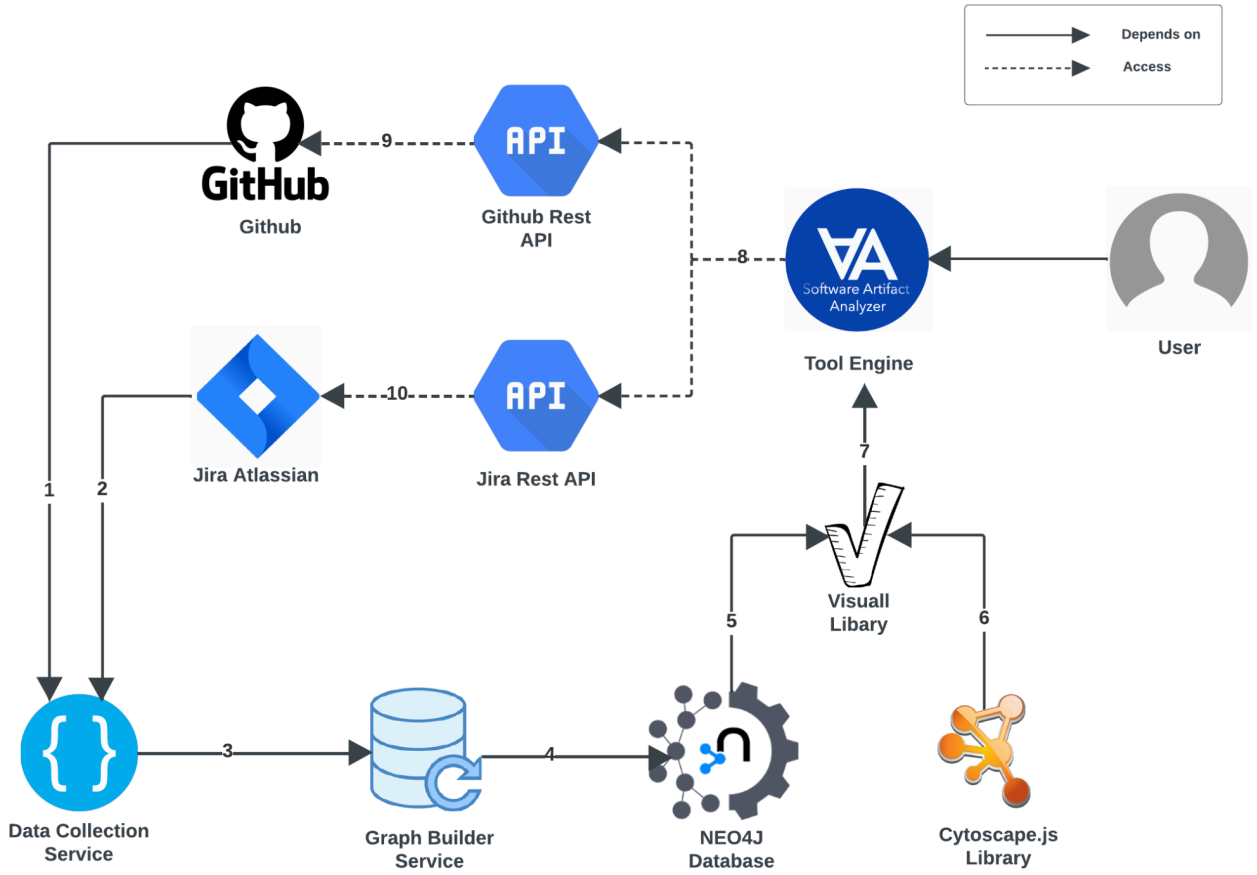
Software Artifact Analyzer Developer Guide

Version 1.0.0 January 2024

1 Introduction

This guide will show you how to develop new features inside the Software Artifact Analyzer tool (SAA), designed to enhance efficiency in software development processes. The SAA tool meticulously analyzes various software artifacts, including source code files, pull requests, issues, and commits, and their interconnected relationships with developers within a project. It uses an advanced drawing canvas with features such as a context menu, visual cues, and more to facilitate this comprehensive analysis. SAA uses a structured approach, and at its core is the open-source toolkit Visuall [1], which provides a solid foundation for its functionalities such as the user-friendly interface for developers to interact with the system. With this interface, developers can explore and make informed decisions by leveraging insights derived from the comprehensive artifact traceability graph. This guide details how a custom application can be integrated into SAA. We assume the reader has already gone over the SAA User Guide. As many features are inherited from the base toolkit Visuall [1], you might also want to refer to Visuall Develop Guide for details on customizations of generic features.



