Next-Generation Threat Modelling!

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Keywords—Threat Modelling, ChatGPT, Artificial Intelligence, Cybersecurity, security, risk assessment

# Introduction

Threat modeling is on the rise as standards emphasize its importance, resulting in early vulnerability detection and improved long-term product quality [1]. Threat modeling have proven to be highly efficient, however they don’t scale well to keep up with the ever-evolving computing and threat environment [2]. With the increasing digitalization of business operations, addressing all high-priority threats using traditional methods has become exceedingly time-consuming, resulting in numerous unattended vulnerabilities.

ChatGPT is an AI chatbot that has gained immense popularity and has become a sensation among users since its release in late 2022. It is being utilized for a wide range of applications, including coding assistance, code reviews, policy drafting, blog writing, and numerous other use cases [3].

In this research, we are conducting an investigation into the utilization of ChatGPT for threat modeling. Our objective is to determine if leveraging the capabilities of ChatGPT can help overcome the efficiency challenges faced by traditional threat modeling approaches in the present computing and threat landscape. By integrating ChatGPT into the threat modeling process, we aim to explore whether it can offer a viable solution to the time-consuming nature of addressing an organization's high-priority threats. This research seeks to assess the potential of ChatGPT in effectively identifying and mitigating vulnerabilities, ultimately contributing to enhanced threat modeling. And for executing this approach we are creating a small microservice system model connected to MongoDB and hosted on AWS cloud.

# Background Reading

## Threat Modelling

Microsoft introduced the concept of threat modelling at the turn of the century [4]. It was formally documented in the book by Swiderski and Snyder [5] and was incorporated as a component in the initial release of the Microsoft Security Development Lifecycle (SDL) [6]. Threat modelling is a crucial process in identifying, communicating, and managing security weaknesses; provides a deeper understanding of critical aspects of the system and enables organizations to identify vulnerabilities and potential security threats [7]. During the threat modelling process, developers and security experts analyse the application's architecture, data flows, and access controls to identify potential threats and security vulnerabilities; this helps developers to realize the security consequences of their design, code, and configuration choices, and to implement effective security measures to mitigate the identified threats [7].

There are various existing approaches to threat modelling, varying from conceptual frameworks to practical tools. Myagmar, Lee, and Yurcik define threat modelling as a process aimed at comprehending the intricacies of a system and identifying all potential threats to it [8]. According to Shostack in [9], threat modelling typically involves two models: one representing the system to be built and another depicting the actual threats to the system and the mitigations. For this research on creating threat model using ChatGPT, we are developing two models, a system model that portrays the microservice connected to MongoDB and hosted in the AWS cloud, alongside a threat model that highlights the identified threats and the corresponding measures to mitigate them with the assistance of ChatGPT.

There is a wide range of threat modelling methodologies that companies can make use of, as each is a unique approach and provides varied benefits. Among these, the most common are STRIDE, OCTAVE, TRIKE AND PASTA [10]. Threat modelling methodologies aids in generating a system abstraction and offering analyses of potential attackers, including their objectives and techniques. Moreover, it provides valuable insights on potential vulnerabilities and threats that may arise in the future. These are some of the best methodologies used, which have unique methods and frameworks to identify, analyse, measure, and sort threats [11].

STRIDE, developed by Microsoft, is a highly regarded and refined threat modeling methodology that has proven to be exceptionally effective. It involves the application of STRIDE to data flow diagrams (DFDs) to identify system boundaries, events, and entities efficiently. The STRIDE acronym encompasses six major threat classes, namely Spoofing identity, Tampering with data, Repudiation, Information disclosure, Denial of service, and Elevation of privilege. This comprehensive list covers a wide range of potential threats that a system may encounter. [11]

OCTAVE (Operationally Critical Threat, Asset, and Vulnerabilities Evaluation), developed by the Carnegie Mellon Software Engineering Institute, is a risk-based methodology that prioritizes organizational risks over technological risks; its focus is on understanding how risks can impact an organization's operational capabilities [10].

TRIKE is a unique open-source threat modeling process that approaches the security auditing process from a risk management and defense standpoint. Unlike previous methodologies discussed, TRIKE emphasizes the importance of assigning a level of risk to each asset and ensuring it is acceptable to stakeholders. The primary goal of TRIKE is to guarantee that all stakeholders find the assigned risk level for each asset acceptable. [12]

PASTA, which stands for Process for Attack Simulation and Threat Analysis, is a risk-oriented methodology consisting of seven steps. It provides a dynamic approach to identifying, enumerating, and scoring threats. By conducting a thorough analysis of identified threats, experts can develop an asset-centric mitigation strategy that views the application from an attacker's perspective. This methodology facilitates a comprehensive understanding of the potential threats and enables developers to implement effective security measures. [12].

With regards to tools, Microsoft's Threat Modelling Tool (MS-TMT) [13] is a widely used freely available tool for threat modelling. There are other alternatives in the market, one such tool is OWASP Threat Dragon [14], which supports Windows, Linux and MacOS and a web app. While the drawing function in Threat Dragon may not be as user-friendly as desired, it does support Confidentiality, Integrity and availability (CIA) analysis and privacy threat modelling (LINDDUN) [4], and the STRIDE methodology [15]. Another tool available is SPARTA [16], which extends STRIDE threat modelling by using Data Flow Diagrams (DFDs) to link explicit countermeasures to each identified threat. SPARTA includes simulations that estimate solution vulnerability, accounting for the capabilities of different types of attackers.

To initiate the process of threat modelling, a diagram is often created in every methodology that outlines the system's architecture, components, trust zones, and authentication flows [17], [18]. The inclusion of data flows in a diagram can prove to be extremely advantageous, as it provides a clear representation of how information is received and transmitted by the system, how it is altered, and where it is stored [17]. The primary goal of a data flow diagram (DFD) is to provide an overview of the system's scope and boundaries as a whole and a comprehensive analysis of the system's security posture. For this paper, in the initial stage we are utilizing DFDs for the system model and the threat model to carry out the process of threat modelling the microservice system.

