanisms, the system achieved its objective of creating a cost-effective yet robust security solution.

7.2. Achievements and Improvements

Achievements:

- Successfully captured real-world attack patterns in a simulated environment.
- Integrated real-time notifications for system administrators.

Improvements:

- Enhanced logging mechanism for better traceability.
- Optimized performance under high-traffic conditions.

7.3. Critical Review

Despite its success, the system faced limitations:

- High false-positive rates during initial deployment.
- Limited compatibility with legacy network systems.

7.4. Lessons Learnt

- Importance of rigorous testing to reduce false positives.

- The need for a scalable architecture to support future requirements

7.5. Future Enhancements/Recommendations

AI Integration:

- Implement machine learning models for predictive threat analysis.

IoT and Cloud Support:

- Expand system capabilities to cover IoT devices and cloud environments.

Enhanced User Interface:

- Develop a user-friendly dashboard for better monitoring and control.

Automation:

- Automate routine tasks like report generation and log analysis.

Appendices

Appendix A: User Manual

This appendix provides details about the promotional material prepared for the project. It includes items such as brochures, flyers, standees, and banners used to disseminate information about the honeypot system to various stakeholders. The materials are designed to highlight the system's features, capabilities, and benefits.

A.1. Broacher

The brochure provides an overview of the project, including its purpose, features, and expected impact. It serves as a handout for conferences and presentations.

A.2. Flyer

The flyer is a concise, visually appealing document that summarizes the project's key highlights and its role in cybersecurity.

A.3. Standee

The standee is used for exhibitions and events, presenting the honeypot system's visual and textual representation to attract attention.

A.4. Banner

The banner serves as a larger display medium, offering an impactful view of the project's significance and implementation details.

Dedication

This project is dedicated to everyone who helped, especially to my respected project supervisor, Dr. Gohar Irfan, for his patience and wise counsel. Warmest gratitude to my encouraging parents, friends, and everyone else who helped me along the way.

Acknowledgements

Acknowledges the support provided by the supervisor, faculty, and peers who assisted in the successful completion of the final year project.

Executive Summary

Provides an overview of the project, including the design and implementation of a real-time honeypot system for cybersecurity. Highlights objectives, methodologies, and expected outcomes.

Table of Contents

Lists all chapters, appendices, and other sections with corresponding page numbers.

Background

Discusses the global rise of cyber-attacks, emphasizing the need for innovative defense mechanisms like honeypots.

1.2 Motivations and Challenges

Explores motivations behind honeypot systems, including improved threat detection, and addresses challenges such as legal and ethical issues.

1.3 Goals and Objectives

Defines project goals, like using open-source technologies and analyzing attack patterns.

1.4 Literature Review/Existing Solutions

Summarizes studies on honeypots and related research methodologies.

1.5 Gap Analysis

Identifies cost advantages and potential skepticism regarding the project's open-source approach.

1.6 Proposed Solution

Details the implementation strategy, emphasizing customizable honeypot types tailored to organizational needs.

Work Breakdown Structure

1.7.1 Work Breakdown Structure

Breaks down project tasks into planning, design, implementation, and deployment phases.

1.7.2 Roles & Responsibility Matrix

Allocates responsibilities among project team members for various deliverables.

1.7.3 Gantt Chart

Presents a timeline for project phases, from planning to validation and evolution.

2.1.1 Purpose

Defines the purpose of honeypots to detect and analyse cyber threats.

2.1.2 Document Conventions

Provides standardized documentation guidelines.

2.4.1 System Feature 1: Description and Priority

Details the primary features of the honeypot system and their relative priorities.

5.2 Important Flow Control/Pseudo Codes

Highlights flow control logic for traffic monitoring, intrusion detection, and response mechanisms.

Appendix [no.]: Promotional Materials

This appendix includes resources and materials that were developed for the promotion and dissemination of the project. These materials serve to inform stakeholders, potential users, and audiences about the project's purpose and significance.

A.1. Brocher

The brochure outlines the key objectives, features, and benefits of the honeypot system. It is intended for distribution at conferences, seminars, or academic forums. The design highlights the importance of cybersecurity and the project's role in addressing modern threats.

A.1.1. Brocher Layout and Content

This subsection discusses the layout and content of the brochure. It features a concise introduction, project overview, and a summary of its innovative aspects. Visual elements like diagrams and infographics were used to enhance its appeal.

A.1.1.1. Visual Design of the Brochure

The brochure's visual design includes the project's logo, a color scheme reflecting cybersecurity themes (blue and black), and high-quality images of network infrastructure. The layout ensures clarity and ease of understanding, with minimal text and clear headings.

Reference and Bibliography

Reference and Bibliography

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