

**Arab American University**

**Faculty of Information Technology**

SENIOR PROJECT (II)

**PacketsWall**

**(DDoS Attack Detection and Prevention System)**

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# Declaration

This is to declare that the graduation assignment entitled (PacketsWall) below the supervision of (Dr. Mohammed Hamarsheh) is our very own paintings and does now not contain any unacknowledged paintings or material formerly posted or written by using any other person, except wherein due reference is made inside the text of the record.

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# Abstract

Distributed Denial-of-Service (DDoS) assaults have come to be a notable and all of sudden evolving hazard to the current-day internet. Given the increasing frequency and class of these attacks, it's far vital to mix the latest improvements in cybersecurity into instructional packages to better equip college students and professionals with the expertise and abilities required to combat these threats.

This project introduces the design and implementation of a senior project centered on DDoS Attack Detection and Mitigation. The assignment pursuits to develop a testbed environment to simulate real-world DDoS assaults, detection mechanisms, and defensive strategies. An entire study is conducted on several DDoS assault equipment, detection systems, and protection techniques. The project consists of installing a community environment, appearing a sequence of tests, and analyzing the experimental effects to evaluate the effectiveness of different defense techniques, through monitoring with a system that has a graphical interface to track all network movements.

This is to claim that the graduation venture entitled (PacketsWall) under the supervision of (Dr. Mohammed Hamarsheh) is our private paintings and does now not include any unacknowledged paintings or fabric previously posted or written by means of the use of another person, besides wherein due reference is made within the textual content of the document.

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# Chapter One. Introduction

## Background and Motivation

The rapid growth of the net and the growing reliance on on-line offerings have made cybersecurity an important trouble in nowadays virtual landscape. Among the numerous cybersecurity threats, Distributed Denial of Service attacks stand out due to their potential to cause large disruption, monetary loss, and damage to reputation for businesses and people alike. DDoS assaults comprise overwhelming a aim server, provider, or community with a flood of visitors, rendering it inaccessible to valid users. This form of attack can originate from a big style of dispensed resources, often leveraging botnets to perform the attack.

The frequency and complexity of DDoS attacks have escalated extensively through the years, with attackers continuously evolving their techniques to skip conventional security features. As companies emerge as greater depending on internet-based services, the significance of growing effective DDoS detection and protection mechanisms has never been extra critical. Understanding the dynamics of these attacks and enforcing proactive measures is essential to safeguarding on-line infrastructure.

This venture pursuits to explore and simulate actual-world DDoS assaults, specializing in their detection and tracking strategies. By constructing a testbed environment, this painting presents a possibility to test with various DDoS assault gear and defense systems, with a graphical interface for ease of use and network monitoring to track this type of attack. Vicinity of cybersecurity. Furthermore, this project pursuits to equip college students with the technical abilities necessary to apprehend and mitigate the risks posed by DDoS assaults, in the long run contributing to the improvement of extra resilient and secure network systems.

## Aims and Objectives

#### **Aim**

#### The primary goal of this project is to design and implement a simulated distributed denial of service (DDoS) attack environment, with a focus on detection and tracing mechanisms, especially for the most vulnerable protocols. The project seeks to provide a comprehensive understanding of the nature of DDoS attacks, explore different attack tools, and examine unique detection and mitigation techniques such as the Scapy Python tool, in a controlled real-world environment.

#### **Objectives**

**Developing a Detection Mechanism**

**The DDoS detection gadget on this mission is designed to become aware of and analyze abnormal site visitors’ patterns within the network using Scapy and Python. The gadget uses packet sniffing and deep packet inspection to screen incoming visitors in real time, and distinguish between legitimate and malicious requests. The detection module makes a specialty of figuring out TCP SYN floods, UDP floods, HTTP request floods, and ICMP floods by means of analyzing packet frequency, source IP behavior, and protocol anomalies. This detection will help us mitigate and prevent capacity DDoS assaults.**

**Implement a Mitigation and Prevention System**

The mitigation and prevention gadget objectives to lessen the effect of DDoS assaults through implementing automatic protection mechanisms that respond fast to detected threats. The prevention module is designed to reduce excessive requests, and leverage packet filtering to make sure that valid users maintain to get right of entry to community sources without interruption. The system may even send emails to alert the community administrator of the presence of the attack with details, as a way to act as fast as feasible.

**Enhance Network Security Awareness**

This project aims to raise awareness by providing a comprehensive analysis of modern DDoS techniques, through which students will gain hands-on experience in detecting, analyzing, and mitigating DDoS attacks. By exploring vulnerabilities in common network protocols and the tactics attackers use to exploit them, they will develop a proactive mindset towards network security.

**Leverage Cloud Services for Scalability and Data Management**

Utilize Firebase cloud services for scalable data storage, real-time synchronization, and robust backup capabilities. This integration will support the storage of detection logs, system configurations, and historical baseline data, enabling persistent learning of network behavior and centralized management across distributed environments.

**Integrate Real-Time Monitoring and Management Interfaces**

Create both a local graphical user interface (GUI) and a comprehensive web-based application for continuous traffic monitoring, attack detection, and response control. The web application will provide a centralized dashboard with real-time network event logging, graphical visualizations of attack distribution and rates, and seamless integration with cloud data for remote oversight.

**Develop a Web Admin Interface**

Design and implement a comprehensive web-based admin panel to facilitate remote monitoring, management, and system configuration. Built with modern web technologies and integrated with Firebase, the interface provides real-time access to attack statistics, protocol-specific graphs, blocked IP logs, and system status updates. Administrators can visualize traffic patterns, review alerts, adjust detection settings, and oversee historical data, all through a responsive and intuitive dashboard accessible from any device.

## Problem Statement

DDoS attacks are a significant issue in modern organizations due to the reliance on networking systems. Attackers use huge numbers of infected devices to direct excessive traffic to a single server, aiming to crash it or lower its speed. This can result in financial losses, disruption of offerings, and damage to a employer's recognition. The proposed venture aims to put into effect a real-time technique to locate DDoS attacks and implement countermeasures before a server or community crash is precipitated. The Scapy library, a Python-based language, will be used to identify traffic patterns indicating an attack is in progress and execute countermeasures like filtering or blocking suspicious traffic. This solution will be more reliable and secure by eliminating human error, which has been a cause of security breaches in the past.

## Target Audience

This project in the first-place targets network administrators, cybersecurity and IT specialists accountable for protecting the organization’s infrastructure. It also addresses the needs of scholars and students who are keen on studying network security by providing a hands-on environment to work on modern DDoS attacks' detection and mitigation techniques. Moreover, small and medium-sized enterprises without the means to purchase cost prohibitive commercial solutions can take advantage of an open-source, Python-based tool to boost their cyber defense capabilities.

## Risks of DDoS Attack

#### Distributed Denial of Service (DDoS) assaults are some of the maximum critical threats dealing with networks and systems inside the virtual age. The risks associated with these attacks are numerous, as they could lead to prolonged service disruptions, which affect device overall performance and result in sizable economic losses, specially while the website or service is predicated on it for revenue era. Additionally, repeated assaults can erode consumer accept as true with and harm the agency’s popularity. Furthermore, DDoS attacks can drain network assets, along with bandwidth, disrupting other structures that rely on the identical network. Another hazard is that those attacks can be used as a smokescreen to conceal different extra harmful sports, inclusive of statistics robbery or system breaches. Ultimately, DDoS attacks gift a tremendous cybersecurity hazard, unfavorable network sources, causing carrier outages, and negatively impacting the employer’s reputation and business operations.

## Structure of the Report

In the First chapter we provide an overview of the project, outlining its main objectives and highlighting the global risks posed by DDoS attacks. In the second chapter, we will mention some projects similar to ours and explain the features of each of them. And in the Third chapter, here, we analyze the technical aspects of DDoS attacks in detail. We examine how these attacks function, identify the network protocols most susceptible to exploitation, and describe how attackers leverage these vulnerabilities. Additionally, we simulate a DDoS attack to illustrate its underlying principles and review the key tools commonly used to launch such attacks. And in chapter Four, in this chapter focuses on methods for detecting and tracing DDoS attacks. We discuss best practices for mitigation and prevention, explore various defensive techniques, and demonstrate how to protect systems and networks from potential threats. We will also create a regular network monitoring interface that displays all network details and sends emails to the administrator about the presence of an attack. In the final chapter, we reflect on the core skills gained throughout the project and discuss potential avenues for future improvement and expansion. We also highlight how these skills can be applied to broader contexts in cybersecurity and beyond.

# Chapter Two. Literature Review

## Overview

The purpose of this section is to explore and study works that are related to our project in order to provide a better understanding of our project and highlight its added value. We would like to point out that after extensive search; we have found no single project that comprehensively demonstrates both the detailed simulation of DDoS attacks—crucial for understanding how they work—and the techniques to mitigate and reduce them. Moreover, many existing resources overlook certain network protocols typically targeted by denial of service. In contrast, our project addresses all such protocols, illustrating how each can be flooded and providing measures to protect against these attacks.

## Existing Systems

In this section, we will review a set of projects similar to our proposed project. In the next section, we can look at the details of each project system, and present the strengths, as well as the weaknesses, of each project.

1. **TCP Syn Flood Attack Detection and Prevention System using Adaptive Thresholding Method** [1]

This research problematizes DDoS assaults, particularly that of TCP SYN flood attacks, which exploit the vulnerability thus of the TCP three-way handshake mechanism. This paper proposes a system where an (ATA) detects and prevents such attacks. This system monitors incoming packet rates and segregates them into either legitimate packets or malicious packets with dynamically calculated thresholding. So as to minimize the number of false positives and enhance the detection rate. With the front-end application used extensively to the back to execute the procedure, the system slots in Abe where it uses Python and Scapy programs with separate operational modules for detection and prevention.

1. **Generation of Distributed Denial of Service Network Data with Phyton and Scapy**[1]

This research uses synthetic methods to create realistic network traffic data with a focus on DDoS attacks, using Python and the Scapy library. It simulates real-world attack scenarios like SYN flooding and UDP flooding to produce high-quality model training datasets for machine learning intrusion detection systems. This approach competes with traditional simulators by ensuring accurate traffic in a controlled environment, aiming to improve detection systems and provide a cost-effective alternative to physical botnet setups.

1. **Entropy-based distributed denial of service attack detection in software-defined networking**[2]

In this work, we introduce an entropy-based algorithm for the detection of DDoS attacks over Software-Defined Networks. Variations from the normal in the destination IP address entropy are monitored, which helps to indicate cases of DDoS such as UDP flooding. By building on the POX SDN controller and implementing an entropy-based detection algorithm, the work seeks to better enable early detection and response to attacks, thus ensuring the stability and security of the network/destroying attacks. The system was able to proficiently detect malicious traffic and notify the administrators and showed good accuracy and efficiency while emulating the network setting.

## Analysis of Existing Systems

After presenting the details of the related work, below we provide a table comparing between the explored systems using a set of comparison criteria.

Table 2. Comparison Between Systems

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **TCP Syn Flood Attack Detection and Prevention System using Adaptive Thresholding Method** | **Generation of Distributed Denial of Service Network Data with Phyton and Scapy** | **Entropy-based distributed denial of service attack detection in software-defined networking** | **PacketsWall** |
| **Target Protocols** | TCP Protocol | UDP Protocol | UDP and ICMP Protocols | TCP, UDP, HTTP and ICMP  Protocols |
| **DDoS Attack Detection and Prevention** | **✓** | ✘ | **✓** | **✓** |
| **Graphical Display** | ✘ | ✘ | ✘ | **✓** |
| **Real-Time Traffic Analysis** | ✘ | **✓** | ✘ | **✓** |
| **Email Notification** | **✓** | ✘ | ✘ | **✓** |
| **Cloud Integration** | ✘ | ✘ | ✘ | **✓** |
| **Attack Logging and Reports** | ✘ | ✘ | ✘ | **✓** |
| **Web Admin Page** | ✘ | ✘ | ✘ | **✓** |

## Summary

This chapter has evaluated and surveyed a number of research works pertaining to DDoS attacks, comparing and contrasting the differentiating aspects of these studies to our proposed project. This analysis enabled the elicitation of shortcomings dissipated in past research in upholding the effects of targeted protocols or, in most instances, ineffective detection and mitigation mechanisms. With these observations in view, we engaged in developing our project so as to overcome these deficiencies while ensuring a more whole-some and efficient system. Most importantly, the view behind this analysis was to utilize insights gleaned from the earlier studies and factors improvable for augmenting our project work in respect to responses for detecting and mitigating attacks thereby contributing overall big value to the field of cybersecurity.

# Chapter Three: DDoS Attack Background



## Introduction

In this chapter presents a complete history on DDoS attacks, that specialize in their ability objectives, inclusive of servers, networks, and websites, in addition to the network protocols maximum at risk of exploitation, together with TCP, UDP, HTTP, and ICMP. Additionally, it outlines the methodologies used to simulate these attacks the usage of Python and Scapy, highlighting their realistic implications for cybersecurity research and protection strategies. By analyzing the attack mechanisms and their effect on network infrastructure, this bankruptcy establishes the inspiration for imposing detection and mitigation strategies to decorate system resilience against DDoS threats.

## Analysis of Existing Systems

The literature and research review aims to gather information on DDoS attacks, their mechanisms, and vulnerable network protocols to understand the entire attack cycle. After completing the review, an assessment is made to ensure the simulation approach addresses basic aspects for successful attack simulation and mitigation, meeting performance, security, and usability standards. This will provide a robust and reliable defense against DDoS attack threats, ensuring a comprehensive understanding of the attack cycle.

## Potential DDoS Attack Targets & Protocols

DDoS Attacks are designed to overwhelm systems, networks, or websites by flooding them with a massive amount of traffic or requests, and we will learn about these systems and protocols that DDoS can disable and deny service to it.

* + 1. **Potential DDoS Attack Targets**

#### **Servers**

A Distributed Denial of Service (DDoS) attack is a malicious attempt to disrupt the normal functioning of a targeted server or service, by overwhelming it with a flood of internet traffic. Which originates from a single source, a DDoS attack employs multiple compromised systems, often organized into a botnet, to generate the attack traffic.

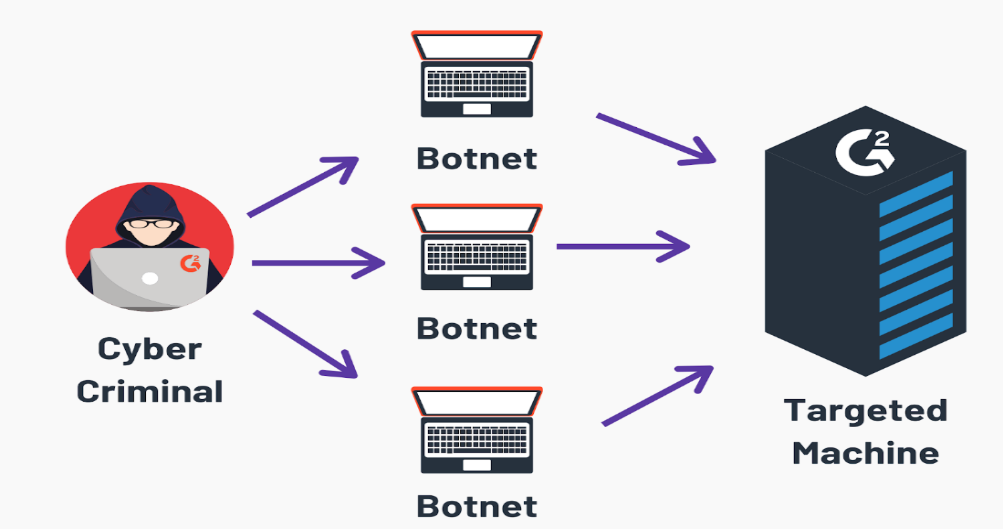


Figure 3. DDoS Attack on Servers

* **Botnet** is a network of compromised devices (bots) controlled by a malicious actor, often used to perform coordinated cyberattacks such as DDoS, spam distribution, or data theft. These devices, infected with malware, operate without the owner's knowledge and execute commands from the attacker.

#### **Networks**

These attacks target the **network infrastructure** of a system, such as**routers, switches,** or **firewalls**, with the aim of overwhelming them with traffic. This can be achieved through techniques such as **flooding**, where the attacker sends a large number of packets to the target, or through a **ping flood**, where the attacker sends a huge number of[ping requests](https://www.firewall.cx/networking/network-protocols/icmp-protocol) to the target, causing it to become unresponsive, as shown in Figure 3.2.

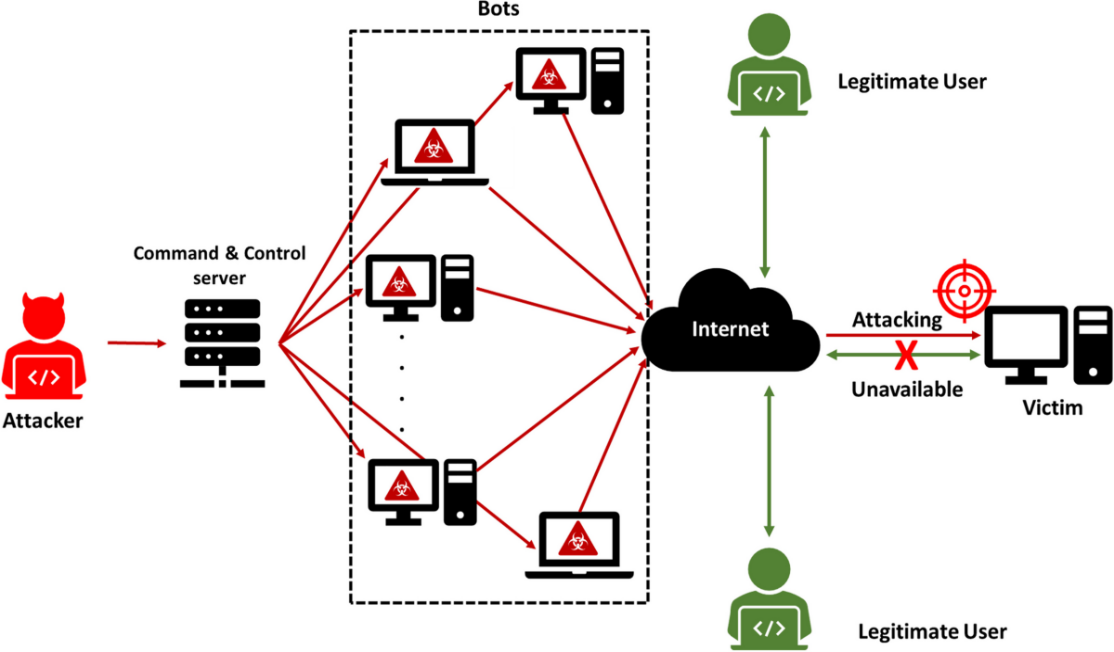


Figure 3. DDoS Attack on Networks

The Figure illustrates the structure and mechanism of a DDoS attack targeting network infrastructure. It showcases how an attacker uses a botnet under the control of a command-and-control server to flood the victim's network resources, such as routers, switches, or firewalls, with excessive traffic. This overwhelming surge of requests disrupts service availability for legitimate users, causing the targeted system to become unresponsive or inaccessible.

