Software Requirement Specifications

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Introduction

The **Bot to Report Abusive Domains (B.R.A.D)** is a cybersecurity-focused application designed to automate the investigation and analysis of domain abuse reports. With the increasing prevalence of phishing websites, malware-hosting domains, and other forms of DNS abuse, organizations require efficient, secure, and intelligent tools to support cybersecurity operations.

B.R.A.D addresses this need by providing a streamlined web-based platform where users can submit suspicious URLs. Upon submission, a secure, containerized bot performs automated scraping and forensic analysis on the domain—extracting content, detecting potential malware, collecting metadata (such as WHOIS data, IP addresses, and SSL certificates), and classifying risk levels using AI techniques. The system compiles this data into structured forensic reports, which are made available to cybersecurity investigators through a dedicated dashboard.

Business Need

Modern cyber threats are increasingly sophisticated, targeting individuals, businesses, and infrastructure through deceptive and malicious domains. Manual approaches to investigating these threats are often time-consuming and reactive. There is a clear need for an automated solution that facilitates the rapid assessment and reporting of potentially harmful domains. B.R.A.D aims to fill this gap by providing a secure, scalable system for domain abuse detection and reporting.

Project Scope

The scope of this project includes the design and implementation of:

- A **User Submission Portal** for reporting suspicious domains
- A **Containerized Bot** for automated domain visits and content scraping
- **Forensic Data Collection** to gather and store domain intelligence
- **AI-Powered Risk Classification** to evaluate the level of threat
- An **Investigator Dashboard** for reviewing and analyzing reports
- Optional integration with threat intelligence sources and real-time alerting

The B.R.A.D system will support both a user-friendly interface and API-based access to ensure integration flexibility and ease of use.

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User Stories

1.Role: General user(Reporter)

Description:

- A member of the public or organization who wants to report a suspicious website.

User Story:

- As a general user I want to submit a suspicious domain so that I can check if it's legal and safe to use.

Definition of done:

- I can submit a suspicious domain via a simple form.
- I can optionally add notes or upload evidence.
- I receive confirmation that my report is submitted.
- I can track my report status and receive feedback.
- I can request to reset or change my password if I forget it.

2.Role:Investigator

Description:

- A cybersecurity analyst who reviews and classifies domain submissions.

User Story:

- As an investigator I want to view all reports submitted and their results so that I can analyse them, change their status, and send feedback to the reporter.

Definition of done:

- I can view all submitted reports.
- I can see risk scores and AI verdicts.
- I can open a detailed report with metadata and evidence.
- I can update the report status.
- I can send feedback to the original reporter.
- I can request to change or reset my password if I forget it.

3.Role:Admin

Description:

- A system administrator responsible for managing user roles.

User Story:

- As an admin I want to view all users and manage their roles so that I can control who has access to specific functionalities.

Definition of done:

- I can view all registered users and their current roles.
- I can promote a user to the role of investigator.
- I can demote an investigator to a general user.
- I can change users role to admin.
- I can create new users.
- I can request to change or reset my password if I forget it.

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Use cases

Use cases for demo 1

This outlines and analyses the three main use cases of the B.R.A.D (Bot to Report Abusive Domains) cybersecurity application. Each use case is detailed with user perspectives,system responsibilities, and variations in workflow depending on the implementation of automated vs manual bot analysis.

Use Case 1: Submit Domain Report

User Perspective:

The Reporter wants to submit a suspicious domain via a simple and secure interface.They may optionally upload supporting evidence (screenshots,emails,etc.).

System Role:

• Validates the domain

• Stores the report in the database

•Optionally or automatically triggers the investigation bot depending on chosen version

•Provides confirmation of submission

Steps(General):

1. Reporter logs into the platform.
2. Fills in the domain name.
3. Uploads evidence(optional).
4. Submits the report.

5. System processes the submission accordingly.

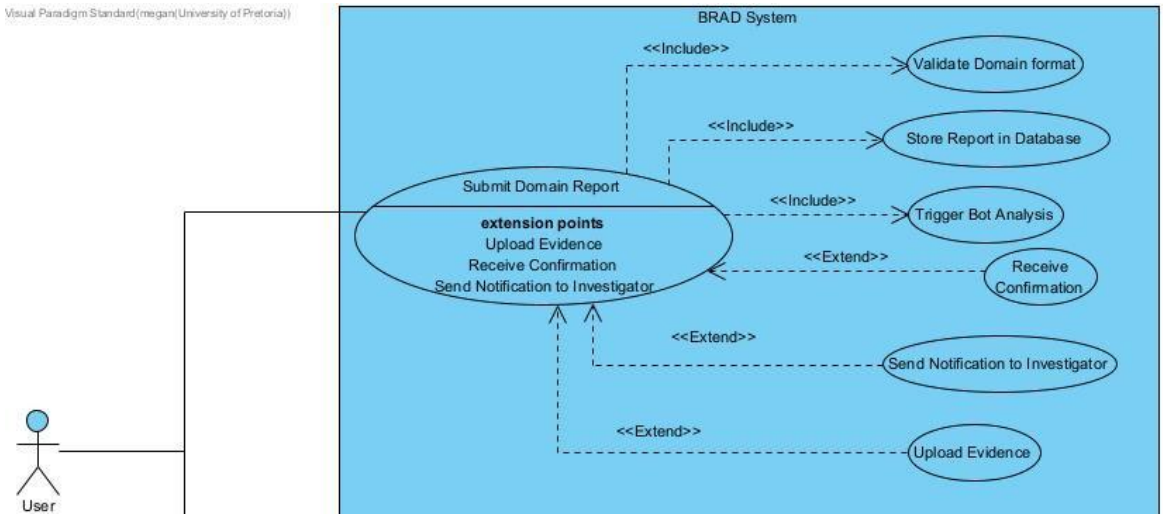
Version 1: Bot is triggered automatically u pon submission.

• Trigger BotAnalysis becomes an<<include>>usecase.

• Investigation starts immediately in the background.

• Reporter receives a confirmation that investigation has started.

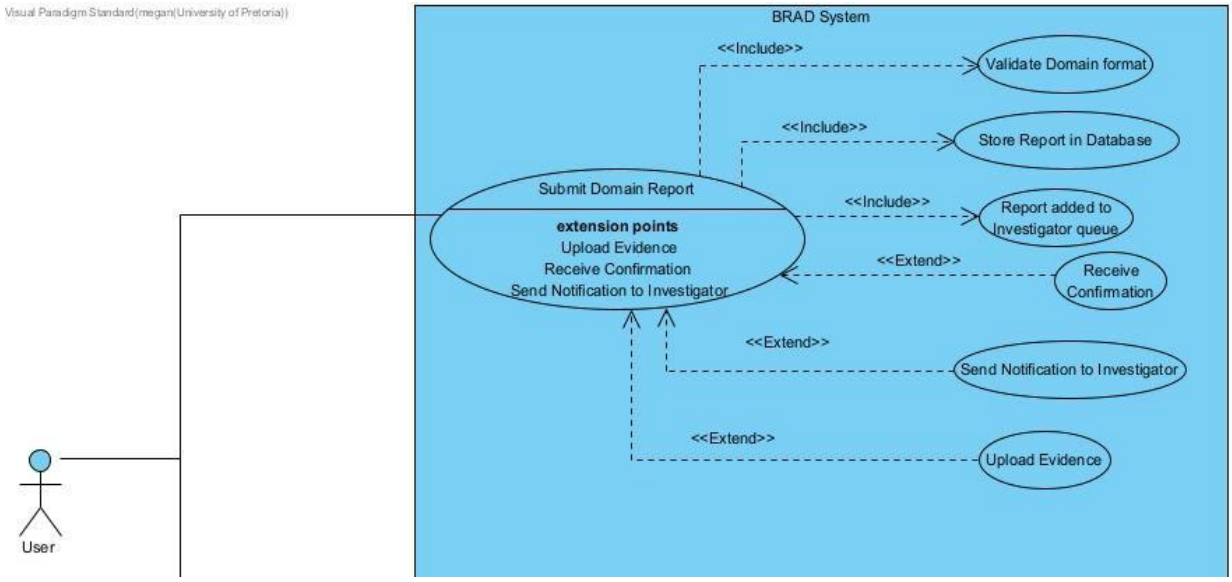
• Optional: Investigator is notified post-analysis.



Version 2: Investigator manually launches the bot later.

• Submission is stored and queued for human review.

• Investigator decides when to initiate investigation.



Use Case 2: View Submitted Reports

User Perspective:

The Reporter wants to track the status of their previous submissions,including any analysis results or reports generated by investigators.

System Role:

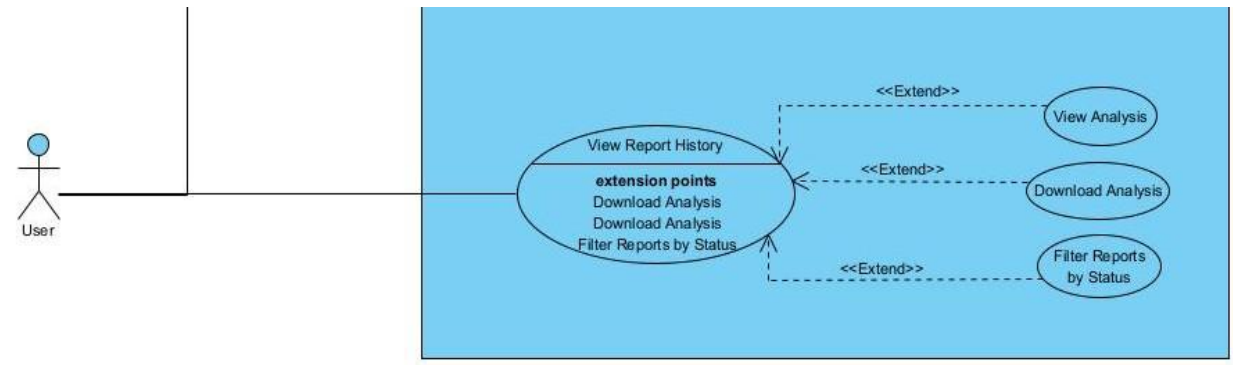
• Authenticates the user

• Retrieves and displays submission history and current statuses

• Optionally allows filtering,downloading reports,or receiving notifications

In **Version1:** statuses update quickly as bot analysis runs automatically.

In **Version2:** status may show as "AwaitingInvestigation" until an investigator initiates the process.



