Politécnico de Leiria
Escola Superior de Tecnologia e Gestão
Departamento de Engenharia Informática
Mestrado em Cibersegurança e Informática Forense

AUTOPSY – ENHANCED DISTRIBUTED FORENSIC ANALYSIS

PEDRO HENRIQUE GASPAR CORDEIRO FERREIRA

Leiria, 25 de Fevereiro de 2020

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RESUMO

No contexto do mestrado em Cibersegurança e Informática Forense, uma das escolhas para o último ano curricular é a realização de um estágio, sendo este documento o relatório resultante da realização desse estágio.

A empresa VOID SOFTWARE, S.A. e o estudante chegaram a um acordo para a realização de um estágio curricular de 9 meses, com o objetivo de desenvolver uma plataforma de análise forense digital baseada na plataforma Autopsy.

Existem bastantes plataformas de análise forense digital, mas o Autopsy é a opção grátis e de código aberto com mais reconhecimento.

A plataforma desenvolvida tem como objetivo complementar a plataforma Autopsy com uma das funcionalidades mais importantes das plataformas de análise forense digital, a colaboração, adaptando a plataforma para um modelo cliente-servidor.

O desenvolvimento da plataforma é feito com as práticas habituais da empresa, utilizando uma *framework* ágil e trabalhando com diferentes entidades como *designer*, *tester* e *product owner*.

ABSTRACT

In the scope of the master's degree in Cybersecurity and Digital Forensics, one of the choices for the final curricular year was preforming an internship. This document is the report produced from the realization of said internship.

VOID SOFTWARE, S.A. and the student reached an agreement for a 9 month long curricular internship, where the scope is building a digital forensics platform based on the existing Autopsy platform.

Plenty of options of digital forensics platforms are available, but Autopsy is the free and open source option with most recognition.

The developed platform aims to complement the existing Autopsy platform with one of the most important features digital forensics platforms have, which is collaboration, by adapting the platform into a client-server model.

The development of the platform is done with the usual practices of the company, by having an agile framework and working with different parties such as a designer, tester and product owner.

TABLE OF CONTENTS

Appendices

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

API Application Programming Interface.

ASCII American Standard Code for Information Interchange.

BEC Belkasoft Evidence Center.

BSD Berkeley Software Distribution.

CSS Cascading Style Sheets.

DOS Disk Operating System.

EXIF Exchangeable Image File Format.

FTK Forensics Toolkit.

FTP File Transfer Protocol.

GPT GUID Partition Table.

HTML HyperText Markup Language.

JSON JavaScript Object Notation.

JWT JSON Web Token.

MIME Multipurpose Internet Mail Extensions.

NFTS New Technology File System.

NIST National Institute of Standards and Technology.

OS Operating System.

OTP One Time Password.

REST REpresentational State Transfer.

RSA Rivest-Shamir-Adleman.

STIX Structured Threat Information eXpression.

TSK The Sleuth Kit.

U2F Universal Second Factor.

UUID Universally Unique Identifier.

XML Extensible Markup Language.

1 INTRODUCTION

In the scope of the master's degree in Cybersecurity and Digital Forensics, students had the choice between writing a thesis, developing a project or doing an internship. This document is the report for a curricular internship conducted at VOID SOFTWARE, S.A., where the main goal of the internship was to develop a collaborative digital forensics platform, while also learning to develop software in an enterprise environment.

This chapter encompasses the motivation for this internship, a characterization of the host entity, the scope of the proposed project, and a summary of this document's structure.

1.1 MOTIVATION

Collaboration is a major feature included in most forensics software, and while Autopsy [1] allows the software to be configured in a manner to allow collaboration, it involves a complicated setup and has certain limitations. The setup required for collaborative cases in Autopsy is as follows:

- Shared hard drive accessible to every machine using the same drive letter
- PostgreSQL [2] Database server
- Apache Solr [3] indexing server
- Apache ActiveMQ [4] messaging server.

The limitations of Autopsy's multi-user case feature are that it requires every user to be using a Windows Operating System (OS) computer and it also requires specific configuration on each machine involved in the case that is set up.

The goal of this internship is to transform the existing Autopsy platform into a more complete digital forensics platform, including a client-server model that facilitates collaboration.

As a computer science student, my major interest has always been software engineering, and even after completing the first year of a master's degree in a more advanced subject, my interests remained unchanged. Based on that interest, the opportunity to work in an enterprise environment was captivating, as I could gain experience in the field while also developing an interesting project to complement my education.

1.2 HOST ENTITY

As a first step, an interview was conducted at VOID SOFTWARE, S.A., and a 9 month long curricular internship was planned. The initial project proposals were (1) the development of a client-server model for the existing Autopsy platform, or (2) the adaptation of the existing Autopsy platform for MacOS environments; The chosen proposal was the former.

1.2.1 *Company Characterization*

VOID is a privately held software development company established in Leiria, Portugal, in 2006, focused on building high-end products embodied in web, mobile and desktop applications, supported by creative software engineering tailored to each challenge's specific needs. It currently employs 30 high-end professionals in several fields of expertise.

VOID prides itself in providing very good conditions to its workers, making them feel like they are at home while working, and also to feel motivated to come to work every day. These conditions include the work environment itself, which is an open space where everyone can interact with each other, the "play areas" where people can relax while playing a game of pool or video games, and the rooftop terrace where workers can relax on sunny days. The company also makes sure nothing is missing to provide the best work environment possible by providing food and drink to all its workers at any time.

1.2.2 *Areas of Expertise*

VOID mostly functions as a company that develops software tailored to the specifications provided by the client, although it can also provide services in different areas like cybersecurity and digital forensics.

The company is capable of comfortably providing services in the following areas:

- Blockchain
- Machine learning and data science
- Augmented reality and virtual reality
- Mobile applications
- Web applications
- Desktop applications
- Cybersecurity and digital forensics.

Throughout its 14 years of being active in the software development industry, VOID has conducted some very interesting projects, as can be seen in Table 2.

Name	Description
Yes Account	A suite of applications for automated digitization of accounting documents
Web Portal	A large scale project for the European commission
Digital Archive	A digital preservation application
Dream Football	A social network along with web and mobile applications
Fuel Write	A comprehensive platform for fleet management, data collection and route optimization
Caspers	A mobile augmented reality customer experience and engagement
PBCore Toolkit	A desktop application to support the creation, editing, and export of moving image-related inventory metadata as PBCore XML records
Avenue Securities	A trading platform

Table 2: VOID's Main Projects

1.3 PROJECT SCOPE

The proposed solution consists in adapting Autopsy into a client-server model, and such adaptation can be categorized in the field of digital forensics. Even though the main focus is on typical software development, there are plenty of advanced concepts related to forensics science and cybersecurity that must be assimilated for the project to succeed.

The platform aims to cover three main aspects:

1. Accessibility
2. Collaboration
3. Organization.

1.3.1 *Accessibility*

Given a client-server architecture, any client with access to the network where the server is located can access the contents provided by the server. The aim is to condense the processing heavy features of Autopsy in a single server and provide any number of clients access to this information, requiring less resources from each client, allowing collaboration and removing any type of setup required for each of the client machines, while also providing a more modern and user friendly design.

1.3.2 *Collaboration*

In order to provide collaboration, all the information is maintained in a single server, or a collection of servers providing different functions (like exposing endpoints, storing data and indexing searches), and every client can preform all the allowed actions whether they consist in consulting, generating, or removing information. Collaboration comes naturally with a client-server model, as the same server that provides the endpoints can also communicate with each client using WebSockets, maintaining information in a coordinated state along every connected client.

1.3.3 *Organization*

Digital forensics investigations are usually done by specialized organizations, that need to organize their human resources in an efficient and secure manner. Assigning investigators to teams, assigning teams to cases, allowing access to the platform and certain information is a critical part of the activities preformed by a company that specializes in digital forensics, so having these functionalities properly integrated into a digital forensics platform should be an important feature.

1.4 CONTRIBUTIONS

This project aims to contribute to the existing Autopsy platform with the following features:

- Easy setup for multi-user projects
- Web based user interface
- Lower requirements from each client machine
- Personnel management system
- Centralized module repository
- Shared configurations between users and machines
- Bug fixes
- Improved Linux [5] support

1.5 DOCUMENT STRUCTURE

This document contains five chapters: the first one provides an introduction about the internship that was carried out, the second contains important concepts to help better understand the contents of this document, the third focuses on the main goal of the internship which is the development of the proposed platform, the fourth presents experiences from being involved in different projects inside the company, and finally, the conclusion about the performed internship is presented in the fifth chapter.

2

BACKGROUND

The scope of this internship concerns digital forensics, as it focuses on adapting an existing forensics platform into a collaborative client-server model.

In this chapter, a contextualization of digital forensics is given, an analysis of both The Sleuth Kit (TSK) [6] and Autopsy is made, and it's given a brief description and analysis of the existing forensic platform alternatives.

2.1 DIGITAL FORENSICS

According to NIST [7], "forensic science is the use of scientific methods or expertise to investigate crimes or examine evidence that might be presented in a court of law".

The definition of digital forensics is directly related to the definition of computer forensics, which is the collection, preservation, analysis, and presentation [8] of evidence stemming from digital sources for use in a legal matter using investigative processes, tools, and practices.

Digital forensics [9] is the application of computer technology to criminal cases where evidence includes items that are created by digital systems.

Digital forensics is the field of forensic science that is concerned with retrieving, storing and analysing electronic data that can be useful in criminal investigations. This includes information from computers, hard drives, mobile phones and other data storage devices.

The list of challenges digital forensic investigators face includes "extracting data from damaged or destroyed devices, locating individual items of evidence among vast quantities of data and ensuring that their methods capture data reliably without altering it in any way" [9].

According to *Digital Forensics for Legal Professionals*, "personal data should ultimately be attributable to an individual; however, making that attribution can be difficult due to the presence or absence of individualized user accounts, security to protect those user accounts, and the actual placement of a person at the same location and time when the data is created“ [8].

2.1.1 *Digital Evidence*

Digital evidence is any type of digital data with incriminating characteristics, which can result from any type of action performed by a user, like transactions and recordings.

Nowadays it is virtually impossible not to leave a digital track behind, since most of us carry and use devices capable of connecting to the internet.

The explosion of social media [8] sites has created a whole new area of electronic evidence. Most people today are willing to share all kinds of information through social media platforms.

In order for electronic data to become digital evidence, it must be stored and be recoverable by a forensic examiner. One of the great challenges is not whether digital evidence may exist, but where the evidence is stored, getting access to that storage, and finally, recovering and processing that digital evidence for relevance within a civil or criminal action.

The potential storage options for electronic evidence has shifted from being only contained locally to being either located locally or remotely in what is called “The Cloud“ [10].

More and more everyday computing processes are moving to the Internet where companies offer software as a service [11]. Software as a service means that the customer no longer has to install software on their computer, allowing access to the software remotely, and not storing any data locally.

2.1.2 *Processes and Procedures*

Digital forensics is the application of forensic science to electronic evidence in a legal matter.

While there are many different subdisciplines and many types of devices, communication and storage methods available, the basic principles of digital forensics apply to all of them.

Larry and Lars Daniel [8] conclude that these principles encompass four areas:

1. Acquisition
2. Preservation
3. Analysis
4. Presentation.

Each of these areas includes specific forensic processes and procedures.

Acquisition

Acquisition is the process of collecting electronic data. Seizing a computer at a crime scene or taking custody of a smartphone in a civil suit are examples of device acquisition, but the data must be extracted from these devices using specific procedures that equate to making a copy of the storage devices, while following strict rules to ensure the integrity of all the extracted data.

Since acquisition is the first interaction between the investigators and the evidence, it is the step where it's most likely to occur modifications of the contents of the seized devices, because turning on the device or extracting the data without following the right procedures can alter its contents irreversibly.

Preservation

For evidence to be defendable in court, it must be preserved properly. Preservation in the forensics context is the process of creating a chain of custody [12] that begins before collecting the evidence and ends when the evidence is released. Any interference in the chain of custody can lead to issues regarding the validity of the evidence. Additionally, preservation includes maintaining the evidence in a safe environment, preventing intentional destruction with malicious purpose or accidental modification by unqualified people.

A chain of custody log allows proving that the integrity of the evidence has been maintained from seizure through presentation in court. It should contain entries for every time that a piece of evidence has been touched, including collection, storage transport and any time the evidence is checked out for handling by any personnel.

Analysis

Analysis is the process of locating and categorizing items from evidence that has been collected in a case. Each case is unique as the circumstances surrounding each case can vary immensely, not only in the evidence being analysed, but also in the approach used to perform the analysis. The analysis is the area where the individual skills, tools used, and the training of the forensic examiner have the greatest impact on the outcome of the examination. Considering that electronic evidence appears in so many forms and comes from diverse locations and devices, the training and experience of the examiner has a much greater impact on the results of the examination.

Analysis of digital evidence is more than just determining whether a file exists on a hard drive, it involves finding out how that file got on the hard drive, and if possible, who put the file on the hard drive.

Presentation

Presentation of the examiner's findings is the last step in the process of forensic analysis of electronic evidence. This includes not only the written findings or forensic report, but also the creation of sworn statements, depositions of experts, and court testimony. There are no exact rules or standards for reporting the results of an examination. Each entity may have its own particular guidelines for reporting. However, forensic examination reports should be written clearly, concisely, and accurately, explaining what was examined, the tools used for the examination, the procedures used by the examiner and the results of the examination. The report should also include the collection methods used, including specific steps taken to protect and preserve the original evidence and how the verification of the evidence was performed.

2.2 THE SLEUTH KIT

TSK (https://www.sleuthkit.org/sleuthkit) is a library and collection of command line tools that allow the investigation of disk images. The core functionality of TSK allows volume and file system data analysis. The plug-in framework allows incorporation of additional modules to analyse file contents and build automated systems. The library can be incorporated into larger digital forensics tools and the command line tools can be directly used to find evidence.

The original part of TSK is a C library and collection of command line file and volume system forensic analysis tools. The file system tools allow examining file systems of a computer in a non-intrusive fashion. Because the tools do not rely on the operating system to process the file systems, deleted and hidden content can be shown.

The volume system tools allow examination of the layout of disks and other media. TSK supports DOS partitions, BSD partitions, Mac partitions, Sun slices, and GPT disks. With these tools, partition locations can be identified and extracted so that they can be analysed with file system analysis tools.

When performing a complete analysis of a system, command line tools can become tedious. Autopsy is a graphical interface to the tools in TSK, which allows easier conduction of an investigation. Autopsy provides case management, image integrity, keyword searching and other automated operations.

A complete analysis also requires more than just file and volume system analysis. However, a single tool can't provide support for all file types and analysis techniques. The TSK Framework allows tools to easily incorporate file analysis modules that were written by other developers.

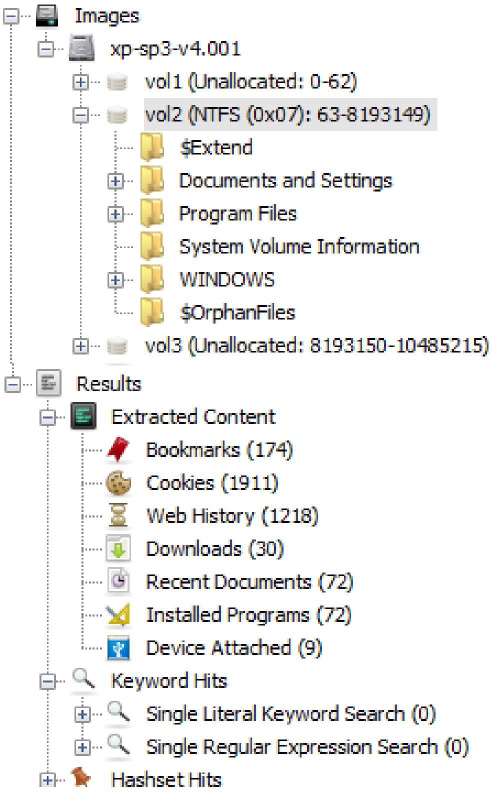
TSK allows listing allocated and deleted ASCII and Unicode file names, can display the details and contents of all NFTS attributes, can display file system and meta-data structure details, can create time lines of file activity, which can be imported into a spread sheet to create graphs and reports. TSK allows the lookup of file hashes in hash databases, it organizes files based on their type, and pages of thumbnails can be made from graphic images to facilitate quick analysis.

2.3 AUTOPSY

Autopsy (https://www.sleuthkit.org/autopsy/) is a digital forensics platform and a graphical interface to TSK along with other digital forensics tools. It is used by law enforcement, military, and corporate examiners to investigate what happened on a computer. It can even be used by anyone to recover photos from a camera's memory card.

Autopsy was designed to be intuitive out of the box. Installation is easy and wizards guide the user through every step. All results are shown in a single tree, as can be seen in Figure 1.

Autopsy was designed to be an end-to-end platform with modules that come with it out of the box and others that are available from third-parties. An overview of Autopsy's modules can be found in Table 4.



- Images
  - xp-sp3-v4.001
    - vol1 (Unallocated: 0-62)
    - vol2 (NTFS (0x07): 63-8193149)
      - $Extend
      - Documents and Settings
      - Program Files
      - System Volume Information
      - WINDOWS
      - $OrphanFiles
    - vol3 (Unallocated: 8193150-10485215)
- Results
  - Extracted Content
    - Bookmarks (174)
    - Cookies (1911)
    - Web History (1218)
    - Downloads (30)
    - Recent Documents (72)
    - Installed Programs (72)
    - Device Attached (9)
  - Keyword Hits
    - Single Literal Keyword Search (0)
    - Single Regular Expression Search (0)
  - Hashset Hits

Figure 1: Autopsy's Explorer Tree

Name	Description
Timeline Analysis	Advanced graphical event viewing interface
Hash Filtering	Flag known bad files and ignore known good
Keyword Search	Indexed keyword search using Solr to find files that mention relevant terms
Web Artifacts	Extract history, bookmarks, and cookies from Firefox, Chrome, Internet Explorer and Microsoft Edge
Data Carving	Recover deleted files from unallocated space
Multimedia	Extract EXIF metadata from pictures and videos and display these files
Indicators of Compromise	Scan a computer using STIX

Table 4: Autopsy's Modules

Autopsy runs background tasks in parallel using multiple cores and provides results as soon as they are found.