#### **Websites**

A Distributed Denial of Service (DDoS) attack on websites is a targeted attempt to overwhelm a website's server or resources, rendering it inaccessible to legitimate users. These attacks flood the website with excessive traffic, often generated by a botnet, to exhaust its bandwidth or computing capacity. The most common forms of website DDoS attacks include HTTP floods, DNS amplification, and SYN floods, which target the application and protocol layers of the website.

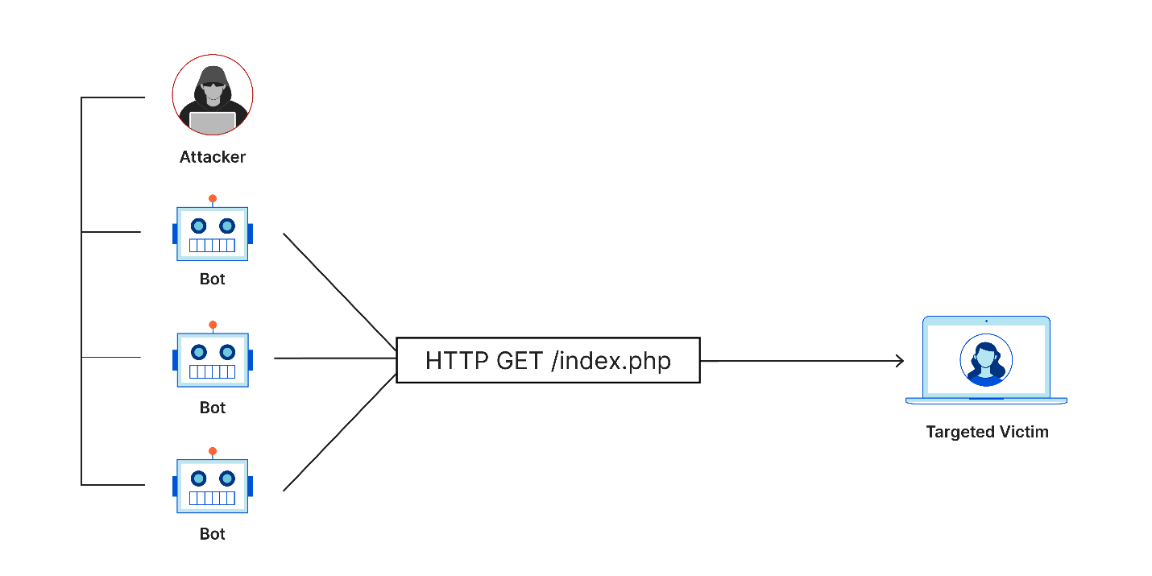


Figure 3. DDoS Attack on Websites

The diagram demonstrates how a DDoS attack specifically targets a website by leveraging multiple bots to send an overwhelming number of HTTP requests, such as "GET /index.php." This flood of traffic is designed to exhaust the server's resources, ultimately preventing the website from responding to legitimate user requests.

* + 1. **Vulnerable Protocols**

These attacks attempt to consume and exhaust compute capacity of various network infrastructure resources like servers or firewalls by sending malicious connection requests, including TCP, UDP, HTTP and ICMP protocol.

1. **TCP SYN Flood Attack:**

**SYN Flood attack**, a type of DDoS attack that targets the victim’s server to exhaust its resources and render it unavailable to legitimate users. In this attack, an attacker uses a compromised device (bot) to send a large number of **spoofed SYN packets** to the target system. These packets initiate a connection by imitating the first step of the **TCP handshake**. The target server responds with **SYN-ACK packets** as part of the handshake process, expecting an **ACK response** to complete the connection. However, since the SYN packets have spoofed IP addresses, the ACK response never arrives. as shown in Figure 3.5.

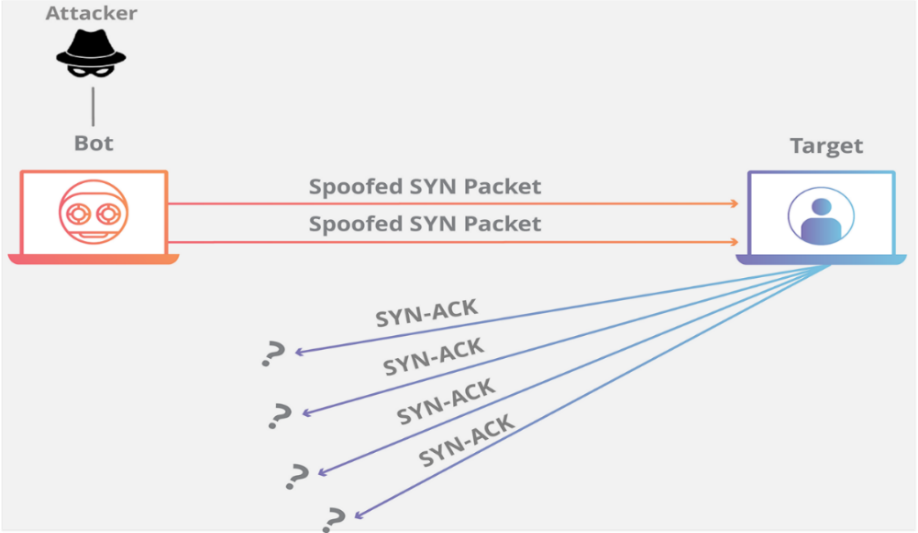
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Figure 3.  How Does TCP SYN Flood Attack work

The server is left waiting for responses to numerous incomplete connections, which consume its resources and eventually overwhelm it. This disrupts normal server operations, denying legitimate users access to its services. The attack exploits the way the TCP handshake is designed and relies on the inability of the server to handle such a high volume of incomplete connections.

1. **UDP Flood Attack:**

**UDP Flood attack** is a type of Distributed Denial of Service (DDoS) attack that overwhelms a target system with a large volume of User Datagram Protocol (UDP) packets. These packets are sent to random ports on the target, causing the system to repeatedly check for applications listening on those ports. If no application is found, the target responds with ICMP "Destination Unreachable" packets. as shown in Figure 3.7.

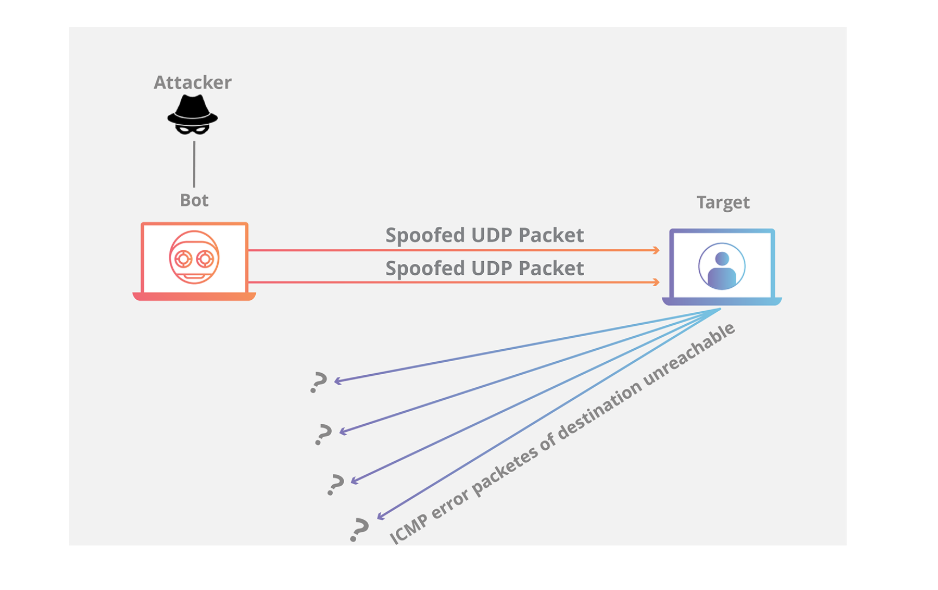
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Figure 3. How Does UDP Flood Attack Work

The non-stop processing of these packets consumes the system's resources, inclusive of bandwidth, CPU, and memory, potentially rendering it unresponsive or inaccessible to valid users. UDP Flood assaults are often amplified by using the use of spoofed IP addresses, making it harder to trace the foundation of the attack. This attack exploits the connectionless nature of UDP, which lacks integrated mechanisms for handshake verification, making it particularly susceptible to flooding.

1. **HTTP flood DDoS attack:**

HTTP flood attacks are a kind of “**layer** **7**” DDoS attack. Layer 7 is the utility layer of the OSI version, and refers to net protocols including HTTP. HTTP is the basis of browser-based net requests, and is usually used to load webpages or to send shape contents over the Internet. Mitigating utility layer assaults is especially complex, because the malicious visitors is hard to distinguish from normal traffic.

In order to obtain most efficiency, malicious actors will commonly appoint or create botnets so that it will maximize the impact in their assault. By making use of many devices infected with **malware**, an attacker is able to leverage their efforts by launching a bigger extent of attack visitors.

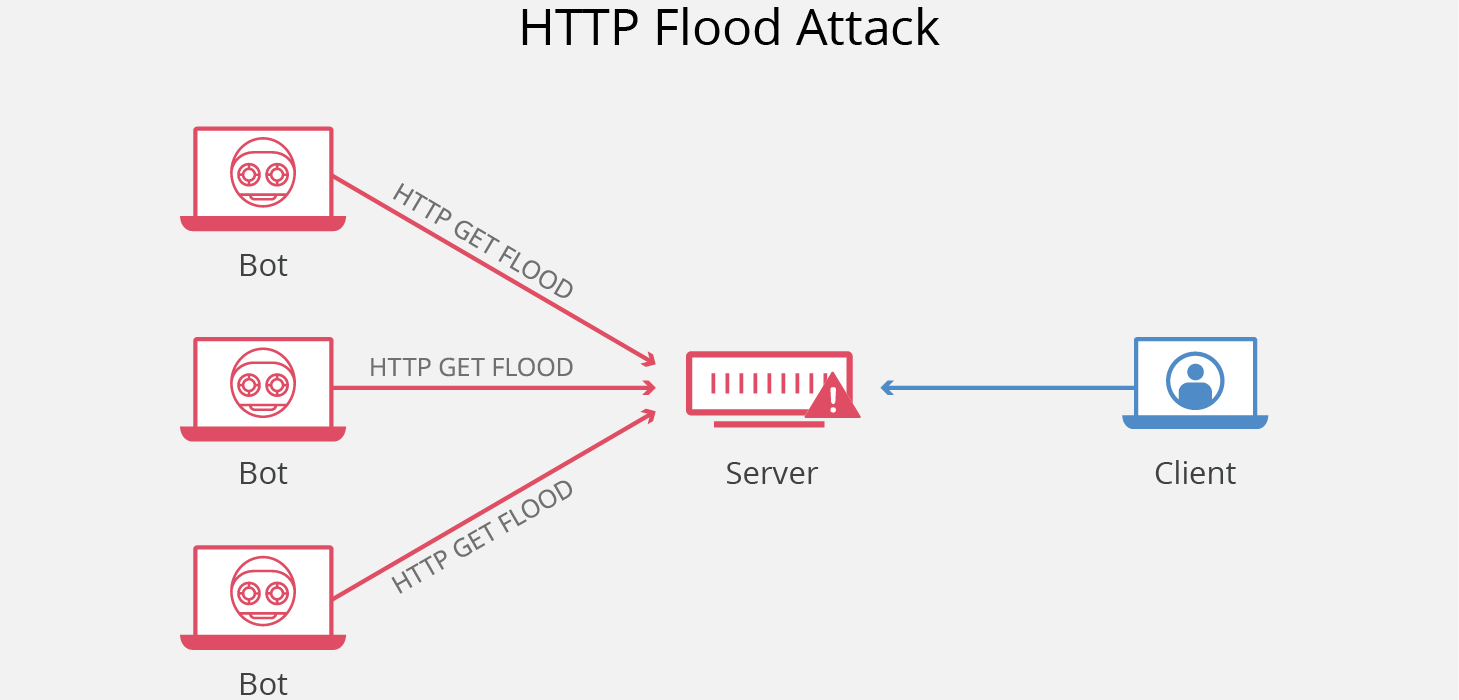


Figure 3. How Does HTTP Flood Attack work

1. **HTTP GET attack** - in this form of attack, more than one computer systems or other gadgets are coordinated to ship more than one requests for photographs, files, or some different asset from a centered server. When the goal is inundated with incoming requests and responses, denial-of-service will arise to extra requests from valid site visitors’ assets.
2. **HTTP POST attack** - typically when a shape is submitted on a internet site, the server needs to manage the incoming request and push the statistics right into a patience layer, most usually a database. The method of handling the shape records and going for walks the necessary database instructions is extraordinarily in depth as compared to the amount of processing energy and bandwidth required to ship the POST request. This assault utilizes the disparity in relative useful resource intake; by sending many put up requests immediately to a targeted server till its capability is saturated and denial-of-service takes place.
3. **ICMP Flood Attack:**

**ICMP (Internet Control Message Protocol)** is a protocol used for network diagnostics**,** such as in tools like **ping** and **traceroute**. In a **Ping Flood attack,** a large number of **ICMP echo-request** packets are sent to a target device, forcingit to process these requests and send **ICMP echo-reply** responses**,** as shown in Figure 3.9.

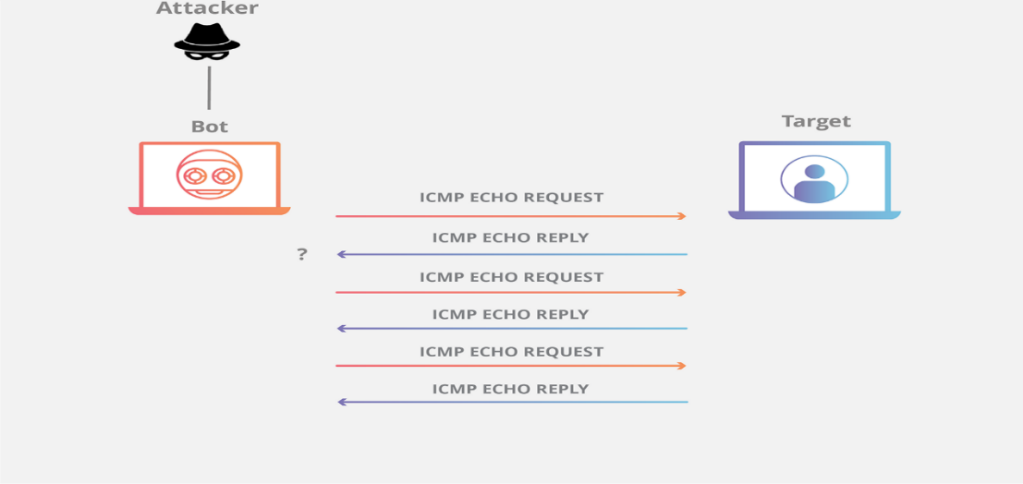


Figure 3. How Does ICMP Flood Attack work

This process consumes the target's resources and bandwidth, potentially overwhelming it. The attack often utilizes a botnet to flood the target with requests, making it unnecessary to spoof IP addresses. The attack can be summarized in two steps: attackers send **ICMP echo-request** packets from multiple devices, and the target responds with **ICMP echo-reply** packets, leading to network disruption.

## Summary

Covers conducting DDoS simulations using Python and Scapy, targeting TCP, UDP, HTTP and ICMP protocols. Explains the setup process, including installation of dependencies and automation of attacks using paramiko and SSH. Simulations present vulnerabilities like exploitation of TCP handshake, connectionless nature of UDP, and flooding of HTTP requests. Attack success is confirmed by logs, underscoring the need for understanding such patterns so as to build potent defenses.

# Chapter Four: Methodology



## Introduction

In this Chapter, the methodology used to undertake the design, development, and implementation of PacketsWall is presented. PacketsWall is an integrated system for the detection and mitigation of Distributed Denial of Service (DDoS) attacks. The architecture of the system features real-time analysis at a local level combined with cloud-enabled data management and user interfaces. It exploits both Python-based backend tools and modern frontend technologies. The components, algorithms, and mechanisms that comprise the system will be detailed in this chapter with particular emphasis placed on its adaptive detection capabilities, multi-protocol support, and scalable infrastructure.

PacketsWall was developed both from theory and practiced experimentation. As the project matured, it took in refinements forged during real-world testing and senior-level implementation phases. These enhancements enabled the system to better respond to dynamic attack patterns and varied network environments. By integrating adaptive thresholding, automated responses, and cloud-based monitoring, PacketsWall provides a comprehensive and responsive solution tailored to meet the challenges posed by increasingly sophisticated DDoS attacks.

## System Architecture and Structure

The structure of PacketsWall turned into designed to achieve a stability among localized actual-time detection and cloud-primarily based oversight. To cope with the velocity and scale of modern DDoS assaults, the system follows a hybrid architecture that leverages each edge-aspect processing and centralized monitoring. This method guarantees well timed detection and mitigation at the factor of assault, at the same time as also permitting scalable control and logging via the cloud.