1.1 Current System Architecture

1, 2) Data Collection Service retrieves project data from respective backends as a JSON format.
3) The metadata is processed and cleaned by the data retrieval service to prepare it for use by the Graph Builder service.
4) Based on the prepared graph model, The Graph Builder Service creates and merges nodes and edges in the Neo4j database.
5) The database instance is connected to the Visuall [1] library.
6) Visuall [1] uses the Cytoscape.js library for web-based graphic and network visualization.

7) SAA engine is developed on top of the Visuall [1] toolkit and provides a user interface for developers to interact with the system.
8,9,10) The tool engine uses GitHub and Jira APIs, to access Github and Jira platforms to send data to these platforms through these APIs.

1.2 Build & Maintenance

To establish their development environment, developers can initiate the process by creating a fork of both repositories. It is recommended to fork all branches. Forking all branches ensures that developers have a complete replica of the original repository, including all development branches. This allows them to work on feature branches, bug fixes, or other changes without any limitations.

They can synchronize their forked repositories with the original repositories by executing the following commands:

```
# Add the original repository as a remote
git remote add base
https://github.com/iVis-at-Bilkent/software-artifact-analyzer.git
# Fetch all the commits from the original repository
git fetch base
git merge base/master
```

To selectively integrate specific commits from the original software-artifact-analyzer repository, developers can use the cherry-pick command:

```
# Fetch a specific commit
git cherry-pick -n 12ae1…
```

2 Data Collection & Graph Database

The data collection and graph-building tasks are orchestrated by the software-artifact-analyzer-configuration repository, which forms an integral part of SAA. The software-artifact-analyzer-configuration operates as a Flask Angular project, providing a user-friendly interface for users to retrieve their project data. The backend architecture comprises three distinct modules: data retrieval, data cleaner, and graph builder. Each module serves a specific purpose and is designed to be adaptable to new requirements.

2.1 Flask Server

The server.py file encompasses the definition of all API endpoints responsible for data retrieval, confirming cleaned data for use by the graph builder module, and handling various tasks in collaboration with the SAA. This includes tasks such as user authentication checks and interactions with the Jira API for comment submissions.

To start the flask server execute;

```
pip install -r requirements.txt
python server.py
```

2.2 UI

The user interface of the software-artifact-analyzer-configuration project is built on Angular. The central component is the stepper, which encapsulates each step of the data collection and graph-building process. Additional new steps can be seamlessly integrated into the stepper component to accommodate specific requirements of new analyses. The Angular project communicates with the Flask server, exchanging data through RESTful APIs.

To start the UI, first, you should navigate to the `ui` folder:

```
cd ui
```

Before running the Angular UI in development mode, make sure to install the project dependencies using:

```
npm install
```

To run the Angular UI in development mode, you can use the Angular CLI's `ng serve` command. This command compiles the application, launches the development server, and opens your application in a default web browser http://localhost:4200/.

```
npm run ng serve
```

To prepare your Angular application for production, you need to build the application using the Angular CLI's ng build command. After building, you can use a simple Node.js server to serve the production-ready application.

- Build the Angular application:

  ```
  npm run ng build
  ```

  This will generate a `dist/` directory containing the production-ready files.

- Start the Node.js server:

  ```
  npm start
  ```

By default, the server will start on port 4450. You can access your production-ready application by navigating to http://localhost:4450/ in your web browser. You can access the production-ready application through the SAA user interface's top navbar by navigating to "Project | New..." The production-ready application is embedded as an iframe within the SAA user interface.