## ChatGPT

ChatGPT, created by OpenAI, was launched on November 30, 2022, as an AI-powered natural language processing tool that enables you to engage in human-like conversations and offers a wide range of capabilities and it is available for free, allowing you to ask unlimited questions and engage in conversations [19]. The architecture powering ChatGPT is based on the Generative Pre-trained Transformer (GPT) developed by OpenAI [19]. As stated by OpenAI [20], ChatGPT specifically utilizes a fine-tuned version from the GPT-3.5 series. To access ChatGPT, you can easily visit chat.openai.com [21], create an OpenAI account, and begin conversing. According to a recent analysis conducted by UBS [22], ChatGPT has achieved unprecedented growth as the fastest-growing app in history. The analysis suggests that within just two months of its launch, ChatGPT had already amassed an impressive user base of 100 million active users in January.

ChatGPT serves as a versatile tool capable of assisting with an unlimited range of projects, spanning various domains such as software development, writing, and translations [19]. With its ability to generate responses to prompts we can ask any burning questions to ChatGPT; it has the potential to become a significant tool for content generation, surpassing traditional search engines. It can assist in diverse tasks such as writing essays, summarizing books, coding and debugging, performing calculations, resume compilation, translating information, and much more.

In this research paper, we are exploring an innovative approach to threat modelling that incorporates a combination of different threat modelling methodologies and tools by leveraging the capabilities of ChatGPT; evaluate the effectiveness of this novel approach and its potential impact.

# Methodology

## Objective

Upon reviewing the available literature, several methodological approaches have been identified. that can be effectively employed for the purpose of conducting threat modelling. This paper aims to create a methodology to model cyber threats using ChatGPT which unlike the conventional methodologies which typically rely on manual processes that involve subject matter experts, stakeholders, and other key personnel to identify and assess potential threats to a system, creating a threat model using ChatGPT relies on an artificial intelligence language model that can analyse vast amounts of data and generate insights based on that analysis. The objective for this paper is creating a threat model for a microservice system connected to a MongoDB instance and hosted in AWS using ChatGPT which would assist in identifying potential threats and vulnerabilities that could impact the system's security. And by analysing the system and its associated risks, developing a comprehensive threat model that outlines specific measures to mitigate the identified threats.

## Approach

This section presents the methodology used in the paper to establish a structured threat modelling approach for a microservice system. Firstly, a Data Flow Diagram (DFD) is created for the system model, which outlines the various dataflows and services used in the system. The system model serves as the input for asking ChatGPT to create the threat model, which is then used to generate a threat model for the system. Based on the outputs provided by ChatGPT, a DFD for the threat model is created, which outlines the potential threats that could impact the system's security. To address these threats, solutions are asked to ChatGPT which again will be added to the threat model DFD and implemented to mitigate the identified threats.

### System Model: A model is created for a spring boot microservice built which is connected to a mongo dB database (Fig.1). Both the microservice and database are hosted in AWS EC2 virtual machine using the EC2 and S3 bucket AWS services. Created an AWS Linux EC2 instance from the AWS Management Console by launching a new instance and configured its settings, including selecting the desired Linux AMI. Security groups were set up to allow incoming connections on MongoDB and microservice ports. Accessed the EC2 instance from local terminal using a secret key pair by setting the key file's permissions and using SSH. Downloaded and installed MongoDB on the EC2 instance, updated its configuration to accept remote connections, and created a MongoDB user. Installed MongoDB Compass on the local machine and connected to the MongoDB instance on the EC2 instance. Created a Spring Boot microservice with IntelliJ (Appendix B), built and compiled it to generate a JAR file, and created an S3 bucket in AWS to store the JAR. Jar file was uploaded to the S3 bucket and copied to the EC2 instance. Successfully started the microservice application on the EC2 instance and tested its endpoints using a tool like Postman, specifying the EC2 instance's public IP address or DNS name (Appendix A).