Autopsy is free and open source, allowing for cost-effective digital forensics analysis and community contributions.

2.4 RELATED SOFTWARE

There are plenty of alternatives to Autopsy in the form of digital forensic analysis platforms, but the ones with most recognition work on a software as a service model, without providing a free trial, so even though it wasn't possible to test them, they were analysed based on the available information.

2.4.1 *Nuix Lab*

Nuix Lab [13] allows investigators to work on large investigations. It can be used for local or small regional forensic labs handling high data volume, variety, and complex digital evidence and looking to build or upgrade a dedicated digital forensics facility.

The core technologies of the Nuix Lab, Nuix Workstation and Nuix Investigate, give digital forensic technicians and case investigators different viewpoints into the same case data. Investigators can collaborate on the same data at the same time by using browser based tools.

The Implementation of Elasticsearch [14] as a data store for the Nuix Lab boosts evidence processing, investigation, and intelligence capabilities.

Nuix Lab also claims to contain powerful artificial intelligence, machine learning, and analytics which should make it stand out from the competition.

2.4.2 *EnCase Forensic*

EnCase Forensic [15] enables searching, identifying, and prioritizing potential evidence, in computers and mobile devices, to determine whether further investigation is warranted.

It can collect from a wide variety of operating and file systems, including over 25 types of mobile devices, and parses the most popular mobile apps across iOS, Android, and Blackberry devices. Has strong decryption capabilities, allowing identification and unlocking password-protected files, and contains a custom indexing engine.

EnCase Forensic provides a wide range of capabilities that enable performing deep forensic analysis as well as fast triage analysis from the same solution, and provides a flexible reporting framework that empowers tailoring case reports to meet specific needs.

2.4.3 *Forensics Toolkit*

Forensics Toolkit (FTK) [16] is an award-winning, court-cited digital investigations solution.

It locates evidence, collects and analyses any digital device or system producing, transmitting or storing data by using a single application for multiple devices.

All digital evidence is stored in one case database. It reduces the time, cost and complexity of creating multiple datasets, and there is continuous data transfer between AccessData's forensic and e-discovery solutions, allowing for collaboration between all parties working on the case.

FTK allows users to create images, process a wide range of data types, analyse the registry, crack passwords and build reports.

FTK allows collaboration, contains indexed searches, constructs timelines and other graphical assets, categorizes all the extracted artifacts and also contains malware identification modules.

2.4.4 *Magnet AXIOM*

Magnet AXIOM [17] provides a complete investigation platform capable of recovering data, analyzing it, and producing reports.

It allows the recovery of digital evidence from most sources, such as phones, computers, IoT devices and cloud services.

AXIOM provides a very complete package that allows the analysis of all kinds of data in a large variety of ways, allowing the attribution of possession, as well as the ability to determine when each file or artifact was handled.

It lacks the ability for multiple users to collaborate on the same case instance, but it can export cases to allow working on the same case in parallel.

2.4.5 *Belkasoft Evidence Center*

Belkasoft Evidence Center (BEC) [18] is a more affordable digital forensics platform.

It encompasses the most critical stages of digital forensics, by allowing acquisition, preservation and analysis of digital evidence. It provides solid tools for these stages of the investigation, but lacks features that could make it stand out from the, still it should be seen as a valid option for digital forensics investigations.

2.5 COMPARISON

A comparison of the features offered by each software is presented in Table 6.

Feature	Autopsy	Nuix	Encase	FTK	AXIOM	BEC
Collaboration	✓	✓	✓	✓	✗	✓
Web Based Interface	✗	✓	✗	✗	✗	✗
Indexed Searches	✓	✓	✓	✓	✓	✓
Decryption	✗	✗	✓	✓	✓	✗
Artificial Intelligence	✗	✓	✓	✗	✓	✗
Malware Analysis	✗	✗	✗	✓	✓	✗
Report Generation	✓	✓	✓	✓	✓	✗
Free and Open Source	✓	✗	✗	✗	✗	✗
Extensible	✓	✗	✗	✗	✗	✓

Table 6: Software Comparison

Every software listed has its pros and cons; Autopsy mainly benefits from being free and open source, and allowing the development of modular plugins, while the other options seem to try to offer a very complete package out of the box.

Any of these software options seem viable for any kind of digital forensics investigation, and as a digital forensics firm, the teams should first test the available options that seems to provide all the wanted features and chose the one that best suits their needs.

3 KENSENTME PLATFORM DELEVOPMENT

The main goal of the internship is the development of a collaborative platform based on Autopsy, which was soon named “KenSentMe“ by the company’s designer. The chosen name was based on a video game, as it was a password used to access a forbidden area in the game.

Each step taken towards the development of this platform is documented in this chapter, from project planning to full roll out on a production environment.

3.1 DEVELOPMENT FRAMEWORK

The project development followed an agile workflow, using a JIRA [19] board to organize bi-weekly sprints.

The project had four intervening parties involved. The developer was responsible for developing the software. The product owner provided help in decisions surrounding the developed product. The designer came up with ideas for the user interface and user experience of the platform. And the tester made sure everything was working as intended.

For each sprint the process was identical: a sprint review was conducted to assess the progress made in the previous sprint, then a new sprint would be planned by the developer, the features would be implemented during the two week duration of the sprint, and developed features would be tested thoroughly before the sprint ended.

3.2 PROJECT AIM AND MILESTONES

Autopsy by itself is capable of providing a distributed solution for multi user collaboration, but it is very resource intensive, requires many complex configuration steps and is also only fully supported on the Windows OS.

The plan for this project is to achieve the same kind of functionality provided by the original software, but without the dependency on arduous pre-configuration or hardware intensive requirements, resulting in needing only single capable server, and allowing the program to be used by multiple low capacity client devices using any web capable OS.

To achieve that goal, the project is an adaptation of the original Autopsy source code, into a client-server model, with the server developed in Java using the Quarkus [20] framework, and the client developed in JavaScript using the React [21] framework.

The project is outlined to work in a multi user environment, allowing users to be assigned to teams and teams assigned to cases, and allowing multiple users to interact with a case simultaneously.

Autopsy has a major limitation, which is it only allows one case to be open at a time; Ideally in this project a workaround should be created to allow working on multiple cases at once, but dedicating a server instance (which a single machine can contain many within) per case is a good enough approach, though as future work the ability to spawn different containers as requested to work on different cases at once is an interesting challenge.

Given that the core features will be running in a remote server, it was decided that the addition of data sources to cases will be handled by an FTP client, allowing users to transfer files to their respective data source directories, and FTP access will be controlled according to each user's credentials on the platform.

The architecture of the expected result is represented in Figure 2, where it can be seen that multiple clients can connect through a REST API, WebSockets and FTP with the KenSentMe server, which requests and provides data to both database and indexation servers.

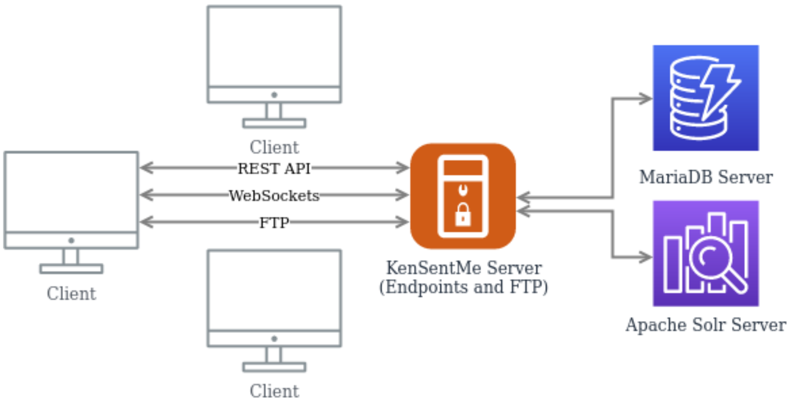


Figure 2: Software Architecture

The KenSentMe server described in the previous figure provides different services, such as authentication, case resources, entity management, and others, as can be seen in Figure 3.

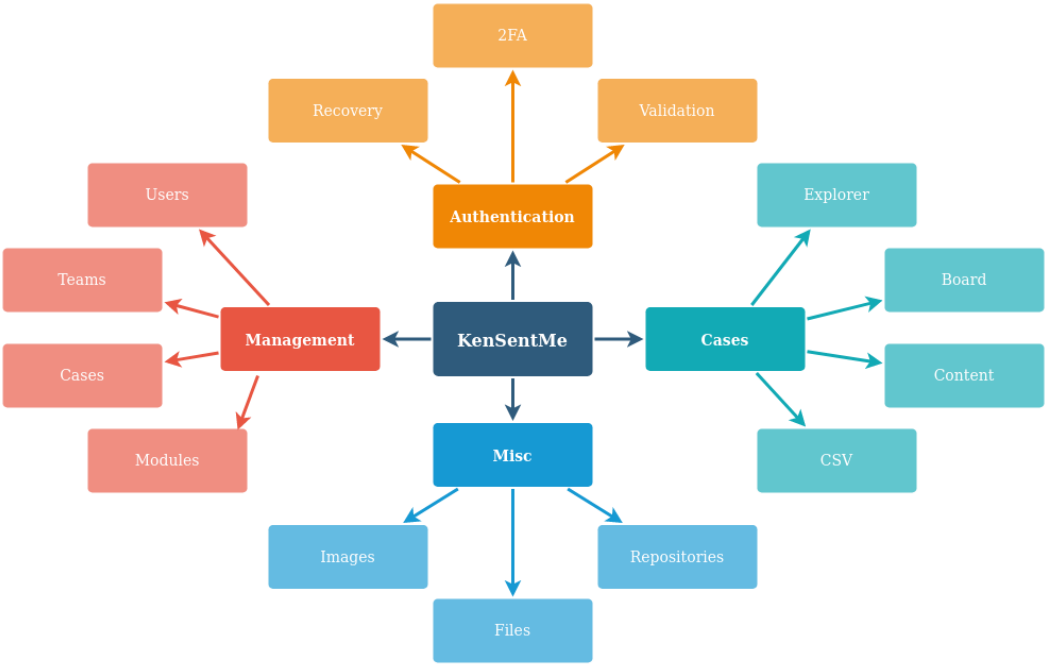


Figure 3: Platform's Services

3.3 AUTOPSY SOURCE CODE ANALYSIS

Autopsy is a digital forensics analysis software that is available as Open Source Software [22] on GitHub [23].

With the goals set for this project, the source code was analysed to understand which components need to be replicated and adapted in order to obtain the same logic flow.

The "Core" module is where the most important components are located, and after analysis it was concluded that the following directories present in Table 7 contain relevant information.

Name	Description
Actions	User interactions
Casemodule	Case class and other resources needed for the functioning of an autopsy case like data sources and artifacts
Centralrepository	Data persisted and accessed by multiple cases (Correlation Engine)
Contentviewers	Panels used for data representation
Coordinationservice	Configuration information distribution system
Core	Addition of command line options, system configurations and collaboration monitor
Corecomponents	Main user interface components
Datamodel	All the entities needed to represent ingested data
Datasourceprocessors	Data processing utilities
Directorytree	File explorer for ingested artifacts
Ingest	Utilities and events for data ingestion
Keywordsearchservice	Utility to search artifacts by keyword
Modules	All the pre-included modules (data ingestion procedures)
Progress	Progress indicators and similar classes
Python	Resources needed for the functioning of the Jython language
Rejview	Resources used to analyse Windows registry
Report	Report generation utilities and modules
Timeline	Recent addition to Autopsy, allows visualization of artifacts in temporal chart, only available for Windows OS

Table 7: Autopsy Core Module Overview

The “KeywordSearch“ module is also of critical importance as it provides one of the most meaningful features, which is filtering all the artifacts in a case with a keyword search using the Apache Solr search platform. Solr indexes the text contents of all the artifacts and allows extremely fast searching through a large amount of data.

Another module that needs to be adapted is the “RecentActivity“ module, which contains the tools needed to extract information from browsers, registry and other important resources, providing a great amount of critical evidence from data sources.

Each autopsy case contains its own SQLite [24] database, which contains the tables present in Table 8.

tsk_db_info	tsk_db_info_extended	tsk_objects
tsk_image_info	tsk_image_names	tsk_vs_info
tsk_vs_parts	tsk_fs_info	data_source_info
tsk_files	file_encoding_types	tsk_files_path
tsk_files_derived	tsk_files_derived_method	tag_names
review_statuses	blackboard_artifacts	blackboard_attributes
ingest_modules	blackboard_attribute_types	ingest_module_types
reports	blackboard_artifact_types	ingest_jobs
ingest_job_modules	ingest_job_status_types	account_types
accounts	account_relationships	tsk_event_types
tsk_examiners	blackboard_artifact_tags	content_tags
tsk_file_layout	tsk_event_descriptions	tsk_events
tsk_pool_info		

Table 8: Case Database Tables

The tables containing the information accessed most frequently are the ones related to blackboard artifacts, along with tables related to files and tags.

Autopsy’s source code allows access to most of the important entities present in this database, through pre-defined queries which return entities like data sources, abstract files, or artifacts. But in order to add features like pagination and tag deletion, custom queries must be created, so that the queries may return only a specific amount of entity ids, or so that delete commands may be executed.

3.4 DEVELOPMENT STAGES

3.4.1 *Basic Autopsy Functionalities*

As a first step into replicating the functionalities of the original program, the most basic functionality from Autopsy was adapted, the ability to open an Autopsy case, as can be seen in Figure 4.

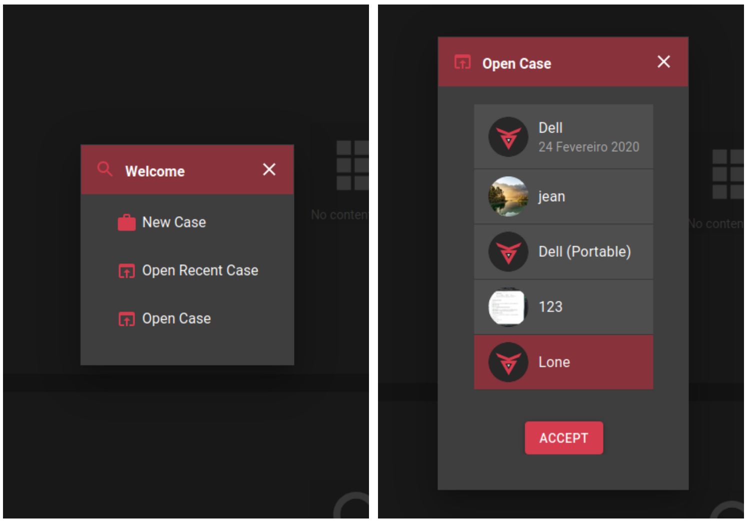


Figure 4: Welcome and Open Case Modals

For this, some elements of the original ”Casemodule” package were adapted, and after that all the other similar actions like closing, creating and deleting cases were also adapted.

Autopsy cases have a case file containing case metadata, which allows the program to connect to the right database when the case is open: this database is also present in a file inside the file system, which uses the SQLite database engine. So, for the cases to be usable in the server, these files must also be present in the server, which resulted in the creation of a directory within the server called “repository“, containing all the different cases created within the application.

Later in the development there was the need to create an additional directory alongside the “repository“ called “central-repository“. The central repository contains the database used by the Correlation Engine, a feature that finds files present in multiple cases to ingest data that can be queried by any case.

The development of autopsy features was done with the original software as a reference, so that every new feature implemented into the platform could be compared and verified with the original software. It was reassuring to see that cases created through one of the versions of the software were capable of being opened through the other version, meaning that the source code provided by autopsy, with some tinkering, could be used in a client-server model.

3.4.2 *Authentication Process*

The authentication process is handled through a REST API, when the authentication is completed the user receives a JSON Web Token (JWT).

JWT is an open standard that defines a compact and self-contained way for securely transmitting information between parties. This information can be verified and trusted because it is digitally signed. JWT contain three parts, as can be seen in Table 10.

Name	**Contents**
Header	Information about the signing algorithm used
Payload	Information about the user, such as username, e-mail and roles
Signature	A signature used to verify the contents weren't changed

Table 10: JWT Composition

The authentication can be performed with either username or e-mail and a password, and extra authentication factors can be added such as One Time Password (OTP) [25] and Universal Second Factor (U2F) [26].

If no extra factors were added to an account, the authentication attempt with the user's credentials will return the JWT when successful and the user can freely access protected content.

When extra factors are present in an account, the response from the same request will contain an array with the extra factors added, and a UUID, which is a pseudo random string, which must be sent in the next request to validate the user's identity.

This UUID is saved in the database in the form of salted hash using the Blowfish [27] algorithm, and is invalidated after a successful login attempt. The user then has the choice between any of the extra factors and must complete the required steps to validate that factor, as can be seen in Figure 5.

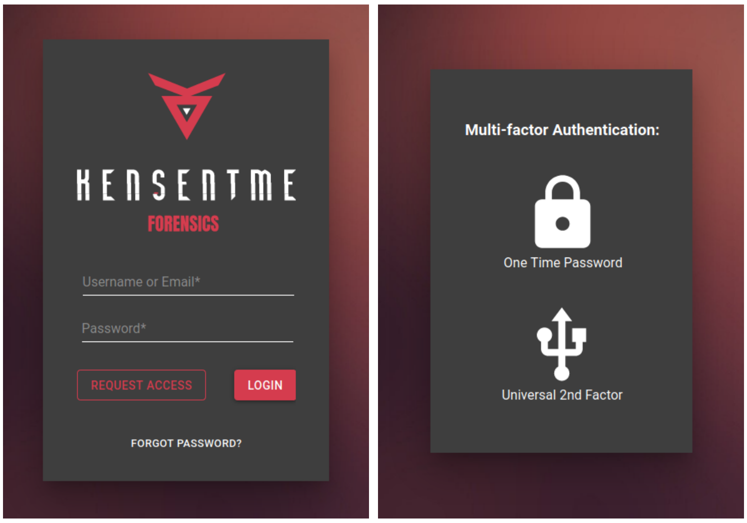


Figure 5: Login Screen and Extra Factors

One Time Password

The process of setting up OTP for an account begins with generating a secret string, which is used by both the server and the authenticator app to generate OTP. When the secret is generated, it is saved as a temporary secret after being encrypted by the RSA algorithm.