Use Case 3: Analyse Forensic

User Perspective:

The Investigator logs in to review assigned or submitted domain reports.They access metadata, interpret bot analysis results,and provide a final analysis.

System Role:

• Authenticates the investigator with secure access

• Displays report information and metadata

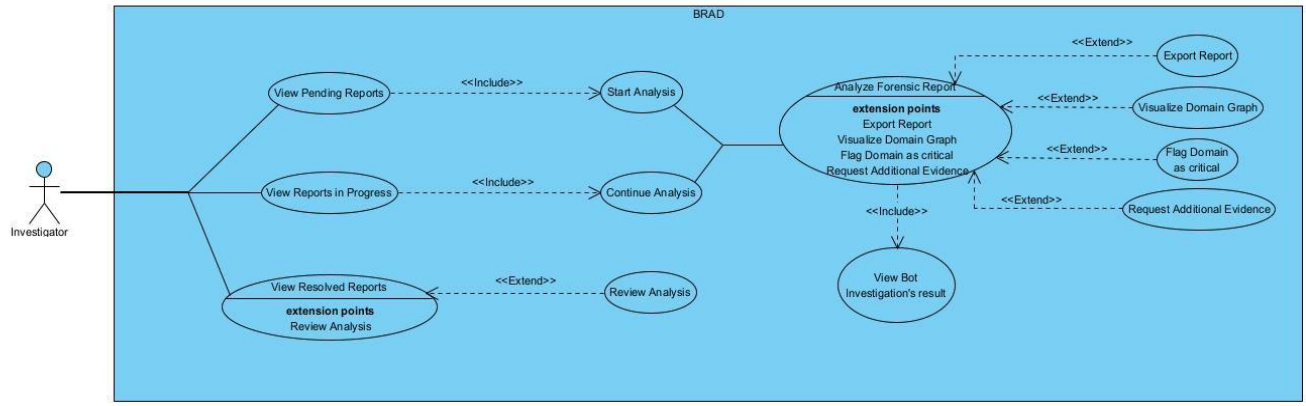
• Runs or fetches bot out put depending on the version

• Supports visual analysis tools,export features,and escalation options

Version 1: Bot is Auto Triggered

• Investigator accesses already-analysed results

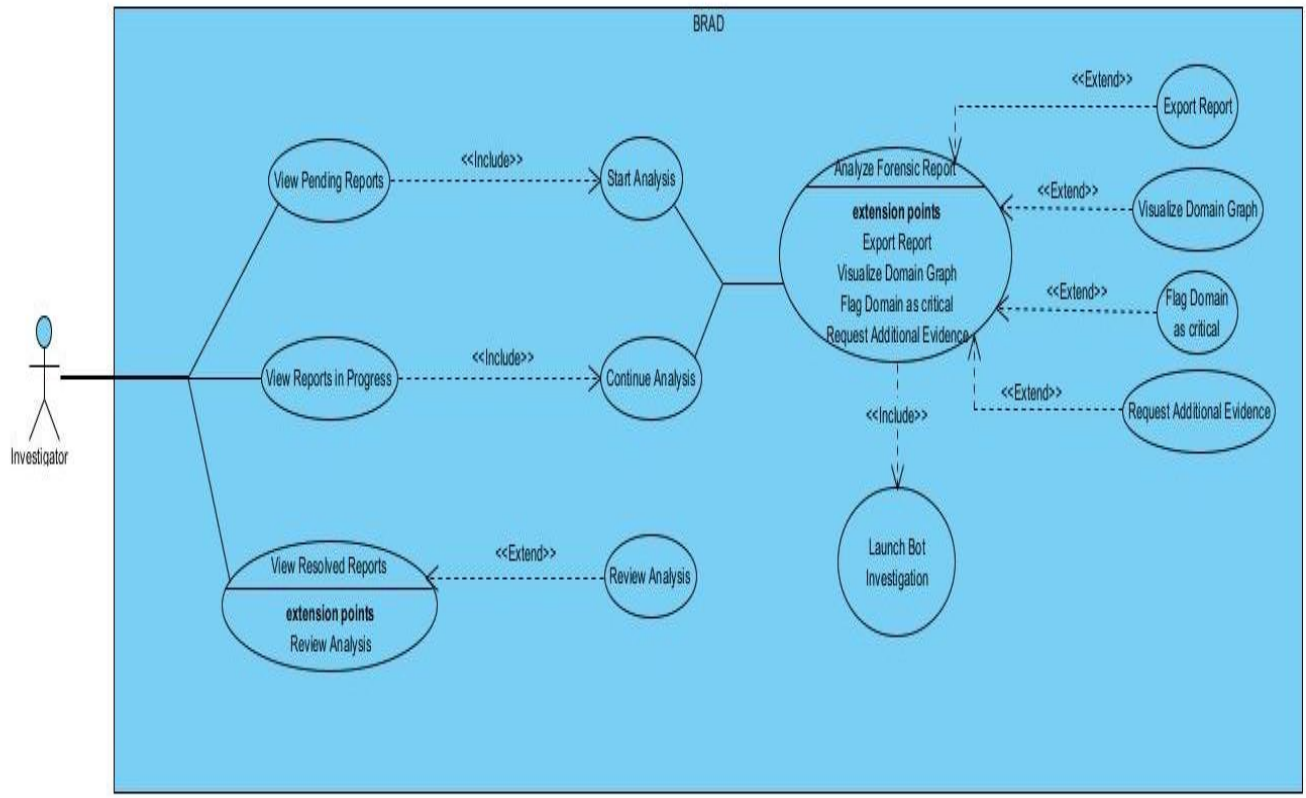
• Main task is interpretation and risk assessment



Version 2: Bot is Manually Triggered

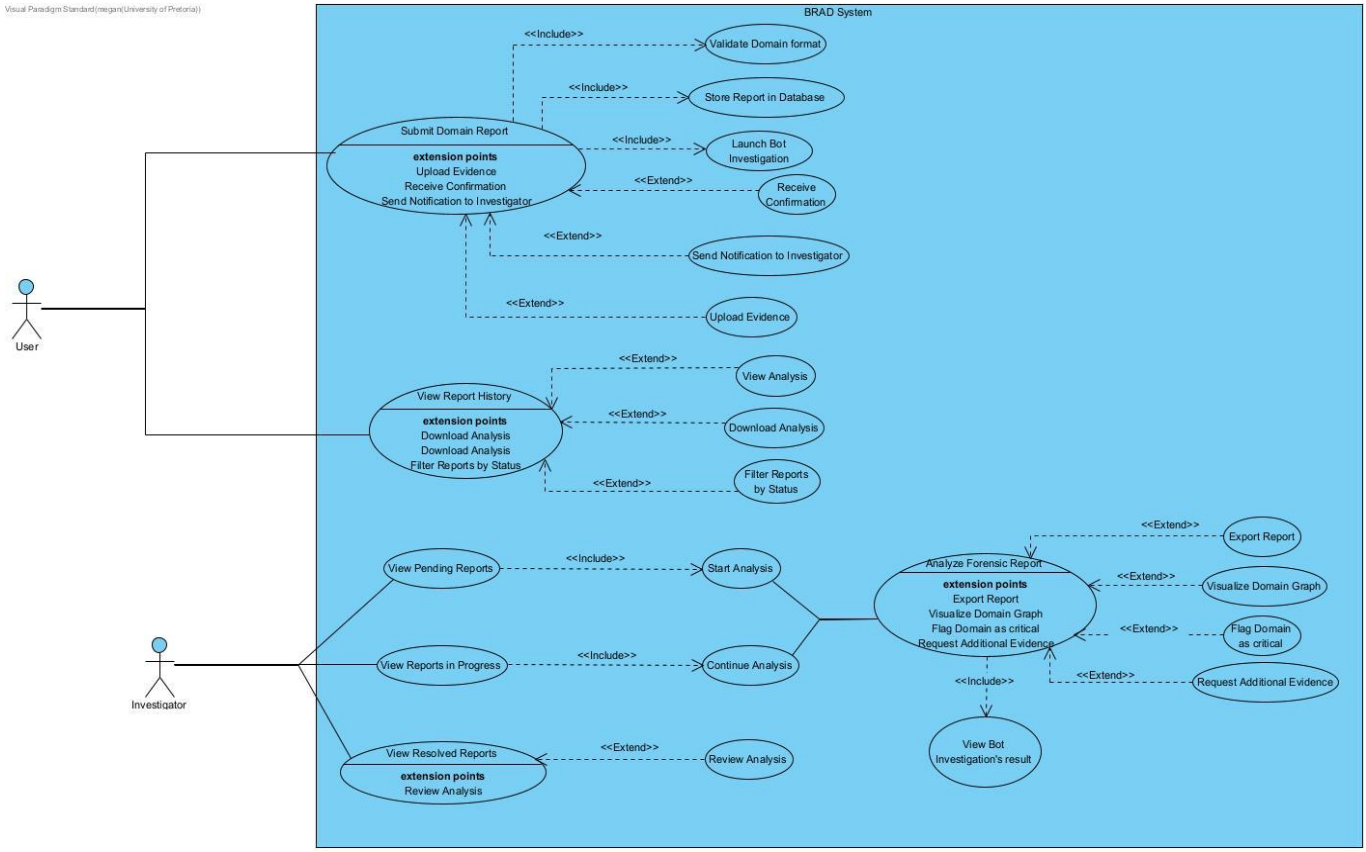
• Investigator must explicitly launch the bot from the dashboard