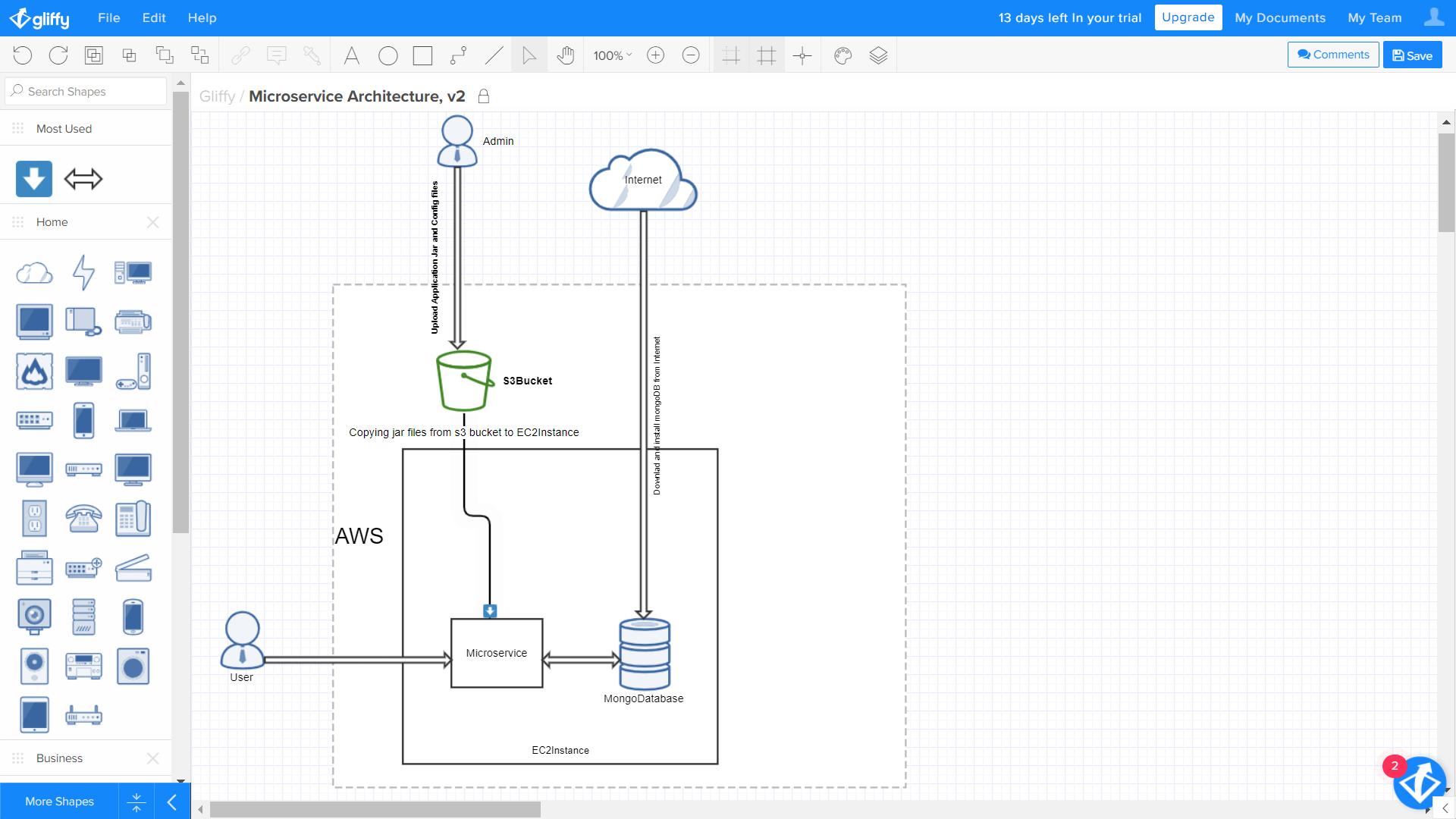


Fig.: Microservice System Model

### Threat Model: Asked ChatGPT to create a threat model for the microservice system model created. ChatGPT provided a list of potential threats (Fig.2). A threat model has been developed solely based on the provided information (Fig.3). According to ChatGPT, here are the potential threats to consider for the system:

* Unauthorized access to EC2 instance and MongoDB database.
* Injection attacks, such as SQL, NoSQL, or command injection.
* Insecure communication channels, leading to interception or manipulation of data.
* Insufficient authentication and authorization mechanisms.
* Denial of service (DoS) attacks, causing unavailability or unresponsiveness.
* Weak passwords or credentials.