2.3 Data Retrieval

The data retrieval module serves as a critical component within the software-artifact-analyzer-configuration repository, seamlessly integrating Perceval backends for the three primary data sources: Git, GitHub, and Jira. The intricate process involves retrieving data from each of these sources and storing it meticulously in the data folder, specifically in JSON format. For the incorporation of an additional data source, the procedure is as follows: the corresponding backend must be introduced into the data retrieval module. This newly integrated backend should

then undergo a transformation process, converting the retrieved data into JSON format. Subsequently, the processed data should find its place under the data folder.

```
/software-artifact-analyzer-configuration
|-- data
|    |-- git_commit.json
|    |-- github_pr.json
|    |-- jira_issue.json
|    |-- new_backend.json    # Example for the newly integrated backend
|-- data_retrieval
|    |-- data_retrieval.py
|    |-- perceval_git_commit.py
|    |-- perceval_github_pr.py
|    |-- perceval_jira_issue.py
|    |-- new_backend.py      # Corresponding file for the new backend
```

2.4 Data Cleaner

The data cleaner module is primarily responsible for identifying similar developers across different sources and merging them into a unified developer profile. This module is designed to function seamlessly without requiring any customization.

2.5 Graph Builder

The Graph Builder module serves as the bridge between your application and the Neo4j database instance. It facilitates the integration by establishing a secure connection. To initiate this connection, you must specify the bolt address of your Neo4j instance along with the required authentication credentials. These credentials, including the username and password for the Neo4j driver, should be carefully defined within the graphbuilder/GraphBuilder.py file.

The connectors/Neo4jConnection.py is instrumental in handling and executing various tasks, such as merging or creating new nodes and edges. The merging process involves utilizing source classes and methods, which are specific to each backend. For every type of artifact in our project, there is a corresponding source class. These source classes are responsible for creating instances based on retrieved data and are then used to merge or create the artifact in the Neo4j database.

If you're introducing a new backend for a different type of artifact, follow these steps:

1. *Define a new source class for the specific artifact type in the 'graph_builder/connectors/extra_source_classes.py' file. Let's call this class ArtifactType1. Define the structure and methods for handling ArtifactType1 data.*

   ```
   # graph_builder/connectors/extra_source_classes.py
   class ArtifactType1:
   ```

   Import the newly created source class (ArtifactType1) into the Neo4jConnection.py file.

   ```
   #graph_builder/connectors/Neo4jConnection.py
   from graph_builder.connectors.extra_source_classes import ArtifactType1
   ```

2. *Update the classes dictionary in the addMultipleArtifacts method in Neo4jConnection*

```
classes = {
    "git": GitCommit,
    "jira": JiraIssue,
    "github-pr": GithubPr,
    "artifacttype1": ArtifactType1,  # Add this line…}
```

3. *Add a new method to the Neo4jConnection class that includes the logic for merging ArtifactType1 and its respective edges into the graph.*

```
def __addArtifcat1(self, tx, artifact1: ArtifactType1, projectId,
analysisId):
```

4. *Update the methods dictionary in the addMultipleArtifacts method in Neo4jConnection*

```
methods = {
    "git": self.__addCommit,
    "jira": self.__addIssue,
    "github-pr": self.__addPullRequest,
    "artifact1": self.__addArtifcat1,  # Add this line
```

With these modifications, your Neo4jConnection class will be capable of handling the merging of the new artifact type (ArtifactType1) into the Neo4j database.

2.6 Creating and Connecting to a Neo4j Database

In SAA, we utilize Neo4j as our database management system. Developers may need to create their own Neo4j database instance for testing, development, or customization purposes. This section provides guidelines on how developers can establish a new Neo4j database instance and connect it to our system.

2.6.1 Establishing a New Neo4j Database Instance

Developers have the flexibility to create their own Neo4j database instances using various methods. Here, we discuss a common approach which is using Neo4j Desktop:

1. *Install Neo4j Desktop: If not already installed, download and install Neo4j Desktop from here.*

2. *Create a New Project: Open Neo4j Desktop and create a new project by clicking on the "Add" button and selecting "New Project."*

3. *Add a New Database: Within the created project, click on the "Add Database" button. Choose the desired Neo4j version and configure the database settings as needed.*

4. *Start the Database: Once configured, start the database instance by clicking on the "Start" button.*

2.6.2 Preparing the NEO4J Database Instance

Before connecting to the system, it is recommended to install essential plugins such as APOC. Additionally, if you are using custom procedures, ensure they are correctly configured and available within the Neo4j database instance.