• Once results are ready,analysis and reporting proceed as usual

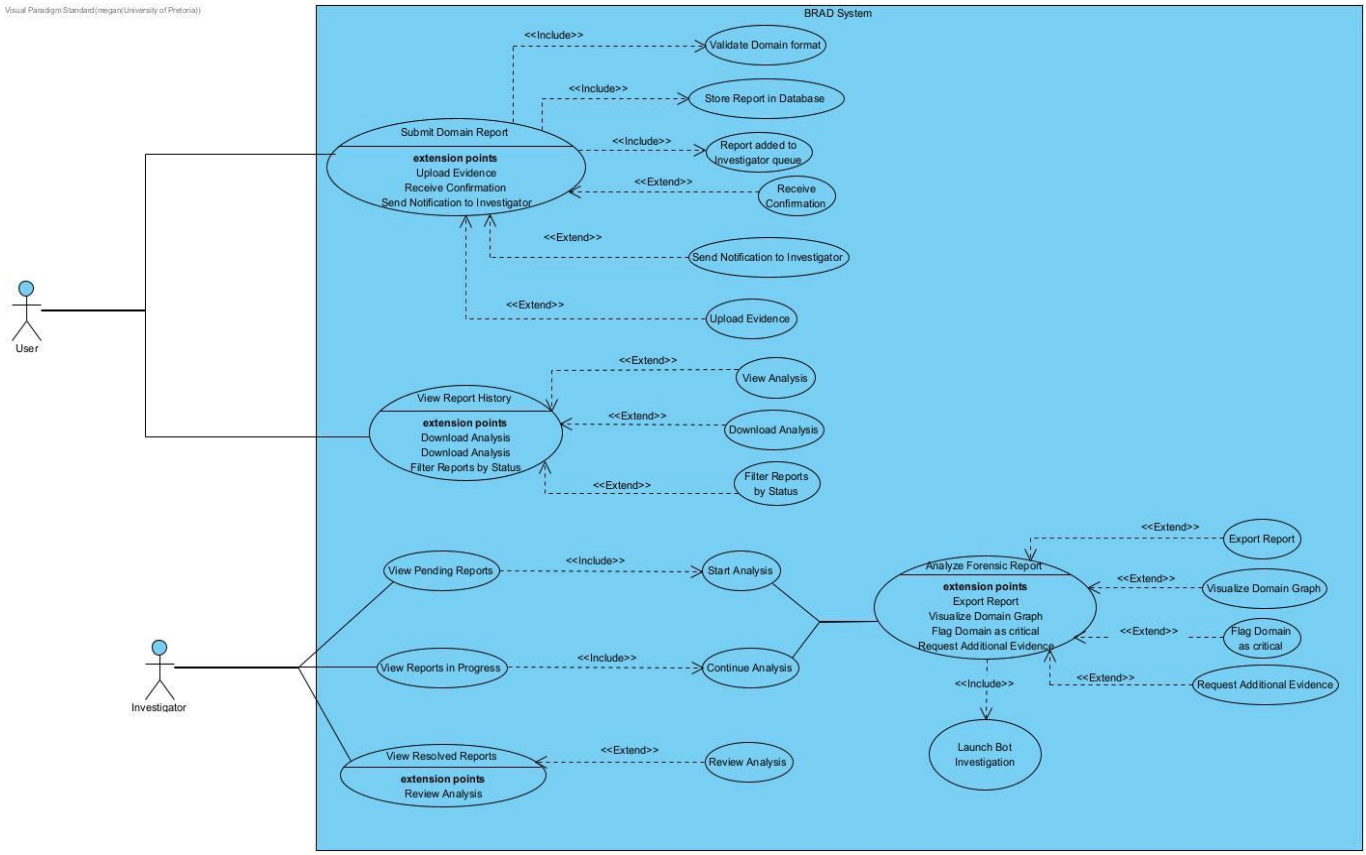


Complete use cases daigrams:

Version 1 is ideal for rapid,scalable analysis where automation speeds up feedback loops.



Version 2 introduces flexibility and manual control for nuanced investigations.



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Use Cases for Demo 2

Use Case 1: Admin Adds a New User

User Perspective:

The **Admin** adds a new user by filling in user details.

System Role:

- Stores the new user’s username and email
- Sends a One-Time Password (OTP) to the user's email
- Redirects the user to complete their setup via the link

Steps:

1. Admin enters the new user's:
    - Username
    - Email
    - Role (Admin / Investigator / Reporter)
2. System sends OTP link via email
3. User clicks the link and:
    - Enters OTP
    - Enters and confirms new password
    - Gets redirected to login

Use Case 2: Admin Manages Users

User Perspective:

The **Admin** wants to manage users efficiently by modifying roles or removing accounts.

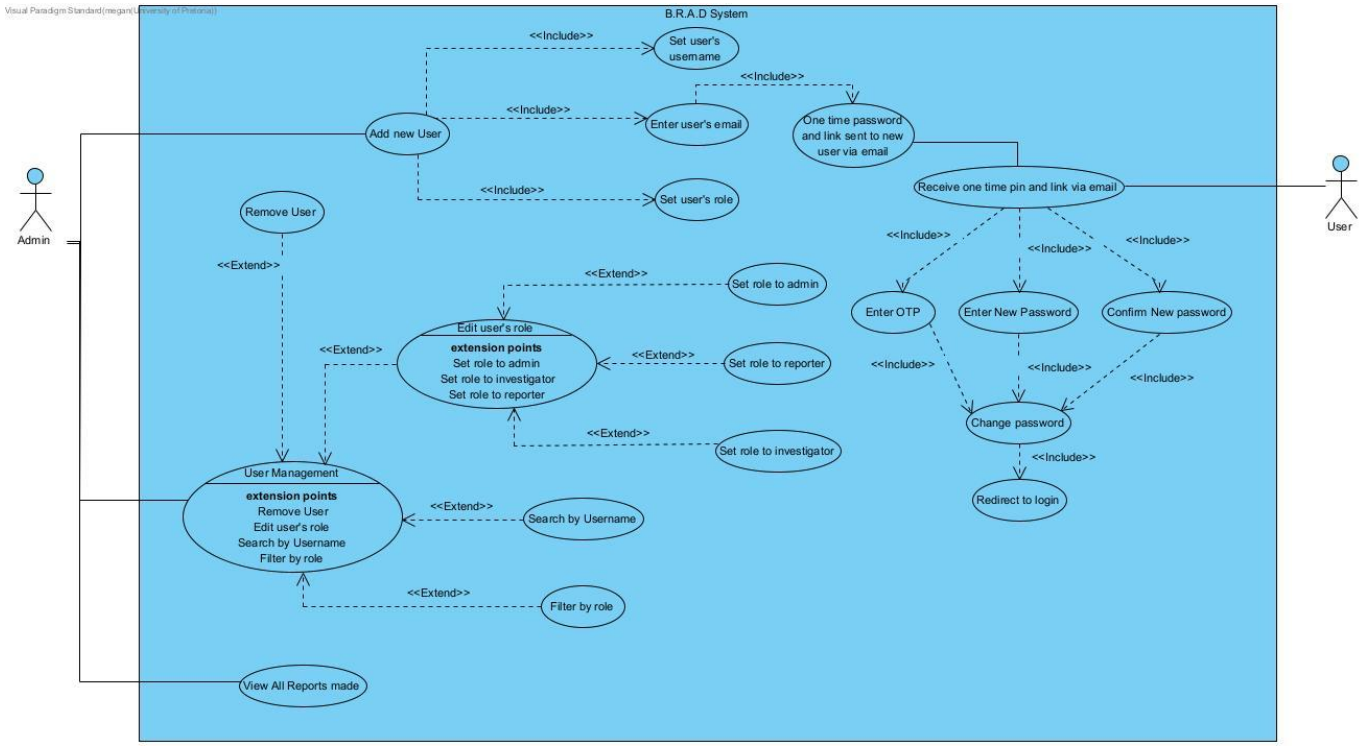
System Role:

- Allows filtering and searching of users
- Enables role editing and deletion

Admin Can Perform:

- Remove user
- Edit user role:
    - Admin
    - Investigator

    - Reporter
- Filter by role
- Search by username



Use Case 3: Investigator Analyzes Report Using Bot Response

User Perspective:

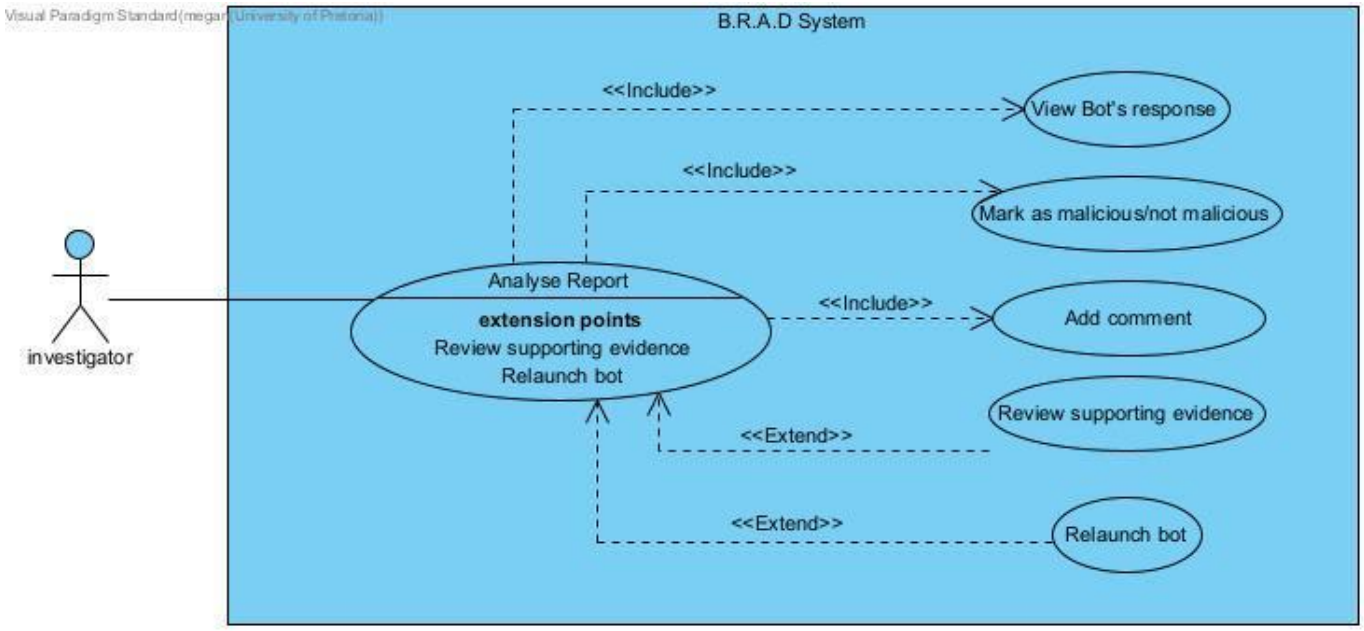
The **Investigator** evaluates a reported domain using bot results and evidence.

System Role:

- Displays bot-generated results
- Allows investigator to interpret and label the report

Steps:

1. View bot response
2. Mark report as malicious / not malicious
3. Add comments
4. Review supporting evidence
5. Relaunch bot if needed



Use Case 4: Reset or Change Password

User Perspective:

Any **user** who has forgotten or needs to reset their password can initiate recovery.