The architecture consists of four interdependent additives. The first is the **local detection engine**, a Python-based module that video display units’ community visitors in real time and applies adaptive thresholding algorithms to perceive anomalies. This module makes use of the Scapy library for deep packet inspection, permitting specific traffic category throughout a couple of protocols which include TCP, UDP, HTTP, and ICMP. Upon detecting an assault, the system can immediately block malicious IPs the use of gadget-level firewall controls consisting of iptables.

The second component is the **cloud records management layer**, built on Firebase. This layer enables actual-time statistics synchronization and continual storage of detection logs, system configurations, and historical baselines. By offloading those obligations to a secure, scalable cloud platform, the system achieves high availability and remote access without compromising system-wide performance.

The third component is the **web-based administrative interface**, developed using React. This interface provides a centralized dashboard where administrators can visualize network activity, monitor ongoing attacks, and review system logs. Features such as real-time attack charts, protocol-specific breakdowns, and log filtering enhance the usability of the system and support efficient incident response.

The fourth and final component includes the **automated response and alert mechanisms**. These are tightly coupled with the detection engine and include real-time email notifications and firewall-based IP blocking. Every response action—such as blocking an IP or sending an alert—is logged and mirrored in the Firebase backend for traceability and post-incident analysis.

Together, these components form a cohesive system that supports detection, response, monitoring, and administration. This modular design not only enhances scalability and maintainability but also ensures that PacketsWall remains effective against a diverse and evolving set of DDoS threats.

## System Architecture and Cloud Integration

The PacketsWall system implements a hybrid that integrate local real-time detection with cloud-based data management and monitoring. This setup allows for quick responses to attacks while also providing thorough logging and remote monitoring capabilities through integration with Firebase cloud services, as shown in figure 4.1.

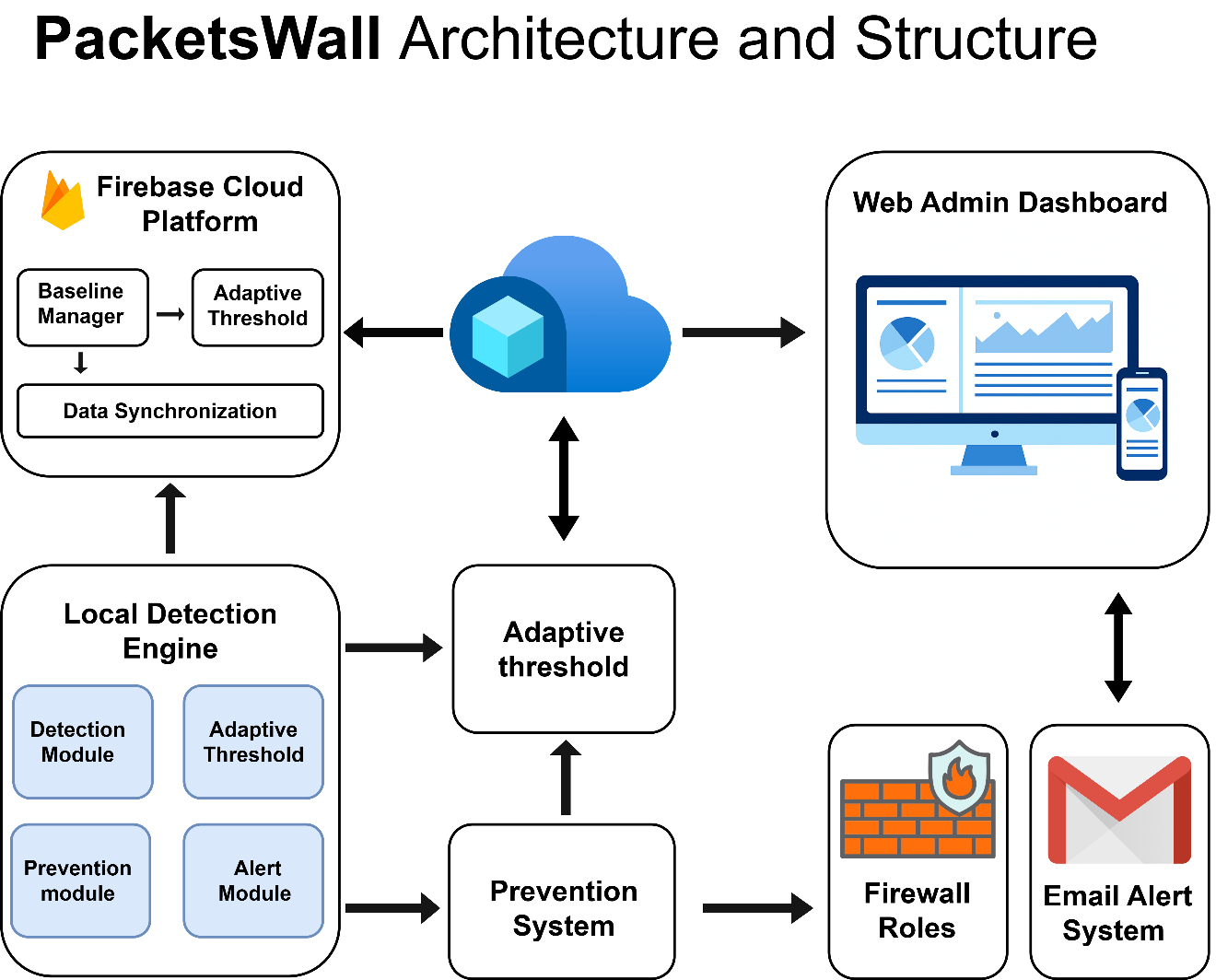


Figure 4. 1 PacketsWall Architecture and Structure

The system architecture consists of four interdependent components working in concert to provide comprehensive DDoS protection. The first component is the local detection engine, a Python-based module that monitors network traffic in real-time and applies adaptive thresholding algorithms to identify anomalies. This module utilizes the Scapy library for deep packet inspection, enabling precise traffic classification across multiple protocols including TCP, UDP, HTTP, and ICMP. Upon detecting an attack, the system can immediately block malicious IP addresses using system-level firewall controls such as iptables on Linux systems or Windows Firewall on Windows platforms.

The second component is the cloud data management layer, built on Google Firebase platform. This layer enables real-time data synchronization and persistent storage of detection logs, system configurations, and historical baselines. By offloading these responsibilities to a secure, scalable cloud platform, the system achieves high availability and remote access capabilities without compromising local system performance. Firebase provides enterprise-grade infrastructure with automatic scaling, real-time database capabilities, and robust security features.

The third component is the web-based administrative interface, developed using React framework with Progressive Web Application (PWA) capabilities. This interface provides a centralized dashboard where administrators can visualize network activity, monitor ongoing attacks, and review system logs. Features such as real-time attack charts, protocol-specific breakdowns, and advanced log filtering enhance system usability and support efficient incident response. The PWA architecture enables mobile access and offline capabilities, ensuring administrators can monitor the system from any device.

The fourth component encompasses automated response and alert mechanisms that are tightly integrated with the detection engine. These include real-time email notifications, firewall-based IP blocking, and comprehensive logging systems. Every response action, such as blocking an IP address or sending an alert, is logged and mirrored in the Firebase backend for traceability and post-incident analysis.

## Cloud Integration Architecture

The cloud integration represents a fundamental aspect of PacketsWall's architecture, enabling scalable data management, remote monitoring, and cross-device synchronization. The Firebase platform serves as the central hub for all cloud operations, providing real-time database capabilities, secure authentication, and scalable storage solutions, as shown in figure 4.2.

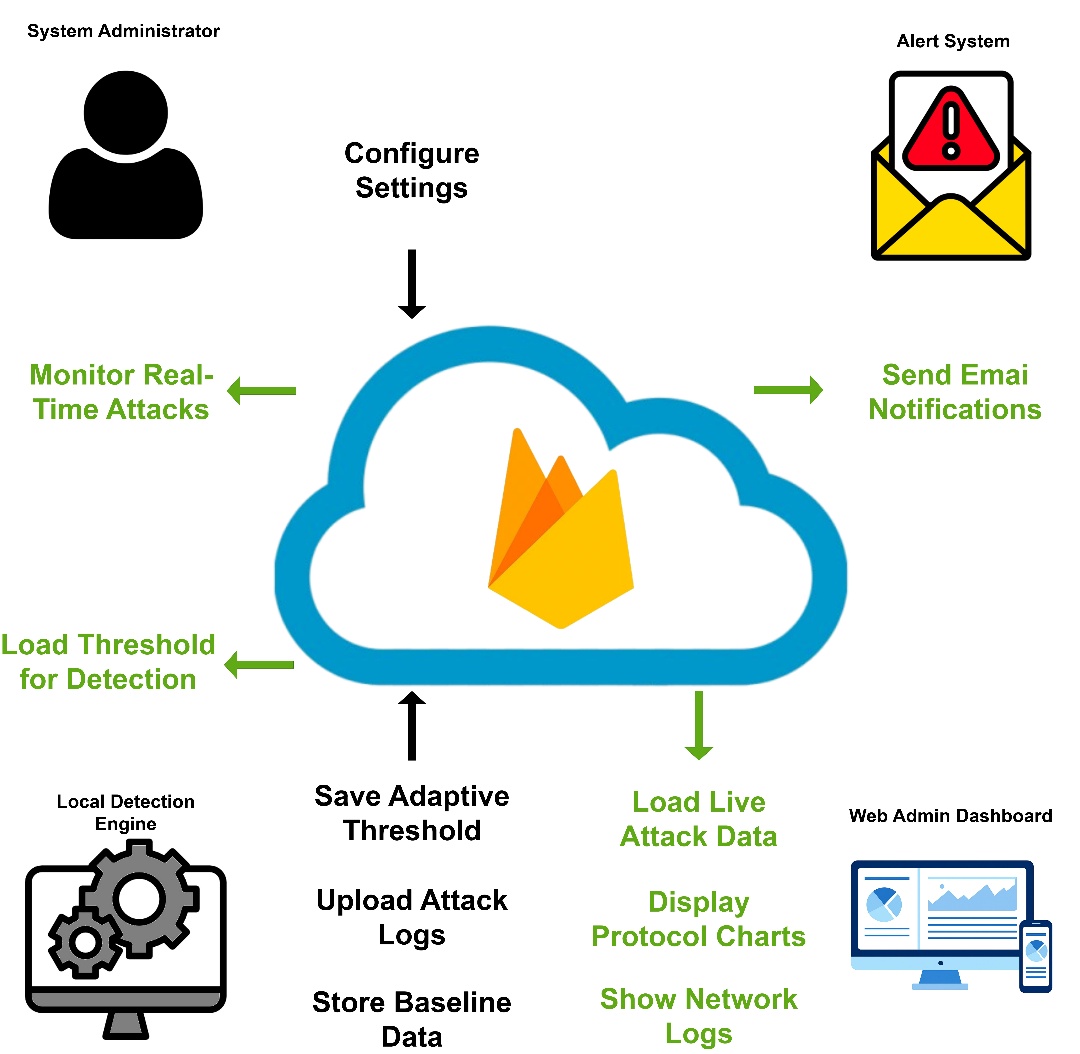


Figure 4. 2 PacketsWall Cloud Integration Architecture

The cloud integration architecture facilitates multiple critical functions within the PacketsWall ecosystem. The System Administrator can monitor real-time attacks and configure thresholds through the cloud interface, while the Alert System displays live charts and shows protocol distribution data. The Local Detection System uploads attack logs and receives configuration updates, while the Web Dashboard provides comprehensive filtering of network logs and real-time visualization capabilities.

Firebase serves as the central coordination point, managing baseline data storage, adaptive threshold synchronization, and real-time data feeds to connected interfaces. This architecture ensures that all system components remain synchronized while maintaining local autonomy for critical detection and response functions. The cloud integration also enables advanced analytics, historical trend analysis, and predictive modeling based on accumulated attack data.

The data synchronization mechanism implements intelligent caching strategies to ensure optimal performance even during network connectivity issues. Local systems maintain operational capability during cloud disconnections, with automatic synchronization resuming upon connectivity restoration. This hybrid approach guarantees continuous protection while leveraging cloud capabilities for enhanced functionality.

## Use Case Analysis and System Interactions

PacketsWall system supports multiple user roles and interaction patterns, each designed to address specific operational requirements and security responsibilities. The use case analysis demonstrates the comprehensive nature of system interactions and the seamless integration between local and cloud components.

The primary actors in the PacketsWall ecosystem include the System Administrator, who manages overall system configuration and monitoring; The Local Engine, which performs autonomous detection and response functions; the Firebase Cloud platform, which provides centralized data management and synchronization; and the Web Admin interface, which facilitates remote monitoring and management capabilities, as shown in figure 4.3.

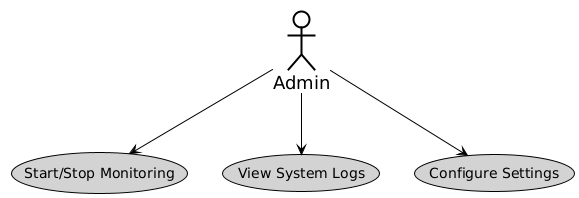


Figure 4. 3 Admin Use Case Diagram

The System Administrator's primary use cases include starting and stopping monitoring operations, viewing system logs, and configuring system settings. These administrative functions are supported by both local interfaces and cloud-based management tools, ensuring flexibility in system management approaches. The administrator can access comprehensive system status information, modify detection parameters, and review historical attack data through multiple interface options.

The Local Engine operates autonomously to detect DDoS attacks, block malicious IP addresses, send email alerts, and synchronize data with Firebase. This autonomous operation ensures immediate response capabilities independent of network connectivity or cloud availability. The engine maintains local decision-making authority for critical security functions while contributing to the broader system intelligence through data sharing, as shown in figure 4.4.

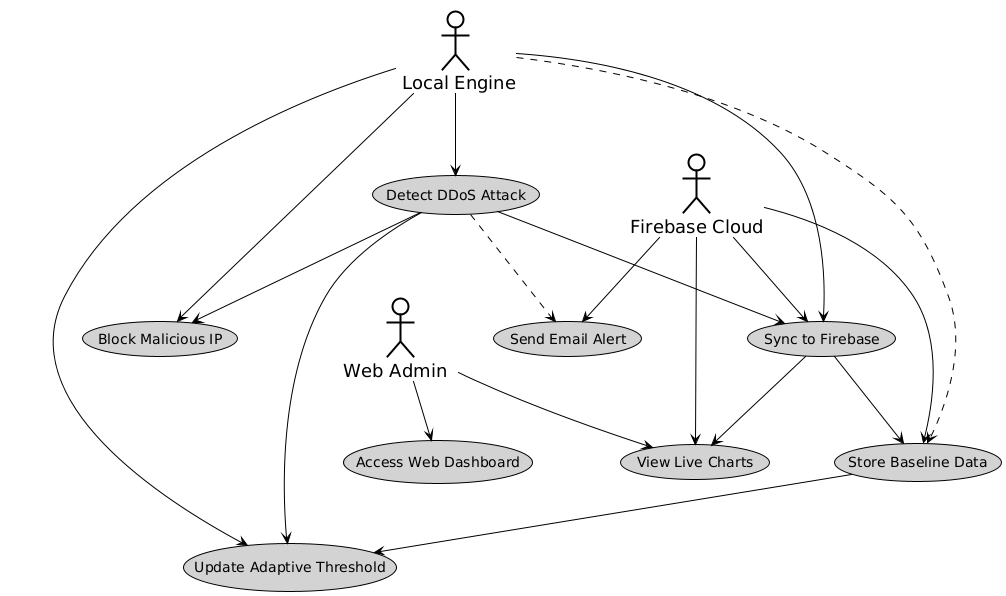


Figure 4. 4 System Use Case Diagram

The Firebase Cloud platform facilitates data storage, baseline management, and real-time synchronization across all system components. Cloud-based use cases include storing baseline data, updating adaptive thresholds, and feeding live charts with current attack information. The cloud platform also enables advanced analytics and historical trend analysis that inform system optimization and threat intelligence.

## Detection Module

The detection module represents the core intelligence of the PacketsWall system, implementing sophisticated algorithms for real-time traffic analysis and attack identification. The module operates continuously, analyzing network packets and applying adaptive thresholding mechanisms to distinguish between legitimate traffic and potential DDoS attacks, as shown in figure 4.5.

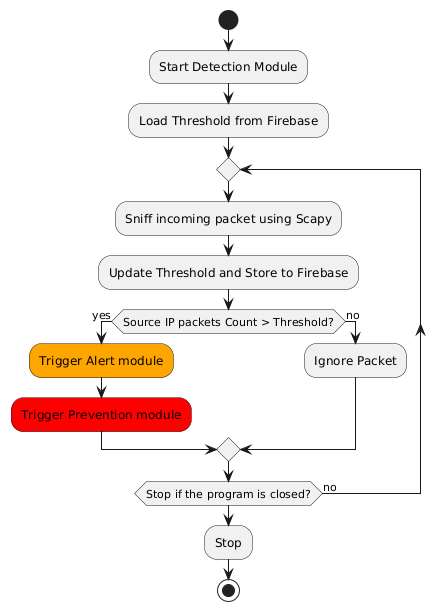


Figure 4. 5 PacketsWall Detection Module

The detection process begins with the initialization of the detection module, which loads current threshold values from Firebase cloud storage. This ensures that the local detection engine operates with the most recent baseline data and configuration parameters. The system then enters a continuous monitoring loop, using Scapy library for packet capture and analysis.

For each captured packet, the system performs deep packet inspection to classify traffic by protocol and source characteristics. The packet analysis includes protocol identification, source IP tracking, and traffic volume measurement. This information is continuously aggregated and compared against adaptive thresholds that are dynamically updated based on network behavior patterns.

When the source IP packet count exceeds the established threshold, the system triggers both alert and prevention modules simultaneously. The alert module generates immediate notifications while the prevention module initiates IP blocking procedures. This parallel activation ensures rapid response while maintaining comprehensive logging and notification capabilities.

The threshold update mechanism operates continuously, implementing Exponentially Weighted Moving Average (EWMA) algorithms to adapt baseline values based on observed traffic patterns. This adaptive approach enables the system to accommodate legitimate traffic variations while maintaining sensitivity to attack patterns. Updated thresholds are stored in Firebase for system-wide synchronization and historical analysis.