Installing APOC (Awesome Procedures on Cypher): APOC is a popular library of procedures and functions for Neo4j, providing additional functionalities beyond what is available in the core Cypher language. Since our SAA utilizes APOC functionalities, it is essential to install the APOC plugin before connecting to the system.

1. *Open Neo4j Desktop: Launch Neo4j Desktop and select the desired project.*
2. *Add Plugin: In the project overview, click on the "Add Plugin" button.*
3. *Select APOC: Choose APOC from the list of available plugins and click "Install." Neo4j Desktop will automatically handle the installation process.*
4. *Restart Database: After installation, restart the Neo4j database instance associated with the project to apply the changes.*

Installing Custom Procedures: If you are using custom procedures in your SAA project, ensure they are correctly configured and available within the Neo4j database instance. You can check how to add custom procedures from section 5.

2.6.3 Connecting NEO4J Database Instance to the System

Once the Neo4j database instance is up and running, developers can connect it to the software-artifact-analyzer-configuration/graph-builder system using the Bolt protocol and the software-artifact-analyzer system using the HTTP protocol. Here's how to establish the connection:

1. *Obtain Bolt Address: Determine the Bolt address of the Neo4j database instance. This typically follows the format bolt://<host>:<port>.*
2. *Obtain HTTP Address: Determine the HTTP address of the Neo4j database instance. This typically follows the format http://<host>:<port>.*
3. *Update Configuration:*
    a. *For the software-artifact-analyzer-configuration, initiate this connection by specifying the Bolt address of your Neo4j instance along with the required authentication credentials. These credentials, including the username and password for the Neo4j driver, should be carefully defined within the GraphBuilder.py file.*
    b. *For the software-artifact-analyzer, update the environment files with the new HTTP address of the Neo4j database instance as described in Section 3.4.*

By following these steps, developers can establish connections between the Neo4j database instance and both the software-artifact-analyzer-configuration/graph-builder and software-artifact-analyzer systems, facilitating seamless data interaction and analysis.

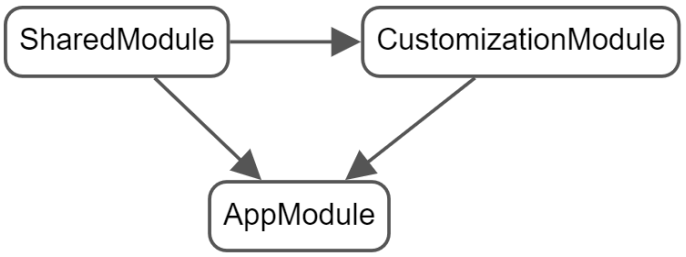
Additional Resources

For more detailed instructions on creating and configuring Neo4j databases, developers can refer to the official Neo4j documentation:

- Neo4j Desktop Documentation
- Establishing a New Neo4j
- Neo4j Documentation

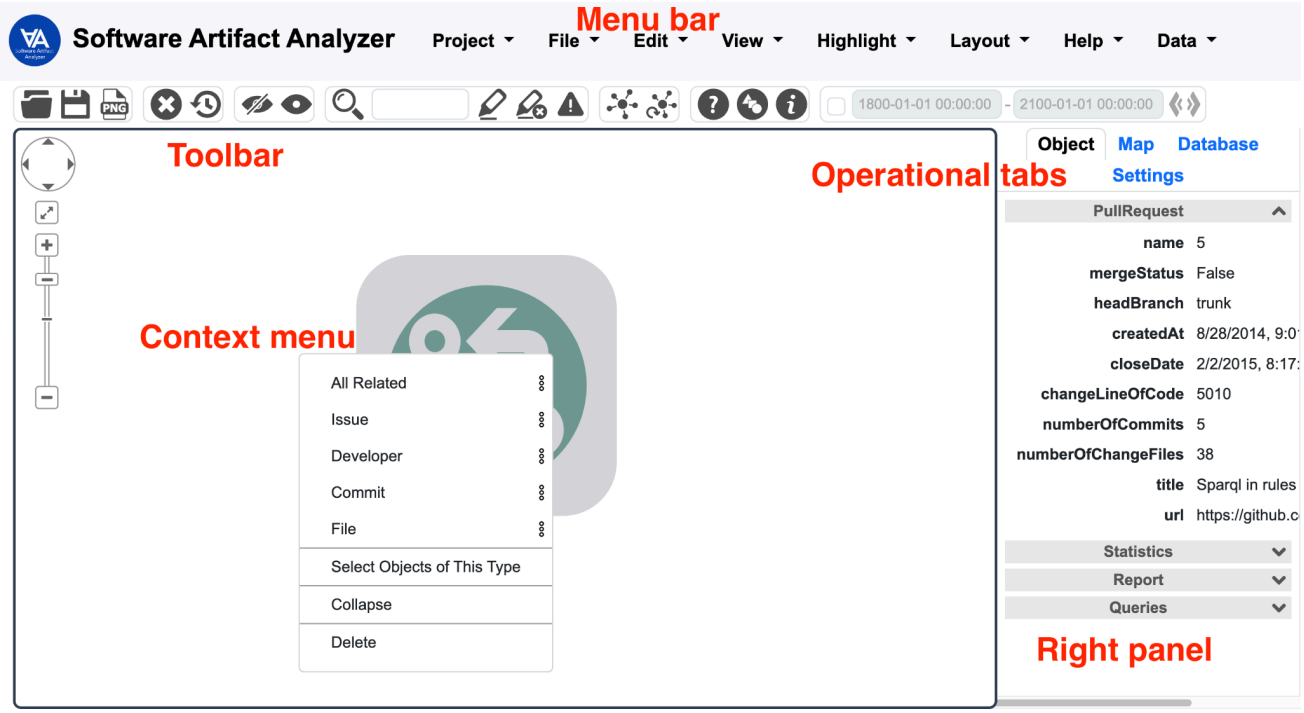
3 Custom Folder

SAA was created using Visuall [1]. Visuall is composed of three main Angular modules: AppModule, CustomizationModule, and SharedModule. To customize SAA to meet our specific requirements, we made changes to the CustomizationModule of the Visuall.



The custom folder includes 3 subfolders and a `customization.module.ts` file. Below you can find the explanation about each folder and file.

```
/src
|-- app
|    |-- custom
|    |    |-- analyses
|    |    |-- customization-service
|    |    |-- config
|    |    |-- operational-tabs
|    |    |-- customization.module.ts
```



3.1 config

The `config` folder includes configuration files such as `app-description.json` file and `enum.json`.

```
/custom
|-- config
|    |-- app_description.json
|    |-- enum.json
```

The `app_description` file includes the description for each node and edge type. You can refer to the Visuall Developer Guide for further explanation about the descriptions of graph elements.

To add a new node type or edge type:

1. *Define a new class of node (e.g., "Method") under the "objects" section with associated properties and data types.*
2. *If necessary, define a new edge type under the "Relations" section, specifying the source and target nodes.*
3. *If the new node or edge requires specific styling, update the "Styling graph objects" section accordingly.*
4. *Define the time mapping for the newly added edge and node types*
5. *If the new node type involves an enum property, update the "Enumeration Mapping" section and add corresponding values to "enums.json." Ensure that the necessary properties, data types, and styling configurations are properly set based on the requirements of the new node or edge type.*

Once this file is prepared, the style generator reads the description file and the Cytoscape.js style file and modifies `index.html`, `styles.css`, `properties.json`, and `stylesheet.json` files using the information in the description file. To do so:

- First, navigate to the `src` folder
- Then, execute `node style-generator.js` (by default it will use `app_description.json`)

Although it might not be necessary, it is recommended to always run this command after changing the description file.

Selecting Node Icon and Color

In the SAA drawing canvas, each node type is represented by an icon and assigned a specific color. The edges originating from nodes also adopt the same color scheme for consistency and clarity. When selecting icons for your nodes, it's essential to consider the following points:

- Use SVG icon images
- Ensure that icons for nodes are as round as possible to facilitate perpendicular edge connections from any location.
- Opt for dark colors when selecting node colors to enhance visibility and contrast within the interface.
- Prioritize simplicity and legibility when choosing iconography to maintain clarity and prevent visual clutter.

3.2 customization-service

The `customization-service` folder houses files dedicated to tailoring features from the Visuall [1], including the Menubar, toolbar, and context menu.

context menu

The context menu stands as a core feature within the SAA, facilitating effortless navigation between artifacts and developer nodes. Each node type must possess a type-specific context menu. Therefore, when introducing a new node type, it's imperative to define its context menu in the context-menu-customization.service.ts file.