System Role:

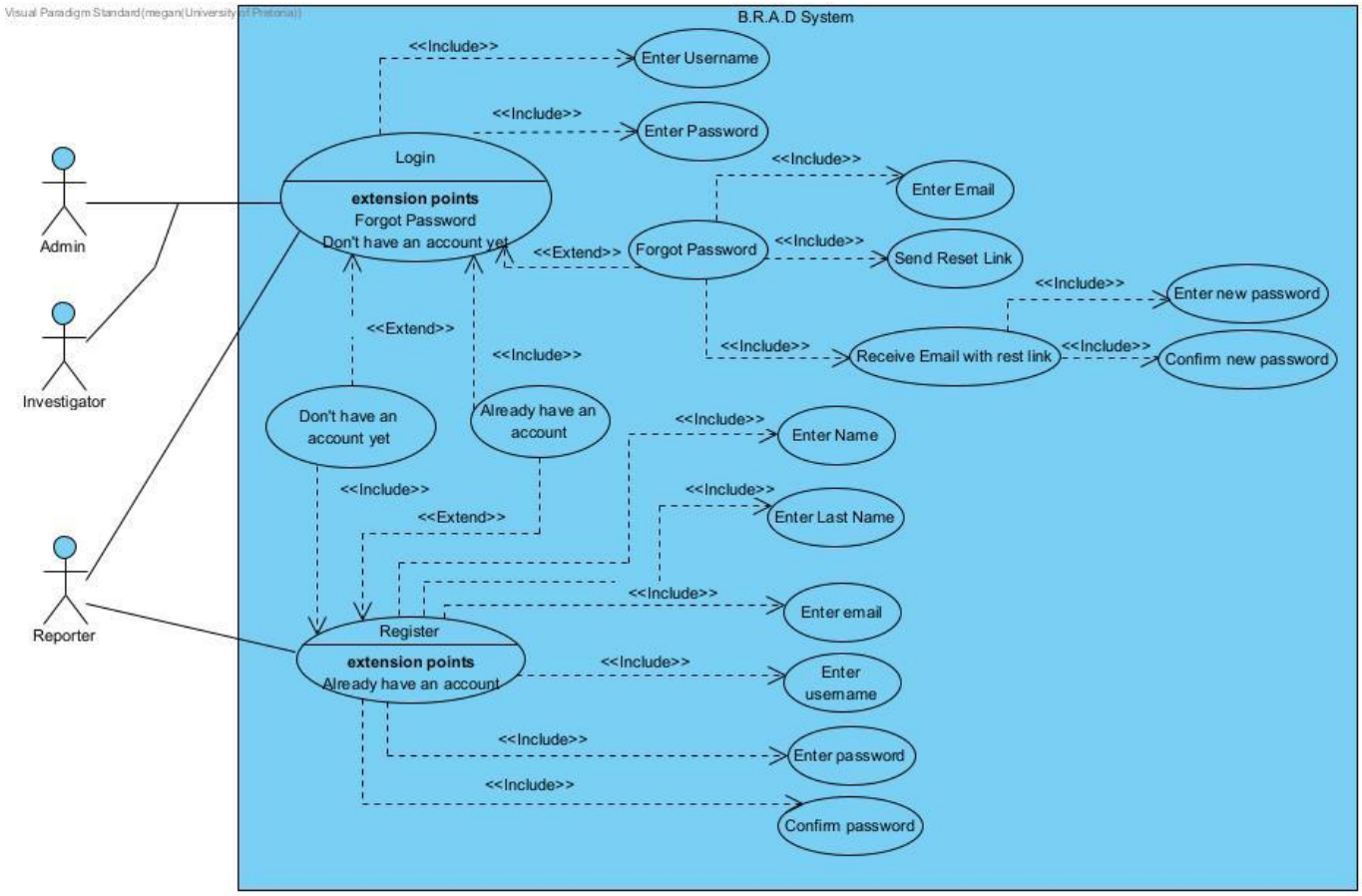
- Sends password reset link to email
- Verifies new password inputs
- Redirects back to login

Steps to Reset Password:

1. On login screen, click **"Forgot Password"**
2. Enter email address
3. Receive email with reset link
4. Click the link and:
    - Enter new password
    - Confirm password

Steps to Register (if not a user):

1. Click **"Register"**
2. Enter:
    - First name
    - Last name
    - Email
    - Username
    - Password
3. Already have an account? Click **"Login"**



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Functional Requirements

Core Requirements

1.1. User Submission Portal

1.1.1. Provide a web form for users to report suspicious domains.
1.1.2. Ensure ease of use with form validation and confirmation messages.

1.2. Scraping & Malware Detection

1.2.1. Deploy a secure, containerized bot to visit submitted domains.
1.2.2. Extract domain content and run malware detection tools.

1.3. Forensic Data Collection

1.3.1. Gather metadata such as IP address, hosting provider, and registrar info.
1.3.2. Fetch SSL certificate and WHOIS data for further analysis.

1.4. AI Risk Analysis

1.4.1. Use machine learning to evaluate domain content and metadata.
1.4.2. Classify domains based on risk level or threat type.

1.5. Evidence Submission

1.5.1. Allow users to upload supporting files (e.g., screenshots, logs).
1.5.2. Validate file types and scan for malware.

1.6. Investigator Dashboard

1.6.1. Provide a UI for analysts to review submitted reports.
1.6.2. Include filters, sorting, and risk classification indicators.

1.7. Secure Storage

1.7.1. Store all data with encryption at rest and in transit.
1.7.2. Implement access controls and secure backups.

Optional Features

2.1. Threat Intelligence Lookup

2.1.1. Integrate with known threat intelligence APIs.
2.1.2. Flag domains found in blacklists or reports.

2.2. Automated WHOIS & DNS

2.2.1. Periodically fetch and update WHOIS and DNS records.
2.2.2. Detect ownership or server changes.

2.3. Domain Similarity Detection

2.3.1. Identify lookalike or typo-squatting domains.
2.3.2. Cluster domains with similar patterns.

2.4. Real-Time Alerts

2.4.1. Send email, SMS, or webhook alerts for critical threats.
2.4.2. Include context and risk score in alert payloads.

2.5. Historical Tracking

2.5.1. Maintain timeline of changes and reports for each domain.
2.5.2. Track repeat offenders and escalation trends.

2.6. Multi-Language Support

2.6.1. Detect and process content in various languages.
2.6.2. Include translation tools or plugins if necessary.

3. Wow Factors

3.1. Live Sandbox Testing

3.1.1. Execute domain resources in an isolated environment.
3.1.2. Capture behavioral traces like redirects or script execution.

3.2. Machine Learning Risk Scores

3.2.1. Train models on historical data to generate risk scores.
3.2.2. Continuously refine with analyst feedback.

3.3. Automated Threat Hunting

3.3.1. Use domain data to proactively scan for similar threats.
3.3.2. Suggest new domains to monitor based on clustering.

3.4. Blockchain Evidence

3.4.1. Store report hashes on a blockchain for integrity proof.
3.4.2. Enable public verification of report authenticity.

3.5. Auto Takedown Requests

3.5.1. Generate pre-filled abuse reports for registrars.
3.5.2. Track status of takedown actions.

3.6. Dark Web Checks

3.6.1. Monitor dark web forums or marketplaces for domain mentions.
3.6.2. Flag domains associated with underground activity

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Service Contracts

API Contract

Communication

- **Protocol**: HTTP/HTTPS (RESTful)
- **Format**: `application/json` (except multipart for file uploads)
- **Auth**:

- `Authorization: Bearer <JWT>` (for user endpoints)
- `X-Bot-Key: <KEY>` (for bot endpoints)

- **Error Handling**:
  - `400` Bad Request (missing fields, invalid values)
  - `401` Unauthorized (invalid/missing auth)
  - `403` Forbidden (role-based access denial)
  - `404` Not Found (invalid report ID)
  - `500` Internal Server Error

Report Report Management

This service handles submission, retrieval, analysis, and status updates of suspicious domain reports. It communicates with a bot (via FastAPI) for domain analysis and stores results with structured forensic data.

Submit Report

Endpoint: `POST /report`

- **Description**: Submit a suspicious domain with optional screenshot/file evidence.
- **Guards**: `AuthGuard`, `RolesGuard`
- **Roles**: `general`, `admin`
- **Content-Type**: `multipart/form-data`
- **Request Body**

Field	Type	Required	Description
domain	string	YES	Domain being reported
evidence	file[]	NO	Up to 5 files (max 5MB each)

- **Response**

```
{
  "_id": "665c861c8b23919a3f823fa1",
  "domain": "suspicious-domain.com",
  "submittedBy": "665c84cf7b7f5b2b04117f3d",
  "evidence": ["file1.png", "file2.jpg"],
  "analyzed": false,
  "analysis": null,
  "scrapingInfo": null,
  "abuseFlags": null,
  "analysisStatus": "pending",
```

```
  "investigatorDecision": null
}
```

Get All Reports

Endpoint: `GET /reports`

- **Description**: Retrieve all reports (admin/investigator) or own reports (general).
- **Guards**: `AuthGuard`, `RolesGuard`
- **Roles**: `general`, `admin`, `investigator`
- **Response**

```
[
{
    "_id": "...",
    "domain": "...",
    "submittedBy": { "username": "user123" },
    ...
}
]
```

Update Analysis (Bot)

Endpoint: `PATCH /reports/:id/analysis`

- **Description**: Update a report with analysis results.
- **Guard**: `BotGuard`
- **Request Body** (DTO: `UpdateAnalysisDto`)

```
{
"analysis": {
    "domain": "site.com",
    "scannedAt": "2025-08-08T10:00:00Z",
    "ip": "123.45.67.89",
    "registrar": "Example Inc.",
    "whoisOwner": "John Doe",
    "sslValid": true,
    "sslExpires": "2025-12-01",
    "riskScore": 8.5,
    "summary": "Possible phishing site",
    ...
},
```

```
"scrapingInfo": {
    "htmlRaw": "<html>...</html>",
    "structuredInfo": {
    "headings": ["Welcome"],
    "links": ["http://..."]
    }
},
"abuseFlags": {
    "obfuscatedScripts": true,
    "suspiciousJS": ["eval", "atob"],
    ...
},
"analysisStatus": "done"
}
```

- **Response**

  Returns the updated report document.