The temporary secret must be added to the user's device, either by inserting the string itself or by scanning a QR code [28], and must be validated by the user by submitting the current OTP; After validation the temporary secret is considered permanent.

All OTP validations have a 30 second threshold, which means the current OTP is valid for an extra 30 seconds after being replaced by the next OTP, allowing the user to have a better experience with these passwords.

The processes of authenticating and removing this authentication factor both depend on validating the current OTP, which is provided by the user's app.

In the event of loss of the device that the user uses to generate OTP, all the authentication factors can be reset using the "Reset Password" functionality, which relies on e-mail validation to prove the user's identity.

Universal Second Factor

Both the set up and validation of U2F are very similar, as these procedures require the server to generate a challenge. This challenge is transmitted to the client and then transmitted to the U2F device, which then generates the response which is used to validate the challenge.

In the case of setting up the device, if the response is validated successfully, the information present in Table 12 is stored in the server and the procedure is completed.

Name	Description
Key Handle	Identification of the registration, allows the same key to be used for multiple accounts in the same domain
Public Key	Resulting from the generation of a key pair specific to the domain, used to verify the information provided by the device
Attestation Certificate	A certificate that can be used to verify the authenticity of the device
Counter	The device's authentication counter, used to prevent the use of cloned devices
Compromised	Flag indicating if the credential is considered to be compromised

Table 12: U2F Registration Composition

When authenticating, the challenge depends on the public key previously stored, which means only the device used to set up can generate the right response to the challenge.

The U2F procedure is represented in Figure 6.

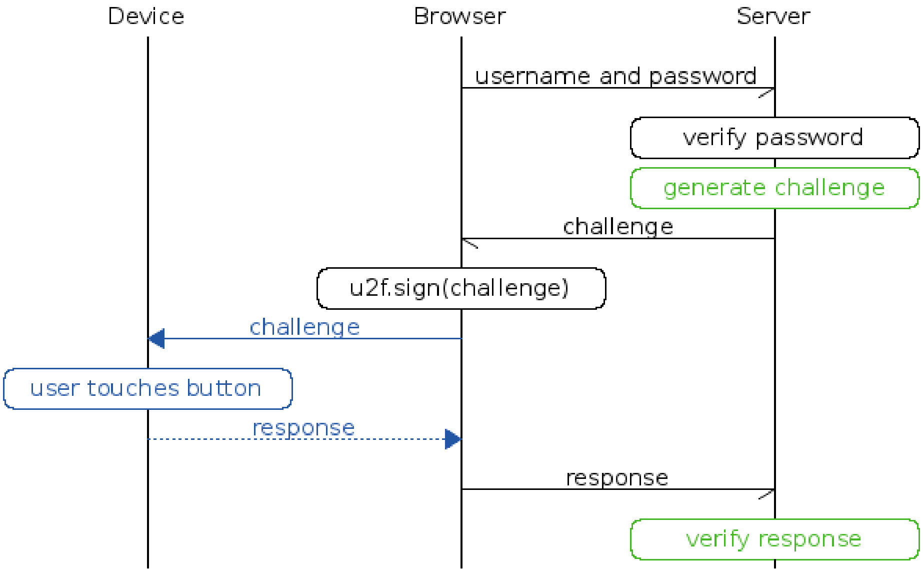
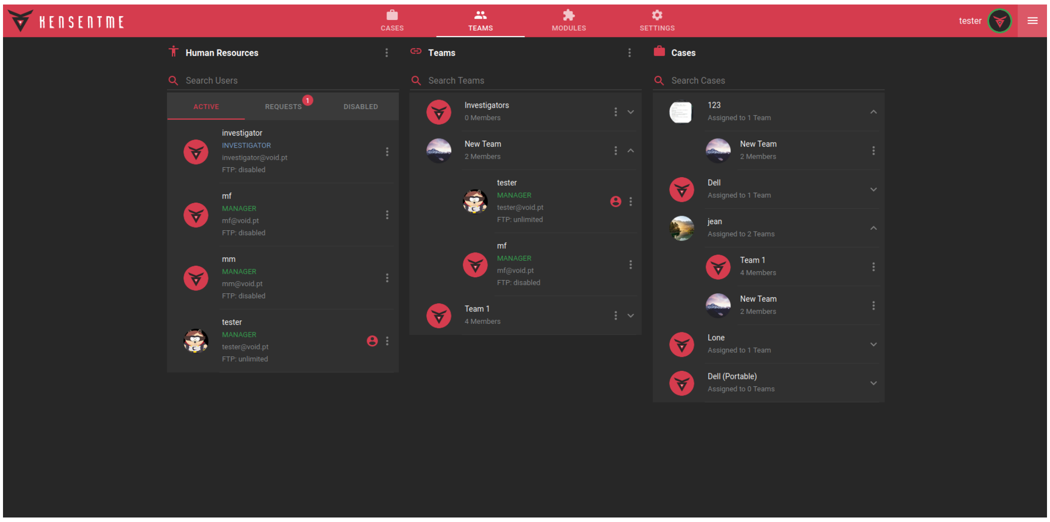


Figure 6: U2F Procedure [29]

3.4.3 *Management Entities*

Further in the development, the different persisted entities were created, which are Users, Teams, and Cases. All the endpoints for actions involving these entities were created, resulting in the ability for the client program to interact with these entities and modify their relationships and other variables.

For these functionalities there are two roles associated: (1) the Manager role allows manipulation of the existing entities, while (2) the Investigator role only has access to his/her own information and the teams and cases he was assigned to. For these interactions, it was decided to create a drag and drop interface, which allows users to be dragged into teams and teams dragged into cases. All these entities are listed side by side and each has its own options and filtering input, as can be observed in Figure 7.



investigator
INVESTIGATOR
investigator@void.pt
FTP: disabled

mf
MANAGER
mf@void.pt
FTP: disabled

mm
MANAGER
mm@void.pt
FTP: disabled

tester
MANAGER
tester@void.pt
FTP: unlimited

Investigators
0 Members

New Team
2 Members

tester
MANAGER
tester@void.pt
FTP: unlimited

mf
MANAGER
mf@void.pt
FTP: disabled

Team 1
4 Members

123
Assigned to 1 Team

New Team
2 Members

Dell
Assigned to 1 Team

jean
Assigned to 2 Teams

Team 1
4 Members

New Team
2 Members

Lone
Assigned to 1 Team

Dell (Portable)
Assigned to 0 Teams

Figure 7: Entity Management Interface

Users can change their own profile picture, while Managers can also change any team or case's display picture.

Managers can add new users to the platform, can approve membership requests, can enable/disable user accounts and can create new teams.

When a user is added by a Manager or his membership request is approved, he/she must define a password when activating his/her account through a received e-mail message.

It was at this step in development that was made clear by the testers that validations must be preformed on both server and client side, and that error handling must be streamlined in order to provide a seamless experience to the user, while also allowing future additions to the platform to be implemented in a similar way without much tinkering.

Because even though the platform still was not fully developed, it already suffered from possible exploits that could break the experience for its users, like the upload of a 5GB file as an image file, which would stop the page from loading, or possible directory traversal attacks, resulting from the creation of case directories.

The lessons learned from the testers on this stage of development carried on through the entire development process and ensured that every new feature added was accounting for possible weaknesses which may result from the new implementations, resulting in a more secure development process.

The platform's resulting data model can be observed in Figure 8.

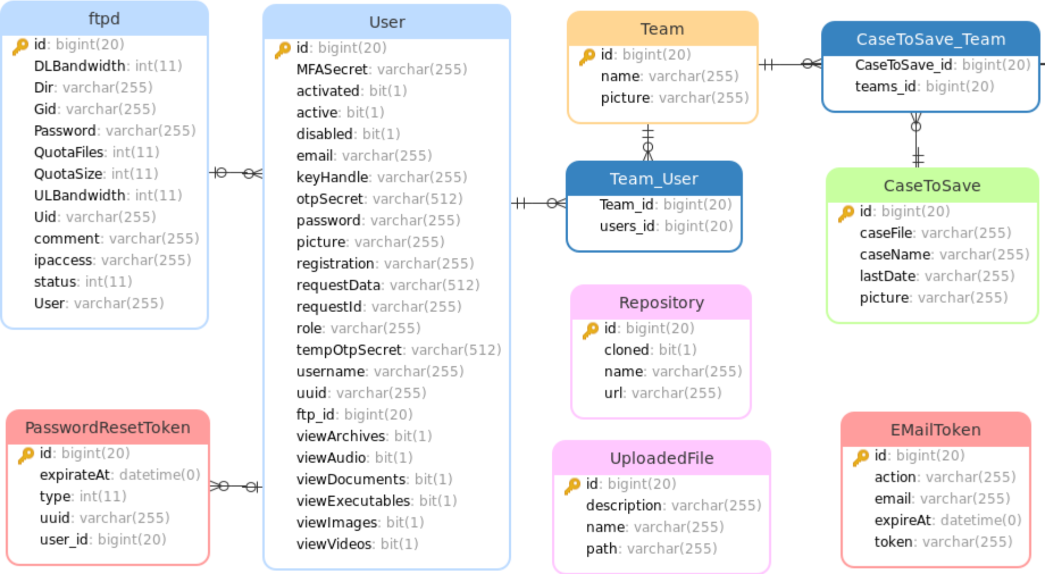


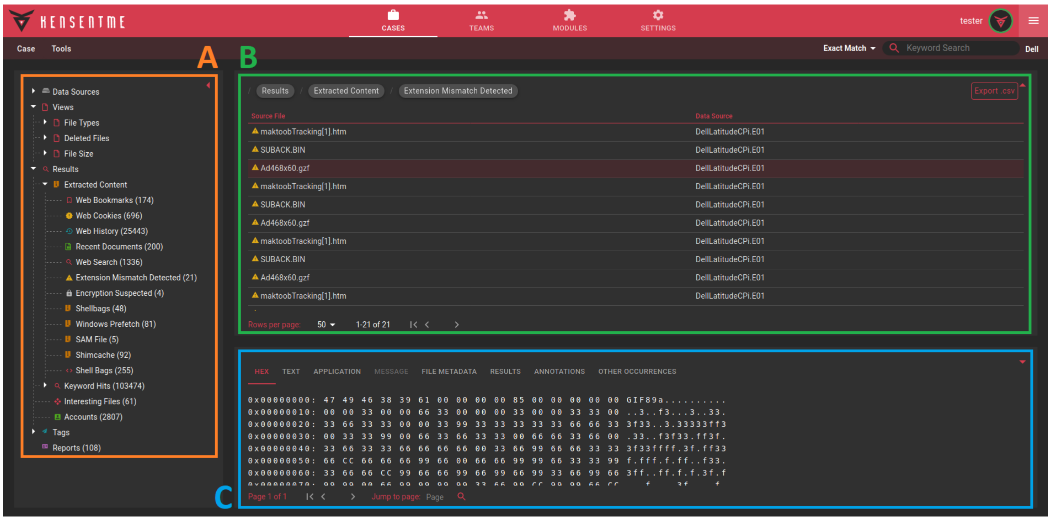
Figure 8: Database Structure

3.4.4 *Ingested Results Presentation*

Ingested results are the items present inside the provided data sources. Autopsy can run multiple modules on each data source to extract results, and the extracted results can either be a file instance or an artifact instance. The difference between a file and an artifact is that an artifact represents only a smaller piece of a file's information, which means a file can contain multiple artifacts, for example a registry file can contain multiple OS user account artifacts.

Even though the data ingestion features weren't implemented yet on the platform, the data that was ingested into a case using the original program could also be used on this platform, which allowed this feature to be developed earlier.

The ingested results are presented in three different containers, one taking the shape of a file explorer, allowing exploration of the structure of all the results, one taking the shape of a table or thumbnail viewer, that can be referenced as a board, presenting all the contents of the results selected from the explorer, and one taking the shape of a content viewer, allowing visualization of the data contained inside the result selected from the table as can be seen in Figure 9.



Source File	Data Source
maktoobTracking[1].htm	DellLatitudeCPi.E01
SUBACK.BIN	DellLatitudeCPi.E01
Ad468x60.gzf	DellLatitudeCPi.E01
maktoobTracking[1].htm	DellLatitudeCPi.E01
SUBACK.BIN	DellLatitudeCPi.E01
Ad468x60.gzf	DellLatitudeCPi.E01
maktoobTracking[1].htm	DellLatitudeCPi.E01
SUBACK.BIN	DellLatitudeCPi.E01
Ad468x60.gzf	DellLatitudeCPi.E01
maktoobTracking[1].htm	DellLatitudeCPi.E01

```
0x00000000: 47 49 46 38 39 61 00 00 00 00 85 00 00 00 00 00 GIF89a..........
0x00000010: 00 00 33 00 00 66 33 00 00 00 33 00 00 33 33 00 ..3..f3...3..33.
0x00000020: 33 66 33 33 00 00 33 99 33 33 33 33 33 66 66 33 3f33..3.33333ff3
0x00000030: 00 33 33 99 00 66 33 66 33 33 00 66 66 33 66 00 .33..f3f33.ff3f.
0x00000040: 33 66 33 33 66 66 66 66 00 33 66 99 66 66 33 33 3f33ffff.3f.ff33
0x00000050: 66 CC 66 66 66 99 66 00 66 66 99 99 66 33 33 99 f.fff.f.ff..f33.
0x00000060: 33 66 66 CC 99 66 66 99 66 99 66 99 33 66 99 66 3ff..ff.f.f.3f.f
```

Figure 9: Ingested Results Presentation (A) Explorer; (B) Board; (C) Content Viewer

The content viewer can display different kinds of information depending on the type of item selected, which can be some of the following:

- Text browser
- Media viewer
- Database browser
- Registry browser
- Key-value browser
- Table data viewer.

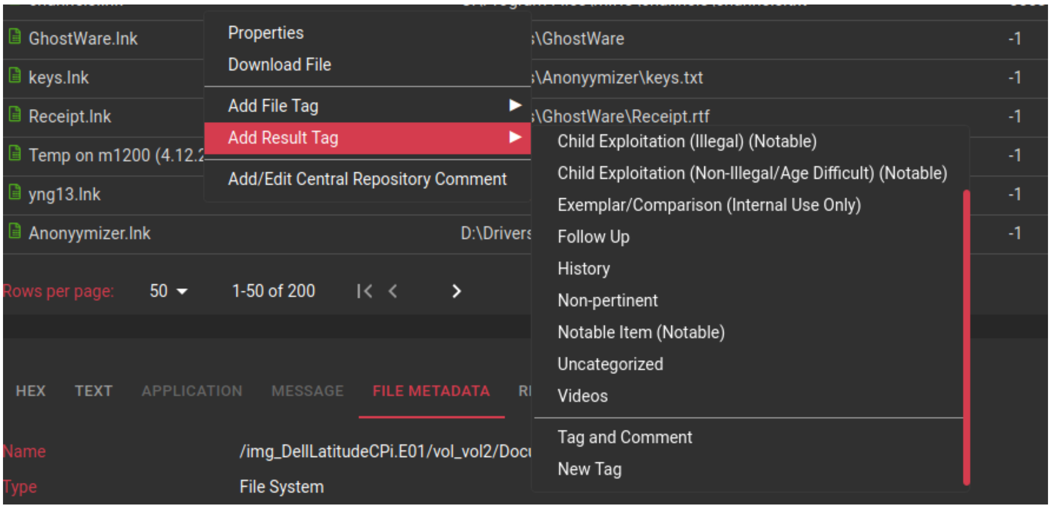
The layout for the ingested results presentation, and for all the case related actions, was based on the original Autopsy layout, so that each container can be re-sized as needed, allowing the user to focus on the information that is most important to him/her.

This development stage was one of the most intensive, as it required understanding Autopsy's data structure very well. The source code used here was rewritten almost completely, because of the way the user interface and the data structure in the original program are interconnected, resulting in the need to adapt and write custom queries to obtain the desired results (which include pagination), creating 65 endpoints so that all the needed information could be supplied, as well as creating and adjusting all the user interface elements to achieve an user experience similar to what Autopsy's users are used to.

3.4.5 *Tag Management*

Tagging content is a very important step in forensics investigations, as it allows the investigators to keep an organized list of important information.

Tagging was added to the platform in the form of a context menu, that is shown by selecting information from the table/thumbnail viewer, as can be seen in Figure 10.



GhostWare.lnk \GhostWare -1
keys.lnk \Anonyymizer\keys.txt -1
Receipt.lnk \GhostWare\Receipt.rtf -1
Temp on m1200 (4.12.2 -1
yng13.lnk -1
Anonyymizer.lnk D:\Drivers -1

Name /img_DellLatitudeCPi.E01/vol_vol2/Docu
Type File System

Figure 10: Tags Context Menu

Tags take the form of file or result tags, and the difference is that a result tag is specific to an artifact, while a file tag is related to the file itself.

Autopsy contains 10 different tag types by default, and more can be added, which can result in a high amount of tag types in use, which deteriorates the user experience.

Tag names are also shared between cases, so it seemed important to have more control over the management of these tags, and the ability to delete tag types was added, even though it didn't exist in the original software.

Since each case contains its own database, it's impossible to synchronize every case at once when a tag is deleted, so it was necessary to create a procedure to synchronize case tags when a case is opened.

3.4.6 *Data Sources*

Using the same credentials used to log-in to the platform, the user can also upload data source files into his folder located inside the server, using an FTP client like FileZilla [30]. Then the user can browse these directories using the web interface and select a data source to add to the case, as can be seen in Figure 11.