## Adaptive Threshold Algorithm

The adaptive threshold management system represents a critical innovation in PacketsWall's approach to DDoS detection. Unlike static threshold systems that require manual configuration and frequent adjustment, the adaptive system continuously learns from network behavior and automatically adjusts detection parameters to optimize accuracy while minimizing false positives, as shown in figure 4.6.

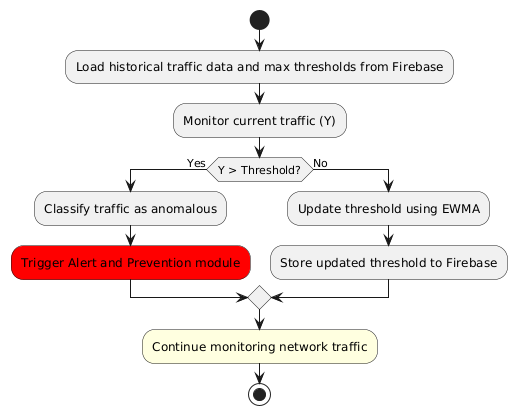


Figure 4. 6 Adaptive Threshold Module

The traffic is considered malicious if the following condition is met:

Where: β>0: Represents the allowed margin of extra packets beyond the threshold.

Definition of Variables:

* ​: The count of packets sent during the -th time interval.
* ​: The mean traffic rate calculated from measurements prior to interval
* **β**: The percentage of additional packets allowed above the adaptive threshold value before classifying the traffic as anomalous.

The adaptive threshold algorithm begins by loading historical traffic data and maximum threshold values from Firebase cloud storage. This historical context provides the foundation for intelligent threshold calculation based on observed network patterns and attack characteristics. The system continuously monitors current traffic levels, designated as Y in the algorithm flowchart.

The core decision logic compares current traffic levels against established thresholds. When traffic exceeds threshold values, the system classifies the traffic as anomalous and triggers alert and prevention modules. When traffic remains within normal parameters, the system updates thresholds using EWMA calculations that incorporate current observations into the baseline model.

The EWMA algorithm provides optimal balance between responsiveness to traffic changes and stability against temporary fluctuations. The mathematical formulation incorporates smoothing factors that can be adjusted based on network characteristics and operational requirements. Updated threshold values are immediately stored in Firebase, ensuring system-wide synchronization and providing data for historical analysis and trend identification.

This adaptive approach enables PacketsWall to operate effectively across diverse network environments without requiring extensive manual configuration. The system automatically accommodates legitimate traffic growth, seasonal variations, and changing usage patterns while maintaining high sensitivity to attack behaviors. The continuous learning capability ensures that detection accuracy improves over time as the system accumulates operational experience.

## Prevention Module

The prevention module implements immediate response capabilities designed to mitigate DDoS attacks at the network level through automated IP blocking and traffic filtering. The module operates in close coordination with the detection system to ensure rapid response while maintaining comprehensive logging and audit capabilities, as shown in figure 4.7.

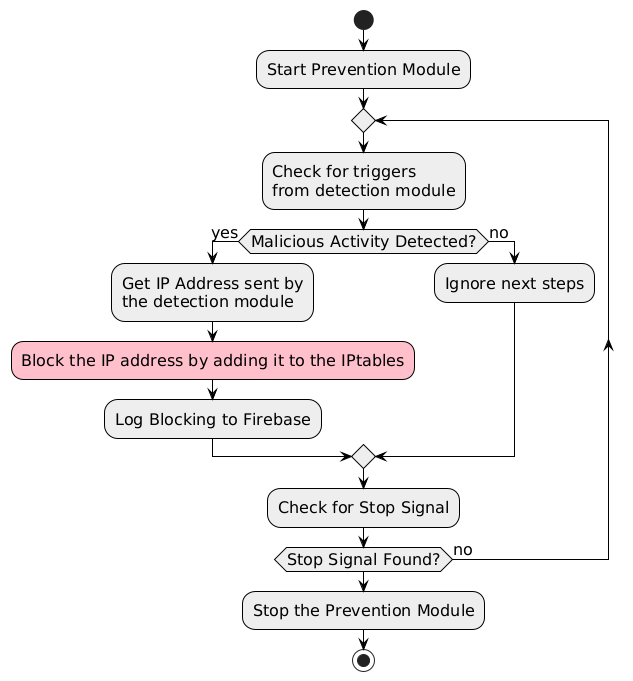


Figure 4. 7 PacketsWall Prevention Module

The prevention module operates through a continuous monitoring loop that checks for triggers from the detection module. Upon receiving a malicious activity detection signal, the module immediately retrieves the IP address information from the detection system and initiates blocking procedures. The blocking mechanism supports both Linux and Windows platforms through iptables and Windows Firewall integration respectively.

The IP blocking process creates system-level firewall rules that prevent further traffic from identified malicious sources. On Linux systems, the module executes iptables commands to add DROP rules for specific IP addresses. On Windows platforms, the system utilizes netsh commands to configure Windows Firewall with appropriate blocking rules. All blocking actions are logged to Firebase for audit purposes and historical analysis.

The prevention module includes intelligent management features such as temporary blocking with configurable durations, automatic rule cleanup, and manual override capabilities for false positive correction. The system maintains a comprehensive database of blocked IP addresses with timestamps, attack characteristics, and blocking duration information. This data supports both operational management and security analysis activities.

Error handling and verification mechanisms ensure reliable operation of the prevention system. The module includes comprehensive error checking for firewall command execution, verification of rule creation, and fallback procedures for system failures. All prevention actions are logged with detailed status information, enabling administrators to monitor system effectiveness and troubleshoot operational issues.

## Alert and Notification System

The alert and notification system provides comprehensive communication capabilities that ensure administrators and security personnel receive timely information about detected attacks and system status changes. The system implements multiple notification channels and supports configurable alert policies to accommodate diverse operational requirements, as shown in figure 4.8.

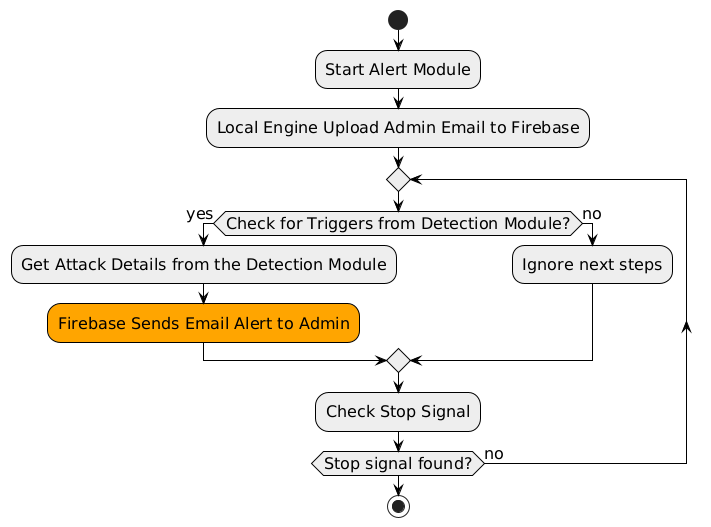


Figure 4. 8 PacketsWall Alert Module

The alert module operates through continuous monitoring for triggers from the detection module. Upon receiving an attack detection signal, the module retrieves detailed attack information from the detection system and initiates notification procedures. The notification process includes both immediate email alerts and cloud-based logging for historical analysis and reporting.

Email notification capabilities utilize SMTP protocols with support for multiple email providers and authentication methods. The system includes configurable email templates that provide comprehensive attack information including source IP addresses, attack characteristics, detection timestamps, and response actions taken. Email delivery includes retry mechanisms with exponential backoff to ensure reliable notification delivery even during network congestion.

Firebase integration enables real-time alert logging and synchronization across all system components. Alert data is structured for efficient querying and analysis, supporting both real-time monitoring and historical trend analysis. The cloud-based alert system enables mobile notifications, web dashboard updates, and integration with external security information and event management (SIEM) systems.

The alert system includes intelligent filtering and escalation capabilities to prevent notification flooding during large-scale attacks. Configurable alert policies enable administrators to define notification frequency, escalation procedures, and alert prioritization based on attack characteristics and system status. This intelligent alert management ensures that critical information reaches appropriate personnel without overwhelming communication channels.

## Web Dashboard and User Interface

The web-based dashboard represents the primary interface for system monitoring, configuration, and analysis. Developed using React framework with Progressive Web Application capabilities, the dashboard provides comprehensive visualization tools and management interfaces accessible from any internet-connected device, as shown in figure 4.9.

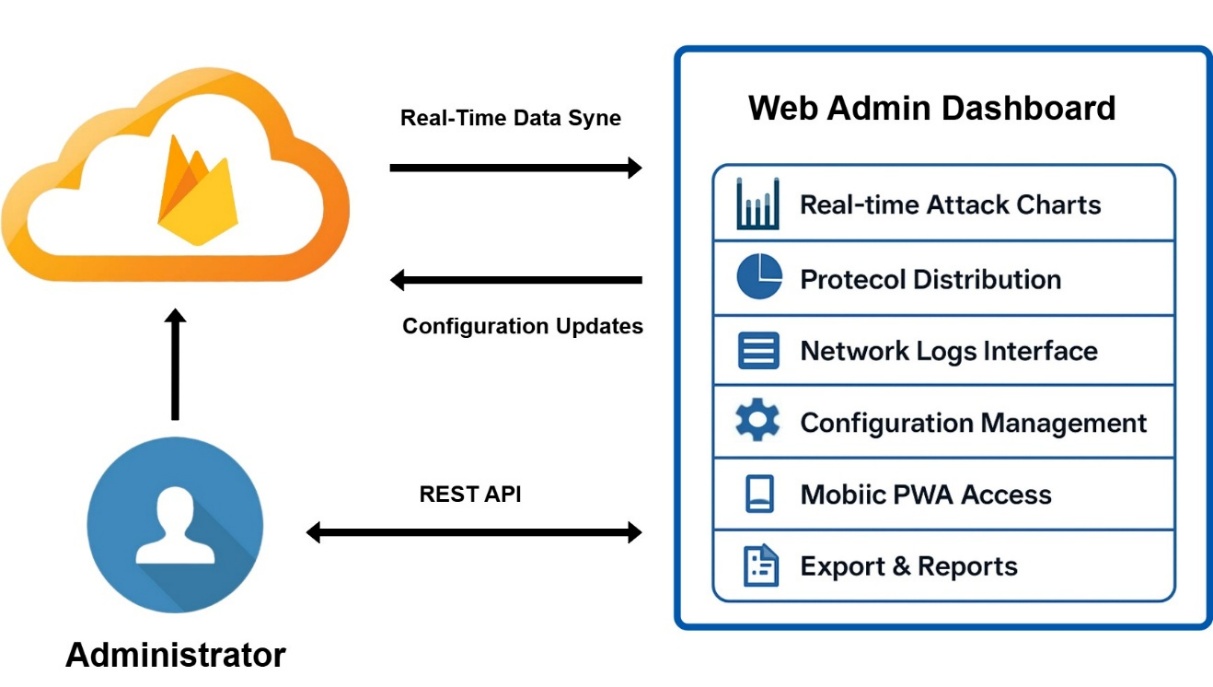
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Figure 4. 9 Web Admin Interface Architecture

The interface architecture implements real-time data synchronization with Firebase, ensuring that displayed information reflects current system status and attack activity. Live charts provide immediate visualization of attack rates, protocol distribution, and network traffic patterns. The interface includes interactive filtering capabilities that enable administrators to focus on specific time periods, attack types, or network segments.

Key dashboard features include real-time attack monitoring with automatically updating charts showing protocol distribution and attack intensity over time. The network logs interface provides comprehensive filtering capabilities by IP address, protocol type, timestamp, and attack characteristics. Configuration management tools enable adjustment of detection parameters, notification settings, and system operational parameters through intuitive web interfaces.

The Progressive Web Application architecture enables mobile access with push notifications and offline capabilities. Administrators can monitor system status and receive alerts through mobile devices, ensuring continuous oversight regardless of location. The offline capability ensures that critical system information remains accessible even during network connectivity issues.

Advanced analytics features provide historical trend analysis, attack pattern identification, and system performance metrics. The dashboard includes export capabilities for generating reports, sharing data with external systems, and supporting compliance requirements. Integration with external systems is facilitated through RESTful APIs and standardized data formats.

## Class Diagram

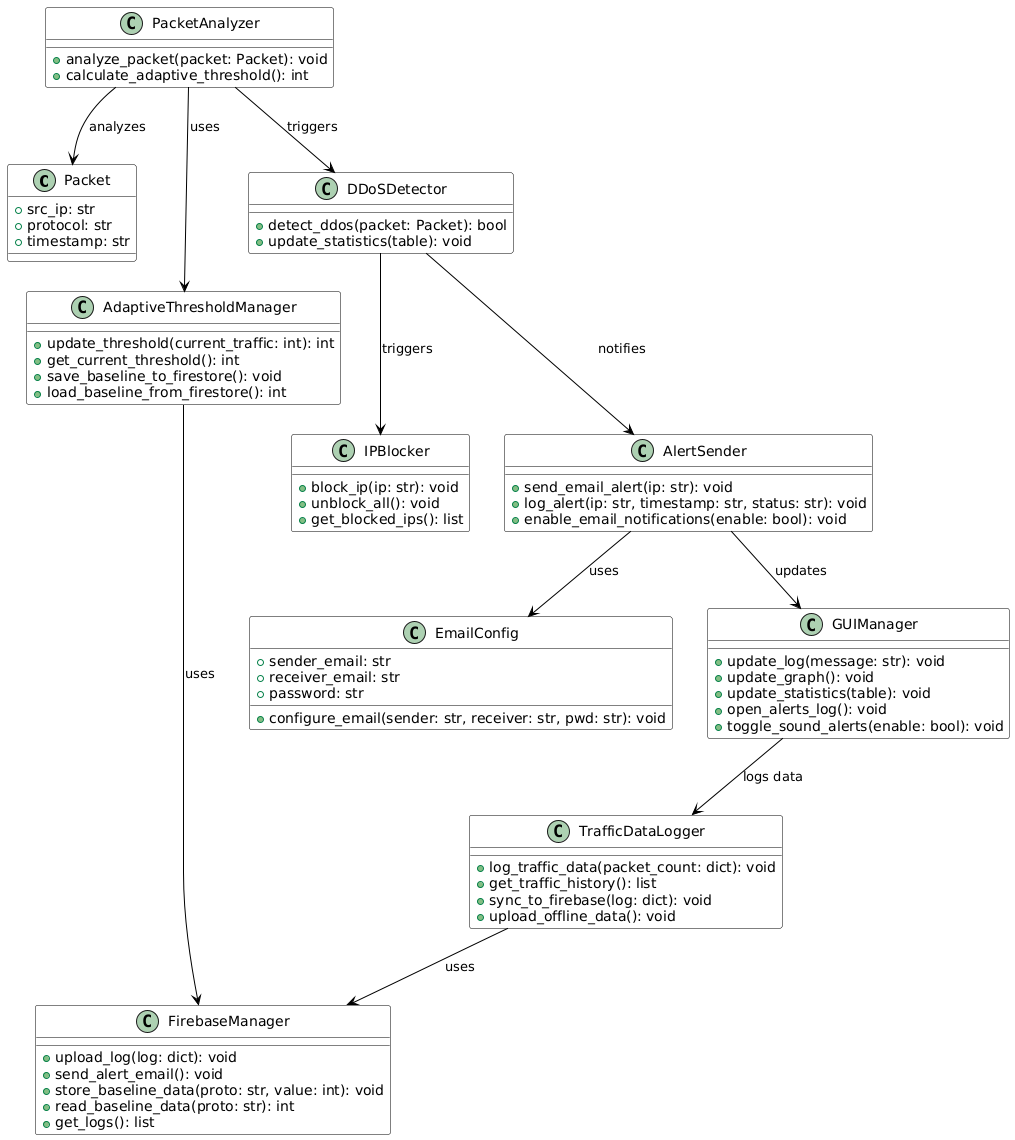


Figure 4. Class Diagram

## Security and Privacy Considerations

Security implementation includes comprehensive authentication and authorization mechanisms protecting cloud data and system access. Firebase security rules implement role-based access control ensuring appropriate data access based on user roles and organizational requirements. Multi-factor authentication support enhances access security for administrative functions and sensitive system operations.

Data privacy protection includes encryption of sensitive data both in transit and at rest, with configurable data retention policies enabling compliance with organizational and regulatory requirements. The system implements data anonymization capabilities for statistical analysis while preserving privacy of network traffic sources. Geographic data residency options support compliance with regional data protection regulations.

Network security includes secure communication channels between local systems and cloud platform using TLS encryption and certificate validation. API security implements authentication tokens, rate limiting, and input validation preventing unauthorized access and abuse. System hardening guidelines provide recommendations for secure deployment and operational security best practices.