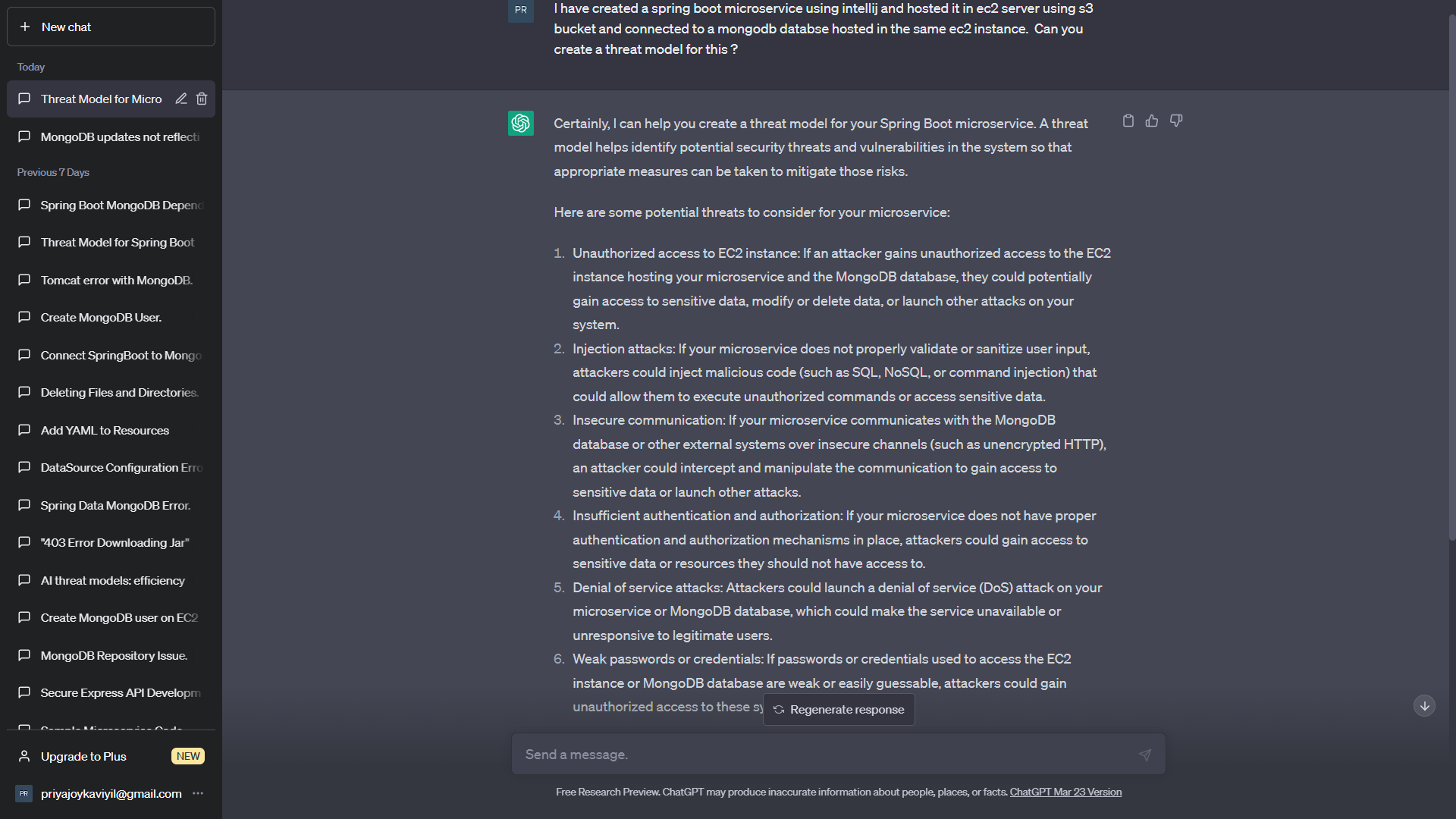


Fig.2: Asking ChatGPT to create threat model

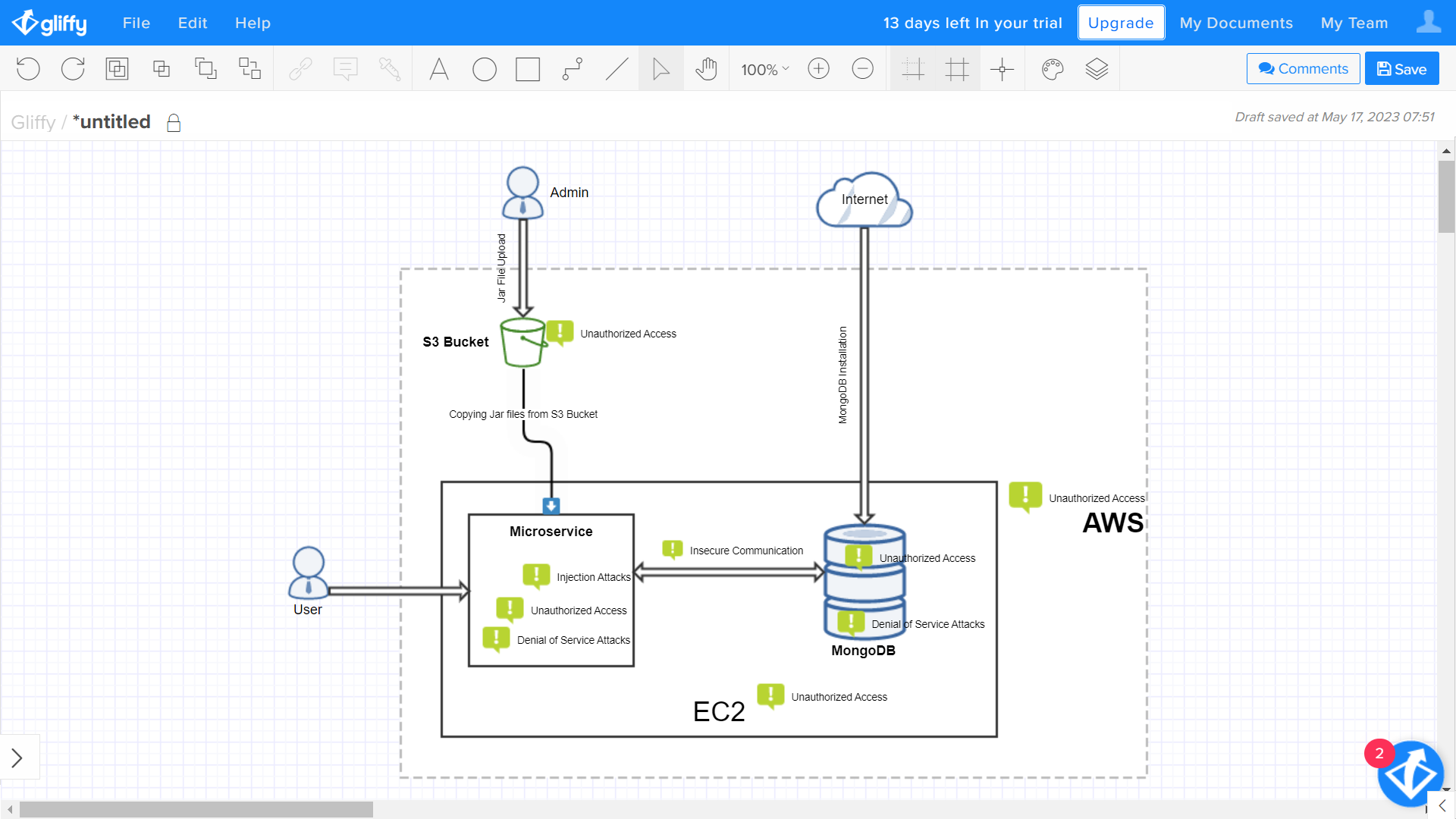


Fig.3: ChatGPT Created Threat Model

### Threat Mitigations: Corresponding mitigation measures for the potential threats were provided by ChatGPT (Figure 4, Figure 5, Appnedix A). According to ChatGPT here are the key points for ensuring the security of your Spring Boot microservice, EC2 instance, and MongoDB database:

For the EC2 instance and MongoDB database:

* Use strong and unique passwords.
* Regularly apply security updates and patches.
* Configure access controls and firewall rules.
* Implement encryption for data at rest and in transit.
* Set up monitoring and logging.
* Take regular backups of the database

For preventing injection attacks

* Validate input data to ensure the expected format and data types.
* Use prepared statements or parameterized queries.
* Sanitize user input by removing or encoding unnecessary characters.
* Utilize security-focused libraries for authentication and authorization.
* Implement input filtering and length limitations

For implementing authentication and authorization mechanisms:

* Use multi-factor authentication, such as MFA.
* Implement role-based access control (RBAC).
* Enforce strong password policies and secure session management.
* Implement API gateway security to control access

For DoS protection:

* Implement rate limiting and traffic filtering.
* Utilize load balancing and caching mechanisms.
* Consider using cloud-based DoS protection services.