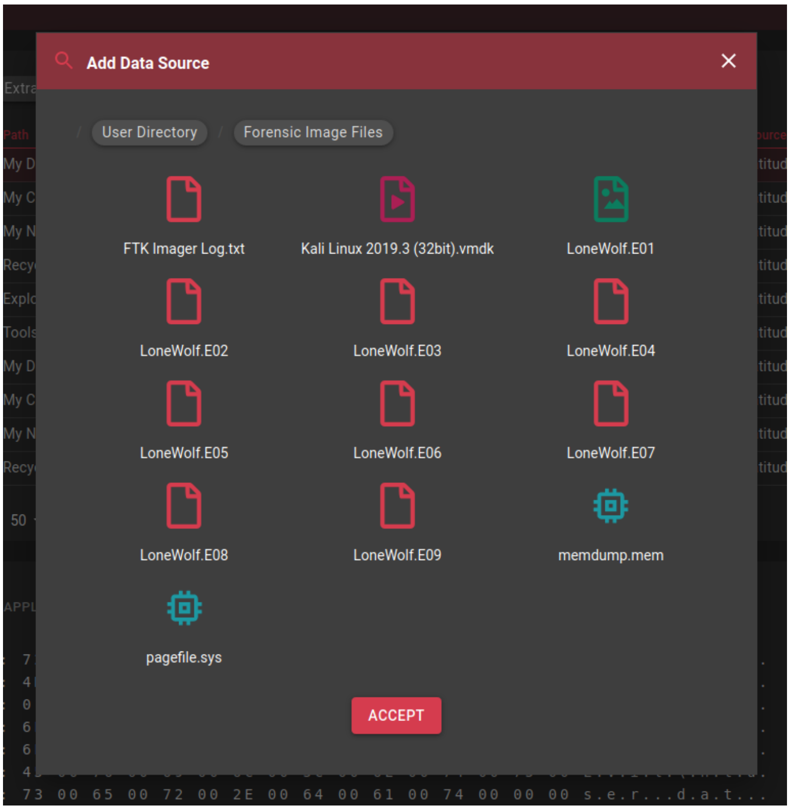


Figure 11: Data Source Selection

The procedure for adding a data source to a case was adapted from Autopsy's source code, and depends on the type of data source added, which can be one of the following:

- Disk image

- Virtual machine
- Logical file collection
- Autopsy Logical Imager [31] results.

Local disk data sources were also an option provided by Autopsy but since the local disks the software has access to belong to a server, this feature is undesired.

When a data source is added to a case, it is processed and instances of abstract files and other entities are created, which allow the user to navigate the data source's contents as soon as it is processed.

Just navigating the data source contents isn't very useful, as the contents are in a raw state, showing mostly the file structure of the source, and not even categorizing files by MIME types, so running data ingestion modules is a critical step into allowing a deeper analysis of a data source, which is covered in the next section.

3.4.7 *Data Ingestion Modules*

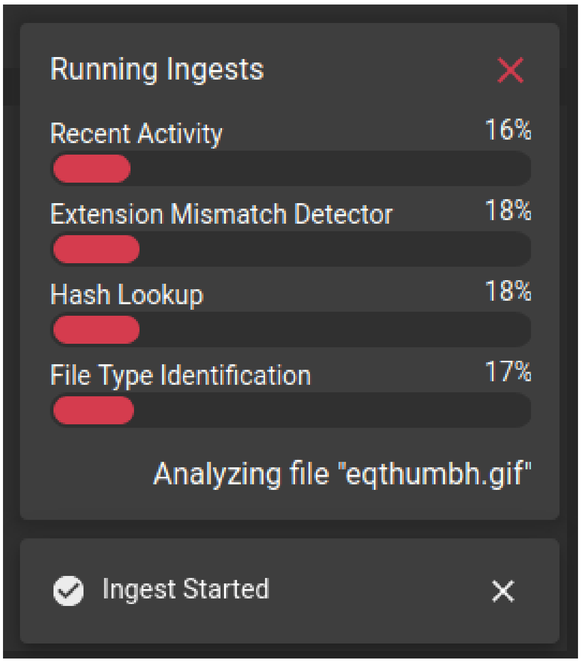
Data ingestion modules can be either file ingest modules, which analyse each file contained in a data source, one by one, or data source ingest modules, which run on specific components of a data source.

To run a collection of modules, the user selects which modules to run, and may also configure some parameters related to the modules. When the request is received by the server, the modules are started in a background thread.

When the modules are running, the server communicates to each client through WebSockets, offering feedback on the progress of the modules, as can be seen in Figure 12.

Originally it was intended to have the clients update their explorer as new information is ingested, but it would slow down the ingest progress considerably, so what was decided was that every client would refresh its explorer every 30 seconds while ingests are running.

There were other measures taken into consideration to improve the performance of the ingest procedure, while also maintaining the user informed of its progress: the server communicates a maximum of one file name per second, and it also only communicates a module's progress when it advances at least one percentage point.



Running Ingests

Recent Activity 16%

Extension Mismatch Detector 18%

Hash Lookup 18%

File Type Identification 17%

Analyzing file "eqthumbh.gif"

Ingest Started

Figure 12: Ingest Modules Communication

3.4.8 *Report Modules*

Report modules consist in generating a file or collection of files, to further process, filter, or present the results found in a case. They can take many shapes such as a text file, spreadsheets, HTML pages or even a portable case that can be imported into Autopsy.

Report modules have the ability to process existing data and generate results based on that, such as validating e-mail addresses or credit card numbers, which are found based on regular expressions by the keyword search module and may contain false positives.

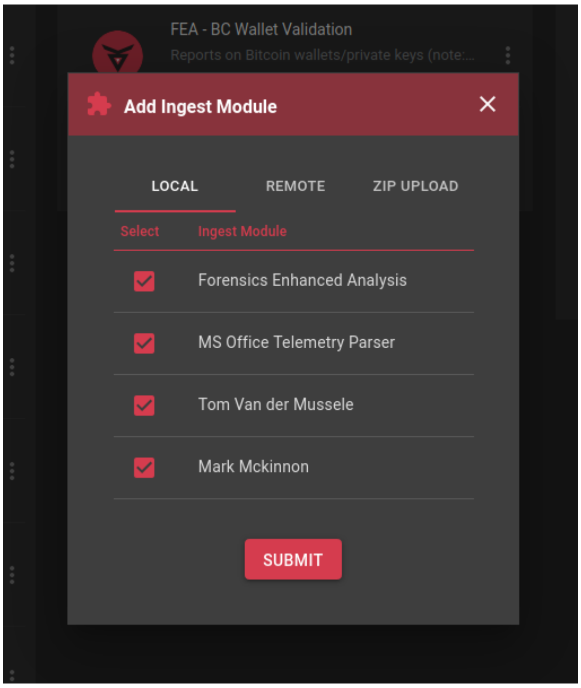
The adaptation of the source code for report modules went pretty smoothly, with the exception that some modules require the user to provide a file when running the module, which resulted in the creation of a file repository within the server, for files to be used in this manner.

3.4.9 *Add-on Modules*

Autopsy supports third party modules in the form or NetBeans [32] module files (NBM), and in the form of python scripts, using the Jython language, which allows python code to run alongside classes defined in Java.

Since the developed platform doesn't support a java user interface, the procedure to install Netbeans modules could not be implemented, as this feature is specific to Netbeans applications. But most modules are made in the Jython language, and the addition of these modules was implemented as intended.

A user with a manager role can add new modules to the platform by either selecting from defined repositories or by uploading a zip archive containing the modules, as can be seen in Figure 13.

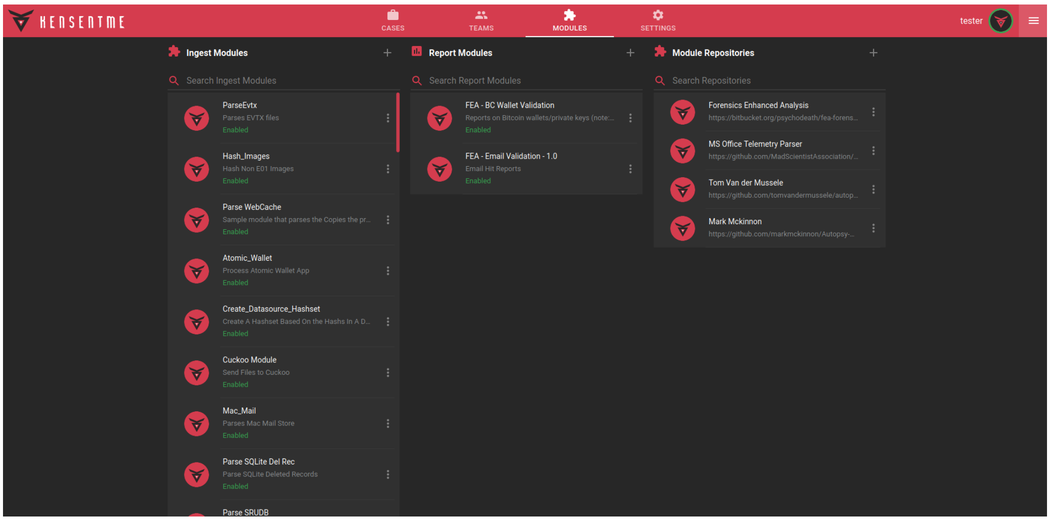

FEA - BC Wallet Validation
Reports on Bitcoin wallets/private keys (note:...
Add Ingest Module
×
LOCAL
REMOTE
ZIP UPLOAD
SUBMIT

Select	Ingest Module
☑	Forensics Enhanced Analysis
☑	MS Office Telemetry Parser
☑	Tom Van der Mussele
☑	Mark Mckinnon

Figure 13: Add-on Modules Addition

These repositories previously mentioned can be defined in the platform itself, or accessed from a remote source, which is a standalone platform developed just for this purpose and could allow the company to provide repository sources to any deployed version of the platform.

The platform also allows management of the added modules, so that managers can enable, disabled and remove certain modules, as can be seen in Figure 14.



Ingest Modules

Search Ingest Modules

- ParseEvtx
  Parses EVTX files
  Enabled
- Hash_Images
  Hash Non E01 Images
  Enabled
- Parse WebCache
  Sample module that parses the Copies the pr...
  Enabled
- Atomic_Wallet
  Process Atomic Wallet App
  Enabled
- Create_Datasource_Hashset
  Create A Hashset Based On the Hashs In A D...
  Enabled
- Cuckoo Module
  Send Files to Cuckoo
  Enabled
- Mac_Mail
  Parses Mac Mail Store
  Enabled
- Parse SQLite Del Rec
  Parse SQLite Deleted Records
  Enabled
- Parse SRUDB

Report Modules

Search Report Modules

- FEA - BC Wallet Validation
  Reports on Bitcoin wallets/private keys (note:...
  Enabled
- FEA - Email Validation - 1.0
  Email Hit Reports
  Enabled

Module Repositories

Search Repositories

- Forensics Enhanced Analysis
  https://bitbucket.org/psychodeath/fea-forens...
- MS Office Telemetry Parser
  https://github.com/MadScientistAssociation/...
- Tom Van der Mussele
  https://github.com/tomvandermussele/autop...
- Mark Mckinnon
  https://github.com/markmckinnon/Autopsy-...

Figure 14: Add-on Modules Management

Third party modules require that a great deal of the original Autopsy source code is accessible in the original namespace, which resulted in the separation of the developed and adapted code into two different namespaces, the original software's namespace which is `org.sleuthkit.autopsy`, and the company's namespace which is `pt.voidsoftware.kensentme`.

This requirement of the original code can also mean that some modules which weren't tested may fail to run due to missing code, but a procedure to handle failure to run modules is implemented, and it informs the user about which modules are failing to run, allowing the user to disable the unsupported modules.

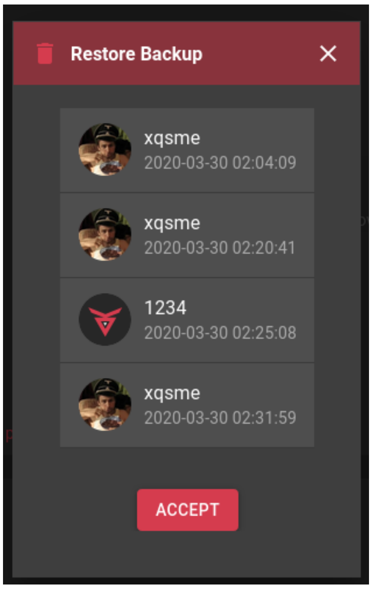
3.4.10 *Extra Features*

The primary features of the platform have been covered in the previous sections, but some other minor features were also implemented, such as:

Database Snapshots

Database snapshots can be created by any user at any time and they work by making a copy of the current case database, associating a user and the current time to it.

They can be used by a case manager to restore the case database to a previous state, as can be seen in Figure 15.



xqsme
2020-03-30 02:04:09

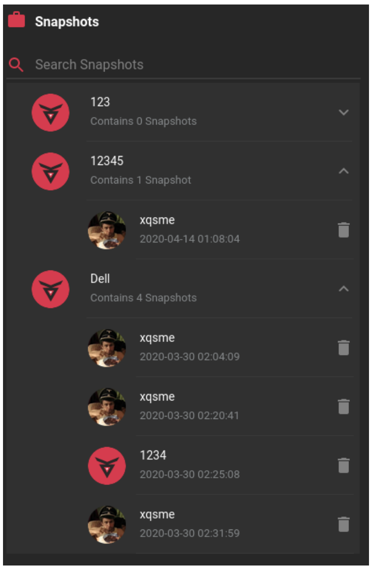
xqsme
2020-03-30 02:20:41

1234
2020-03-30 02:25:08

xqsme
2020-03-30 02:31:59

Figure 15: Snapshot Restoration

Database snapshots can also be deleted by a case manager in order to save space or organize the snapshots, as can be seen in Figure 16.



123
Contains 0 Snapshots

12345
Contains 1 Snapshot

xqsme
2020-04-14 01:08:04

Dell
Contains 4 Snapshots

xqsme
2020-03-30 02:04:09

xqsme
2020-03-30 02:20:41

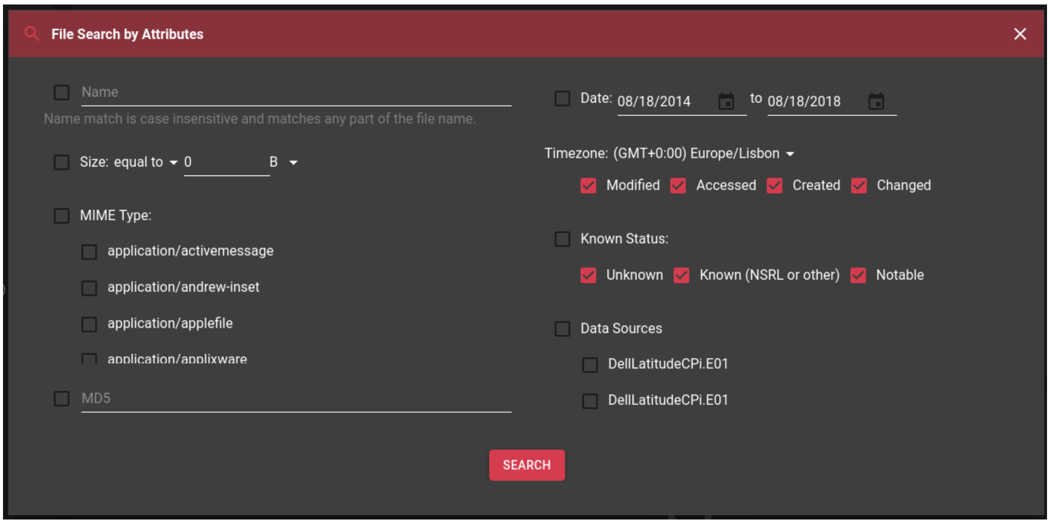
1234
2020-03-30 02:25:08

xqsme
2020-03-30 02:31:59

Figure 16: Snapshot Management

File Search By Attributes

The ability to search the existing files of a case and filtering them with specific attributes is an important feature Autopsy provides, and its adaptation is present in Figure 17.



File Search by Attributes ×

□ Name

Name match is case insensitive and matches any part of the file name.

□ Size: equal to ▾ 0 B ▾

□ MIME Type:

□ application/activemessage

□ application/andrew-inset

□ application/applefile

□ application/applixware

□ MD5

□ Date: 08/18/2014 to 08/18/2018

Timezone: (GMT+0:00) Europe/Lisbon ▾

☑ Modified ☑ Accessed ☑ Created ☑ Changed

□ Known Status:

☑ Unknown ☑ Known (NSRL or other) ☑ Notable

□ Data Sources

□ DellLatitudeCPi.E01

□ DellLatitudeCPi.E01

SEARCH

Figure 17: File Search By Attributes

This feature allows:

- Matching part of the file name
- Filtering by file size
- Filtering by MIME Type
- Matching files with a specific MD5 hash
- Finding files related to a date interval
- Finding files tagged with specific kinds of tags
- Limiting the search to specific data sources.

Data Source Paths Management

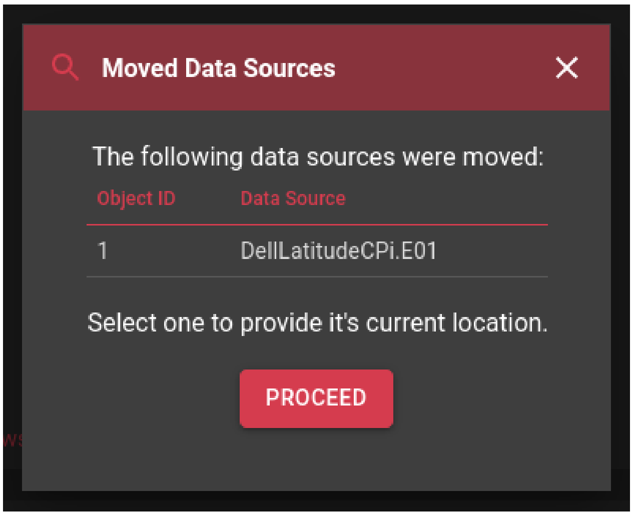
Autopsy provides a feature that detects when a data source is no longer available at the provided path and allows the user to locate it again.

This feature has a flaw, as it allows the user to provide any path he/she wants, resulting in the case not working properly when the provided path is invalid.

This same feature was recreated, as can be observed in Figure 18, but the ability to change data source paths at will was also added, so that mistakes can be corrected.

Importing and Exporting Cases

One of the default report modules included with Autopsy provides the ability to generate a portable case.



Moved Data Sources

The following data sources were moved:

Object ID	Data Source
1	DellLatitudeCPi.E01

Select one to provide it's current location.

Figure 18: Locate Data Source

These portable cases don't contain much information, but it was still important to provide the ability to import these cases.

The ability to export and import a full case was also added, and it works by generating a zip archive in the user's FTP directory or extracting a zip archive from the user's FTP directory.

When the case is imported, the previously mentioned feature is important, as it may be needed to relocate the data sources for the case.