## Software Design

* + 1. **Local Engine Design**
    2. **Dashboard Tab**

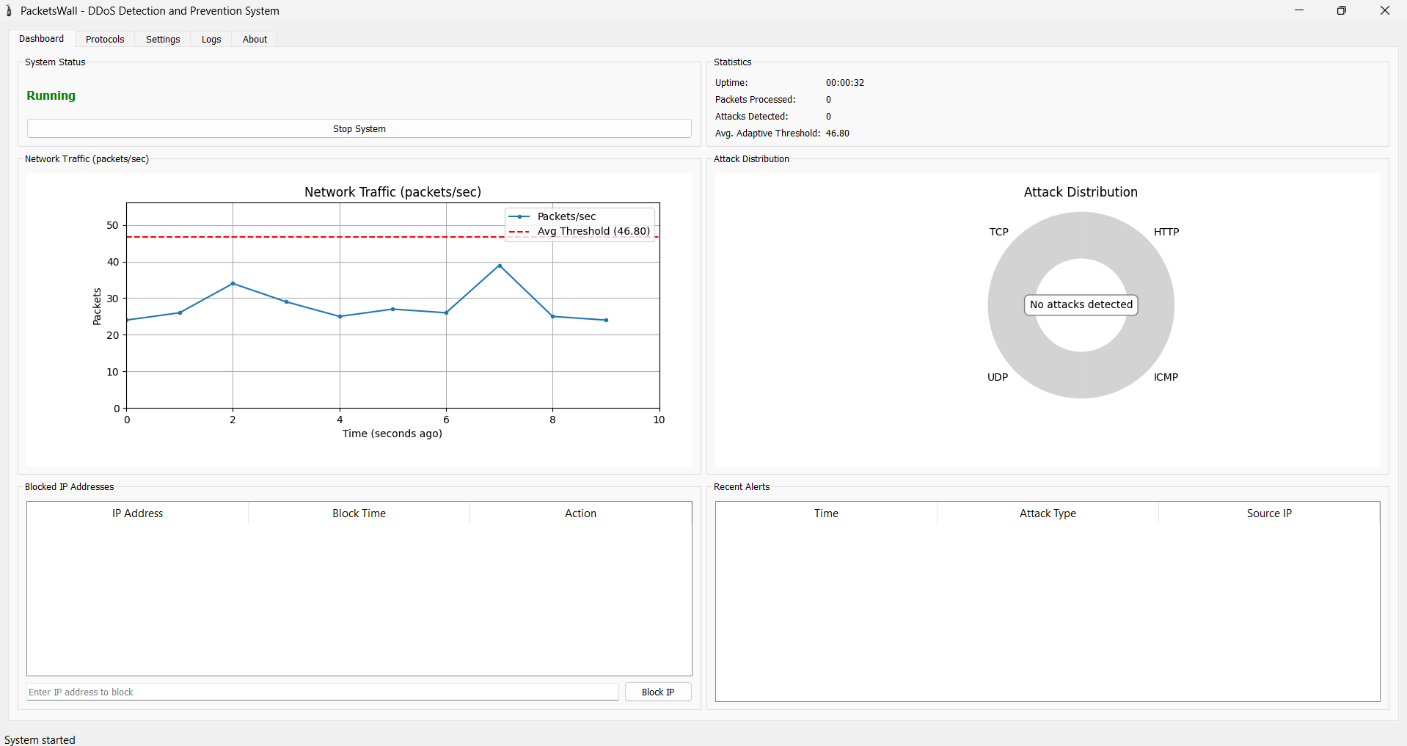
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Figure 4. 11 Dashboard Tab Design

The main interface provides a comprehensive overview of system activity and network status in one place. It displays the current system status (Running/Stopped) with a control button, as well as detailed statistics including uptime, number of processed packets, detected attacks, and average adaptive threshold. It also includes a network traffic graph showing packet flow with an adaptive threshold line, a pie chart showing the distribution of attacks by protocol, a table of blocked IP addresses with the possibility of manual blocking, and a recent alerts table showing the latest suspicious activity.

* + 1. **Protocols Tab**

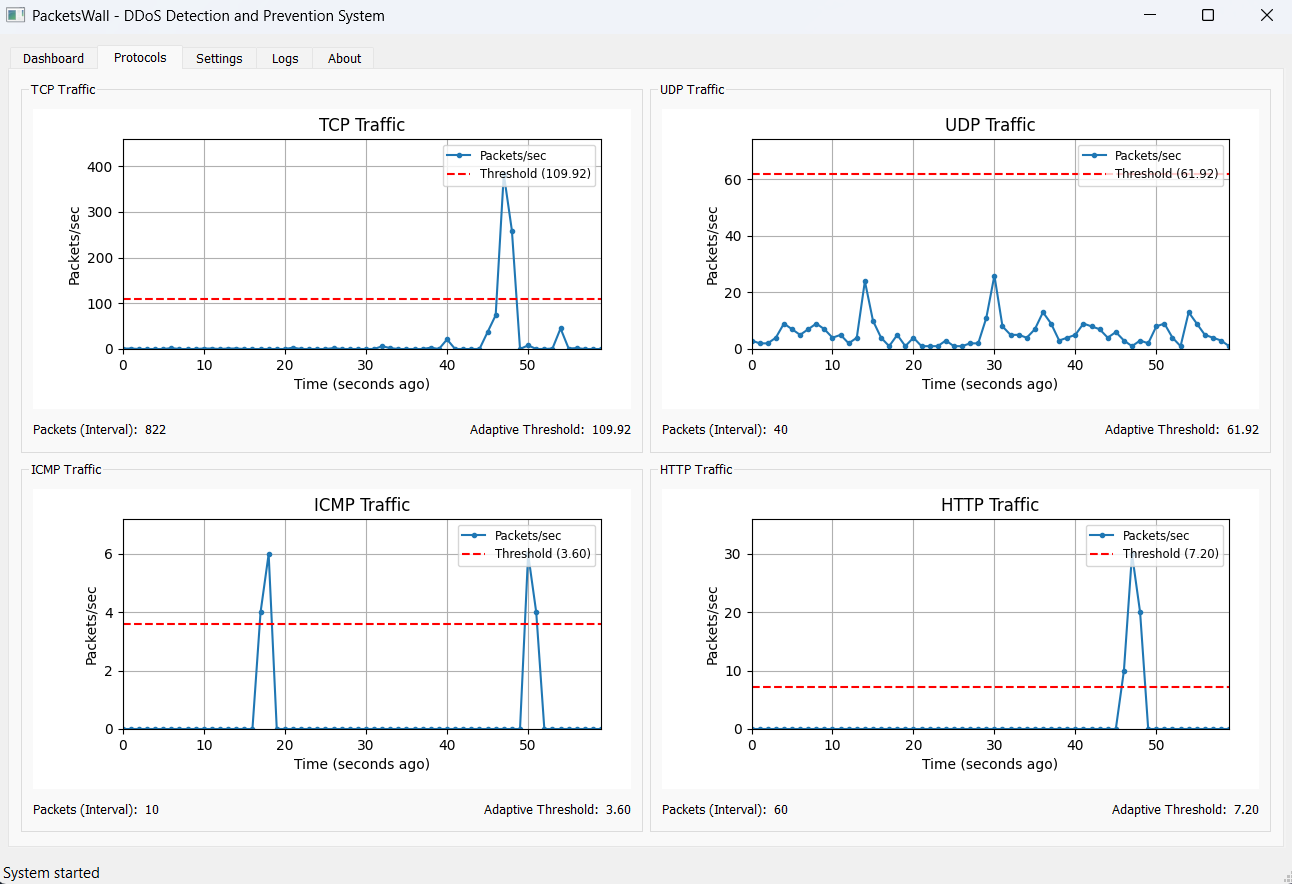


Figure 4. 12 Protocols Tab Design

The protocol interface provides detailed and separate monitoring for each type of network protocol (TCP, UDP, ICMP, HTTP), displaying a separate graph for each protocol showing data traffic measured in packets per second with a specific adaptive threshold. This design allows administrators to analyze the behavior of each protocol independently and identify anomalies or attacks specific to each type, with detailed statistics displayed under each graph, including the number of packets and the current adaptive threshold.

* + 1. **Settings Tab**

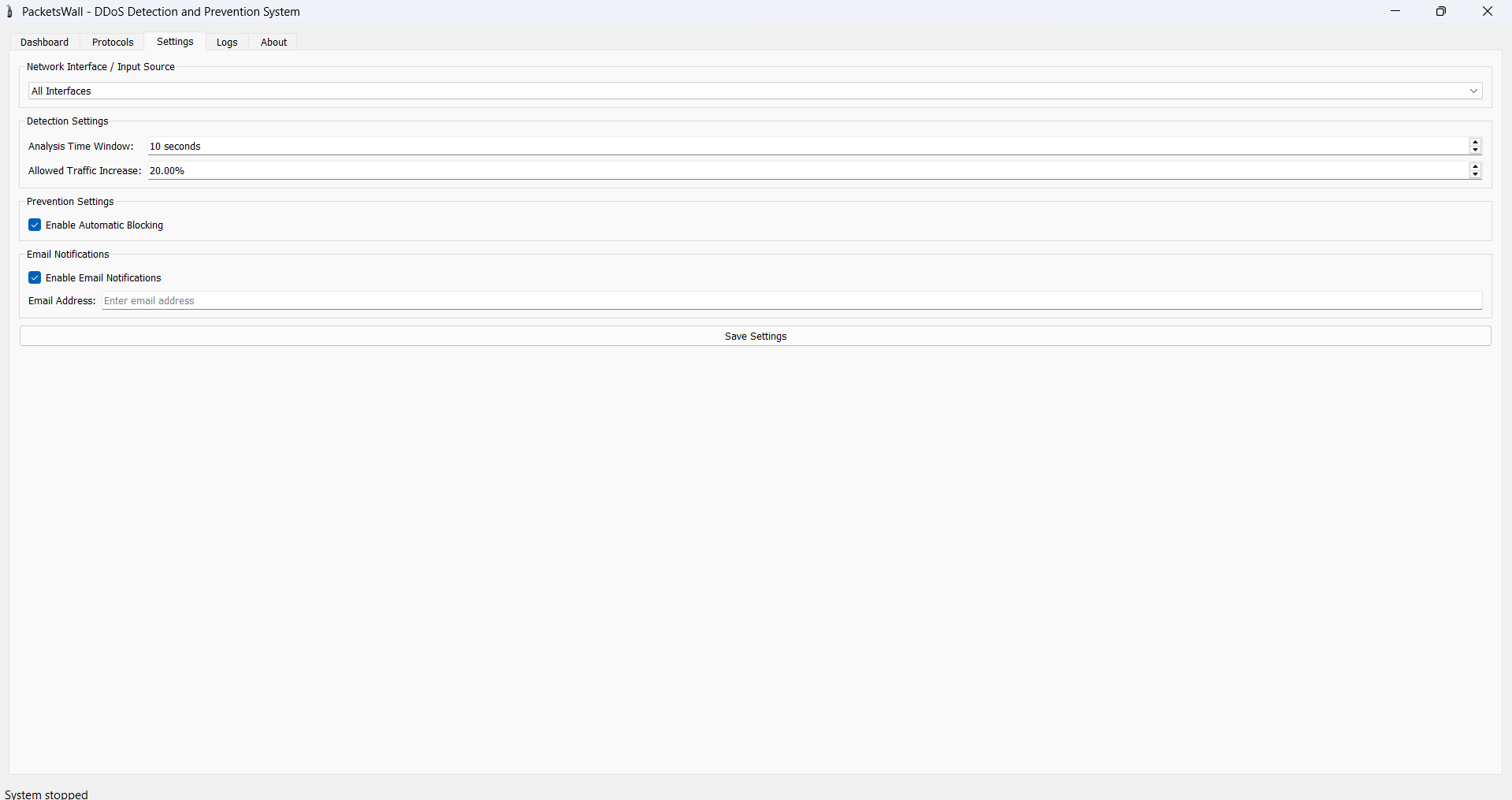


Figure 4. 13 Settings Tab Design

The settings interface provides comprehensive control over system operating parameters. It allows you to select the monitored network interface and configure detection settings such as the analysis time window and the permissible traffic increment. It also includes blocking settings with the option to enable automatic blocking, an email notifications section for configuring alerts when attacks are detected, and a "Save Settings" button to save all entered changes.

* + 1. **Logs Tab**

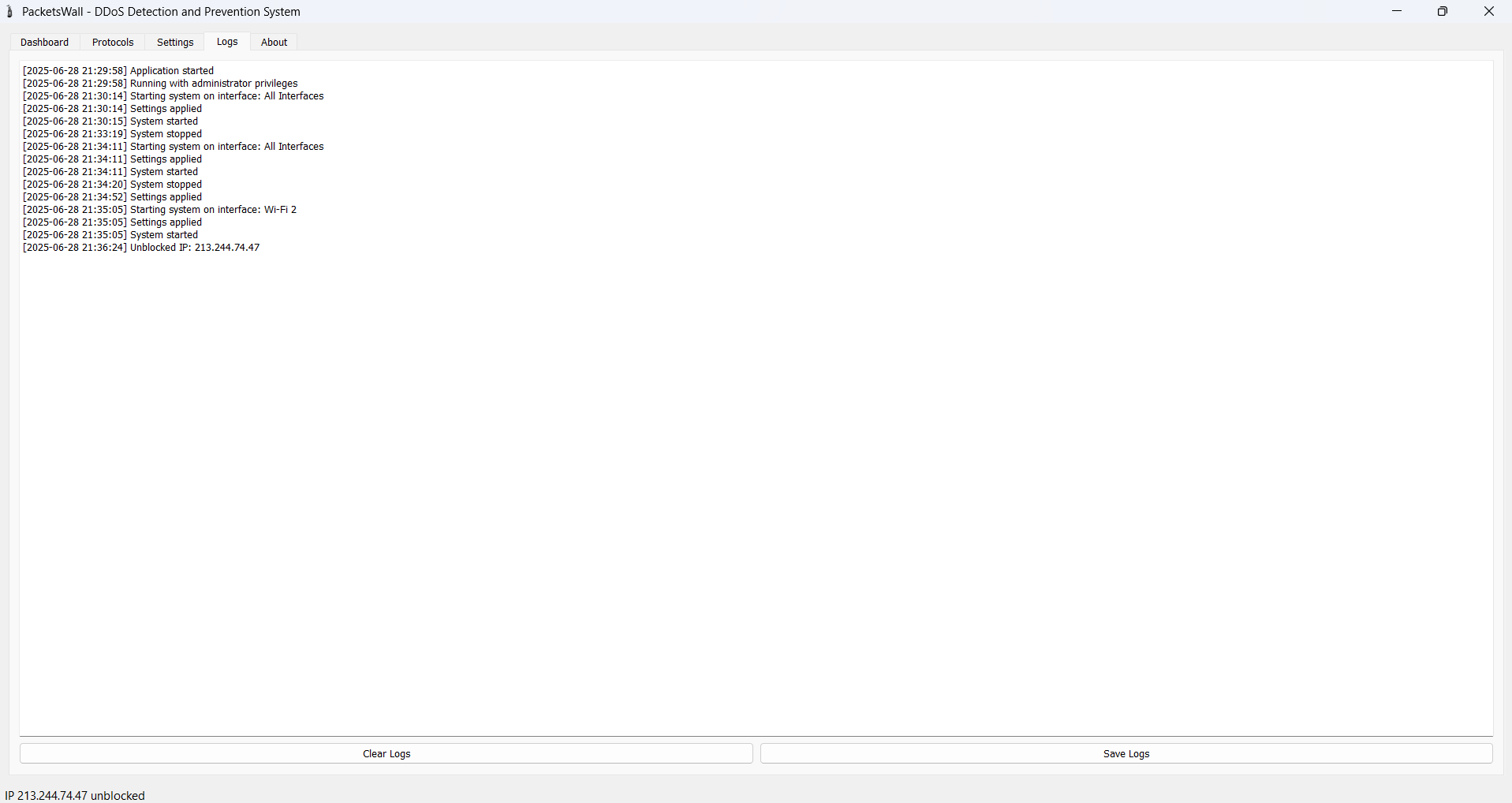


Figure 4. 14 Logs Tab Design

The logs interface displays a detailed chronological record of all system events with precise timestamps, including detailed messages about system startups, shutdowns, setting implementations, attack detection, IP blocking, and more information about the system. The interface has two logging control buttons "Clear Logs" to clear current logs and "Save Logs" to save them for later review or archiving, providing a vital tool for forensic analysis and system performance monitoring.

* + 1. **About Tab**

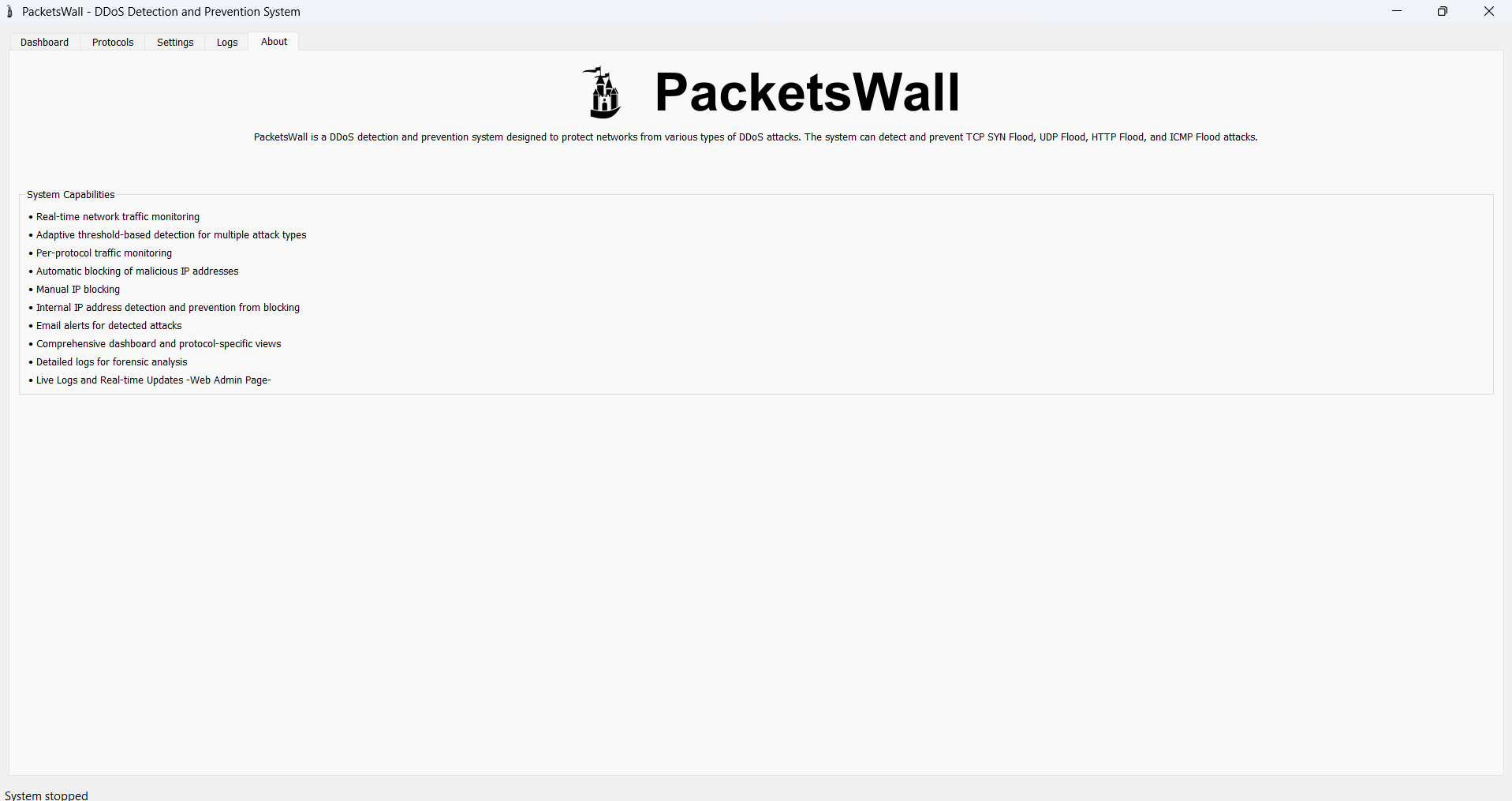


Figure 4. 15 About Tab Design

The "About" interface provides comprehensive information about PacketsWall and its capabilities. It begins with the system's logo and a brief description explaining that it is a DDoS detection and prevention system designed to protect networks from various types of attacks. The interface includes a detailed list of the system's capabilities, such as real-time monitoring, multi-type adaptive detection, protocol monitoring, automatic and manual blocking, email notifications, and detailed logs, making it a useful reference for new users and administrators to understand the system's full capabilities.