> *To integrate the context menu for a new node type and ensure navigation across different node types, follow step-by-step instructions:*
>
> 1. *Within the context-menu-customization.service.ts file, introduce a context menu item tailored for the new node type. This involves specifying the menu items, labels, and actions associated with the context menu for seamless user interaction.*
> 2. *Go beyond merely adding the context menu for the new node type. Extend the other node types' context menus by seamlessly incorporating context menu options that establish meaningful connections with the new node type.*
> 3. *Include queries that illuminate relationships between the new node type and other existing node types. This ensures that users can effortlessly comprehend the associations and dependencies between different elements in the system.*

3.3 operational-tabs

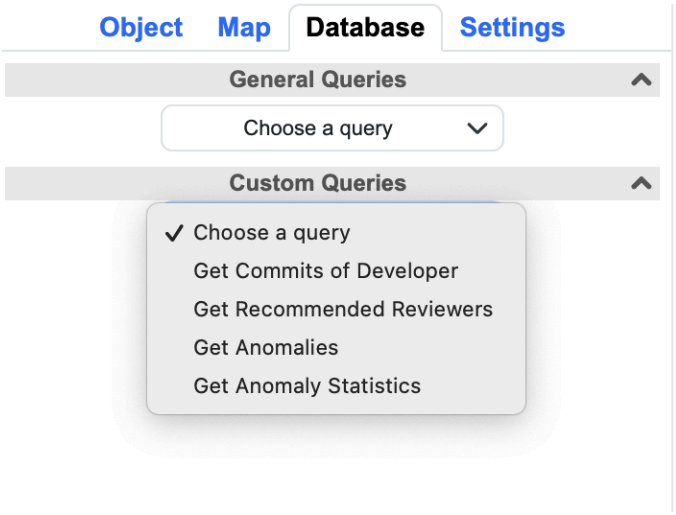
Operational tabs contain one subfolder for each operations tab. If developers wish to add a new sub-tab, they can place the relevant components in the corresponding folders within the operational tab where the new sub-tab is intended to be added. They also should add components into the subtab lists inside the customization.module.ts.

```
/custom
|-- operational-tabs
|    |-- object-tab
|    |-- map-tab
|    |-- database-tab
```

3.4 analyses

The `analyses` folder serves as a repository for housing various analysis components within a system. These analysis components can be strategically organized into two main categories: "custom queries," and "object queries".

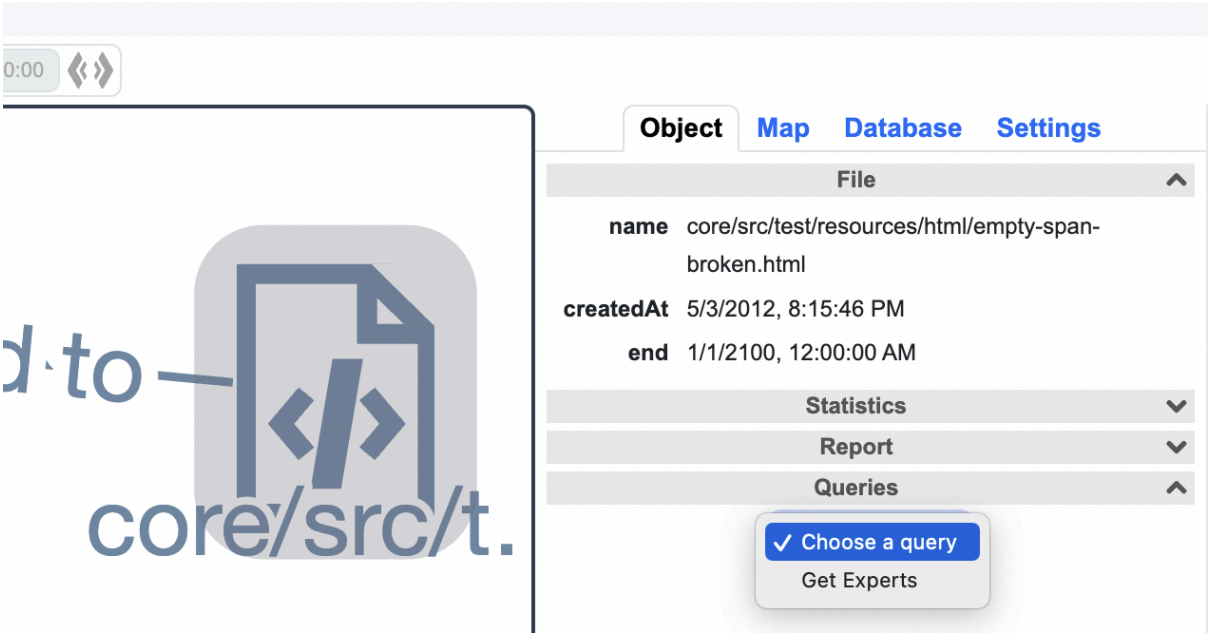
Custom Queries: Under the "custom queries" section of the `analyses` folder, developers have the flexibility to incorporate analysis components that cater to specific, user-defined queries or analytical processes. This section provides a dynamic space for the inclusion of custom-tailored analyses, allowing users to interact with the system in a way that aligns with their unique requirements and objectives. Custom queries often involve more generalized analyses that span across different node types, offering a broad spectrum of analytical capabilities within the application.