3.4.11 *Project Deployment and Documentation*

A "Read Me" document was created, detailing each step required to setup the platform, which involves installing all the dependencies required, as well as compiling the developed code.

The setup was tested in multiple versions of Linux, such as CentOS [33], Mint [34] and Arch [35], and with different versions of needed dependencies, resulting in a controlled step-by-step guide that can be followed in about 30 minutes, which leads to a successful deployment of the complete platform.

The "Read Me" document can be consulted in Appendix A and it also includes some documentation regarding the different packages contained in the project.

The documentation of every endpoint of the platform can be consulted in Appendix B.

The project was also documented using a Javadoc [36] generator.

3.5 CRITICAL ANALYSIS AND PROPOSED IMPROVEMENTS

The development of the platform halted due to it being considered in a finished state, which means that all the objectives for the project were completed successfully.

Given that Autopsy is still in active development, it would be very important to keep following its development and complementing this platform with new features and bug fixes which might come up in the future.

Besides accompanying Autopsy's improvements, it could also be interesting to further develop the platform to better serve the needs of the users, which would require installations of the platform and a feedback channel to better understand the user's needs.

4

CONCLUSIONS

Working in an enterprise environment was very beneficial. It allowed me to develop a product with much higher quality than the results obtained in previous projects. It also allowed me to understand how software development is done in the real world, with many intervening parties collaborating for the same goal.

The internship allowed me to improve my skills in two different fields: digital forensics and web development. The concepts learned from the development of this project allow me to function as a digital forensics professional, while the experience gained from the development of the platform largely contributes to my capabilities as a software developer.

My main goal from this internship was to learn skills related to software development. I obtained a lot of experience working with one of the most used back-end languages, Java, while using Quarkus, a top of the line framework, and learned a great deal about developing secure platforms. I also obtained a lot of experience working with React, one of the most popular front-end frameworks, and now I feel capable of producing professional looking user interfaces.

The results obtained from the accomplishment of this internship, the KenSentMe platform, are very gratifying, as I feel that I've exceeded my expectations and produced a high quality product. These results keep me motivated to further improve my skills and knowledge in software development.

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APPENDICES

A

APPENDIX A

The project's "Read Me" is presented in the following pages.

KenSentMe

Overview

KenSentMe is a graphical interface for The Sleuth Kit, based on an existing graphical interface called Autopsy.

It differs from the existing software by allowing quick configuration for collaboration, and the ability to acess content on any browser.

It is being developed by Pedro Ferreira, a Cybersecurity Student, as a final project for his master's degree, while doing an internship at VOID Software.

Dependencies

- The Sleuth Kit
- photorec - usually installed with testdisk package
- ImageMagick
- FFMPEG
- Apache Solr
- Pure-FTPd
- Git.

Every other dependency is handled through maven repositories.

Setup

The Sleuth Kit

The Sleuth Kit packages are available for some linux distributions but we only support version 4.8.0, so it should be compiled from this fork.

Before compiling TSK, the following packages should also be installed (and compiled from source):

- libuna
- libewf
- afflib
- libvmdk
- libvhdi.

libvmdk's repo includes a zlib folder; it's not recommended to compile it.

Run `autoreconf -f -i` before `./configure` for libvmdk and libvhdi.

Make sure `ant` is installed before compiling TSK, as it is required to generate the java bindings.

Run `ldconfig` to sync libraries after installing TSK.

Jars

Inside the Quarkus repository, cd into `jars` directory and run the following commands:

```
mvn install:install-file -Dfile=sleuthkit-4.8.0.jar -DgroupId=org.sleuthkit
-DartifactId=sleuthkit -Dversion=4.8.0 -Dpackaging=jar
mvn install:install-file -Dfile=Rejistry-1.0-SNAPSHOT.jar -
DgroupId=com.williballenthin.rejistry -DartifactId=Rejistry -Dversion=1.0-
SNAPSHOT -Dpackaging=jar
mvn install:install-file -Dfile=sevenzipjbinding.jar -
DgroupId=net.sf.sevenzipjbinding -DartifactId=sevenzipjbinding -
Dversion=4.65-1.06-rc-extr-only -Dpackaging=jar
mvn install:install-file -Dfile=sevenzipjbinding-Linux-amd64.jar -
DgroupId=net.sf.sevenzipjbinding -DartifactId=sevenzipjbinding-Linux-amd64
-Dversion=4.65-1.06-rc-extr-only -Dpackaging=jar
```

Quarkus

- Clone the repository
- Edit `config.properties` and set the desired properties
- Compile JAR with `./mvnw clean compile quarkus:build`
- Copy `config.properties` to `target`
- Run with `java -Djava.awt.headless=true -jar kensentme-1.0.0-runner.jar`.

React

- Clone the repository
- Edit `src/config.js` file with the server IP
- Run `npm run build`
- Copy `build` to the location used by your web server.

Solr

- Extract `solr.7z` inside `/var/solr` directory

Pure-FTPd

- Make sure MySQL support is enabled and is using the same database as Quarkus

License

KenSentMe is under the Apache License, Version 2.

Documentation

org.sleuthkit.autopsy package

The contents of this package were adapted from the existing Autopsy platform and follow a very similar directory structure.

Not all original classes were transfered into this version and almost all user interface elements were removed except for module configuration panels.

These classes may contain altered functions, which means updating to newer versions of Autopsy must be done in a function by function manner, or at least while checking carefully for differences in each class, to make sure the platform's functionalities remain unchanged.

The code present in this package is taken from the 4.13.0 release of Autopsy.

Contents

- casemodule - Case class, case actions such as data source addition and tag interactions
- centralrepository - Central database used to compare hashes of files between cases
- coreutils - Classes used to handle data
- ingest - Procedures and entities that make data ingestion possible
- keywordsearch - Procedures and entities required to interact with Solr indexing server
- modules - Pre-included ingestion modules
- python - Jython Module Loader, allows the functioning of python modules, contains extra code for module management
- report - Procedures entities and modules used for generating reports.

pt.voidsoftware.kensentme package

The contents of this package are responsible for handling api requests.

Contents

- authentication - Login, registration, 2FA, recovery and activation
- casemodule - Main functionalities of the platform, contains five resources responsible for providing endpoints for general case actions, explorer actions, board actions, content actions and csv generation; each resource is accompanied by a utility class responsible for gathering the requested information or running the required procedure
- file - Simple persisted entity that can be provided as a parameter for ingest/report modules
- ftp - Class required by Pure-FTPd to grant access to the FTP server, associated in one to one to users, also contains the user's ftp directory

- settings - Add-on modules management and tag management
- team - Users can be added to teams and teams can be assigned to cases
- user - User, ftp and 2fa management.

react code

Contains all the UI elements, and interacts with the java api.

Contents

actions

Redux requests for auth, case information, snackbar notification, and users/teams/cases.

assets

Images and styles. Styles are composed by a main file which addresses most of the components, a modal specific file and a context menu specific file.

components

`screens` contain the different pages available in the web app; names are self descriptive.

`elements` contains components that are reused, or were created to make the parent module easier to read.

Directories inside elements:

- esm - Material tree view components that were modified to achieve the desired behavior
- main - Main components of the project, board contains the table/thumbnail viewer, content contains the content viewers, explorer contains the case explorer, and the toolbar contains most of the user interactions as well as a socket handler
- modals - Modals used throughout the whole project.

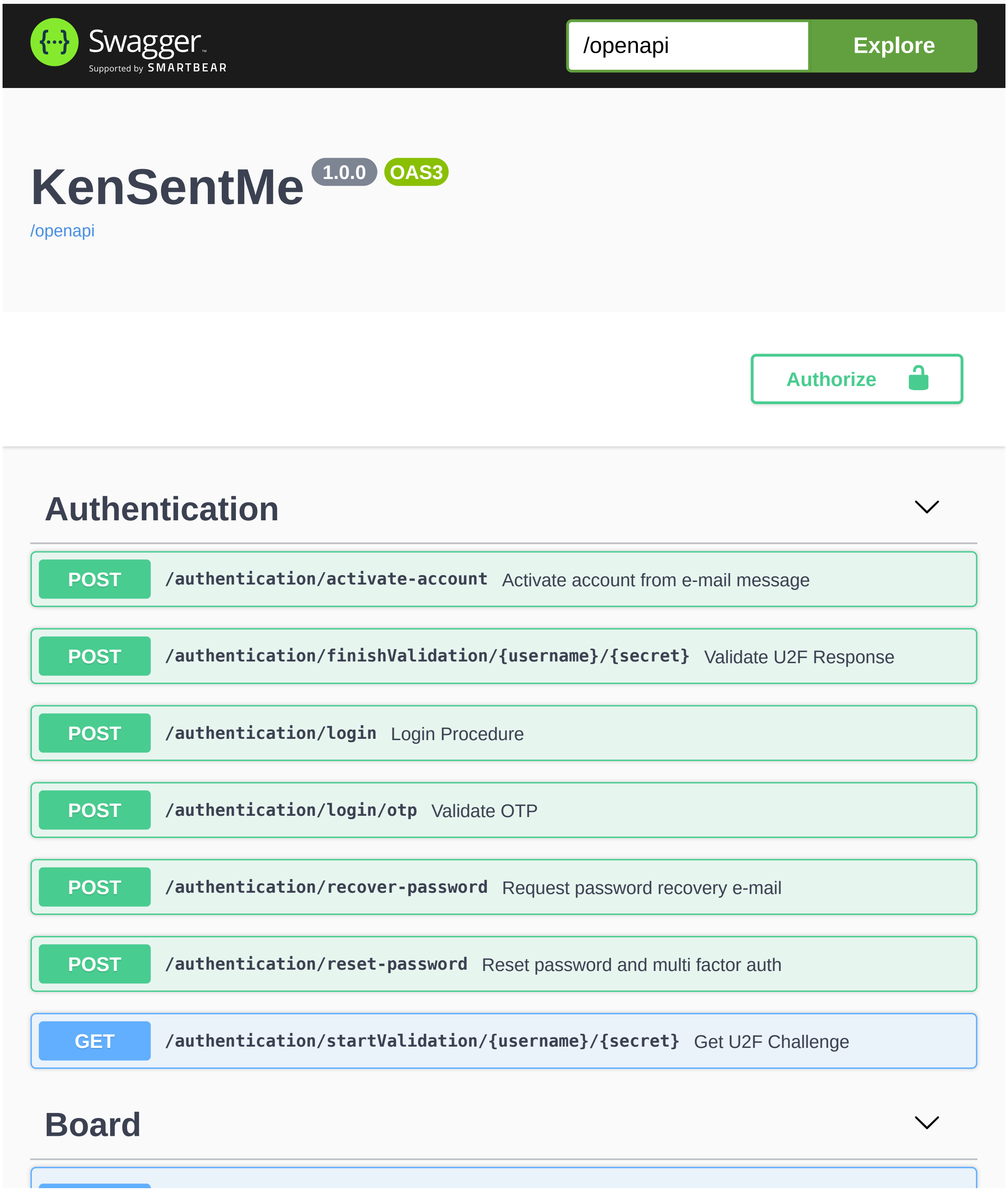
reducers

Redux storage for auth, case information, snackbar notification, and users/teams/cases.

B

APPENDIX B

The endpoints of the KenSentMe platform are presented in the following pages, using the Swagger [37] tool.



Authentication

POST `/authentication/activate-account` Activate account from e-mail message

POST `/authentication/finishValidation/{username}/{secret}` Validate U2F Response

POST `/authentication/login` Login Procedure

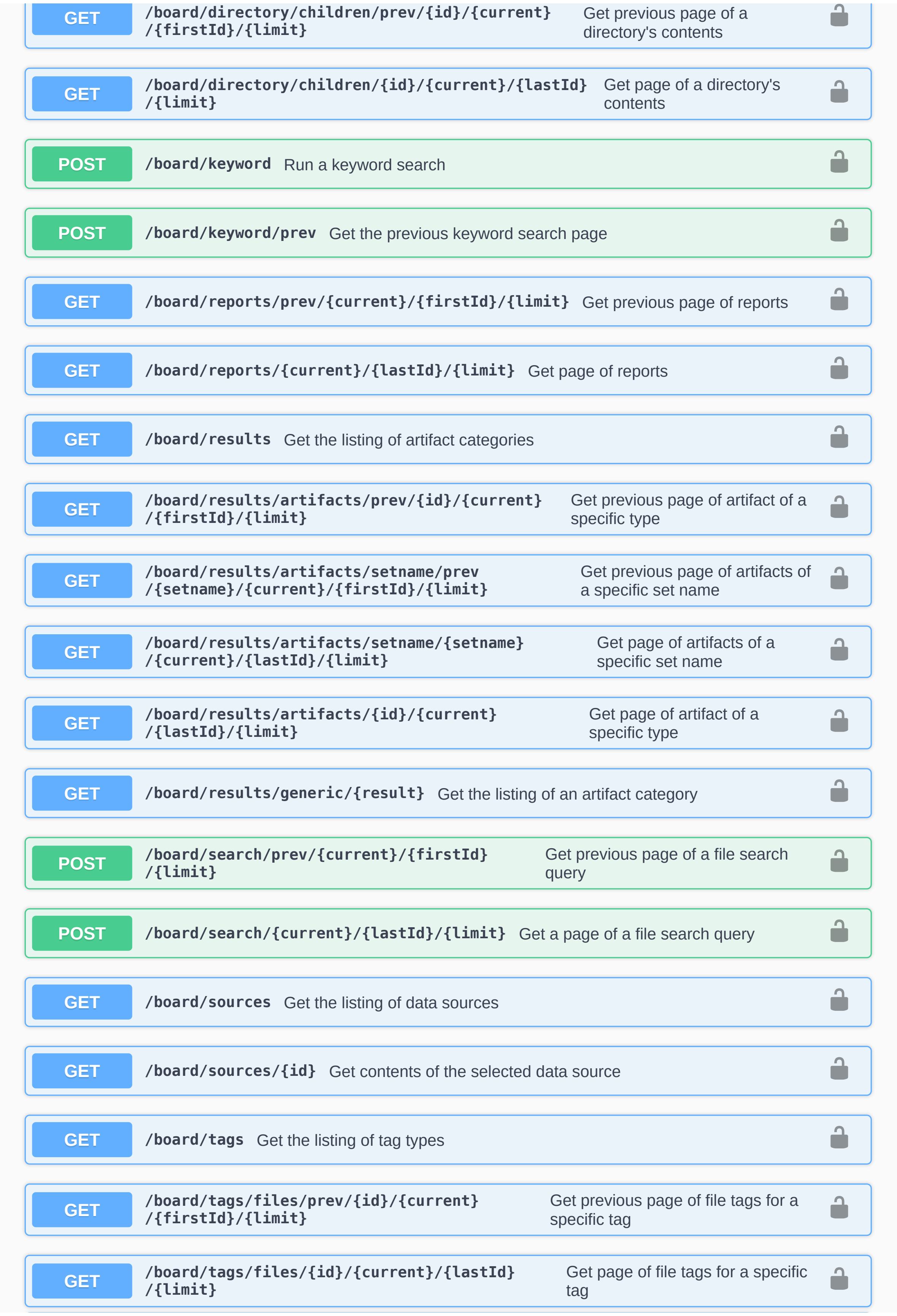
POST `/authentication/login/otp` Validate OTP

POST `/authentication/recover-password` Request password recovery e-mail

POST `/authentication/reset-password` Reset password and multi factor auth

GET `/authentication/startValidation/{username}/{secret}` Get U2F Challenge

Board



GET /board/directory/children/prev/{id}/{current}/{firstId}/{limit} Get previous page of a directory's contents

GET /board/directory/children/{id}/{current}/{lastId}/{limit} Get page of a directory's contents

POST /board/keyword Run a keyword search

POST /board/keyword/prev Get the previous keyword search page

GET /board/reports/prev/{current}/{firstId}/{limit} Get previous page of reports

GET /board/reports/{current}/{lastId}/{limit} Get page of reports

GET /board/results Get the listing of artifact categories

GET /board/results/artifacts/prev/{id}/{current}/{firstId}/{limit} Get previous page of artifact of a specific type

GET /board/results/artifacts/setname/prev/{setname}/{current}/{firstId}/{limit} Get previous page of artifacts of a specific set name

GET /board/results/artifacts/setname/{setname}/{current}/{lastId}/{limit} Get page of artifacts of a specific set name

GET /board/results/artifacts/{id}/{current}/{lastId}/{limit} Get page of artifact of a specific type

GET /board/results/generic/{result} Get the listing of an artifact category

POST /board/search/prev/{current}/{firstId}/{limit} Get previous page of a file search query