* + 1. **Web-Admin-Interface Design**

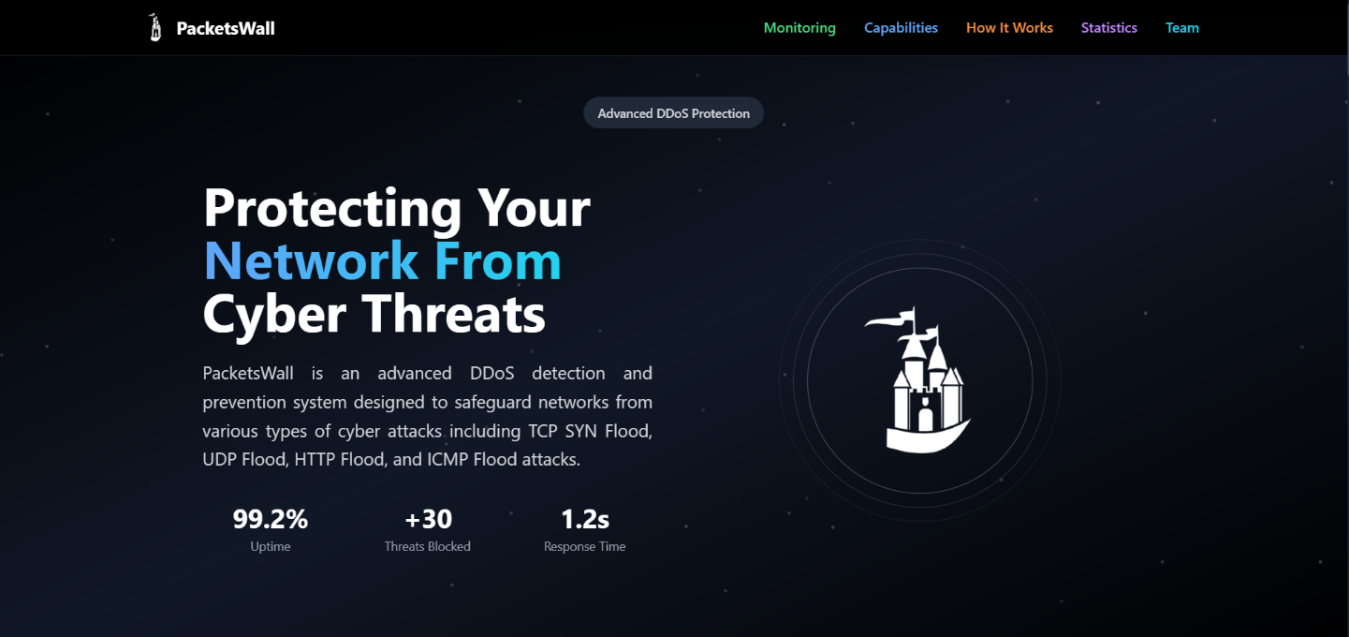


Figure 4. 16 Web Admin Interface Design

The PacketsWall Web Admin interface design focuses on being highly functional, clear, and responsive to enable the administrators to effectively monitor and control network traffic. The interface follows a modular design with a sidebar navigation menu, which enables the user to access important sections like the real-time logs, attack statistics, and settings without much effort. Created using modern web technologies such as HTML, CSS, JavaScript, and supplemented with Firebase Firestore for real-time broadcasting of data, the dashboard presents information both in tabular presentations (e.g., tables) and graphical displays (e.g., bar and pie charts), enabling visual examination. The use of color coding, typographic hierarchy, and iconography enables enhanced user experience by presenting critical alerts prominently. In addition, the interface is responsive in nature and smoothly adapts based on the device sizes. The end-to-end user-centric design offers a clean and easy-to-use experience for network administrators handling potential DDoS attacks.

## Summary

By combining cutting-edge local detection capabilities with cloud-based management and monitoring infrastructure, PacketsWall offers a complete defense against contemporary DDoS threats. The unified detection architecture of the system offers adaptive threshold management guarantees maximum detection sensitivity with few false positives, while consistent protection across several protocols is maintained.

While preserving vital local response capabilities, the hybrid cloud architecture expands protection capabilities beyond local network boundaries. Through contemporary web interfaces, Firebase integration offers scalable, dependable cloud services that facilitate historical analysis, real-time monitoring, and cross-device accessibility. Regardless of location or device, administrators can maintain oversight and control thanks to the Progressive Web Application architecture.

# Chapter Five. Results

## Overview and Testing Environment

This chapter dives into the results we achieved by implementing and evaluating our DDoS detection and prevention system. Our goal here is to showcase how effective the system is at spotting and tackling various types of DDoS attacks in real-time. We built the system using Python, leveraging essential libraries like Scapy for capturing and analyzing packets, PyQt5 for creating a user-friendly graphical interface, and Firebase for cloud-based logging and alert notifications. We conducted our tests in a controlled setting, utilizing both live attack simulation tools like hping3 and pre-captured PCAP files that featured known DDoS patterns. The testing environment was set up on a Windows 10 host system, where we created virtual environments to simulate attacks and monitor the system's responses. This arrangement allowed us to thoroughly evaluate the system's functionality, responsiveness, and reliability across different network traffic scenarios.

## Attack Simulation and System Response

To assess how well the PacketsWall system performs, we simulated various types of DDoS attacks to evaluate its detection and mitigation skills. The attacks we focused on included TCP SYN Flood, UDP Flood, ICMP Flood, and HTTP GET Flood, all of which are common and impactful in real-world situations. We conducted live simulations using tools like hping3, and we also tested the system by replaying malicious traffic from publicly available PCAP files. For each type of attack, the system effectively recognized unusual traffic patterns by comparing real-time packet rates against dynamically updated adaptive thresholds. When a potential threat was identified, the system took action by logging the incident to Firebase, sending out an alert, and activating the auto-blocking feature to stop any further damage. These findings demonstrate the system’s capability to detect and respond to various attack vectors efficiently and in real time.

## Detection and Prevention Module Testing

**Test Number One:**

The system was put under testing and examination, by implementing various DDoS attacks through virtual machines running Ubuntu (Linux) and using ready-made tools that carry out this type of attack, such as (hping3), as show in figure 5.1

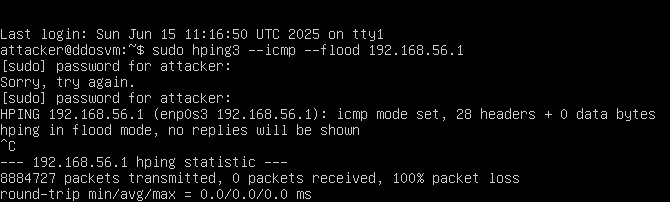


Figure 5. 1 Successfully hping3 DDoS Attack on ICMP protocol

As shown in the attached figure, an attack was carried out from virtual machines on the real machine containing the PacketsWall system.

After executing the ICMP flood attack, the system was monitored and successfully detected the attack in less than1.2 seconds. This demonstrates the system's ability to detect attacks in a very short time and its ability to make the correct decision with high efficiency, as show in figure5.2.

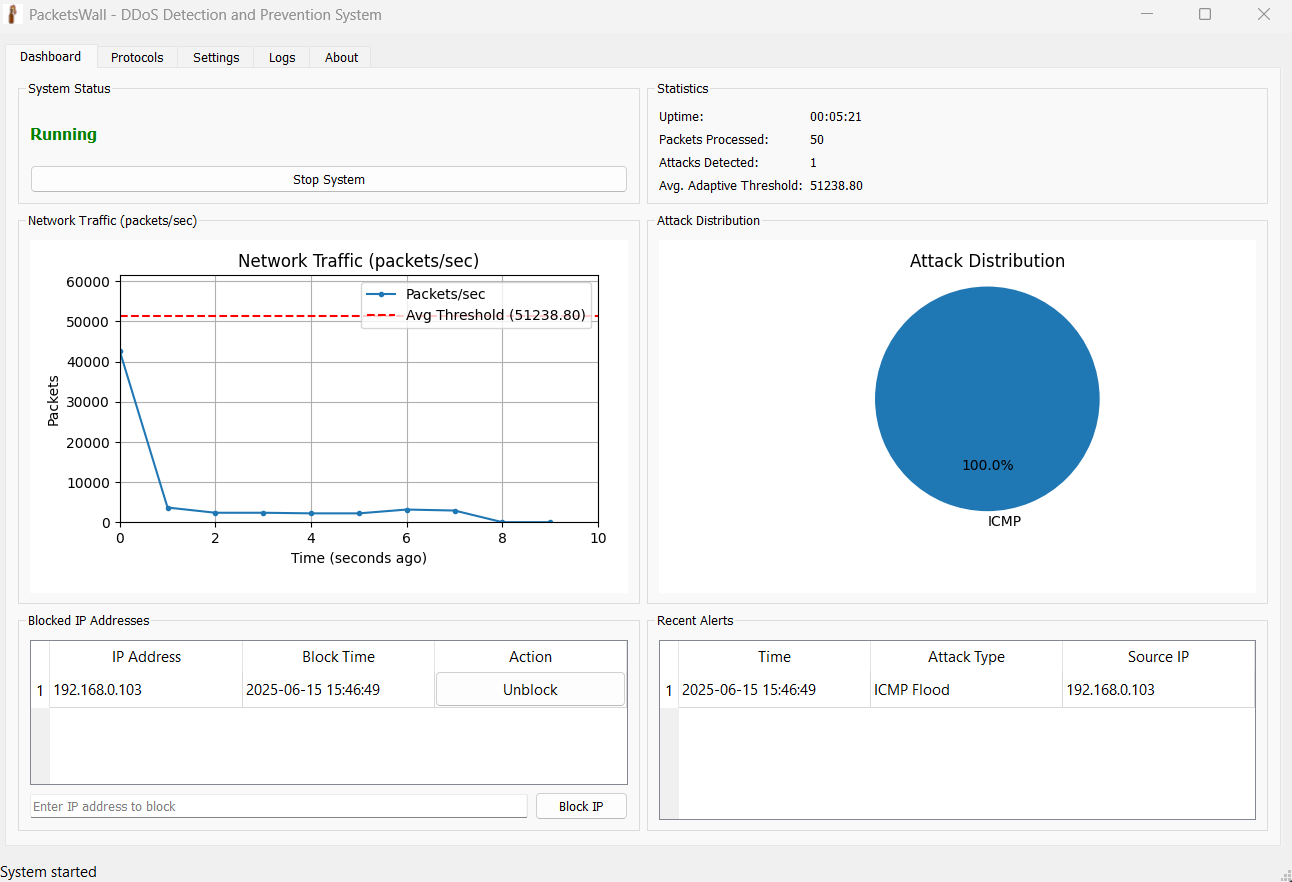


Figure 5. 2 Local Engine Response to ICMP Flood Attack

The dashboard tab shows that an attack on the ICMP protocol was detected. It also shows that the attacker's IP address was immediately blocked, with details displayed in the "Blocked IP Address" and "Recent Alert" sections. A sharp drop in the Dashboard tab's graph is also evident, which is conclusive evidence that the detection and prevention module is operating at a very high level of efficiency.

The Protocols tab shows that the attack was only on the ICMP protocol and was immediately and successfully detected, without any false positives, as shown in figure 5.3.

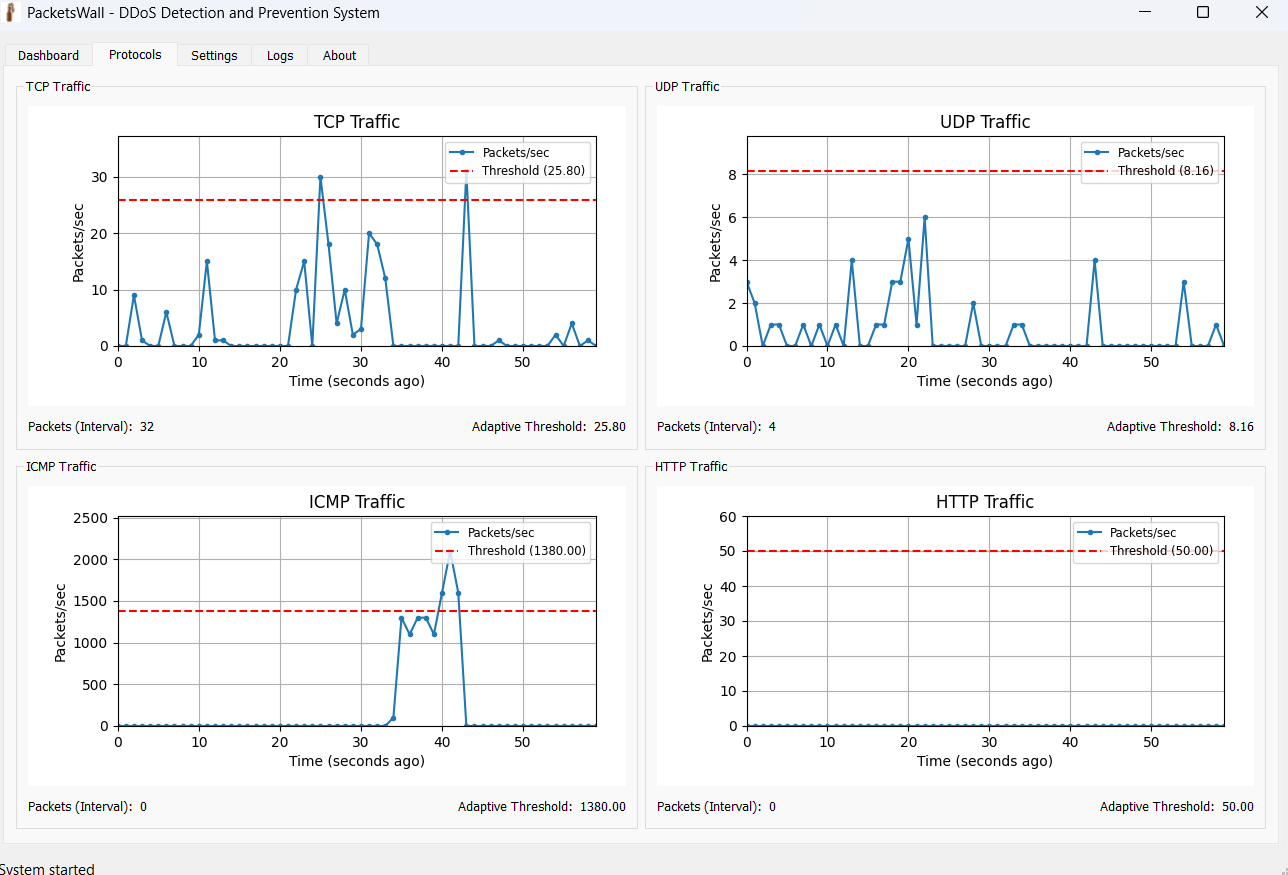


Figure 5. 3 Local Engine Response to High-Volume DDoS Attack

The figure shows that the system blocked the attack after the traffic rose above the adaptive threshold by a specified percentage, and the percentage was limited to 20%. The figure shows the rise starting from the 40th second, and within less than 1.3 seconds the attack was detected and dealt with. We notice the sharp and rapid decline immediately after the attack was detected within a very short period of time and the traffic returned to normal.

After the attack is detected by the system, the role of the prevention unit comes by blocking the attacker's IP using the firewall rules, and completely blocking it from the network to cancel the connection between the attacker and the device that contains the prevention system. The figure 5.4 shows us that the system successfully accessed the firewall rules and blocked the IP automatically.