Submit Investigator Verdict

Endpoint: `PATCH /report/:id/decision`

- **Description**: Investigator marks the report as either `malicious` or `benign`.
- **Guards**: `AuthGuard`, `RolesGuard`
- **Roles**: `investigator`
- **Request Body**

```
{
  "verdict": "malicious"
}
```

- **Response**

```
{
  "investigatorDecision": "malicious"
}
```

Manual Forensic Analysis

Endpoint: `GET /forensics/:id`

- **Description**: Manually trigger forensic analysis using the `ForensicService`.

- **Guards**: `AuthGuard`, `RolesGuard`
- **Roles**: `admin`, `investigator`

Admin Management

This service provides privileged operations to manage users in the system, such as promoting/demoting roles, creating users with one-time passwords, and deleting users. Access is restricted to users with the `admin` role.

Add Admin

Endpoint: `POST /admin/add`

- **Description**: Create a new admin user.
- **Request Body**: `AddAdminDto`

```
{
  "userId": "665d5f9b3f5c2e2a88e98b91",
  "firstname": "Natasha",
  "lastname": "Romanoff",
  "email": "natasha@example.com",
  "username": "nat_romanoff",
  "password": "supersecurepassword"
}
```

- **Response**:

```
{
  "_id": "665d5f9b3f5c2e2a88e98b91",
  "firstname": "Natasha",
  "lastname": "Romanoff",
  "email": "natasha@example.com",
  "username": "nat_romanoff",
  "role": "admin"
}
```

Promote User to Investigator

Endpoint: `PATCH /admin/promote/:userId`

- **Description**: Promote a general user to `investigator`.
- **Params**:

- `userId` — MongoDB ObjectId of the user

- **Response**:

```
{
  "_id": "...",
  "role": "investigator"
}
```

Demote User to General

Endpoint: `PATCH /admin/demote/:userId`

- **Description**: Demote an `investigator` or `admin` user to `general`.

- **Params**:

  - `userId` — MongoDB ObjectId of the user

- **Response**:

```
{
  "_id": "...",
  "role": "general"
}
```

Promote User to Admin

Endpoint: `PATCH /admin/promote-to-admin/:userId`

- **Description**: Promote any user to `admin`.

- **Params**:

  - `userId` — MongoDB ObjectId of the user

- **Response**:

```
{
  "_id": "...",
  "role": "admin"
}
```

Get All Users

Endpoint: `GET /admin/users`

- **Description**: Returns all registered users (passwords excluded).
- **Response**:

```
[
{
    "_id": "665d...",
    "firstname": "Tony",
    "lastname": "Stark",
    "email": "tony@example.com",
    "username": "tony_stark",
    "role": "admin"
},
...
]
```

Delete User

Endpoint: `DELETE /admin/delete/:userId`

- **Description**: Permanently delete a user by ID.
- **Params**:
  - `userId` — MongoDB ObjectId of the user
- **Response**:

```
{
  "message": "User deleted successfully"
}
```

Create New User with One-Time Password

Endpoint: `POST /admin/user`

- **Description**: Create a new user with a randomly generated 5-digit one-time password. The user is emailed a password reset link valid for 30 minutes.
-
- **Request Body**: `CreateUserDto`

```
{
  "firstname": "Steve",
  "lastname": "Rogers",
  "email": "steve@example.com",
  "username": "captain_america",
  "role": "investigator"
}
```

- **Response**:

```
{
  "_id": "665d...",
  "firstname": "Steve",
  "lastname": "Rogers",
  "email": "steve@example.com",
  "username": "captain_america",
  "role": "investigator",
  "mustChangePassword": true
}
```

- An email will be sent to the user with the one-time password and reset link.

Authtication Management

This module handles user registration, authentication, and password lifecycle management (reset, change). It supports login via username or email, sends secure password reset links via email, and enforces first-time password change using OTPs for users created by admins.

Register

Endpoint: `POST /auth/register`

- **Description**: Register a new user (default role: investigator).
- **Public**
- **Request Body**: `RegisterDto`

```
{
  "firstname": "Tony",
  "lastname": "Stark",
  "email": "tony@example.com",
  "username": "tony_stark",
  "password": "strongPassword1!"
}
```

- **Response**

```
{ "userId": "665d..." }
```

Login

Endpoint: `POST /auth/login`

- **Description**: Authenticate with username or email and return JWT token.
- **Public**
- **Request Body**: `LoginDto`

```
{
  "identifier": "tony_stark",
  "password": "strongPassword1!"
}
```

- **Response**

```
{
  "token": "<JWT_TOKEN>",
  "user": {
    "_id": "665d...",
    "firstname": "Tony",
    "lastname": "Stark",
    "email": "tony@example.com",
    "username": "tony_stark",
    "role": "investigator",
    "mustChangePassword": false,
    "createdAt": "2025-08-08T14:26:34.687Z",
    "updatedAt": "2025-08-08T14:26:34.687Z",
    "__v": 0
  }
}
```

- If `mustChangePassword = true`, user must change password before login.

Forgot Password

Endpoint: `POST /auth/forgot-password`

- **Description**: Sends a password reset link to the user's email.
- **Public**
- **Request Body**

```
{ "email": "tony@example.com" }
```

- **Response**

```
{ "message": "Password reset email sent" }
```

Reset Password (via Token)

Endpoint: `POST /auth/reset-password`

- **Description**: Resets password using token from email.
- **Public**
- **Request Body**: `ResetPasswordDto`

```
{
  "token": "reset_token_from_email",
  "newPassword": "newSecurePassword123"
}
```

- **Response**

```
{ "message": "Password has been reset successfully" }
```

Change Password (First-Time OTP)

Endpoint: `PATCH /auth/change-password/:username`

- **Description**: Changes password using a one-time password (for first login).
- **Public**
- **Path Param**: `username` — the username of the user
- **Request Body**: `ChangePasswordDto`

```
{
  "OTP": "12345",
  "newPassword": "newSecurePassword123!"
}
```

- **Response**

```
{ "message": "Password changed successfully. You can now log in." }
```

Queue & Redis Service Contracts

These services handle asynchronous integration between the NestJS API and the FastAPI bot, and queue-based processing via Redis. They support pushing reports into the FastAPI analysis queue and Redis-based message passing.

Queue Service: `queueToFastAPI(domain, reportId)`

Used by: `ReportService.submitReport(...)`

- **Purpose**: Sends a report to FastAPI via HTTP POST for domain analysis.
- **Protocol**: HTTP (JSON)
- **URL**: `${FASTAPI_URL}/queue`
- **Payload**

```
{
  "domain": "example.com",
  "report_id": "665d5f9b3f5c2e2a88e98b91"
}
```

- **Response**

```
{
  "status": "queued",
  "message": "Job successfully received"
}
```

Errors:

- Connection failures or timeouts are caught and logged.

- Error message is printed: `[QueueService] Failed to queue: <message>`
- The exception is rethrown.

Bot Service Contracts

This component is a Python-based bot system built with FastAPI + Dramatiq + Redis. It acts as an asynchronous consumer of analysis jobs pushed from the NestJS backend. The bot performs forensic and scraping analysis on domains and reports results back to the API.

FastAPI Bot Job Endpoint

Endpoint: `POST /queue`

- **Description**: Accepts analysis jobs from the NestJS backend and enqueues them to Redis using Dramatiq.
- **Request Body**

```
{
  "domain": "phishing-site.com",
  "report_id": "665d5f9b3f5c2e2a88e98b91"
}
```

- **Response**

```
{
  "status": "queued"
}
```

Submit Results to API

Endpoint: `PATCH /reports/{report_id}/analysis`

- **Description**: Submits the analysis results back to the NestJS API for storage and further processing.
- **Payload Example**

```
{
  "analysis": {
    "domain": "phishing-site.com",
    "ip": "123.45.67.89",
    "registrar": "ExampleRegistrar",
    "riskScore": 8.5,
```

```
    "riskLevel": "High",
    ...
  },
  "scrapingInfo": {
    "htmlRaw": "...",
    "screenshotPath": "static/screenshots/phishing-site.com.png",
    "structuredInfo": {
      "headings": ["Login", "Submit"],
      "links": ["http://malicious-link.com"]
    },
    "crawledLinks": ["http://phishing-site.com/login"]
  },
  "abuseFlags": {
    "suspiciousJS": ["eval", "atob"],
    "redirectChain": ["start.com → middle.com → end.com"],
    "obfuscatedScripts": true,
    ...
  },
  "analysisStatus": "done"
}
```

- **Error Handling**
  - On failure: logs the error and raises to retry via Dramatiq
  - Retries: Up to `MAX_RETRIES = 3`
  - Timeout: 60 seconds max per job

Data Schema

Report Schema

Field	Type	Description
domain	`string`	Domain name submitted
evidence	`string[]`	Uploaded filenames
submittedBy	`ObjectId`	Reference to submitting user
analyzed	`boolean`	Whether the report has been analyzed
analysis	`Record<string>`	Forensic result
scrapingInfo	`object`	Parsed HTML, screenshot path, links, etc.
abuseFlags	`object`	JS abuse, redirects, CAPTCHAs, etc.
analysisStatus	`enum`	`pending`, `in-progress`, `done`, `error`
investigatorDecision	`enum`	`malicious`, `benign`, or `null`
createdAt/updatedAt	`Date`	Auto timestamps

User Schema

Field	Type	Description
id	`string`	Unique user identifier
firstname	`string`	Users first name
lastname	`string`	Users last name
email	`string`	Users email address
username	`string`	Users login username
password	`string`	bcrypt hash of users password
role	`enum`	`admin`, `investigator`, `general`
mustChangePassword	`boolean`	User must change password on first login
createdAt/updatedAt	`Date`	Auto timestamps

DTO Reference

AddAdminDto

Field	Type	Validation
userId	string	Required
firstname	string	`@IsNotEmpty`
lastname	string	`@IsNotEmpty`
email	string	`@IsEmail`
username	string	`@IsNotEmpty`
password	string	`@MinLength(6)`

createUserDto

Field	Type	Validation
firstname	string	`@IsString`
lastname	string	`@IsString`
email	string	`@IsEmail`
username	string	`@IsString`

Field	Type	Validation
role	string	`@IsIn(['admin', 'investigator', 'general'])`

RegisterDto

Field	Type	Validation & Notes
firstname	string	`@IsNotEmpty()`
lastname	string	`@IsNotEmpty()`
email	string	`@IsEmail()`
username	string	`@Matches(/^[A-Za-z0-9_.-]+$/)`
password	string	`@MinLength(6)`