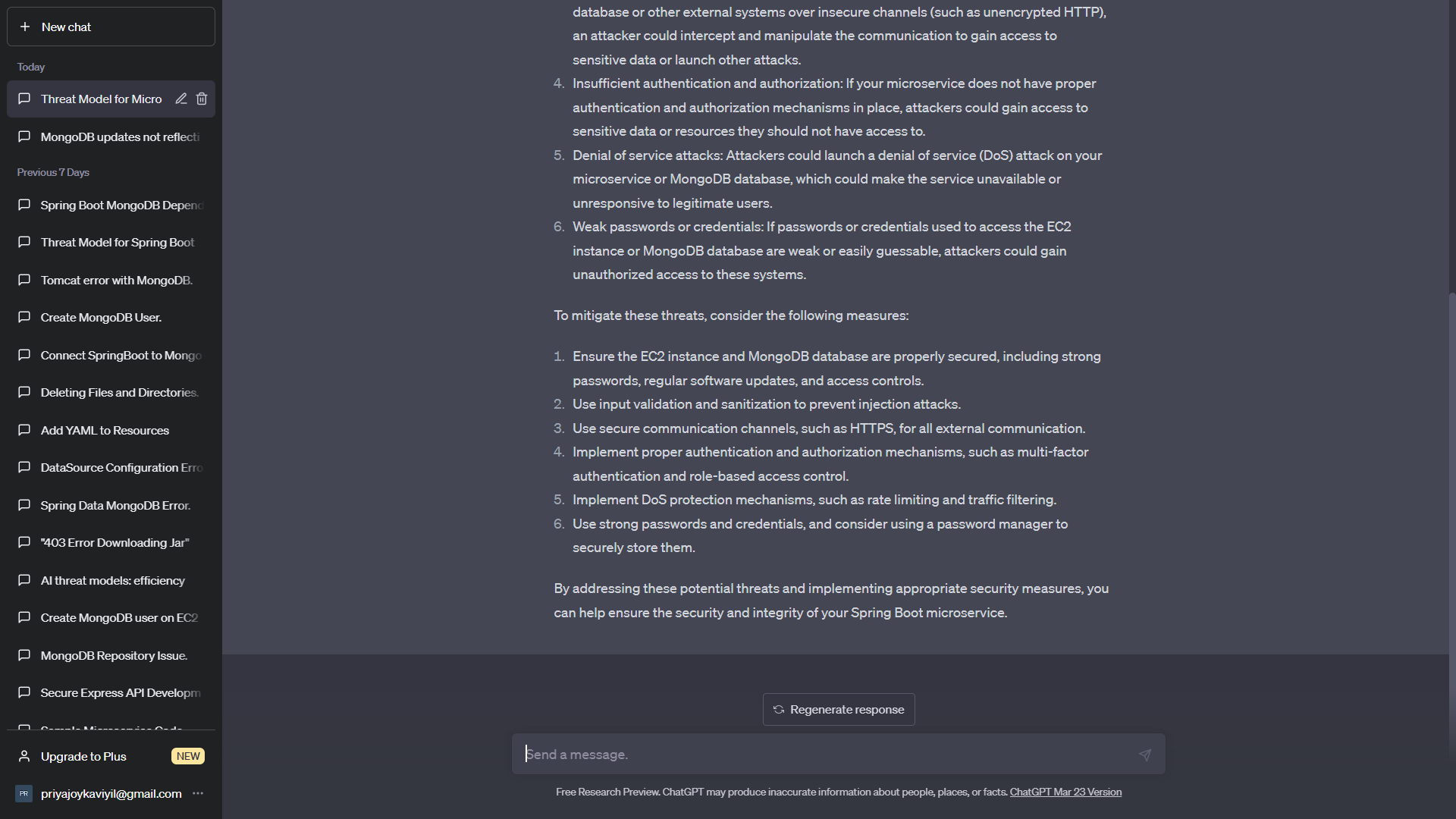


Fig.4: Mitigations

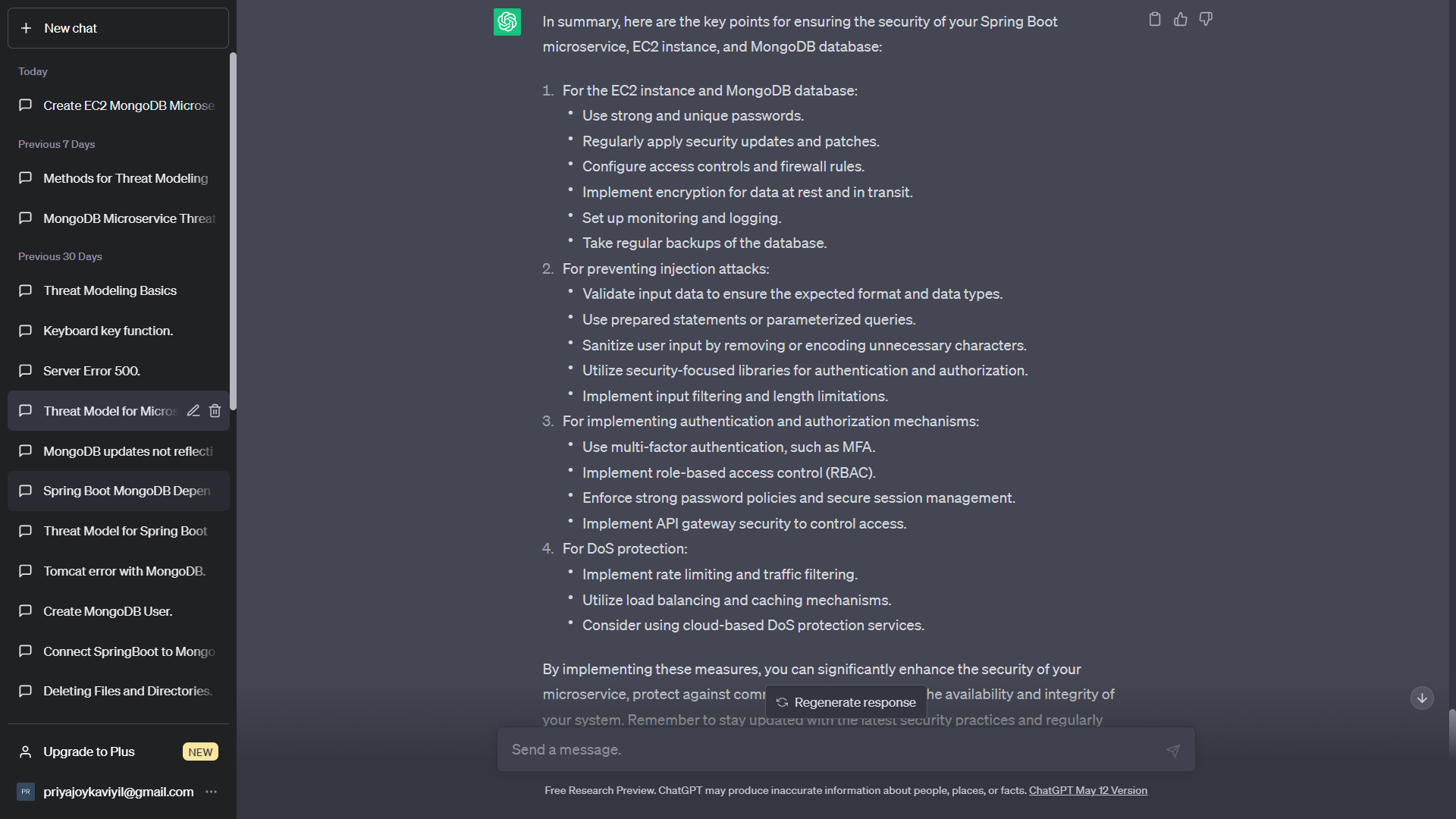


Fig.5 Mitigation Measures

### Implementation: Created a mitigation model from the mitigation and measures information taken from ChatGPT (Fig.6).

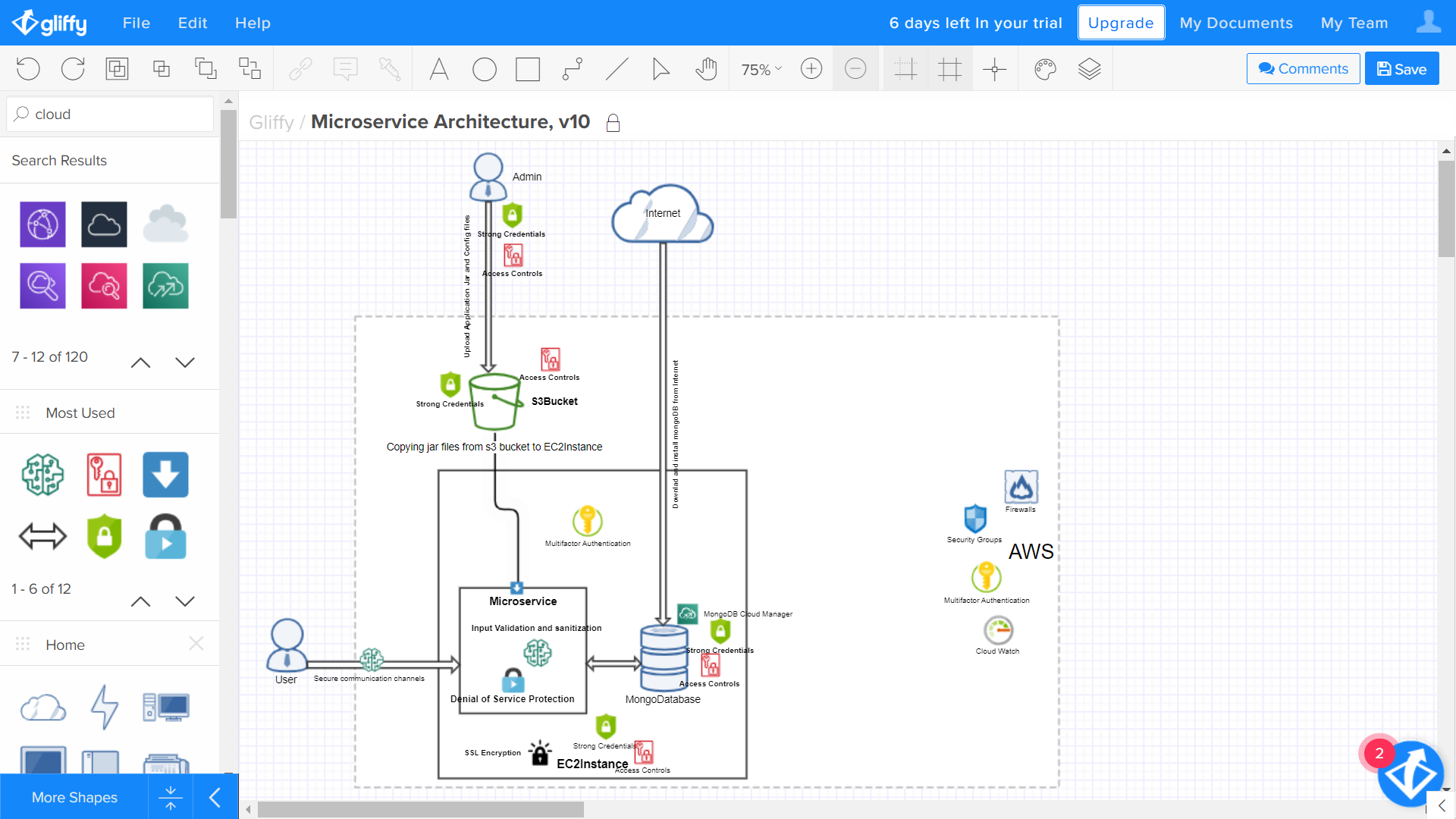


Fig.6: Implementing ChatGPT provided Mitigations

# Case Study

Before you begin to format your paper, first write and save the content as a separate text file. Complete all content and organizational editing before formatting. Please note sections A-D below for more information on proofreading, spelling and grammar.