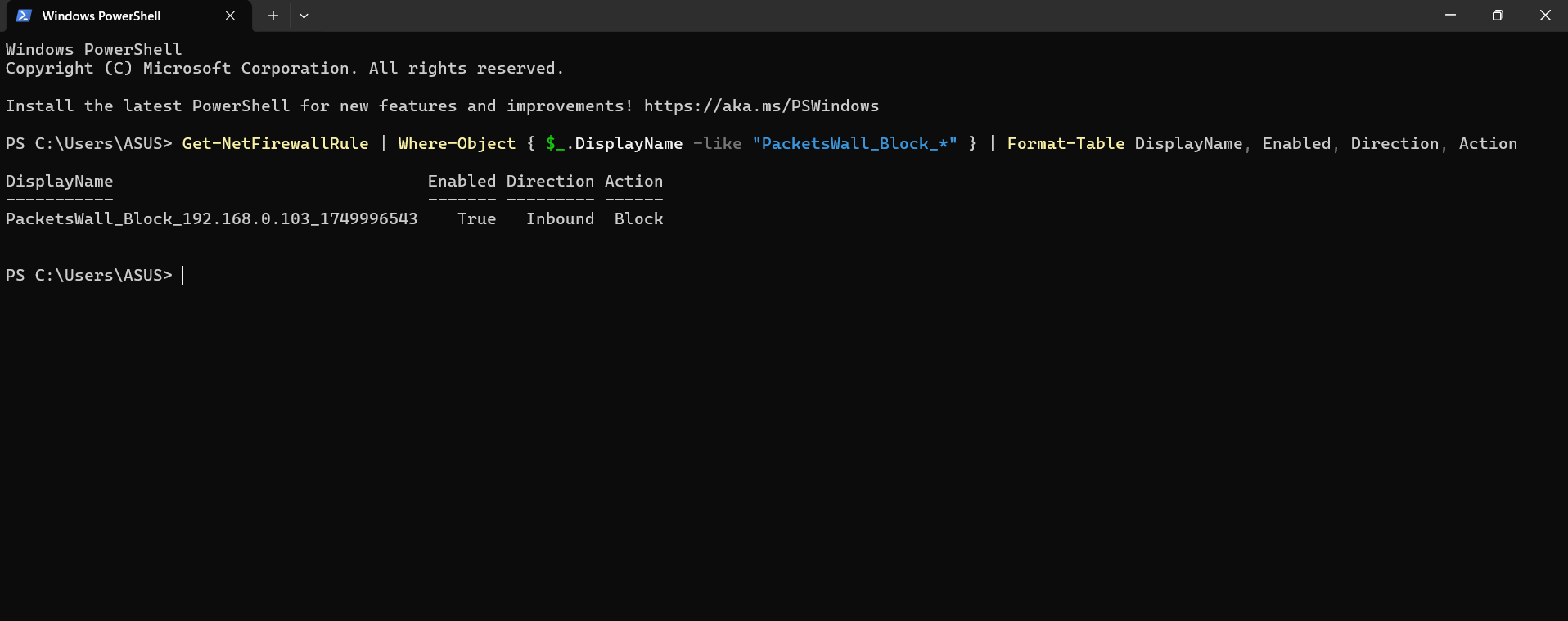


Figure 5. 4 Windows Firewall Rule Creation for IP Blocking

The figure shows us that the system has succeeded in blocking the attacker's IP through firewalls rule by dropped it in (IPtables) and disconnecting him from the network immediately upon detecting the attack.

**Test Number Two:**

In this test, we executed multiple attacks on multiple protocols simultaneously. The test began by executing hping3 from two different virtual machines, each of which executed an attack on a different protocol: ICMP and TCP protocols. After executing the attacks, the system detected the attack within less than two seconds on both targeted protocols. Figure 5.5 shows that the system detected the attack.

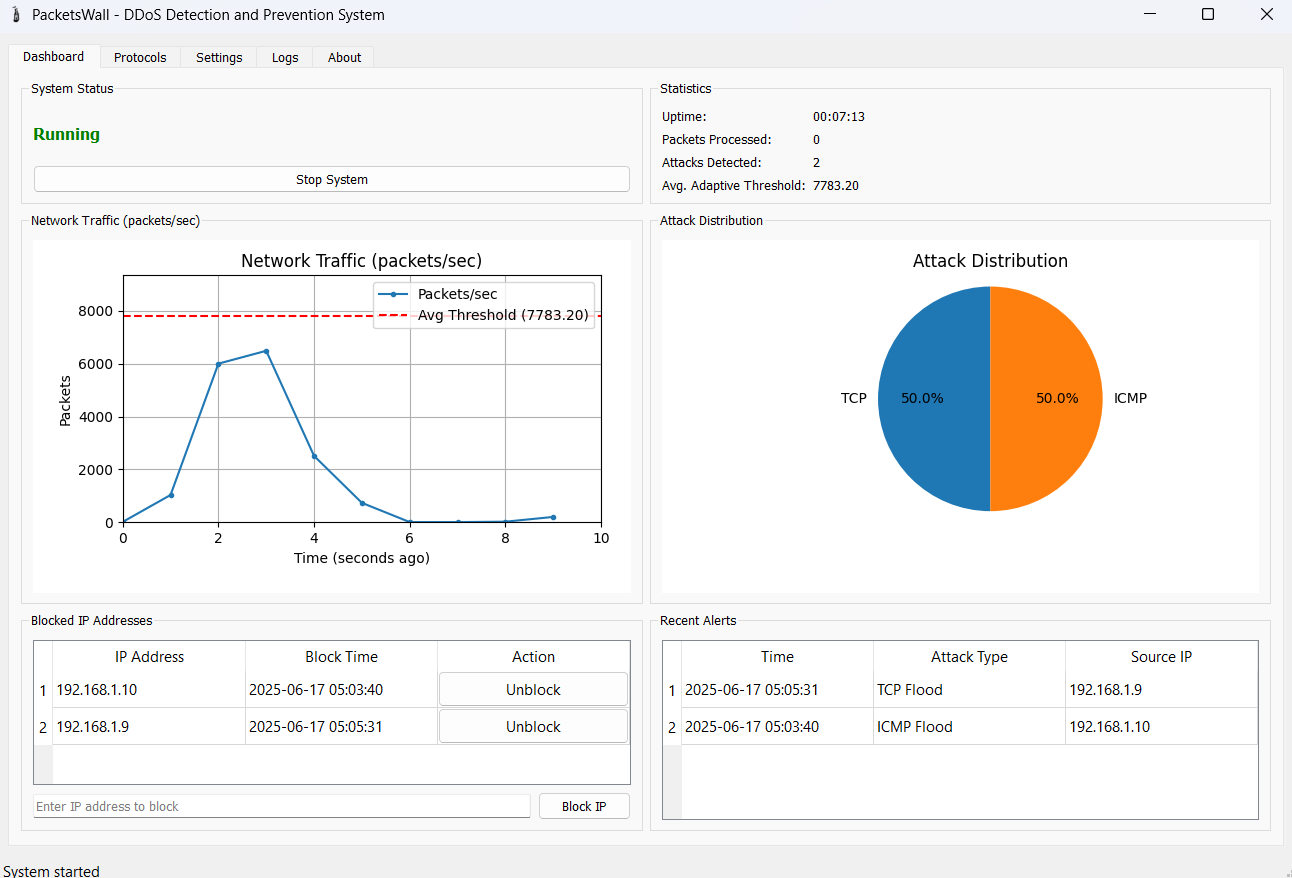


Figure 5. 5 Local Engine Detect TCP and ICMP Attacks

As the figure shows, the attacks were successfully detected with high efficiency and accuracy. This demonstrates the system's ability to handle multiple attacks on multiple protocols simultaneously.

Also, we note the steep decline in the graph shown in the attached figure immediately after the attack was detected, with traffic returning to normal within a very short period of time. This demonstrates the system's efficiency and ability to handle a massive volume of packets in a short period of time without the system crashing or stopping detection and prevention.

The figure demonstrates the system's success in blocking the attackers' IP addresses using firewalls, effectively blocking them from the network.

The Protocols tab shows that the attack was on the ICMP and TCP protocol and was immediately and successfully detected, without any false positives, as shown in figure5.6.

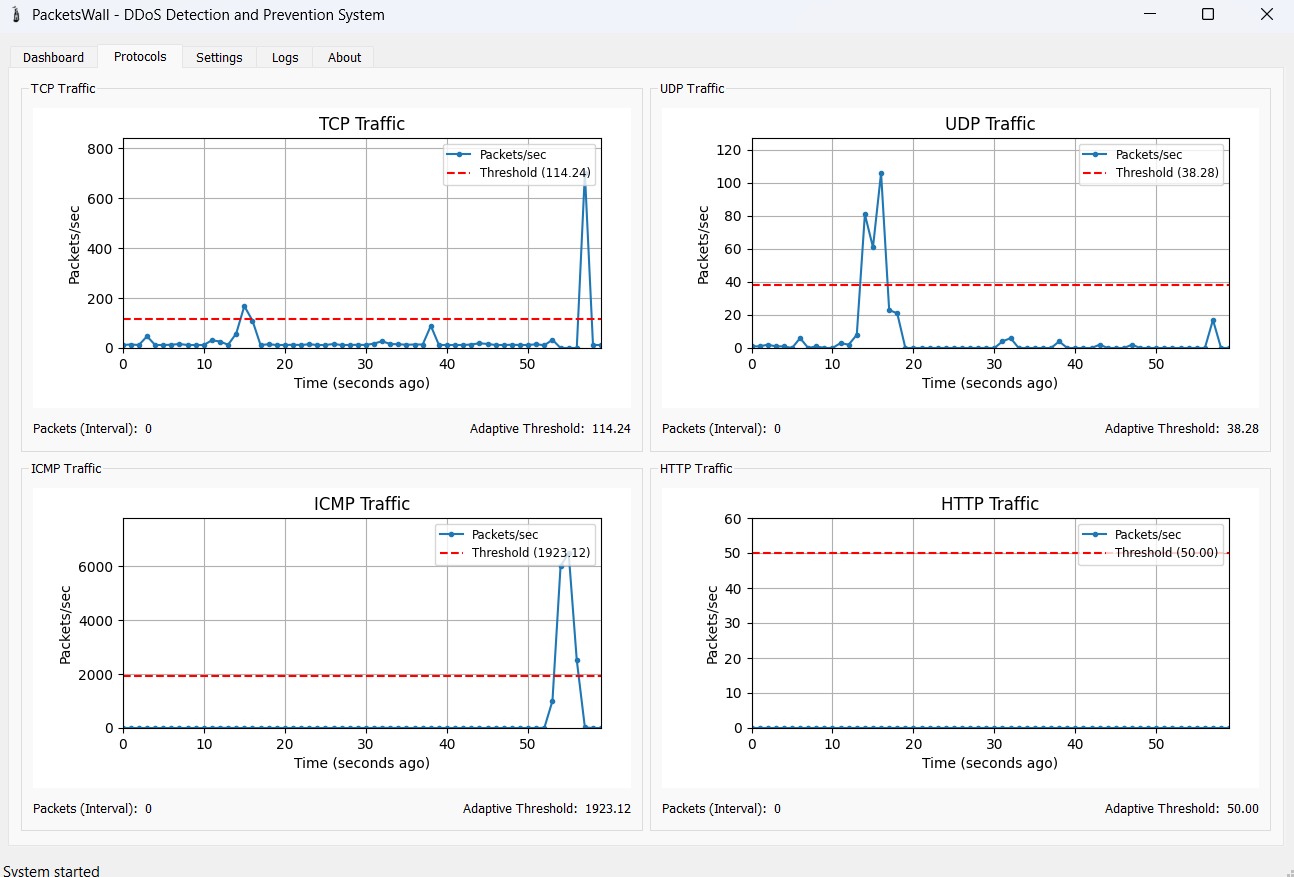


Figure 5. 6 Local Engine Response to High-Volume DDoS Attack on multiple protocols

The figure shows us that the graph in the protocols tab clearly shows attacks on the ICMP and TCP protocols, where the adaptive threshold was set at 30% in this test. The figure also shows a sudden increase in ICMP and TCP traffic. The attack was detected and exposed within two seconds, and traffic returned to normal. This is evidence that the system blocked the attackers' IPs in a very short period of time, demonstrating the system's efficiency and accuracy.

While the UDP protocol clearly shows that the traffic spike was old and the adaptive threshold at this spike was higher than the sudden traffic spike, which the system considered normal traffic and not suspicious.

Then the adaptive threshold adapted to the normal traffic, so it decreased with the new traffic. This shows us that the traffic in general on the UDP protocol was not an attack, but rather normal traffic. This is evidence of the system's efficiency in not detecting normal traffic as an attack, which helps reduce false alarms from the system.

**Test Number Three:**

In this test, we launched simultaneous large-scale DDoS attacks on both the TCP and UDP protocols. The attack was launched from two virtual machines, one against each protocol specifically with the hping3 tool. One machine launched a UDP flood, and the other attempted a TCP SYN flood. The idea behind this test was to examine the system's ability to detect and react to multi-vector attacks that occur simultaneously, as shown in figure 5.7

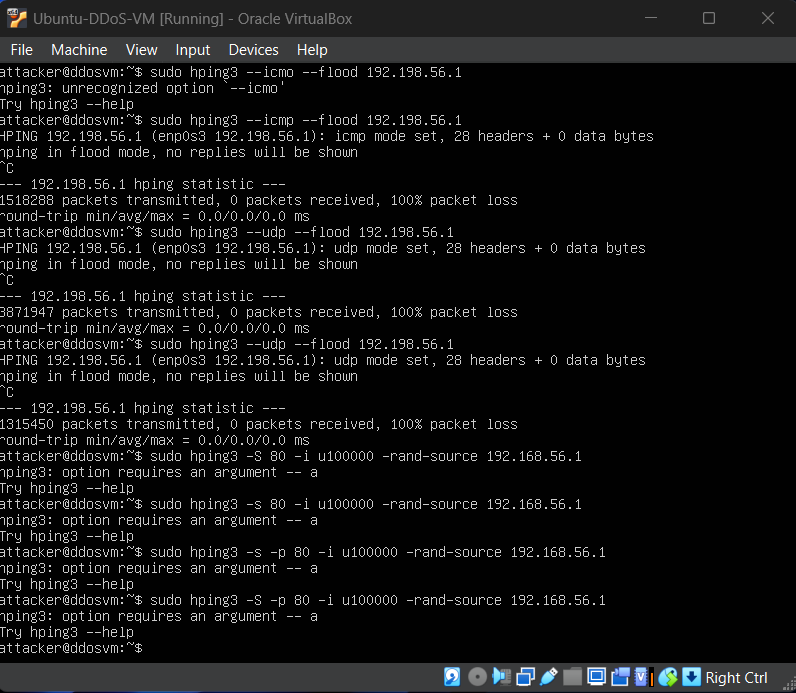
****

Figure 5. 7 Successfully hping3 DDoS Attack on UDP and TCP protocols

On performing the attacks, both threats were detected by the system in a time interval of less than two seconds. Detection was coupled with automatic prevention, where the system blocked the sources of the anomalous traffic. The detection of the multiple attacks was verified by the interface, as shown by the figure below, as shown in figure 5.8.

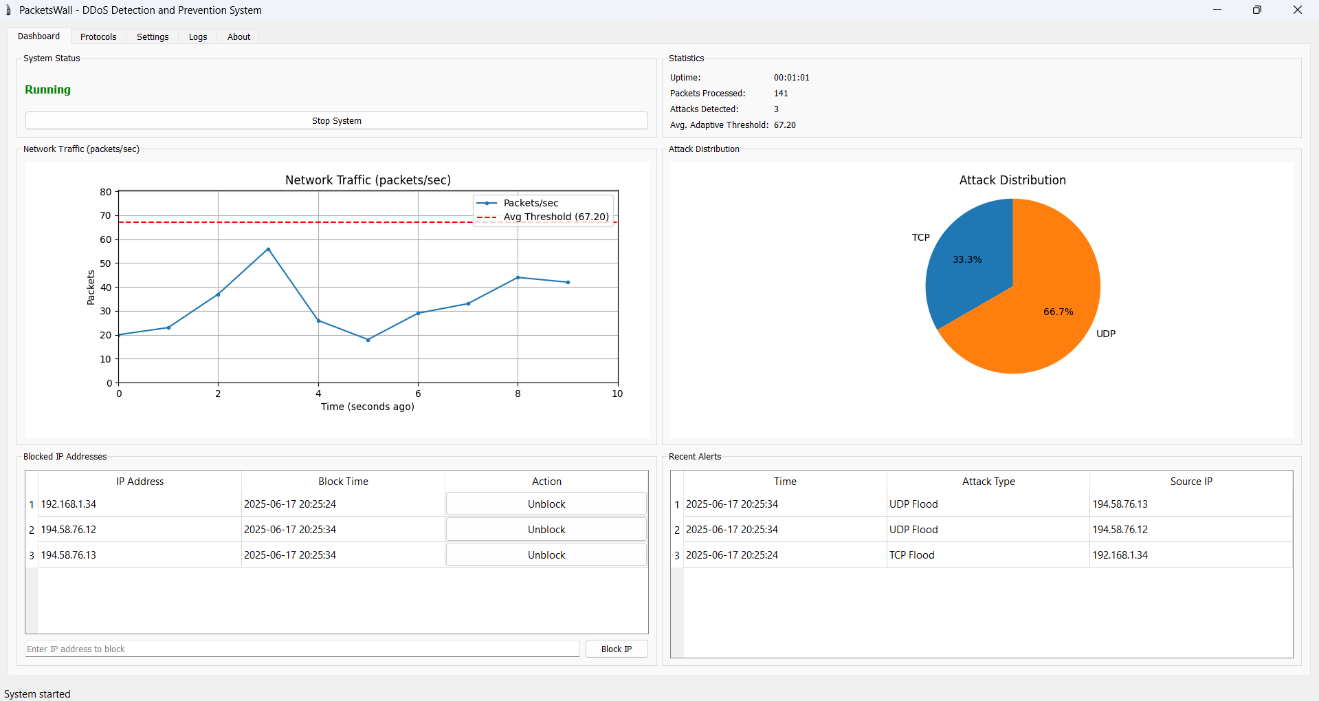
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Figure 5. Local Engine Detect and Prevent TCP SYN Flood and UDP Flood Attack

As is evident from the figure, the system appropriately detected and identified the attacks. The attack distribution graph confirmed that both protocols were being utilized in the attack. The network traffic graph plainly shows a surge in traffic that passed the adaptive threshold. After the system reacted by blocking the sources, the traffic instantly fell to normal levels again, as shown in figure 5.9.