For adding a query component under custom queries you should add it to the list in the query list in the customization.module.ts.

Object Queries: The "object queries" section of the `analyses` folder is designated for analysis components that are intricately linked to specific node types within the system. These analyses focus on the characteristics, properties, and relationships associated with particular types of nodes. Placing these components under "object queries" enhances the organization and accessibility of node-specific analyses, streamlining the process for developers and users alike. Object queries

provide a more targeted approach to analyzing and extracting insights from the data associated with individual node types, ensuring a more fine-grained understanding of the information present in the system. Object queries are specific to each node type and they are under the queries subtab on the Object operational tab.



For adding a query component under object queries you should add it to the node type query list in the [object-queries.component.ts]
To add a new analysis component you can implement the QueryComponent interface by following these steps.

1. *Create an angular component inside the analyses folder*

   ```
   ng generate component analyses/MyQueryComponent
   ```

2. *Define a Data Model: Before implementing the QueryComponent, define the data model (T) that represents the structure of the data you'll present as a table response.*

   ```
   interface MyDataModel {
   // Define the properties of your data model here
   }
   ```

3. *Implement the QueryComponent Interface: Create a class that implements the QueryComponent interface. This class will serve as your analysis component.*

   ```
   export class MyQueryComponent implements
   QueryComponent<MyDataModel> {
     tableInput: TableViewInput = /* Initialize your TableViewInput
   */;
     tableFilled = new Subject<boolean>();
     tableResponse: MyDataModel = null;
     graphResponse: GraphResponse = null;
     clearTableFilter = new Subject<boolean>();
   ```

```
  ngOnInit(): void {
    // Implement the OnInit lifecycle hook if needed
  }

  prepareQuery(): void {
    // Implement the query preparation logic
  }

  loadTable(skip: number, filter?: TableFiltering): void {
    // Implement the logic to load table data
  }

  loadGraph(skip: number, filter?: TableFiltering): void {
    // Implement the logic to load graph data
  }

  filterGraphResponse(x: GraphResponse): GraphResponse {
    // Implement the logic to filter graph response
  }

  fillTable(data: MyDataModel[], totalDataCount: number | null):
void {
    // Implement the logic to fill the table with data
  }

  getDataForQueryResult(e: any): void {
    // Implement the logic to get data for a query result
  }

  filterTable(filter: TableFiltering): void {
    // Implement the logic to filter the table
  }

  filterTableResponse(x: MyDataModel[], filter: TableFiltering):
MyDataModel[] {
    // Implement the logic to filter the table response
  }
}
```

4. *Customize Query Logic: Customize the prepareQuery, loadTable, and loadGraph methods according to your specific data source and query requirements. Update the GraphQL queries, REST API calls, or other data retrieval methods accordingly.*

5. *Handle Data Processing: Customize the fillTable, filterGraphResponse, filterTable, and filterTableResponse methods to handle the processing and manipulation of the retrieved data based on your application's needs.*

6. *Designing the HTML template and style it according to your analysis*

You can easily reference the existing analysis components, such as UnassignedBugsComponent, to gain insights into the implementation details. By making minor modifications to the methods and structure, you can tailor the component to meet the specific requirements of your analysis.