LoginDto

Field	Type	Validation
identifier	string	`@IsNotEmpty()` (username or email)
password	string	`@IsNotEmpty()`

ResetPasswordDto

Field	Type	Validation
token	string	Provided via email
newPassword	string	`@MinLength(6)`

ChangePasswordDto

Field	Type	Validation
OTP	string	One-time password from email
newPassword	string	`@MinLength(6)`

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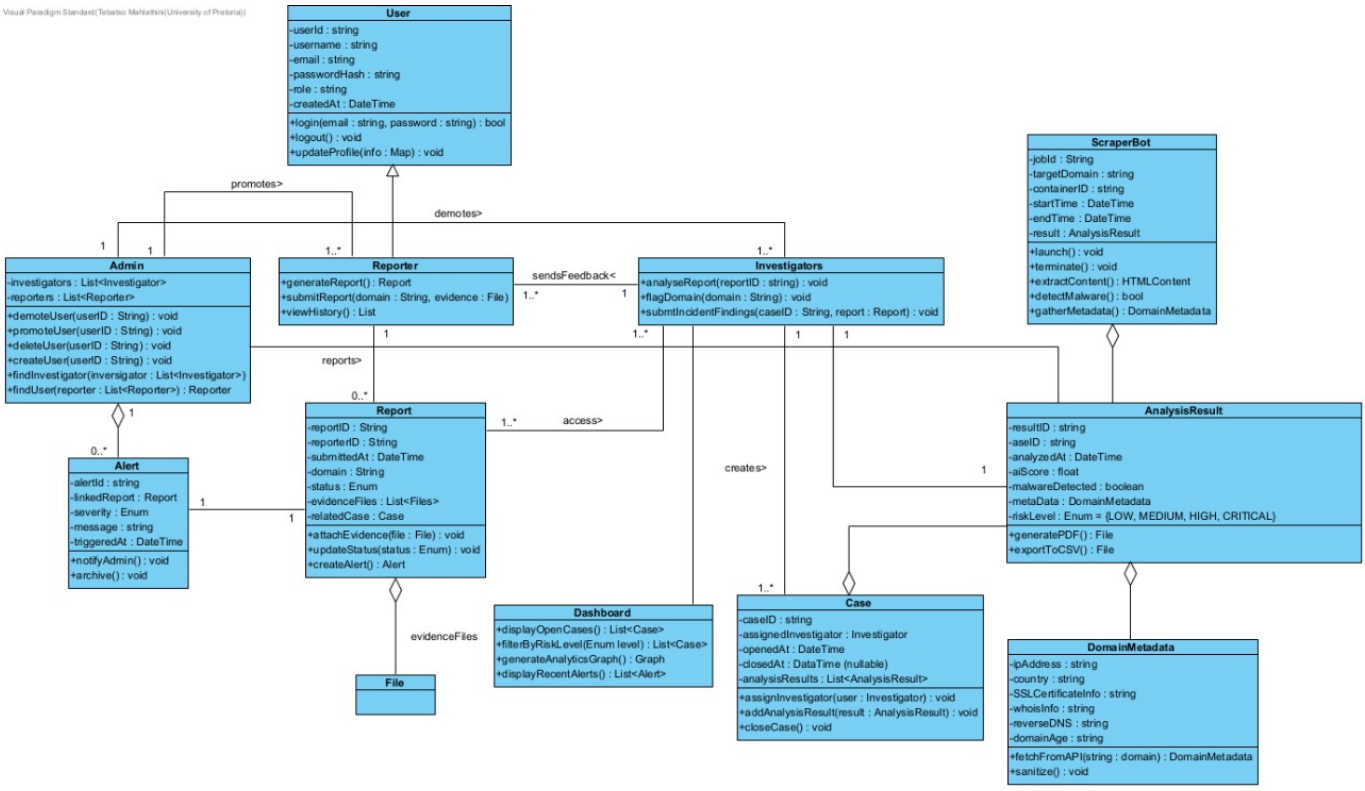
Domain Model



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Architectural Requirements

Architectural Design

Strategy: Design based on Quality Requirements

Making It Easy to Use

Usability is just as important as functionality. We design dashboards and submission pages that are simple and clear so that users don't get confused. This helps reporters submit suspicious domains quickly and investigators work efficiently with the tools we provide.

Building at a Steady Pace

Agile encourages teams to work at a pace they can keep up. By focusing on performance and clean structure, we avoid messy code and make sure the system is efficient and doesn't slow down as it grows. This helps the team avoid burnout and reduces problems later.

Keeping the System Safe and Reliable

Since BRAD works with sensitive information, we always think about security and reliability in our design. We implement strong access control, monitor system activity, and handle failures in a way that doesn't put data or users at risk. This ensures that the system keeps working even under stress.

Collaboration

When we design based on clear quality requirements, everyone on the team knows what matters most. Whether someone is working on the frontend or backend, we all follow the same goals like making the system easy to use, secure, and quick. This makes teamwork smoother and more focused.

Adapting to Change

Cyber-security threats change quickly. Designing around scalability and maintainability helps us make changes without breaking the system. This means we can update the scraper, switch AI models, or add new features easily. It also lets us respond to new ideas or feedback from users as the project goes on.

Step-by-Step Improvements

We build BRAD in small steps. Each sprint adds something new like scraping, AI analysis, or reporting. By keeping each step small and tied to a quality goal (like performance or accuracy), we make sure we're always improving the system in a smart and manageable way.

Customer Trust and Frequent Progress

We want users and stakeholders to feel confident in what we're building. By focusing on quality requirements like security, reliability, and usability, we make sure that every version of the BRAD system is stable, safe, and useful. This helps us deliver real value early and often, which is a key part of Agile.

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Architectural Styles

In developing the Bot to Report Abusive Domains (BRAD) system, we have selected several architectural styles to meet key quality requirements, including security, compliance, scalability, reliability, usability, and maintainability. These styles work together to support BRAD's mission: allowing users to report suspicious domains, processing them through an automated analysis pipeline, and presenting accurate and accessible results to investigators.

The Event-Driven Architecture (EDA) enables BRAD to handle multiple domain reports asynchronously. When a suspicious domain is submitted, it triggers a chain of downstream processes such as scraping, malware checking, AI scoring, and report generation. This pattern boosts scalability and performance by decoupling components and allowing them to process in parallel. It also improves reliability by using persistent queues, which ensure that failed tasks can be retried without data loss.

The Gatekeeper Pattern enforces system-wide security, reliability, and compliance. Acting as a single entry point, it performs user authentication, role-based access control (RBAC), and multi-factor authentication (MFA) where needed. The Gatekeeper also filters and validates all incoming requests, applying rate limiting and logging for auditability. This protects backend services from malicious or malformed input and ensures alignment with data protection laws like POPIA and GDPR.

The Client-Server Model separates the frontend user interface from backend processing. Users interact with the system via a web portal by submitting URLs and reviewing reports while the backend handles authentication, analysis, and data storage. This model enhances usability by allowing a focused and responsive interface. It also supports security and compliance by ensuring that sensitive operations are handled server-side under controlled conditions.

The Layered Architecture organizes the BRAD bot into distinct backend layers: the Scrape Service Layer (responsible for fetching and parsing submitted domains), Malware Detection Layer (examines domains for malicious content), AI Analysis Layer (classifies and scores domain risk based on trained models), and Report Generation Layer (produces and logs investigation reports). This structure improves maintainability, as each layer handles a specific subtask and can be updated or debugged independently. It also enhances reliability, as issues in one layer such as scraping do not directly affect the functioning of others. Security is reinforced by isolating sensitive processes within these internal layers, reducing exposure to external threats.

The Pipe and Filter Pattern structures the backend analysis workflow as a clear processing pipeline: Scrape → Malware Detection → AI Risk Analysis → Report Generation. Each stage is independent, transforming the data and passing it forward. This improves maintainability by allowing individual steps to be replaced or updated. It also enhances reliability by

supporting error handling and recovery at each stage, and improves performance by enabling potential parallel execution of steps.

Event-Driven Architecture (EDA)

Quality Requirements Addressed:

```
• Scalability: Events trigger decoupled processes that scale
independently.

• Performance: Supports real-time, asynchronous
execution.

• Reliability: Persistent queues allow task recovery after failure.
```

Gatekeeper Pattern

Quality Requirements Addressed:

```
• Security: Validates and authenticates all incoming traffic.

• Reliability: Shields services from overload and malformed input.

• Compliance: Enforces logging and data protection rules (POPIA/GDPR).
```

Client-Server Model

Quality Requirements Addressed:

- Usability: Frontend provides clear UI for reporters and investigators.

- Security: Backend controls sensitive operations and data.

- Compliance: Ensures data validation and consent handling on the server.

Layered Architecture

Quality Requirements Addressed:

- Maintainability: Each layer can be changed independently.

- Security: Sensitive logic is isolated in protected backend layers.

- Reliability: Faults are contained within individual layers.

Pipe and Filter Pattern

Quality Requirements Addressed:

- Maintainability: Filters can be updated without breaking the flow.

- Reliability: Pipeline resumes from failed stages where possible.

- Performance: Processing steps can be parallelized and optimized.

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Architectural Quality Requirements

1. Security (Most Important)

Security is the foundation of the B.R.A.D system, given its handling of sensitive data like user-submitted URLs, forensic metadata, and potentially malicious content. Unauthorized access or breaches could lead to severe consequences such as data leaks, false reports, or misuse of the system for cyber-attacks. Therefore, security controls, encrypted storage, secure APIs, role-based access control, and container isolation must be thoroughly enforced to protect both user and system integrity.

Stimulus Source	Stimulus	Response	Response Measure	Environment	Artifact

Stimulus Source	Stimulus	Response	Response Measure	Environment	Artifact
Malicious actors / Attackers	Attempt to compromise data or infrastructure	System should block unauthorized access, validate input and encrypt sensitive information	100% of sensitive data encrypted at rest and in transit. All RBAC and MFA enforced.	Production environment	BRAD Backend / API System

2. Compliance

Compliance ensures that the system operates within the legal and ethical boundaries defined by regulations like GDPR and POPIA. This is especially important for a tool that collects and processes potentially identifiable or legally sensitive data. Compliance includes implementing consent mechanisms, depersonalizing data when possible, logging access to personal data, and providing the right to be forgotten.