POST /board/search/{current}/{lastId}/{limit} Get a page of a file search query

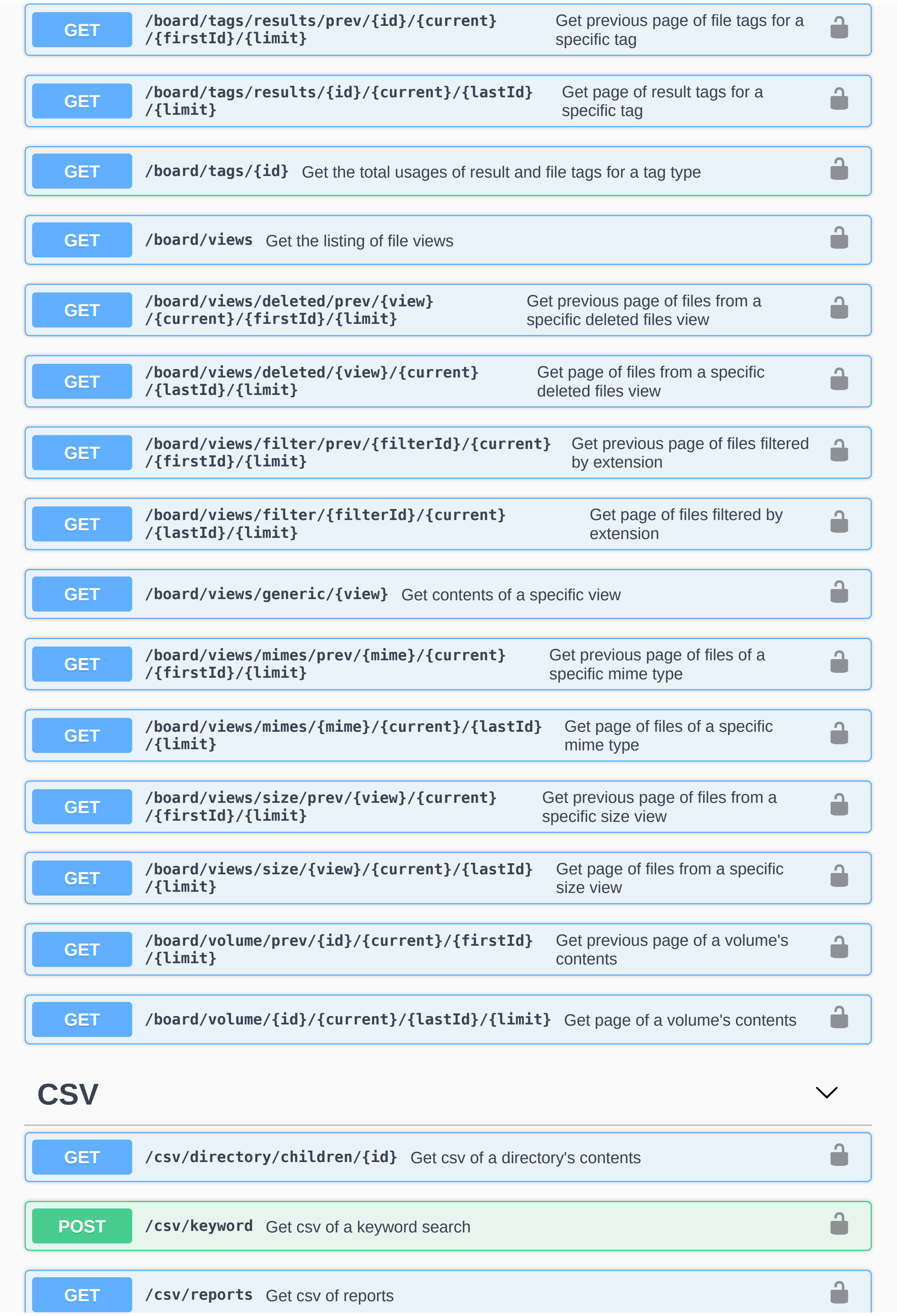
GET /board/sources Get the listing of data sources

GET /board/sources/{id} Get contents of the selected data source

GET /board/tags Get the listing of tag types

GET /board/tags/files/prev/{id}/{current}/{firstId}/{limit} Get previous page of file tags for a specific tag

GET /board/tags/files/{id}/{current}/{lastId}/{limit} Get page of file tags for a specific tag



GET `/board/tags/results/prev/{id}/{current}/{firstId}/{limit}` Get previous page of file tags for a specific tag

GET `/board/tags/results/{id}/{current}/{lastId}/{limit}` Get page of result tags for a specific tag

GET `/board/tags/{id}` Get the total usages of result and file tags for a tag type

GET `/board/views` Get the listing of file views

GET `/board/views/deleted/prev/{view}/{current}/{firstId}/{limit}` Get previous page of files from a specific deleted files view

GET `/board/views/deleted/{view}/{current}/{lastId}/{limit}` Get page of files from a specific deleted files view

GET `/board/views/filter/prev/{filterId}/{current}/{firstId}/{limit}` Get previous page of files filtered by extension

GET `/board/views/filter/{filterId}/{current}/{lastId}/{limit}` Get page of files filtered by extension

GET `/board/views/generic/{view}` Get contents of a specific view

GET `/board/views/mimes/prev/{mime}/{current}/{firstId}/{limit}` Get previous page of files of a specific mime type

GET `/board/views/mimes/{mime}/{current}/{lastId}/{limit}` Get page of files of a specific mime type

GET `/board/views/size/prev/{view}/{current}/{firstId}/{limit}` Get previous page of files from a specific size view

GET `/board/views/size/{view}/{current}/{lastId}/{limit}` Get page of files from a specific size view

GET `/board/volume/prev/{id}/{current}/{firstId}/{limit}` Get previous page of a volume's contents

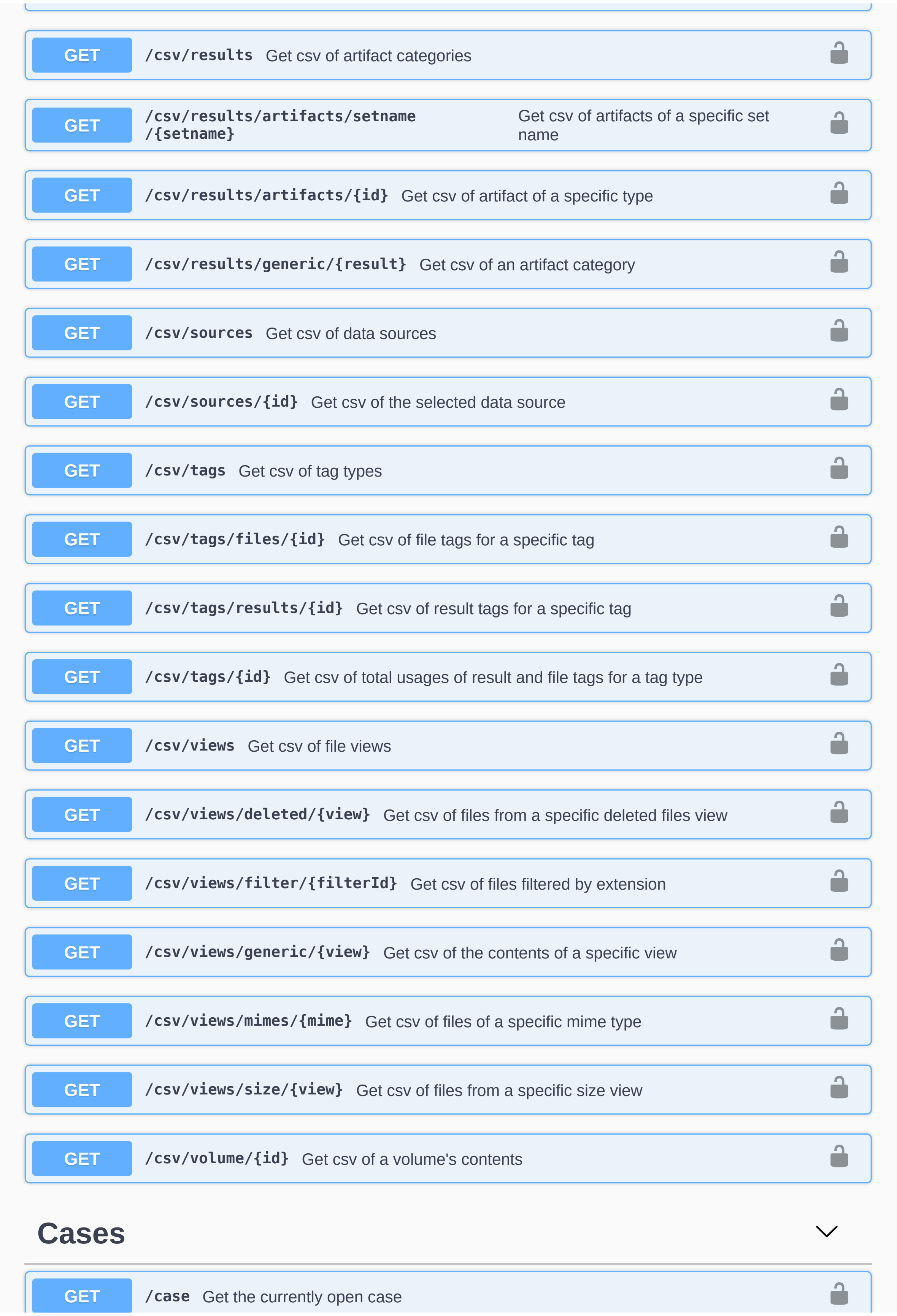
GET `/board/volume/{id}/{current}/{lastId}/{limit}` Get page of a volume's contents

CSV

GET `/csv/directory/children/{id}` Get csv of a directory's contents

POST `/csv/keyword` Get csv of a keyword search

GET `/csv/reports` Get csv of reports



GET /csv/results Get csv of artifact categories

GET /csv/results/artifacts/setname/{setname} Get csv of artifacts of a specific set name

GET /csv/results/artifacts/{id} Get csv of artifact of a specific type

GET /csv/results/generic/{result} Get csv of an artifact category

GET /csv/sources Get csv of data sources

GET /csv/sources/{id} Get csv of the selected data source

GET /csv/tags Get csv of tag types

GET /csv/tags/files/{id} Get csv of file tags for a specific tag

GET /csv/tags/results/{id} Get csv of result tags for a specific tag

GET /csv/tags/{id} Get csv of total usages of result and file tags for a tag type

GET /csv/views Get csv of file views

GET /csv/views/deleted/{view} Get csv of files from a specific deleted files view

GET /csv/views/filter/{filterId} Get csv of files filtered by extension

GET /csv/views/generic/{view} Get csv of the contents of a specific view

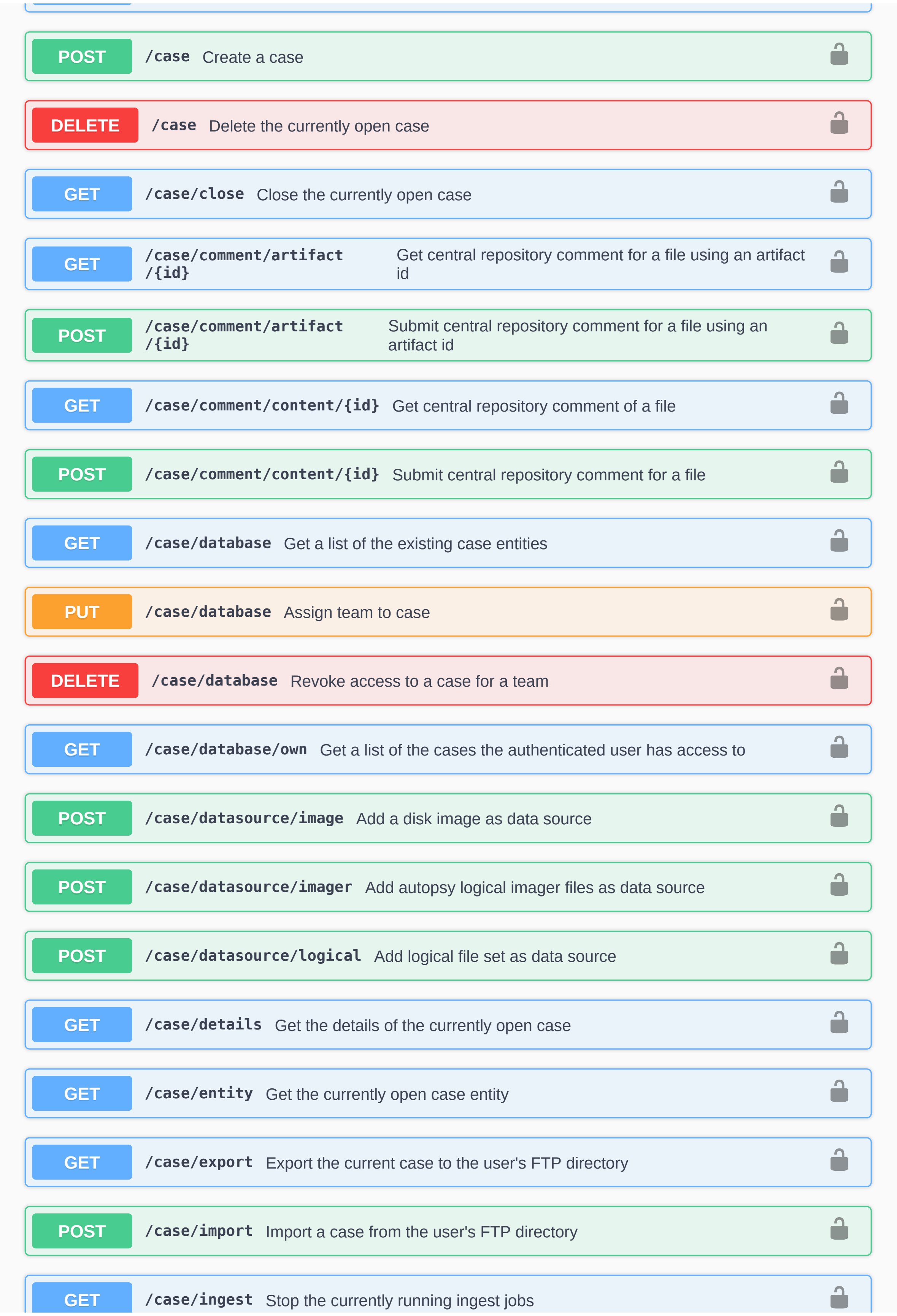
GET /csv/views/mimes/{mime} Get csv of files of a specific mime type

GET /csv/views/size/{view} Get csv of files from a specific size view

GET /csv/volume/{id} Get csv of a volume's contents

Cases

GET /case Get the currently open case



POST `/case` Create a case

DELETE `/case` Delete the currently open case

GET `/case/close` Close the currently open case

GET `/case/comment/artifact/{id}` Get central repository comment for a file using an artifact id

POST `/case/comment/artifact/{id}` Submit central repository comment for a file using an artifact id

GET `/case/comment/content/{id}` Get central repository comment of a file

POST `/case/comment/content/{id}` Submit central repository comment for a file

GET `/case/database` Get a list of the existing case entities

PUT `/case/database` Assign team to case

DELETE `/case/database` Revoke access to a case for a team

GET `/case/database/own` Get a list of the cases the authenticated user has access to

POST `/case/datasource/image` Add a disk image as data source

POST `/case/datasource/imager` Add autopsy logical imager files as data source

POST `/case/datasource/logical` Add logical file set as data source

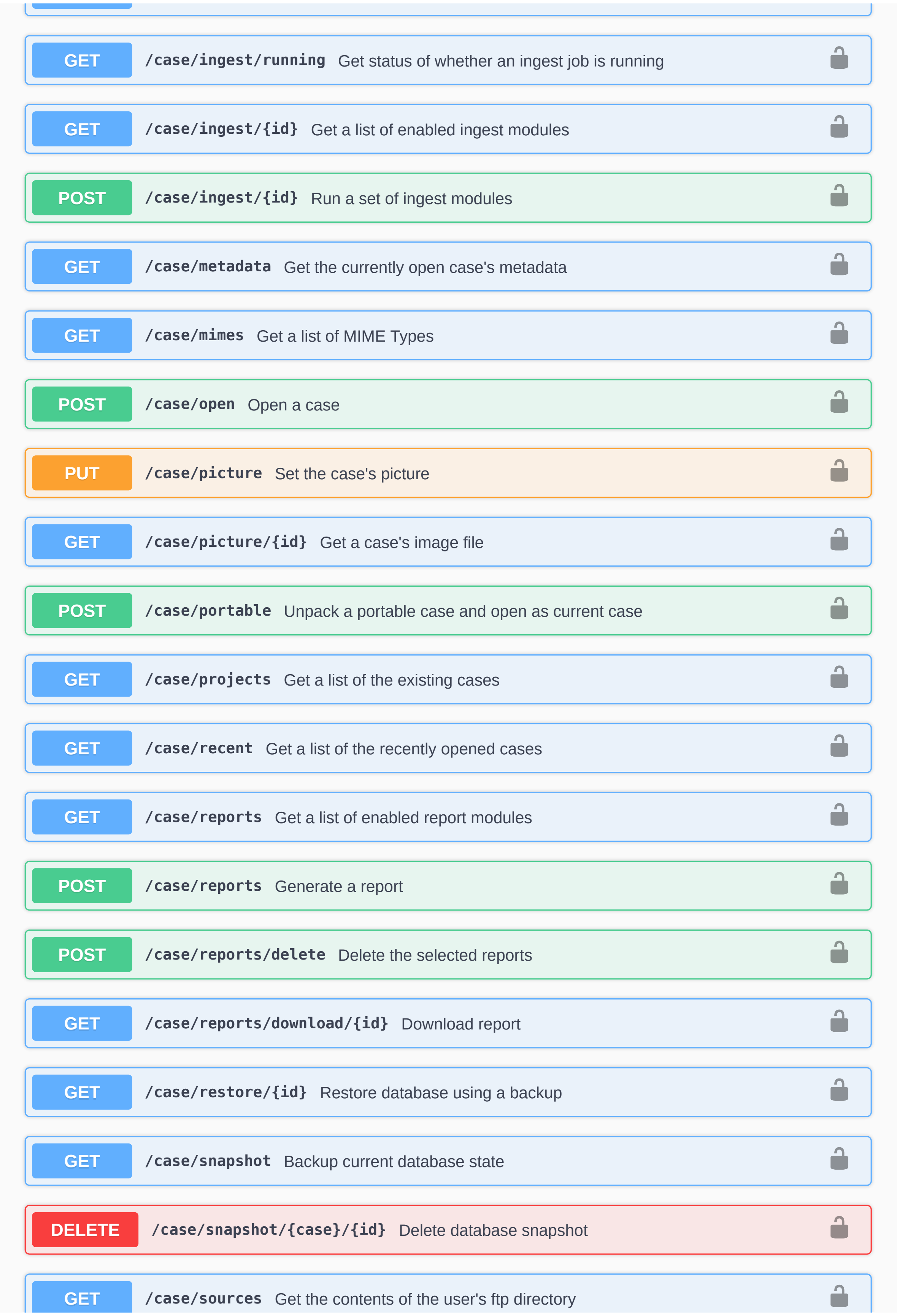
GET `/case/details` Get the details of the currently open case