3.4 Database Connection

To connect to the database, Software Artifact Analyzer uses environment variables. For each different environment you would like to use, you should add a new environment file. You can make your own files similar to these: `environment.ts` and `environment.heroku.ts`.

4 Starting Software Artifact Analyzer

Development Mode

Before running the Software Artifact Analyzer in development mode, make sure to install the project dependencies using;

```
npm install
```

To run the Software Artifact Analyzer in development mode, you can use the Angular CLI's ng serve command. This command compiles the application, launches the development server, and opens your application in a default web browser http://localhost:4200/.

```
npm run ng serve
```

Production Mode

To prepare your Angular application for production, you need to build the application using the Angular CLI's ng build command. After building, you can use a simple Node.js server to serve the production-ready application.

- Build the Angular application:

  ```
  npm run ng build
  ```

  This will generate a `dist/` directory containing the production-ready files.

- Start the Node.js server:

  ```
  npm start
  ```

By default, the server will open on port 4400. You can access your production-ready application by navigating to http://localhost:4400/ in your web browser.

For both the development mode and the production mode, you should also start the Software-Analyzer-Configuration application flask server and UI as described in Sections 2.1 and 2.2, respectively.

5 Custom Procedure

A user-defined procedure is a mechanism that enables you to extend Neo4j by writing customized code, which can be invoked directly from Cypher. Currently, for deploying custom queries for the SAA we add them into the saa-advanced-query project. The saa-advanced-query repository is a fork of the original visuall-advanced-query repository, which serves as a foundation for advanced query capabilities in the context of the Visuall [1] toolkit. The primary objective of saa-advanced-queries is to extend the functionality provided by the original repository to cater to the specific requirements of the SAA and its team of developers. This extension includes the addition of custom Java-based Neo4j procedures tailored to the needs of the SAA. Before beginning to write your custom procedure please review the existing NEO4J document to familiarize yourself with the process. You can access it from here.

Here's a guideline for incorporating custom Java-based procedures into the saa-advanced-queries repository for Neo4j:

1. Set Up Your Development Environment: Ensure that your development environment is set up properly for Java development, including IDE setup and dependency management.
2. Clone the Repository: Clone the saa-advanced-queries repository to your local machine. (we are currently using the unstable version)
3. Create a Feature Branch: Create a new feature branch from the unstable branch where you will add your custom procedures. Make sure the branch name is descriptive of the feature you're adding.
4. Implement Your Custom Procedure: Implement your custom Java-based procedure following the standards and conventions of Neo4j procedures. Refer to the existing procedures and the Neo4j documentation for guidance.
5. Test Your Procedure: Thoroughly test your procedure to ensure it works as expected. This includes unit tests as well as integration tests with Neo4j. You can write your test inside the AdvancedQueryTest.java
6. Update README and Documentation: Update the README file and any other relevant documentation to include information about your new procedure. This ensures that other developers are aware of its existence and how to use it.
7. Create an Executable Jar File: Build your project to create an executable JAR file containing your custom procedure along with any dependencies.
   ```
   mvn clean install
   ```
8. Add executable JAR files containing custom procedures as plugins to Neo4j:
   a. Find the plugins directory within your Neo4j installation. This directory is typically named plugins and is located within the Neo4j installation directory.
   b. Copy the JAR File: Copy the executable JAR file containing your custom procedures into the plugins directory.
   c. Restart Neo4j: Restart the Neo4j database server to allow it to detect and load the newly added plugin. This step is essential for Neo4j to recognize and make use of the custom procedures contained within the JAR file.
9. Verify Installation: Once Neo4j has restarted, verify that the custom procedures from your JAR file have been successfully loaded and are available for use. You can do this by checking the Neo4j logs for any errors during startup and testing the custom procedures' functionality through Cypher queries.

10. Usage in Cypher Queries: With the custom procedures successfully installed as plugins, you can now use them in Cypher queries within Neo4j. Invoke the procedures using the CALL syntax followed by the procedure name and any required parameters.

References

[1] i-Vis Research Laboratory. 2021. “Visuall: A tool for convenient construction of a web-based visual analysis component”, Bilkent University, Ankara, Turkey.