Stimulus Source	Stimulus	Response	Response Measure	Environment	Artifact
Legal / Regulatory Bodies	Data privacy and regulatory audits	System should ensure legal compliance in data handling and provide user data control mechanisms	GDPR and POPIA checklists passed; audit logs maintained; user data deletion supported	Production environment	Data Processing Components

3. Reliability

The reliability of B.R.A.D ensures that forensic investigations can be conducted consistently and accurately. The system should gracefully handle failed URL submissions, avoid crashes during analysis, and recover from bot failures without corrupting data. High reliability builds trust in the system's outputs and enables analysts to depend on its results for critical decision-making.

Stimulus Source	Stimulus	Response	Response Measure	Environment	Artifact
System Users	Submission of various domains, including malformed or malicious ones	System should maintain stable operation and report errors clearly	99.9% uptime, bot recovers from crashes within 60 seconds	Production environment	Bot Engine and Report System

4. Scalability

Scalability is essential to support the analysis of many domain reports simultaneously. B.R.A.D must be able to grow with demand, especially during cyber incident spikes. It should process multiple domain submissions concurrently without bottlenecking the system or slowing down analysis pipelines. By ensuring scalability, the system can maintain optimal performance under high loads, enabling faster processing and quicker turnaround times for forensic results.

Stimulus Source	Stimulus	Response	Response Measure	Environment	Artifact
Multiple Users	Submission of multiple links at the same time	System should scale horizontally to handle multiple concurrent analyses	Supports 500+ concurrent domain submissions with average analysis < 10s/domain	Production environment	Domain Analysis Pipeline

5. Maintainability

B.R.A.D's architecture must allow for frequent updates such as patching vulnerabilities, integrating new threat intelligence feeds or adapting AI models. The system must be designed with modularity and clear interfaces between components (e.g., scrapers, AI, storage) so developers can make targeted changes without affecting the whole system.

Stimulus Source	Stimulus	Response	Response Measure	Environment	Artifact
Development Team	Requirement to update scraping logic or AI model	System should allow modular, low-risk updates with minimal downtime	Docker-based components, automated deployment pipeline, <5 min rollout	Development environment	Bot Container & AI Modules

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Architectural Design and Pattern

In developing the BRAD (Bot to Report Abusive Domains) system, several architectural patterns have been chosen to support the project's critical quality requirements.

Gatekeeper Pattern

The Gatekeeper Pattern is implemented in BRAD as a dedicated security layer that mediates all incoming traffic to the system. This component acts as a centralized entry point that handles user authentication, enforces role-based access control (RBAC), and verifies that each request meets the system's security and compliance policies. By introducing this pattern, BRAD directly addresses security, reliability, and compliance requirements. Unauthorized or malformed requests are blocked before reaching sensitive backend services such as the scraper or AI classifier. The Gatekeeper also integrates multi-factor authentication (MFA) for investigator accounts, further securing access to forensic data. In high-traffic or adversarial scenarios, it supports rate limiting, input sanitization, and logging to mitigate threats such as denial-of-service (DoS) attacks or injection attempts.

Quality Requirements Addressed:

1. **Security**: All requests are authenticated, authorized, and validated before reaching internal services, preventing unauthorized access and injection attacks.

2. **Reliability**: The Gatekeeper handles rate limiting, failover routing, and input filtering to protect internal services from overload or failure.

3. **Compliance**: Every access attempt is logged and checked against regulatory rules, ensuring adherence to GDPR and POPIA obligations.

Event-Driven Architecture (EDA)

The Event-Driven Architecture (EDA) enables BRAD to process large volumes of domain investigation requests by allowing system components to operate asynchronously in response to discrete events. When a user submits a suspicious URL, this event triggers a pipeline of subsequent actions such as scraping, malware scanning, AI-based risk scoring, and report generation each executed by specialized services. This pattern enhances scalability by enabling horizontal scaling of event consumers, allowing the system to handle multiple investigations concurrently. It also improves performance by decoupling producers (e.g., the submission module) from consumers (e.g., the scraper bot), enabling real-time, non-blocking execution. Reliability is also addressed through persistent event logs, which ensure that failed or interrupted processes can be recovered and replayed without data loss.

Quality Requirements Addressed:

1. **Scalability**: New event consumers can be added horizontally to meet increased demand during peak investigation periods.

2. **Performance**: Asynchronous processing enables faster throughput for multiple domain investigations running in parallel.

3. **Reliability**: Persistent queues and event logs allow retries and recovery if services fail mid-process.

Service-Oriented Architecture (SOA)

The Service-Oriented Architecture (SOA) is used to decompose BRAD into modular services such as Scrape-Service, Analyse-Service, and Report-Service, each responsible for a well-defined function. These services interact via standardized RESTful APIs, allowing them to operate independently and be developed, deployed, or scaled without disrupting the system as a whole. This directly improves maintainability, as updates or bug fixes in one service do not cascade into others. It also improves interoperability, enabling future integration with external systems such as threat intelligence databases or registrar reporting interfaces. Moreover, scalability is enhanced by the ability to scale only the services under load (e.g., multiple scraper instances during high-volume submissions) rather than the entire system.

Quality Requirements Addressed:

1. **Scalability**: Each service can be scaled based on load without affecting the others.

2.. **Maintainability**: Services can be independently updated or replaced, supporting long-term evolution.

3. **Interoperability**: Services follow standard formats and protocols (e.g., JSON, HTTP), enabling integration with external threat intel APIs.

Client-Server Model

The Client-Server Model is employed in BRAD to separate the frontend interfaces (client) from backend processing (server). The frontend includes the public user submission portal and the investigator dashboard,

both of which communicate with backend services over secured APIs. This pattern strengthens security, as all critical logic and sensitive data processing are centralized on the server, where access can be tightly controlled. It also supports compliance by allowing the server to enforce data validation, consent mechanisms, and logging in accordance with regulations like POPIA and GDPR. Additionally, the model enhances usability, as the client can be optimized for user experience without compromising backend integrity.

Quality Requirements Addressed:

1. **Usability**: A clear separation between UI and backend enables focused UX design for investigators and general users.

2. **Security**: The server centralizes sensitive operations, enforcing access control and API authentication.

3. **Compliance**: Client submissions are sanitized and validated on the server to meet data protection regulations.

Layered Architecture

The BRAD system applies a Layered Architecture within its backend, which includes both the API and the bot, to organize tasks into sequential, logical layers. This layered structure supports the execution of grouped subtasks in a defined order, improving modularity and control throughout the domain investigation process.

In the bot, the layered execution pipeline consists of:

- **Scrape Service**: Retrieves and collects data from the submitted domain.
- **Malware Detection Service**: Scans the scraped domain content for known malware signatures or suspicious behavior.
- **AI Analysis Service** *(executed within the API)*: Uses artificial intelligence to classify and assess the **risk level** of the domain based on patterns in threat data and previously seen indicators. This logic is kept secure by running it inside the API, which has direct access to the database and enforces access protection.
- **Report Service**: Compiles the output from previous layers into a structured report, ready for review by investigators.

By structuring backend services in layers, BRAD achieves a clear separation of concerns. Each service can be developed, tested, and modified independently. Sensitive operations such as AI-based threat assessment and data handling are encapsulated deeper in the backend (in the API), away from the public interface. This design choice improves system integrity, eases long-term maintenance, and strengthens protection from external threats.

Quality Requirements Addressed:

1. **Maintainability**: The bot's layered services can be updated or replaced individually (e.g., updating malware detection rules) without disrupting other layers.

2. **Security**: Core logic such as domain risk assessment and database operations is isolated within protected backend layers, reducing attack surface.

3. **Reliability**: Layers can be tested in isolation, allowing targeted error detection and ensuring that failures in one component do not cascade through the entire system.

Pipe and Filter Pattern

The Pipe and Filter Pattern underpins BRAD's core investigation pipeline, where data flows through a series of processing components (filters), each performing a specific task in the investigation pipeline:

Scrape → Detect Malware → AI Risk Analysis → Metadata Logging → Report Generation

Each component (filter) transforms the input and passes it along the pipeline. This modular design improves maintainability, as filters can be added, replaced, or removed without redesigning the entire flow. It also improves reliability by allowing error handling and fall-back mechanisms at each stage. Additionally, performance benefits from clearly defined processing stages, which can be parallelized or scaled independently when needed.

Quality Requirements Addressed:

1. **Maintainability**: Each step can be updated or replaced independently.

2. **Reliability**: The pipeline can resume at failed steps without reprocessing the entire chain.

3. **Performance**: Processing is streamlined through well-defined input/output interfaces.

Model-View-Controller (MVC)

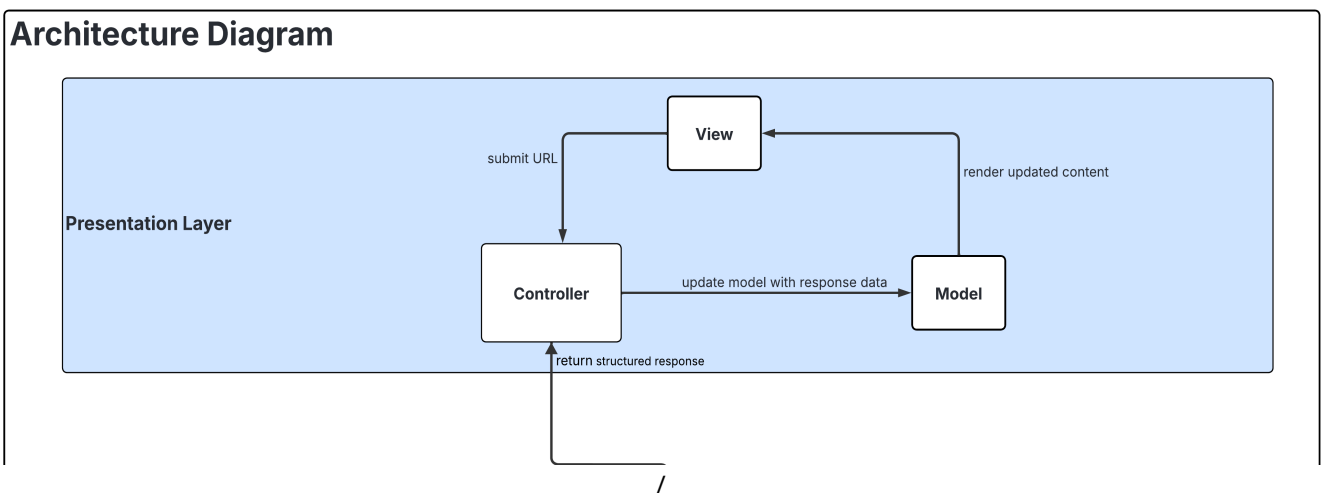
On the frontend, the Model-View-Controller (MVC) pattern is applied to the investigator dashboard to cleanly separate concerns. The model holds domain data and system state, the view renders the UI (e.g., graphs, logs, alerts), and the controller handles user input and orchestrates responses. This structure enhances usability by ensuring that the interface is responsive and intuitive. It also improves maintainability, as frontend developers can update visual components, logic, or data handling independently reducing the likelihood of bugs and simplifying testing.