GET `/case/entity` Get the currently open case entity

GET `/case/export` Export the current case to the user's FTP directory

POST `/case/import` Import a case from the user's FTP directory

GET `/case/ingest` Stop the currently running ingest jobs



GET /case/ingest/running Get status of whether an ingest job is running

GET /case/ingest/{id} Get a list of enabled ingest modules

POST /case/ingest/{id} Run a set of ingest modules

GET /case/metadata Get the currently open case's metadata

GET /case/mimes Get a list of MIME Types

POST /case/open Open a case

PUT /case/picture Set the case's picture

GET /case/picture/{id} Get a case's image file

POST /case/portable Unpack a portable case and open as current case

GET /case/projects Get a list of the existing cases

GET /case/recent Get a list of the recently opened cases

GET /case/reports Get a list of enabled report modules

POST /case/reports Generate a report

POST /case/reports/delete Delete the selected reports

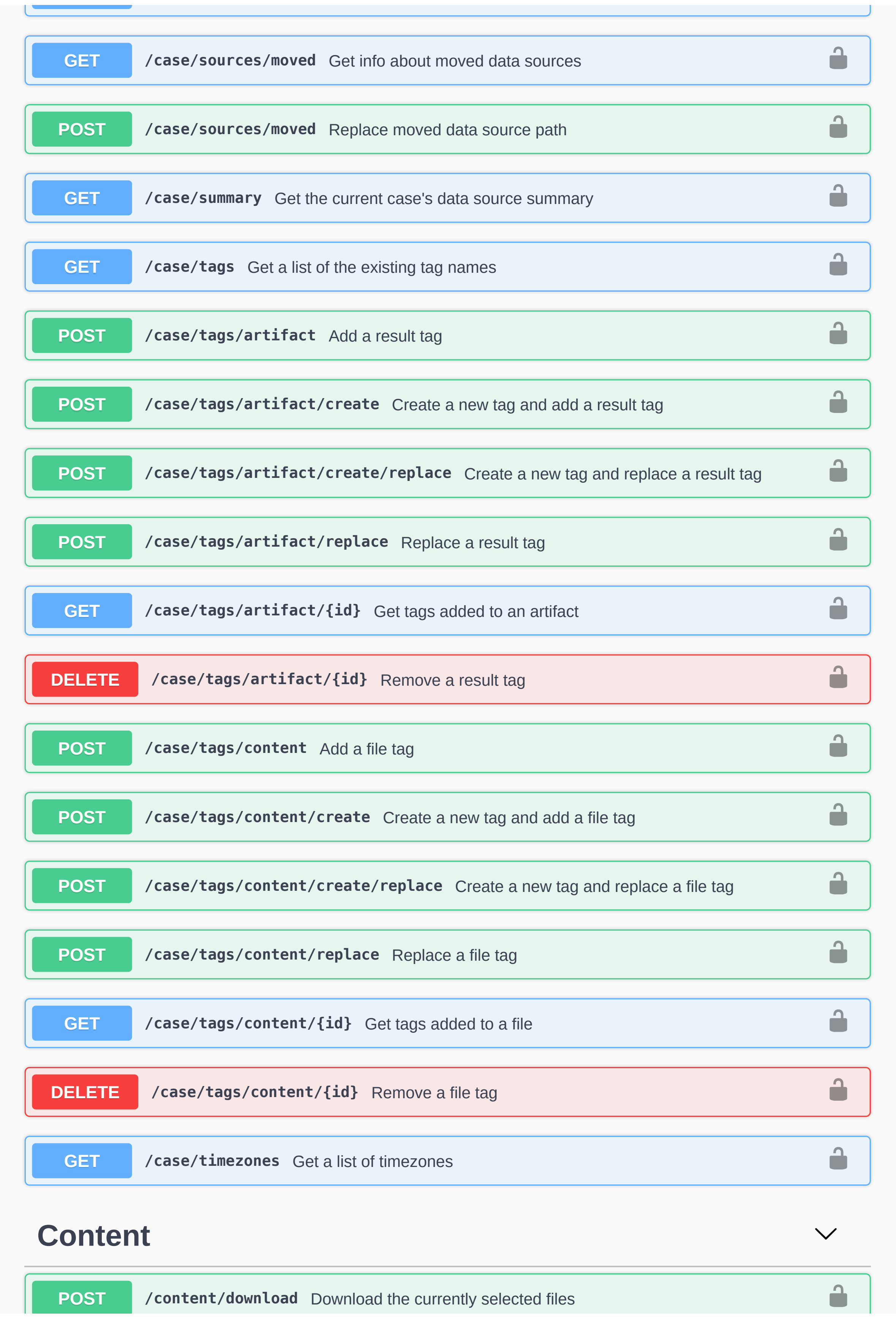
GET /case/reports/download/{id} Download report

GET /case/restore/{id} Restore database using a backup

GET /case/snapshot Backup current database state

DELETE /case/snapshot/{case}/{id} Delete database snapshot

GET /case/sources Get the contents of the user's ftp directory



GET `/case/sources/moved` Get info about moved data sources

POST `/case/sources/moved` Replace moved data source path

GET `/case/summary` Get the current case's data source summary

GET `/case/tags` Get a list of the existing tag names

POST `/case/tags/artifact` Add a result tag

POST `/case/tags/artifact/create` Create a new tag and add a result tag

POST `/case/tags/artifact/create/replace` Create a new tag and replace a result tag

POST `/case/tags/artifact/replace` Replace a result tag

GET `/case/tags/artifact/{id}` Get tags added to an artifact

DELETE `/case/tags/artifact/{id}` Remove a result tag

POST `/case/tags/content` Add a file tag

POST `/case/tags/content/create` Create a new tag and add a file tag

POST `/case/tags/content/create/replace` Create a new tag and replace a file tag

POST `/case/tags/content/replace` Replace a file tag

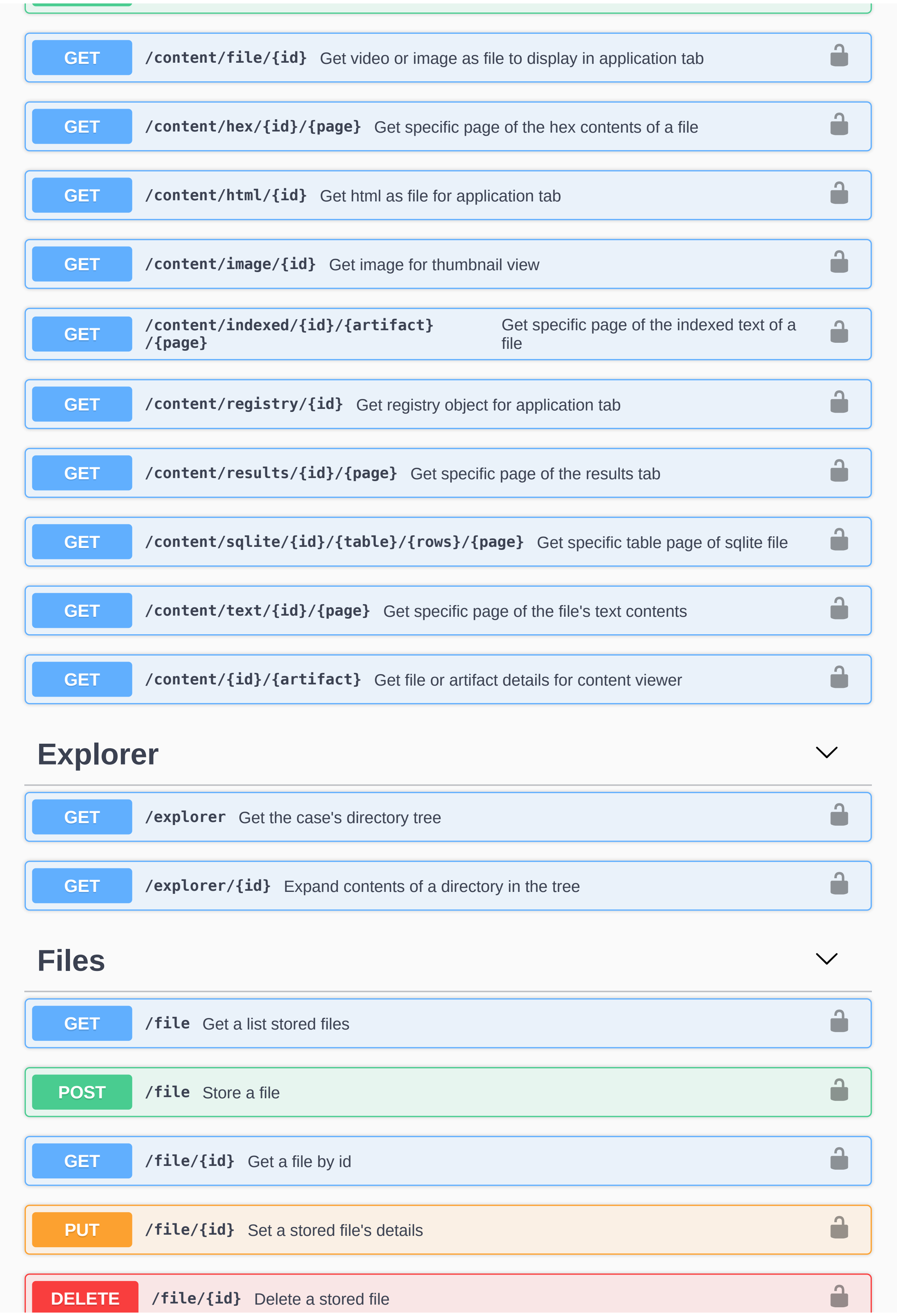
GET `/case/tags/content/{id}` Get tags added to a file

DELETE `/case/tags/content/{id}` Remove a file tag

GET `/case/timezones` Get a list of timezones

Content

POST `/content/download` Download the currently selected files



GET `/content/file/{id}` Get video or image as file to display in application tab

GET `/content/hex/{id}/{page}` Get specific page of the hex contents of a file

GET `/content/html/{id}` Get html as file for application tab

GET `/content/image/{id}` Get image for thumbnail view

GET `/content/indexed/{id}/{artifact}/{page}` Get specific page of the indexed text of a file

GET `/content/registry/{id}` Get registry object for application tab

GET `/content/results/{id}/{page}` Get specific page of the results tab

GET `/content/sqlite/{id}/{table}/{rows}/{page}` Get specific table page of sqlite file

GET `/content/text/{id}/{page}` Get specific page of the file's text contents

GET `/content/{id}/{artifact}` Get file or artifact details for content viewer

Explorer

GET `/explorer` Get the case's directory tree

GET `/explorer/{id}` Expand contents of a directory in the tree

Files

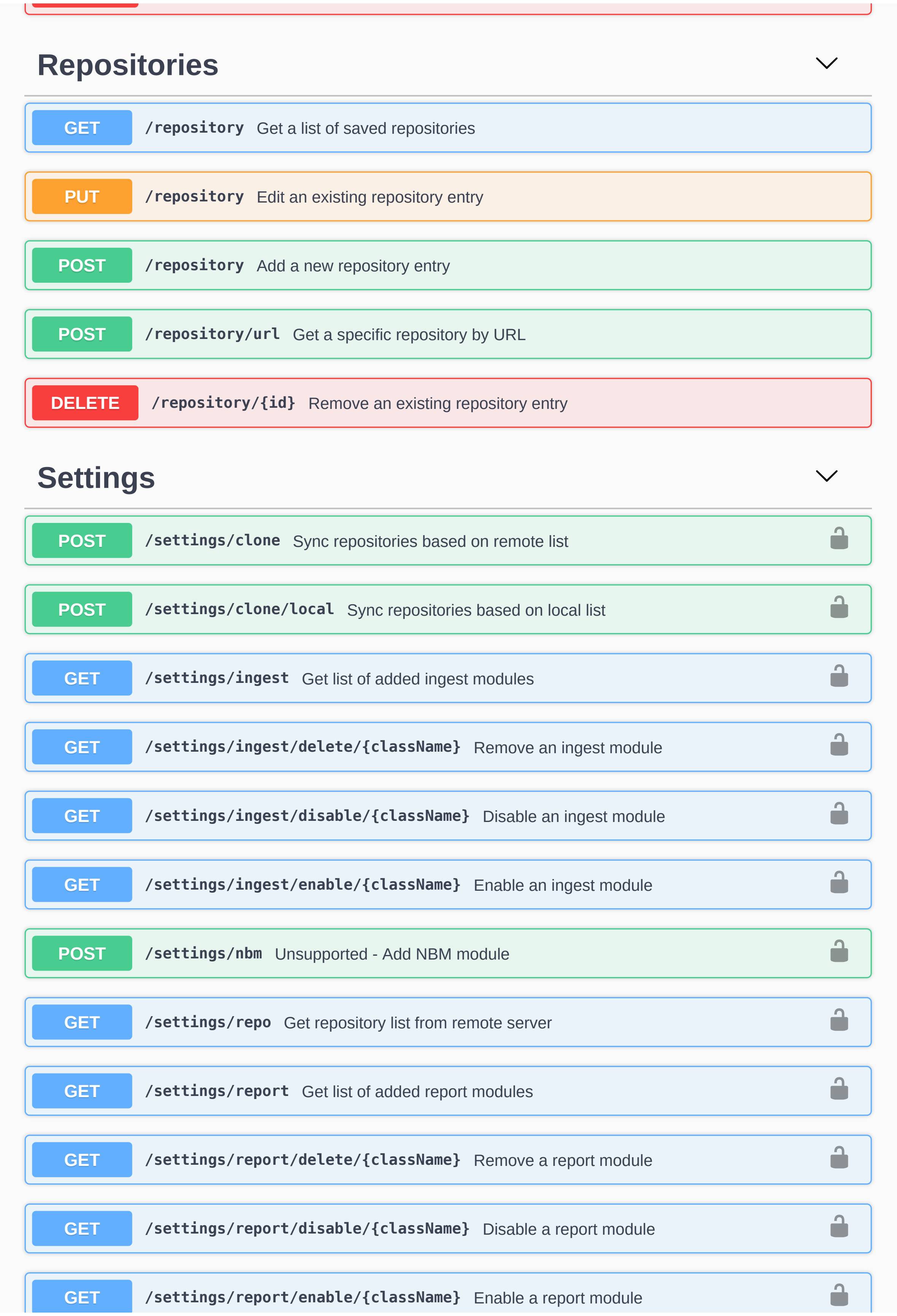
GET `/file` Get a list stored files

POST `/file` Store a file

GET `/file/{id}` Get a file by id

PUT `/file/{id}` Set a stored file's details

DELETE `/file/{id}` Delete a stored file



Repositories

GET /repository Get a list of saved repositories

PUT /repository Edit an existing repository entry

POST /repository Add a new repository entry

POST /repository/url Get a specific repository by URL

DELETE /repository/{id} Remove an existing repository entry

Settings

POST /settings/clone Sync repositories based on remote list

POST /settings/clone/local Sync repositories based on local list

GET /settings/ingest Get list of added ingest modules

GET /settings/ingest/delete/{className} Remove an ingest module

GET /settings/ingest/disable/{className} Disable an ingest module

GET /settings/ingest/enable/{className} Enable an ingest module

POST /settings/nbm Unsupported - Add NBM module

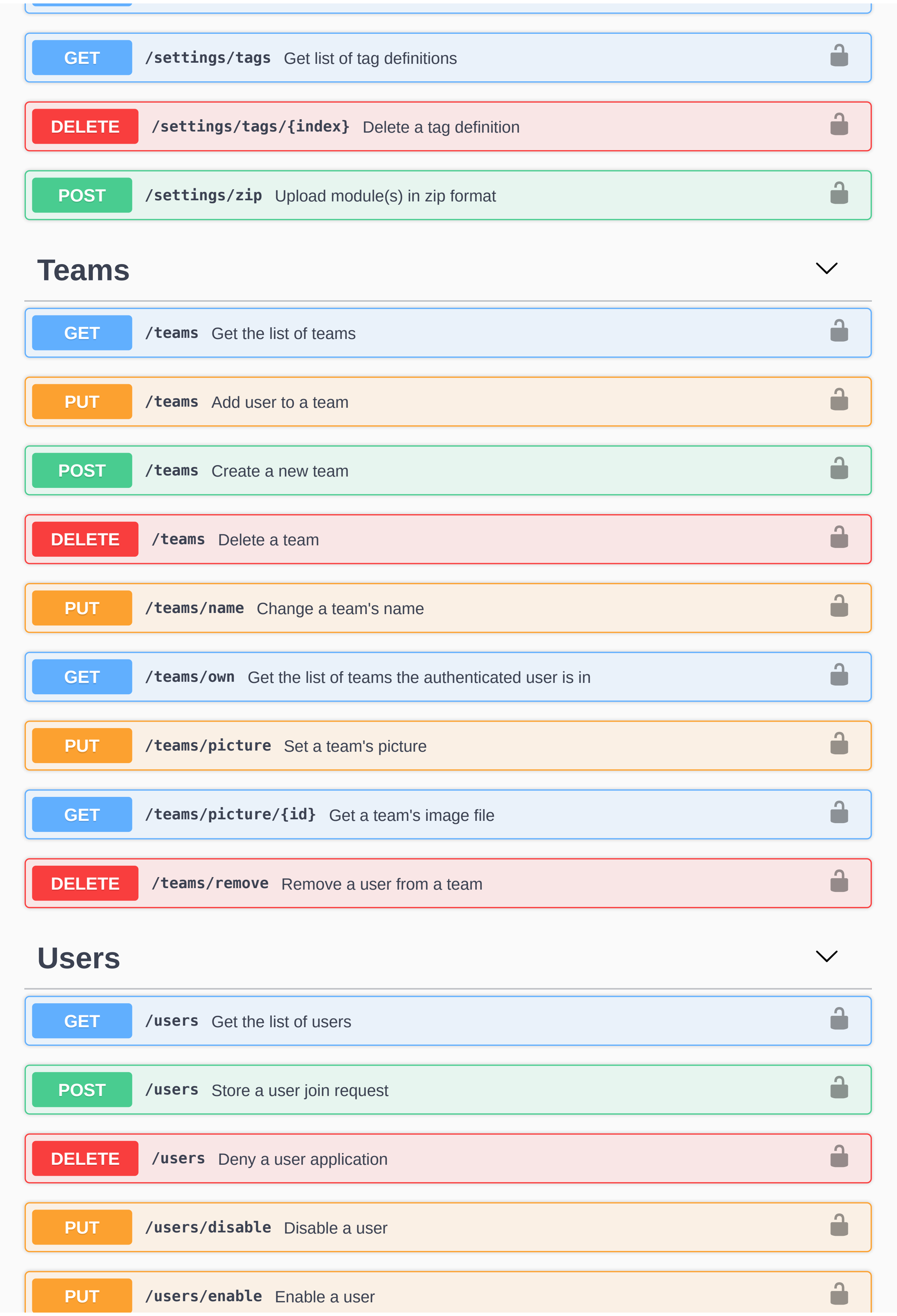
GET /settings/repo Get repository list from remote server