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*a**b* 

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An excellent style manual for science writers is [7].

# Conclusion

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1. Sample of a Table footnote. (*Table footnote*)
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Figure Labels: Use 8 point Times New Roman for Figure labels. Use words rather than symbols or abbreviations when writing Figure axis labels to avoid confusing the reader. As an example, write the quantity “Magnetization”, or “Magnetization, M”, not just “M”. If including units in the label, present them within parentheses. Do not label axes only with units. In the example, write “Magnetization (A/m)” or “Magnetization {A[m(1)]}”, not just “A/m”. Do not label axes with a ratio of quantities and units. For example, write “Temperature (K)”, not “Temperature/K”.

##### Appendice A

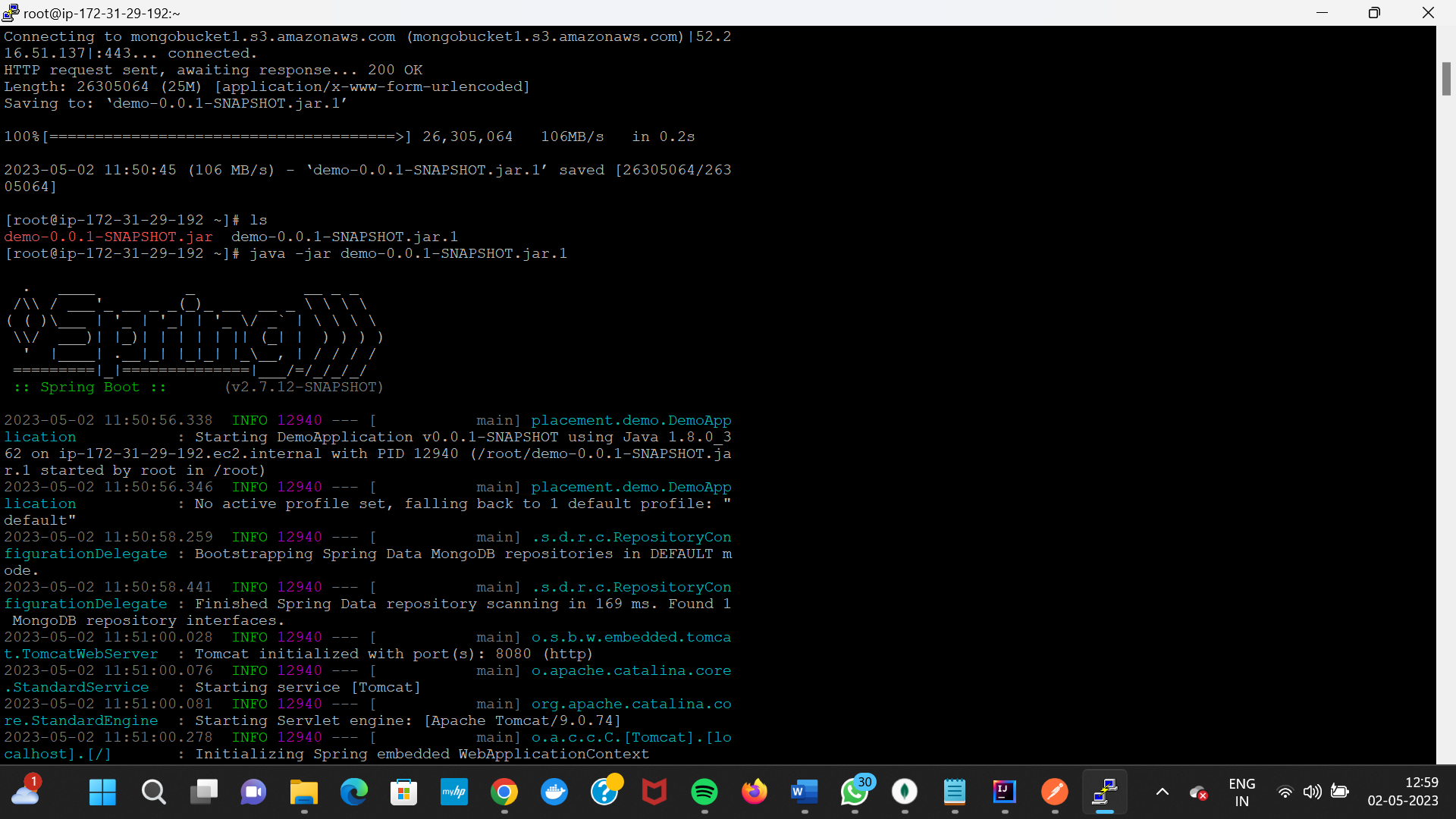


Figure : Microservice Application Running in EC2 Server -A

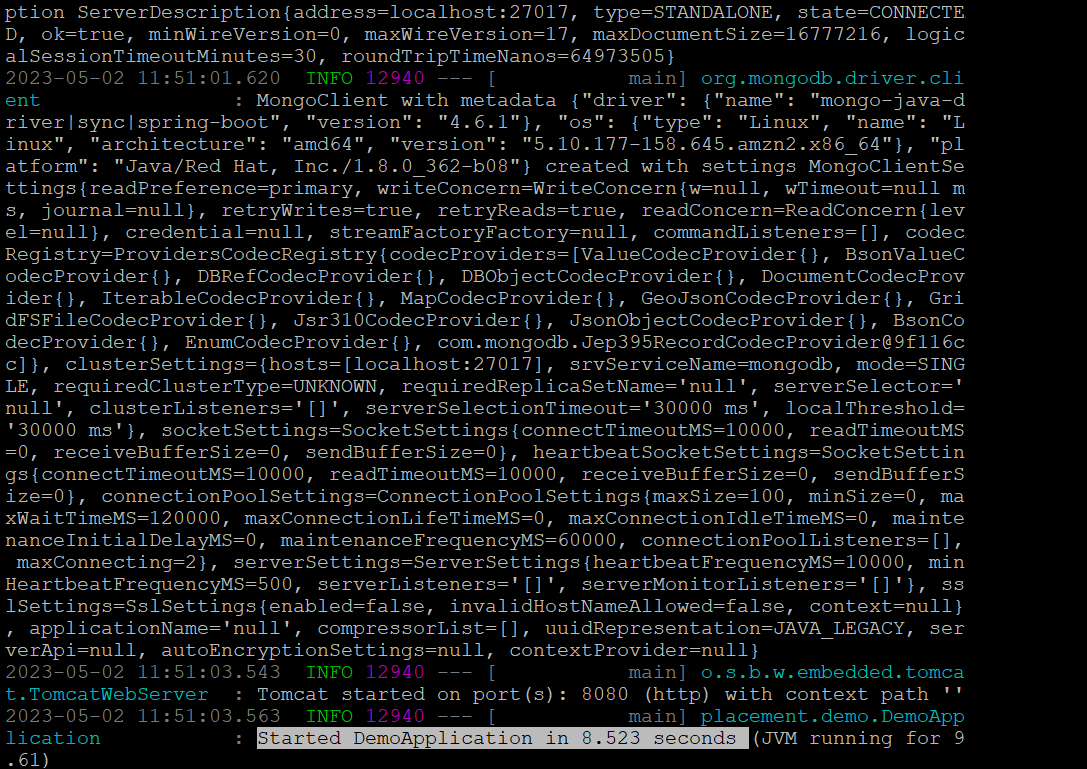


Figure : Microservice Application Running in EC2 Server -B

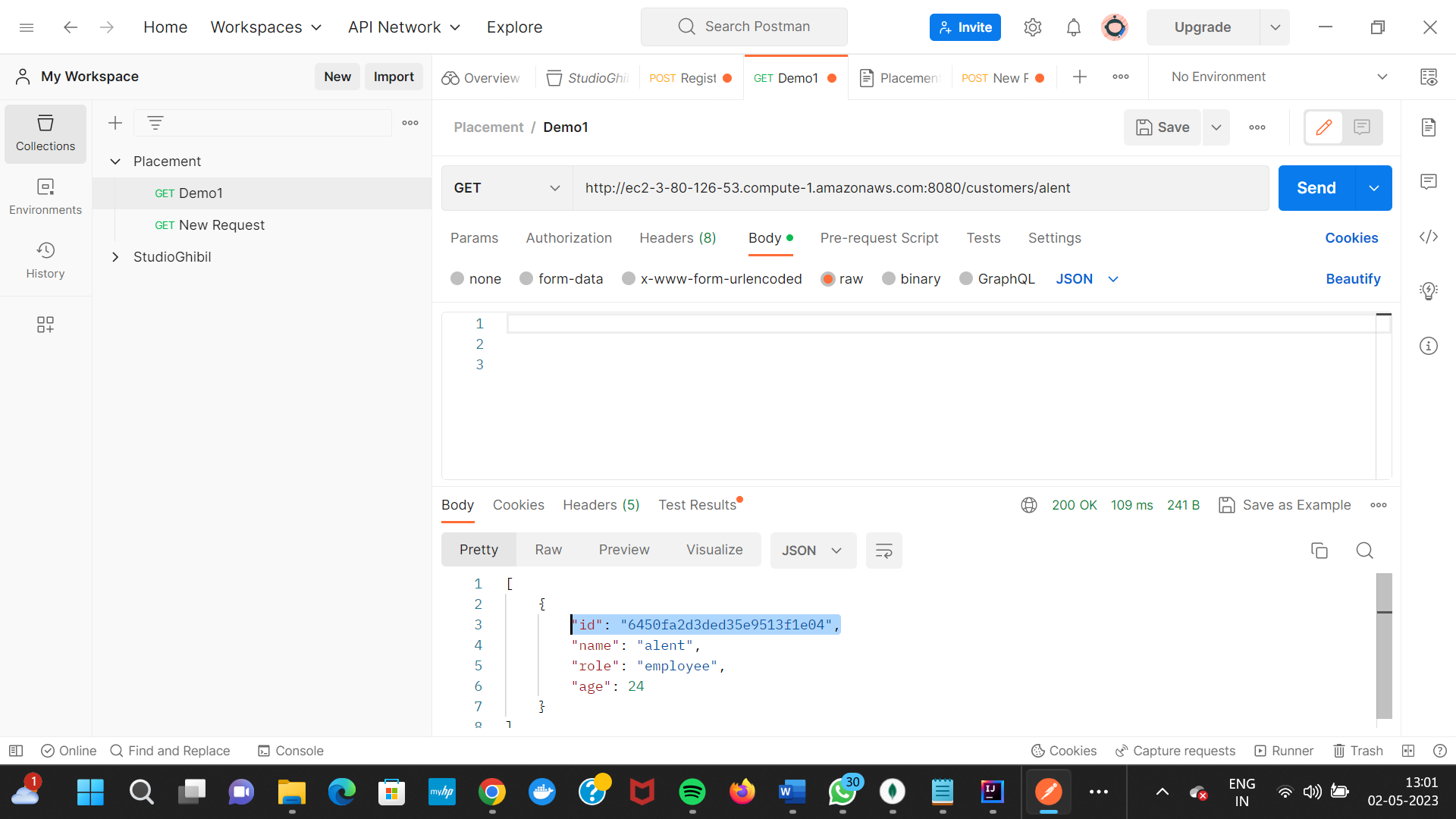


Figure : Testing the endpoints in Postman

##### Appendix B

GitHub Repo of the microservice application created: <https://github.com/L00171183/ThreatModel/tree/main/demo>

##### Acknowledgment *(Heading 5)*

The preferred spelling of the word “acknowledgment” in America is without an “e” after the “g”. Avoid the stilted expression “one of us (R. B. G.) thanks ...”. Instead, try “R. B. G. thanks...”. Put sponsor acknowledgments in the unnumbered footnote on the first page.

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