Quality Requirements Addressed:

1. **Usability**: MVC supports responsive, interactive UIs.

2. **Maintainability**: Clearly separated concerns improve code modularity and testability.

Together, these architectural patterns form a unified blueprint for BRAD's development. Each pattern was chosen not only for technical elegance, but for its direct and measurable impact on the system's critical quality requirements. This ensures that BRAD is not only functional but secure, adaptable, and resilient in the face of ever-evolving cyber-security threats.



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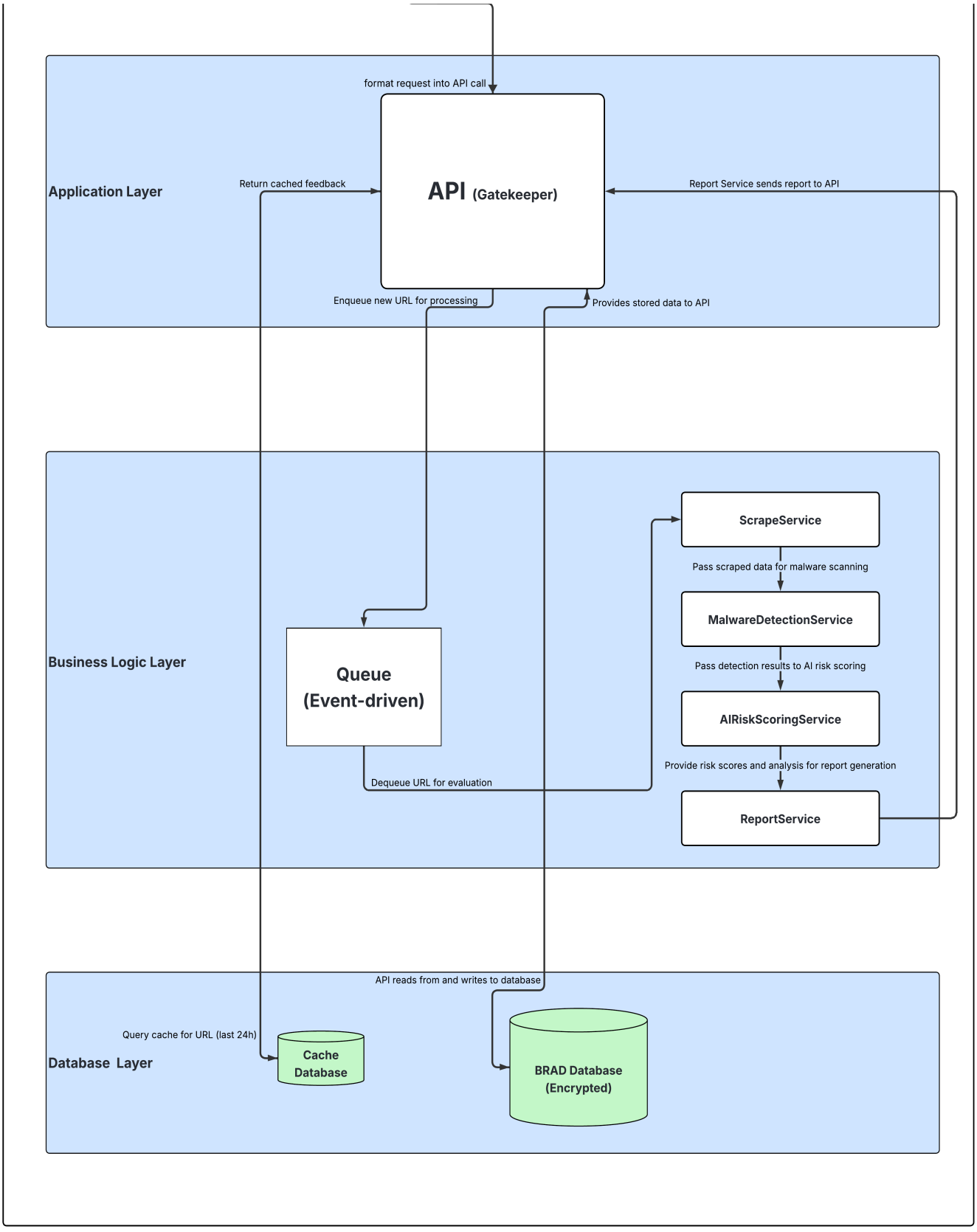

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Design Patterns

Chain of Responsibility

As a group, we have chosen the Chain of Responsibility design pattern as the fundamental approach to how the BRAD (Bot to Report Abusive Domains) system is architected. This pattern aligns naturally with the

system's core investigation pipeline, which follows a sequential flow: **Submission → Scraping → Malware Detection → Metadata Extraction → AI Risk Scoring → Report Generation**. Each stage in this chain represents a specialized processing component responsible for a specific task in the analysis workflow. By structuring BRAD's domain processing in this way, we ensure that data moves through clearly defined steps, allowing each module to operate independently while contributing to the overall forensic report generation.

We selected the Chain of Responsibility pattern because it provides clear separation of concerns, modularity, and flexibility, which are essential qualities for a cyber-security system that must evolve alongside new threats and technologies. This pattern allows us to insert, remove, or replace components in the processing chain (e.g., switching to a new AI model or adding a threat enrichment step) without disrupting the entire system. It also enhances maintainability, since each component is self-contained and testable in isolation, and improves reliability by enabling fine-grained error handling and fall-back mechanisms at each stage. Most importantly, it mirrors the linear and asynchronous nature of BRAD's domain analysis pipeline, making it a natural and effective fit for the architecture.

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Architectural Constraints

Adherence to Legal Standards and Regulations:

> **GDPR and POPIA Compliance**

The BRAD system must enforce strong data protection measures to comply with the General Data Protection Regulation (GDPR) and the Protection of Personal Information Act (POPIA). This includes encrypting sensitive data during submission, storage, and transmission, and ensuring that user consent is obtained before data is processed.

> **Audit Logging and Data Traceability**

To support compliance and forensic analysis, the system must maintain immutable logs of all critical events, including domain submissions, analysis results, and investigator actions. These logs must be securely stored and accessible for auditing without exposing sensitive information.

> **Access Control for Sensitive Operations**

Role-based access control (RBAC) must be implemented to restrict access to investigation tools and domain intelligence data. Investigators and admins must have different permissions than regular users, with multi-factor authentication required for elevated access.

Balancing Automation and Human Oversight:

> **Human-in-the-Loop Decision Making**

BRAD must allow investigators to review and override automated AI decisions, especially in cases where a domain is incorrectly flagged. This means the architecture should support both automated and manual review processes in a seamless workflow.

Technical Limitations and Deployment Constraints:

> **Budget and Infrastructure Limitations**

The system must run within the limits of the provided server resources. This constraint affects how services are deployed and scaled, requiring the use of lightweight containers and efficient background processing to avoid memory and CPU overuse.

Network Restrictions for Scraping

Some domains may block automated scraping using bot detection methods. To handle this, the architecture must support scraping strategies such as headless browsers, IP rotation, and custom user-agents to avoid detection and ensure data can still be collected.

False Positives in AI Classification

AI models are not perfect and may misclassify legitimate domains. The architecture must therefore include a manual verification layer and support model retraining or adjustment without disrupting the rest of the system.

Ethical and Data Handling Considerations:

Data Anonymization and Minimization

User-submitted URLs and metadata may include sensitive content. The system must limit the amount of personal data stored and ensure anonymization wherever full identification is not required for investigation purposes.

Transparency and Explainability

The risk classification system should produce results that investigators can understand and explain. This requires AI outputs to include confidence levels, contributing factors, or traceable indicators rather than just final labels.

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Technology Choices

Frontend

Final Choice: React.js with CSS

Languages/Frameworks Considered:

- Angular
- Vue.js
- React.js ✅

Justification:
React was selected due to its component-based structure, strong ecosystem, and excellent developer tools. CSS was used for styling due to its flexibility and familiarity.

Pros:

- Reusable components

- Huge ecosystem and community
- Easy integration with REST APIs
- Fine-grained styling control using CSS

Cons:

- Requires external tools (like Redux) for complex state
- CSS scalability can become challenging in large apps

Backend

Final Choice: NestJS (built on Node.js using JavaScript)

Languages/Frameworks Considered:

- Java (Spring Boot)
- Python (Flask/Django)
- JavaScript (NestJS) ✅

Justification:
NestJS was chosen for its structured and scalable approach to building backend services in JavaScript. It also integrates seamlessly with MongoDB and supports modular architecture.

Pros:

- TypeScript support and strong typing
- Modular and testable
- Great for building scalable APIs
- Active community and detailed documentation

Cons:

- More complex setup than Express.js
- Steeper learning curve due to decorators and dependency injection

---

Scraping Tools

Final Choice: BeautifulSoup & Playwright (both in Python)

Tools Considered:

- Puppeteer (JavaScript)
- Scrapy (Python)
- BeautifulSoup + Playwright ✅

Justification:
We chose BeautifulSoup for parsing static HTML and Playwright for dynamic content scraping. This Python-based combination gave us flexibility and power without the overhead of browser automation where it wasn't needed.

Pros:

- BeautifulSoup is lightweight and easy to use for parsing HTML
- Playwright handles JavaScript-heavy websites
- Python's readability helped speed up development

Cons:

- Requires managing both static and dynamic scraping logic
- Playwright can be heavier than basic scrapers
- Limited native JavaScript integration (compared to Puppeteer)

DevOps & Collaboration Tools

Tool	Purpose
Git	Version control
GitHub	Remote repository, issue tracking, CI/CD
Docker	Containerization for consistent environments
Swagger	REST API documentation and interactive testing

Programming Languages Used

Language	Used In
JavaScript	Backend (NestJS)
CSS	Frontend styling (React)
Python	Web scraping (BeautifulSoup, Playwright)

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Appendices

No content yet. Previous versions of the SRS will be added here as they become available.

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