GET /settings/report Get list of added report modules

GET /settings/report/delete/{className} Remove a report module

GET /settings/report/disable/{className} Disable a report module

GET /settings/report/enable/{className} Enable a report module



GET `/settings/tags` Get list of tag definitions

DELETE `/settings/tags/{index}` Delete a tag definition

POST `/settings/zip` Upload module(s) in zip format

Teams

GET `/teams` Get the list of teams

PUT `/teams` Add user to a team

POST `/teams` Create a new team

DELETE `/teams` Delete a team

PUT `/teams/name` Change a team's name

GET `/teams/own` Get the list of teams the authenticated user is in

PUT `/teams/picture` Set a team's picture

GET `/teams/picture/{id}` Get a team's image file

DELETE `/teams/remove` Remove a user from a team

Users

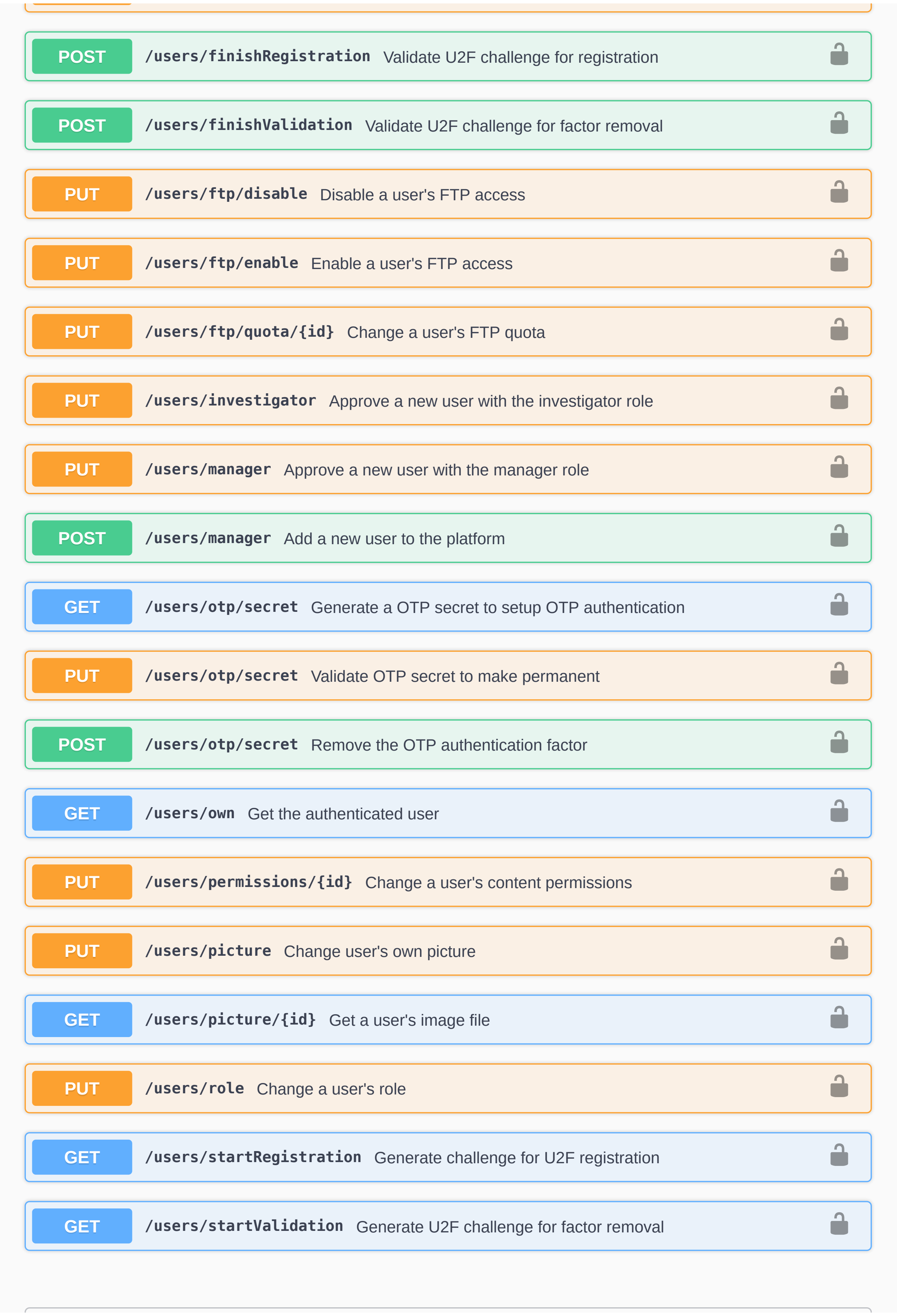
GET `/users` Get the list of users

POST `/users` Store a user join request

DELETE `/users` Deny a user application

PUT `/users/disable` Disable a user

PUT `/users/enable` Enable a user



POST `/users/finishRegistration` Validate U2F challenge for registration

POST `/users/finishValidation` Validate U2F challenge for factor removal

PUT `/users/ftp/disable` Disable a user's FTP access

PUT `/users/ftp/enable` Enable a user's FTP access

PUT `/users/ftp/quota/{id}` Change a user's FTP quota

PUT `/users/investigator` Approve a new user with the investigator role

PUT `/users/manager` Approve a new user with the manager role

POST `/users/manager` Add a new user to the platform

GET `/users/otp/secret` Generate a OTP secret to setup OTP authentication

PUT `/users/otp/secret` Validate OTP secret to make permanent

POST `/users/otp/secret` Remove the OTP authentication factor

GET `/users/own` Get the authenticated user

PUT `/users/permissions/{id}` Change a user's content permissions

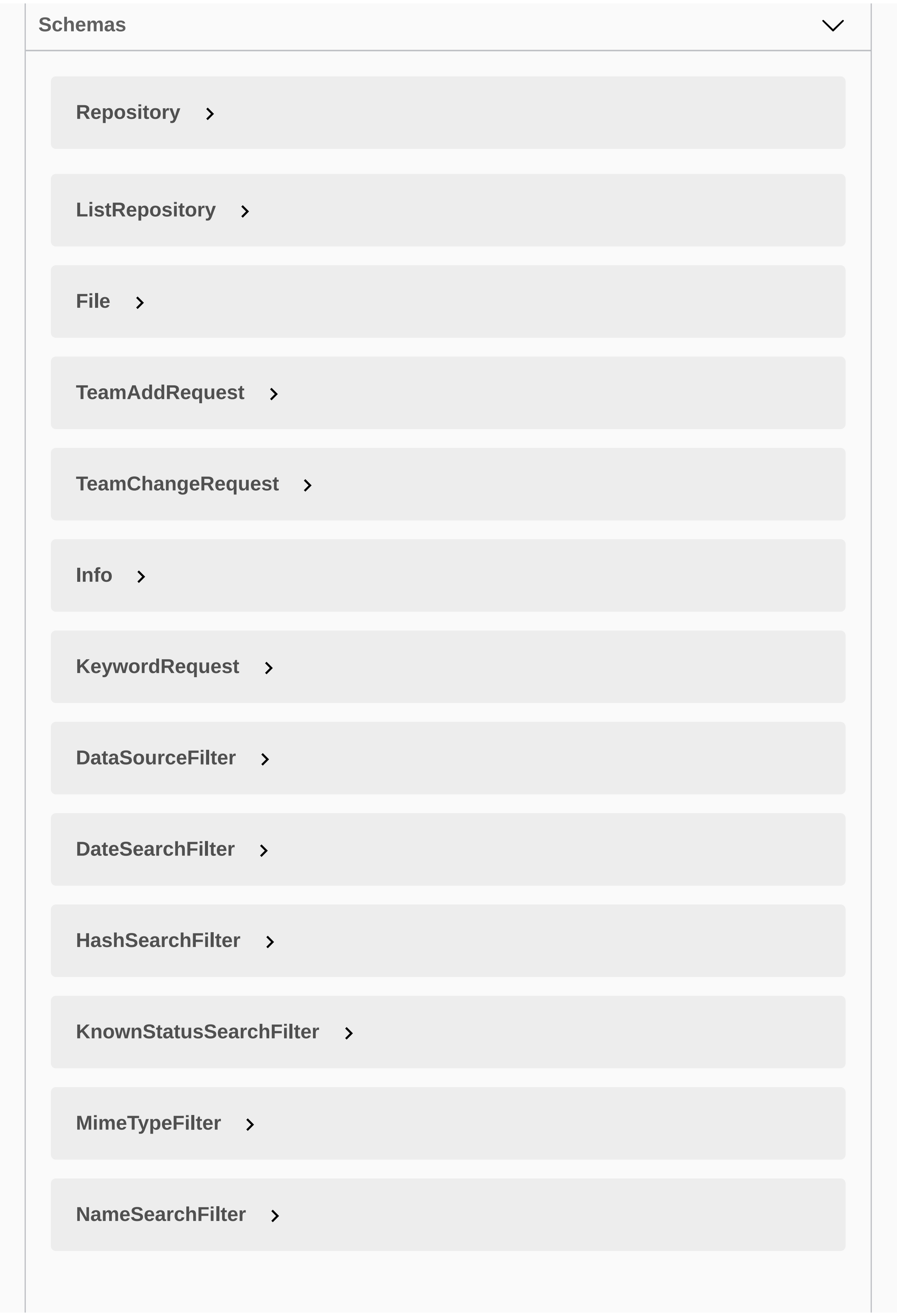
PUT `/users/picture` Change user's own picture

GET `/users/picture/{id}` Get a user's image file

PUT `/users/role` Change a user's role

GET `/users/startRegistration` Generate challenge for U2F registration

GET `/users/startValidation` Generate U2F challenge for factor removal



Schemas

Repository

ListRepository

File

TeamAddRequest

TeamChangeRequest

Info

KeywordRequest

DataSourceFilter

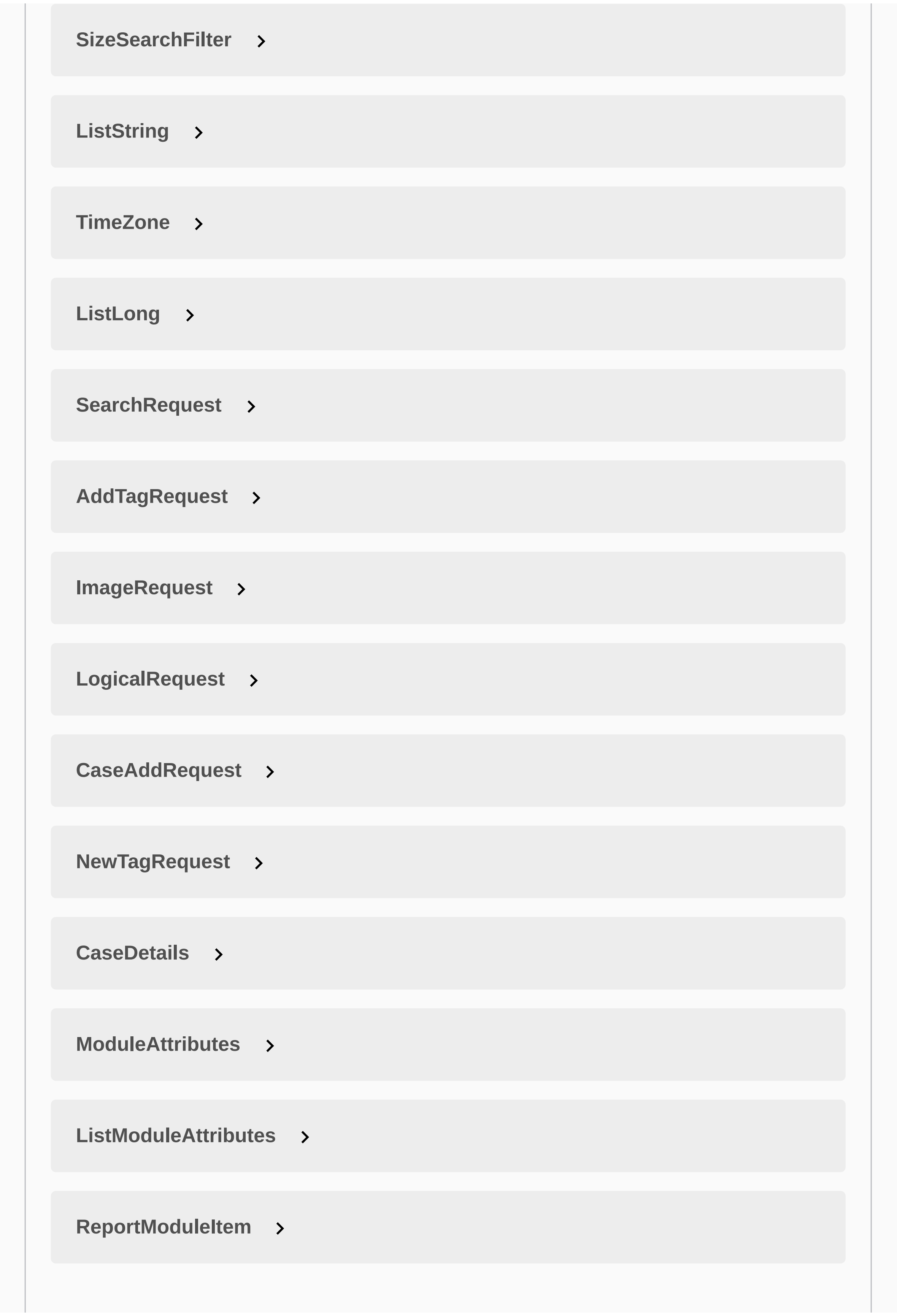
DateSearchFilter

HashSearchFilter

KnownStatusSearchFilter

MimeTypeFilter

NameSearchFilter



SizeSearchFilter

ListString

TimeZone

ListLong

SearchRequest

AddTagRequest

ImageRequest

LogicalRequest

CaseAddRequest

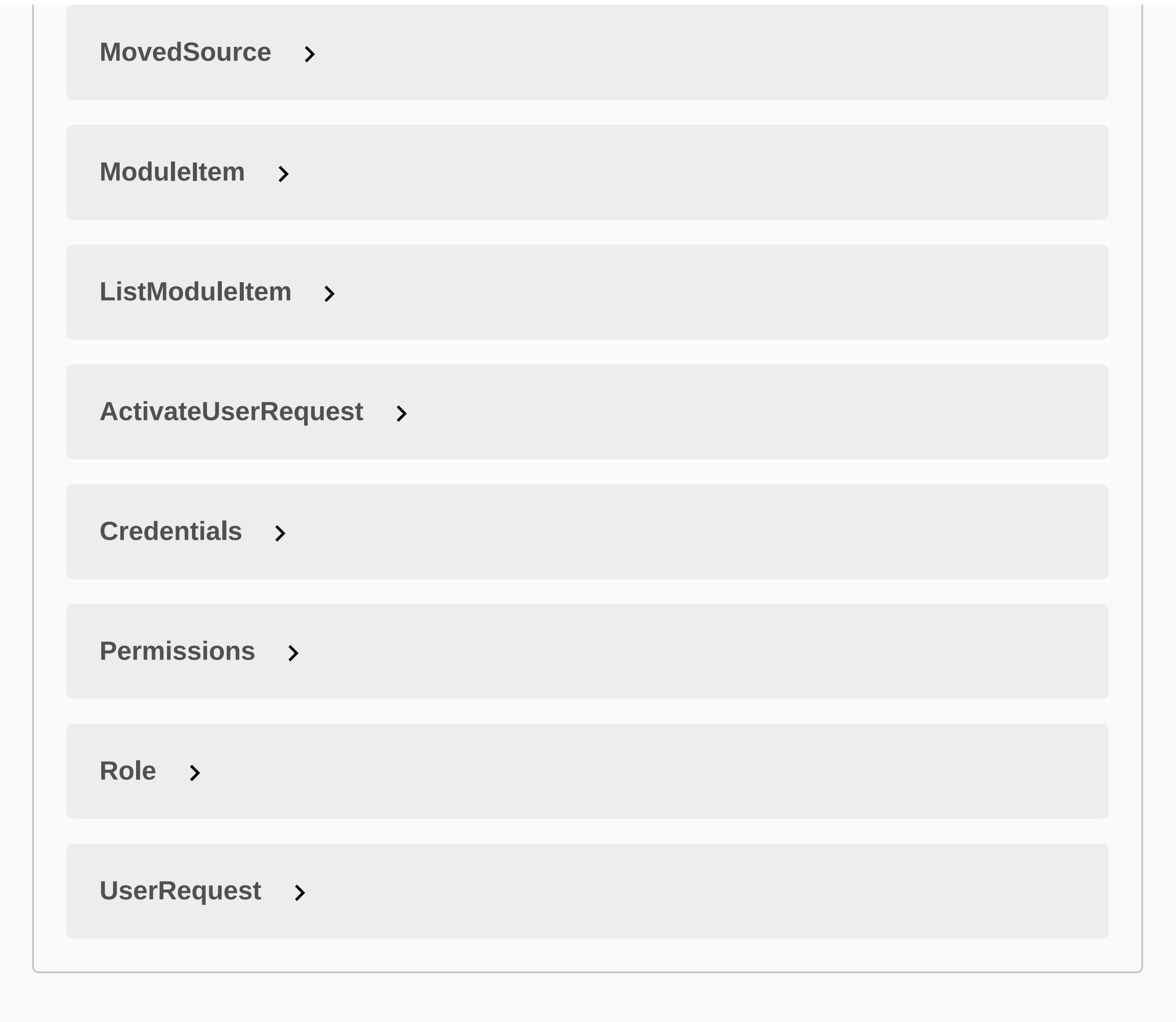
NewTagRequest

CaseDetails

ModuleAttributes

ListModuleAttributes

ReportModuleItem



MovedSource

ModuleItem

ListModuleItem

ActivateUserRequest

Credentials

Permissions

Role

UserRequest

DECLARAÇÃO

Declaro, sob compromisso de honra, que o trabalho apresentado nesta dissertação, com o título *"AUTOPSY – Enhanced distributed forensic analysis"*, é original e foi realizado por Pedro Henrique Gaspar Cordeiro Ferreira (2180078) sob orientação de Professora Doutora Marisa da Silva Maximiano (marisa.maximiano@ipleiria.pt).

Leiria, 25 de Fevereiro de 2020

Pedro Henrique Gaspar Cordeiro Ferreira