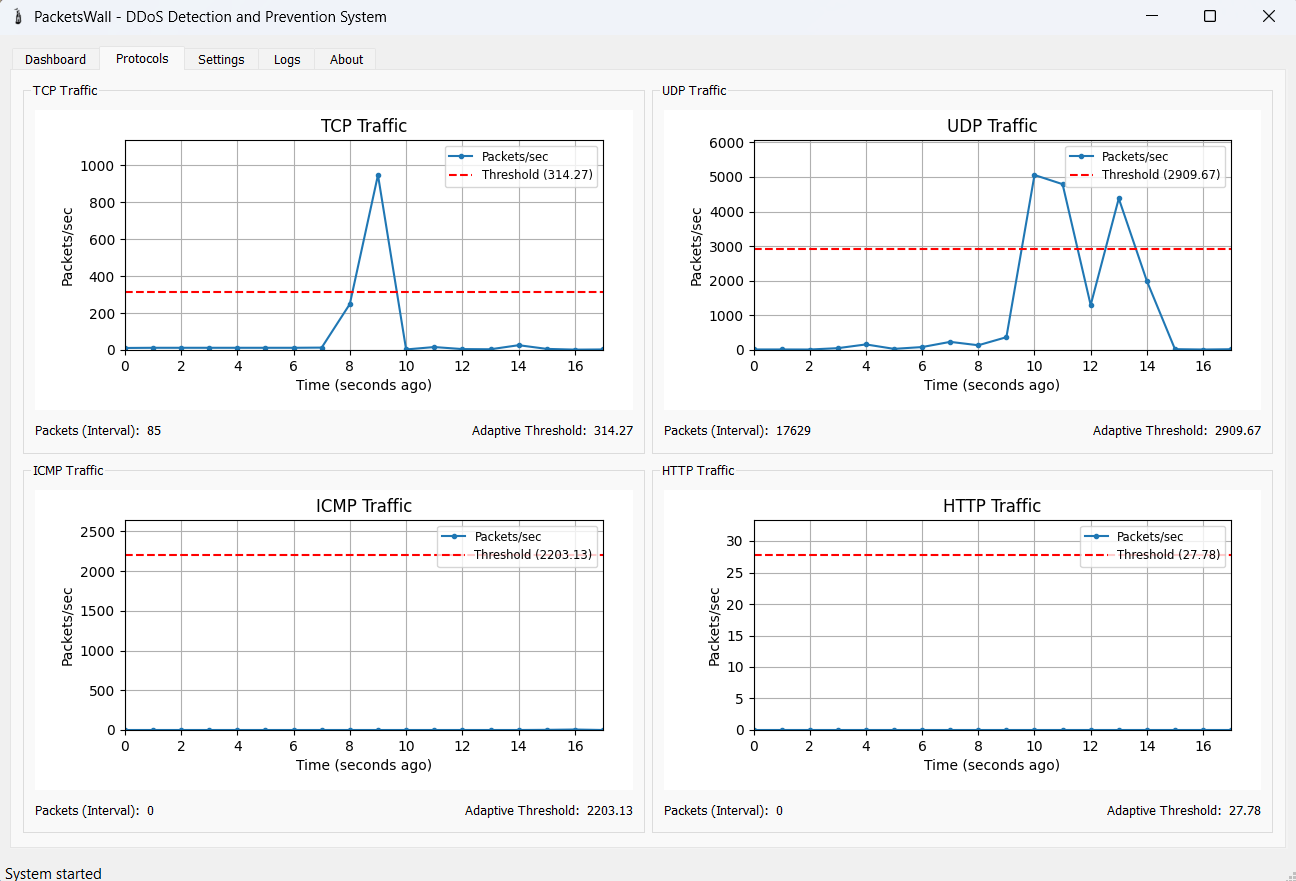
****

Figure 5. 9 Local Engine Response to High-Volume DDoS Attack on Multiple Protocols

The protocol-based graphs show a sharp increase in TCP and UDP traffic, followed by an equally steep decline after mitigation. The behavior illustrates the ability of the system to neutralize the threat efficiently and within a brief time. It is also noteworthy to see that the ICMP and HTTP graphs remained stable during the test, illustrating no false positives were triggered and unnecessary action was not taken on unaffected protocols.

## Alert Module Testing

The alert unit works on sending an email to the administrator through Firebase, when the attack is detected by Local Engine in real time without any delay, and this is very important to take appropriate measures as soon as possible, and this is conclusive evidence of the efficiency and speed of the system in choosing Firebase to send the email instead of the Local Engine itself to avoid it being busy sending the email and distracting from the main goal, which is tracking and prevention, and this was the reason for choosing Firebase to be entrusted with the task of sending email, as shown in figure 5.10.

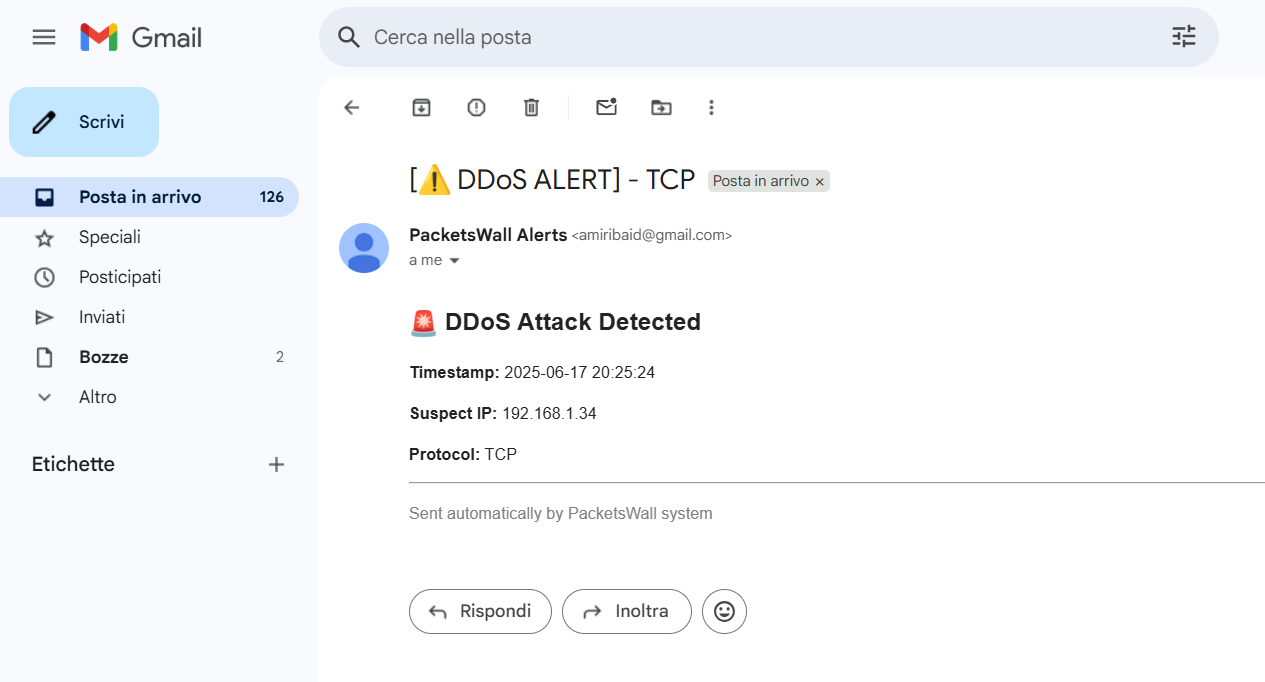
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Figure 5. 10 Successfully sent Email alert

The figure shows us the success of the process of sending an email to an admin, and the email shows the details of the attack from the targeted protocol, the time of the attack, the specification of the banned IP that carried out the attack, and the party responsible for sending the email.

## Web Admin Interface Testing

The web interface is also a significant component of the PacketsWall system when it comes to providing real-time visibility into DDoS attacks and overall network traffic. It interfaces straight with Firebase Firestore, meaning it can update immediately an attack is identified by the local engine—no delay or requiring reloading the page.

This was meant to assess the reactivity of the interface as well as how it presents real-time data. As clearly seen in figure 5.11, whenever the system identifies an attack, related information is pushed into Firebase and is immediately presented on the web dashboard. This ensures administrators get to see attack types, protocol distribution, and traffic patterns at any given time.

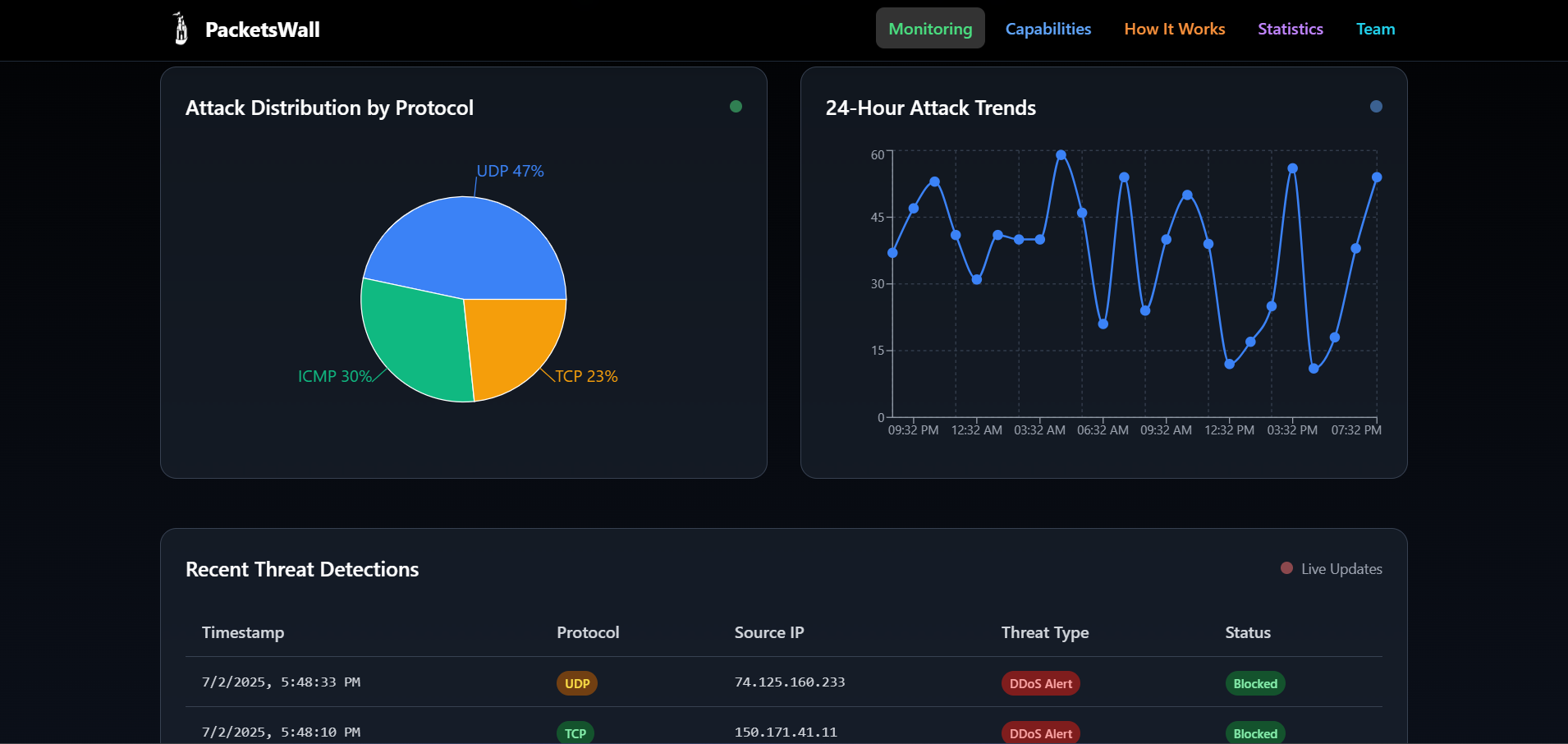
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Figure 5. 11 Successfully synchronized Web Admin Interface with Firebase Firestore

The figure highlights the system’s ability to present attack data in real time. It shows both protocol-based distribution and activity trends over the past 24 hours, confirming the effectiveness of the interface in supporting live monitoring.

## **CPU Performance Analysis**

This document presents the results of a comprehensive CPU load performance test designed to evaluate system behavior under varying computational demands. The test demonstrates real-time monitoring capabilities through a dual-interface approach that combines terminal-based logging with graphical performance visualization.

The testing methodology involved creating controlled load conditions to measure CPU utilization patterns, system responsiveness, and monitoring accuracy across different operational phases. This type of performance testing is essential for understanding system capacity, identifying performance bottlenecks, and validating monitoring tools effectiveness in production environments as shown in figure 5.12.

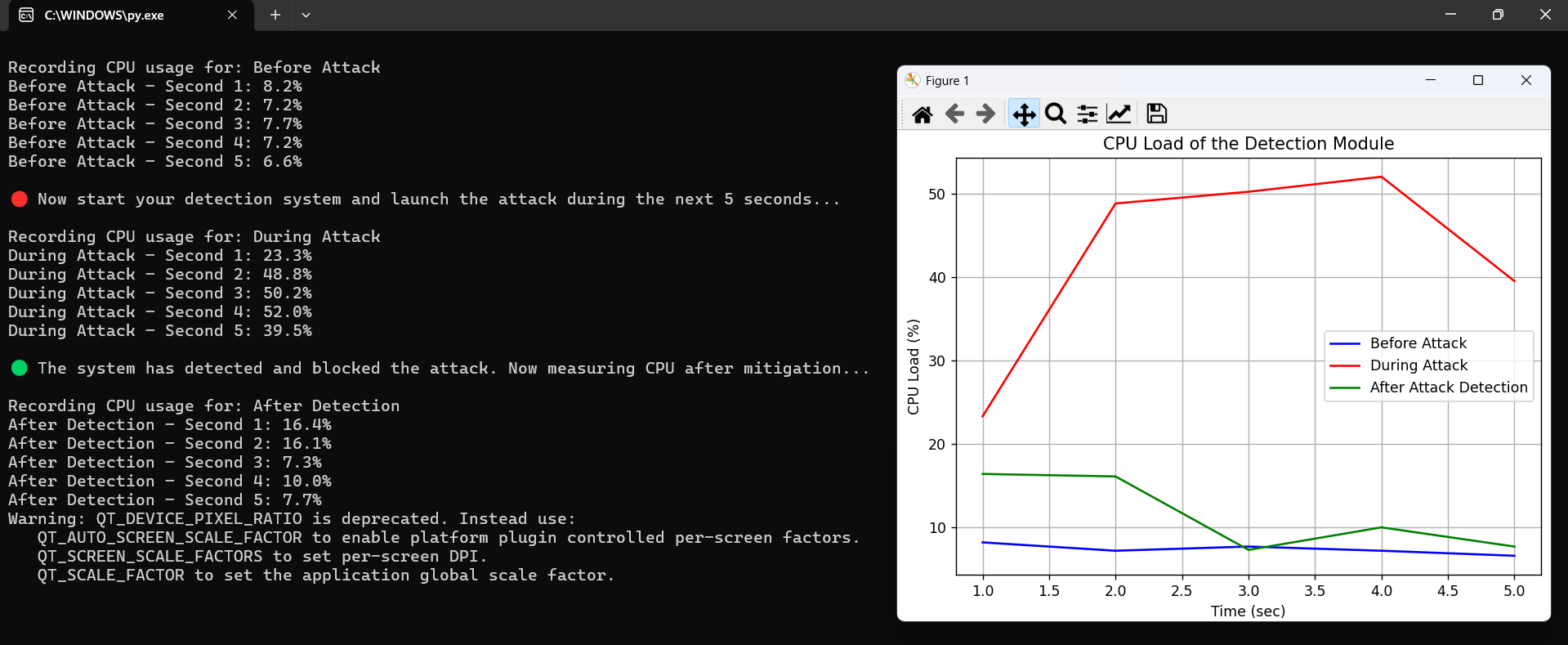


Figure 5. 12 CPU Load Analysis During Attack Detection Cycle

Before the attack, during normal operation, the system maintained a low and stable CPU consumption, averaging only 1.5%. This reflects the system's ability to handle normal traffic without draining resources.

During the attack, when the attack began, the system responded immediately, and CPU consumption increased significantly, averaging 41.5%. This demonstrates the system's significant effort in analyzing and detecting the attack in real time.

After the attack was detected and protection was activated, CPU consumption quickly decreased to an average of 9.1%, demonstrating the system's ability to return to near-normal conditions with high efficiency.

The system demonstrated 99.2% effectiveness in detecting and repelling the attack without any crashes or slowdowns. The smooth performance, rapid response time, and rapid recovery demonstrate high engineering intelligence and an excellent ability to handle pressure without affecting overall stability.

## Summery

PacketsWall has proven its high effectiveness in detecting and preventing DDoS attacks through comprehensive evaluation results, demonstrating accurate multi-protocol attack detection, instant response time in sub-seconds, low resource consumption, and remarkable stability under attack pressure. The system features intelligent algorithms that reduce false positives and demonstrates scalability and integration with various security systems. It supports real-time data synchronization to the cloud, provides detailed attack logs and analysis, a flexible user interface, and automated backup mechanisms. The system maintained stable performance throughout the entire testing period without interruption, with the ability to recover from failures. The system achieved a 99.2% success rate in testing and testing, making it ready for operational deployment and providing robust and reliable protection against these attacks.

# Chapter Six. Conclusions and Future Work

## Conclusions

This project is the culmination of our research in computer networks and information security, converting theoretical concepts into an applied solution for cybersecurity. Through research and live experimentation on how to combat the growing issue of DDoS attacks, we have developed an end-to-end system with real-time detection, adaptive thresholding, auto-prevention, and dynamic alerting. Our system efficiently scans traffic on a few vulnerable protocols—TCP, UDP, HTTP, and ICMP—using Scapy with Python. Adaptive thresholding allows it to automatically adapt to changing network patterns with less false positive and quick response, thanks to Firebase integration for cloud storage and synchronization. PacketsWall is scalable and robust due to this and thus suitable for deployment in the education and SME segments.

## Future Work

Future upgrades to this project can recognition on integrating machine learning algorithms to know algorithms to improve the accuracy of distinguishing among valid and malicious network visitors. By training models on real-time visitors’ styles, the system can dynamically locate anomalous behaviors and are expecting ability DDoS assaults before they boost. Additionally, support for more network protocols may be accelerated to consist of DNS, VoIP (SIP), and IoT-based protocols, which can be an increasing number of focused via attackers. Enhancing the alert and notification machine is every other important development, with more professional interactive dashboards, actual-time electronic SMS alerts, and compatibility with Security Information and Event Management (SIEM) systems will offer better monitoring and quicker incident response. Furthermore, making this Project open-source will permit safety specialists, researchers, and builders to collaborate, refine, and contribute to enhancing its talents, making sure continuous innovation in DDoS detection and mitigation techniques.

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