

## School of Bioinformatics Engineering Faculty of Engineering

**The University of New South Wales**

**Designing and Developing Backend Services for a FHIR-based Questionnaire Management System**

by

Benjamin Charlton

Thesis submitted as a requirement for the degree of Bachelor of Engineering in Bioinformatics Engineering

Supervisor: Prof Nigel Lovell Submitted: 28/04/21

Assessor: Dr Reza Argha Student ID: z5160423

# **Abstract**

This document describes the requirements to theses submitted for the Bachelor of En- gineering in Bioinformatics Engineering degree at the School of Computer Science Engineering. Requirements described are that of both of context and layout of the theses. The document is written using the LATEX template provided by the school.

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# **Abbreviations**

**API** Application Programming Interface

**FHIR** Fast Healthcare Interoperability Resources

**GUI** Graphical User Interface

**HIPAA** Health Insurance Portability and Accountability Act of 1996

**HL7** Health Level 7

**REST** Representational State Transfer

**SDC** Structured Data Capture

**SMART** Substitutable Medical Applications, Reusable Technologies

**SSL** Secure Socket Layer

**TLS** Transport Layer Security

**URL** Uniform Resource Locator

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# **Chapter 1**

# **Introduction**

Fast Healthcare Interoperability Resources (FHIR) is a standardfirst released in 2014 that describes data formats and an API intended to facilitate the exchange of healthcare information between healthcare providers, patients, researchers, and anyone else involved in the healthcare system [6].

Prior to the FHIR standard, the majority of health information exchange and data interoperability was predominantly centred around documents, using the HL7 v2 standard and later the HL7 v3 standard [22]. While this approach provided the foundations for healthcare interoperability and continues to help healthcare organizations communicate information, it is too limiting for meaningful care coordination, decision-making, or data analytics. Additionally, even though HL7 v3 was theoretically deeply and conceptually developed, the standard was deemed too complex at the implementation stage and hence sparked the creation of the FHIR standard [22].

With the creation of this popular, well documented web standard, it was hoped that FHIR would allow the simplistic exchange of healthcare data by lowering of the barrier-to-entry for healthcare providers that want to find new ways to monitor and derive insights from that clinical and patient data [20].

This monitoring and deriving of patient data can be done through forms, of which the FHIR specification has introduced a number of resources to facilitate the use of such forms. Questionnaires are one such resource that have been utilised in recent years to capture data in the healthcare domain, and can prove extremely beneficial in providing meaningful care coordination.

In this report, it is the intention to review elements of current adoptions of the FHIR specification, with a primary focus on the Questionnaire resource. In the context of what has already been achieved, it will then detail a proposal for developing backend services for a FHIR-based Questionnaire management system.

# **Chapter 2**

# **Background**

**2.1 FHIR Overview**

The philosophy behind FHIR is to build a base set of resources that, either by themselves or when combined, satisfy the majority of common use cases in the healthcare domain, using a composition approach [6]. FHIR also aims to simplify implementation without sacrificing information integrity, and it is able to do so by utilising the two main components that form the information exchange model – ‘resources’, and RESTful interfaces [1].

The basic building block in FHIR is a resource, and all exchangeable content is defined as a resource sharing the following set of characteristics; a common way to define and represent them, a common set of metadata, and a human readable part [6]. To manipulate these resources in a simple yet meaningful way, a RESTful API is provided with a rich set of interactions.

Unlike the previously adopted formal standard (HL7), it has been specifically designed for use within the web, providing resources and foundations based in XML, JSON, HTTP and OAuth structures [21]. The tools it provides can be used to improve interoperability in systems – in mobile phones, cloud communications, EHR-based data sharing and amongst institutional healthcare providers.

Broadly speaking, the specification is divided into three components; general documentation, which details how the resources are defined and provides background information such as definition of data types; implementation, which details how to use the resources using REST or messages; and the resource list itself.

# 

# **2.2 FHIR Resource Definitions**

**2.2.1 Resource Overview**

Resources form the foundation for the FHIR specification. Each resource entity; has a known identity (URL) by which it can be addressed; identifies itself as one of the types of resource defined in the specification; contains a set of structured data items as described by the resource definition, and an identified version that changes if the contents of the resource change [10].

These features present themselves in the form of the following; a URL that identifies the resource; common metadata; a human-readable XHTML summary, and a set of defined data elements (a different set for each type of resource) [7].

The identifying URL however is not represented inside the resource; the value arises in a context use, and changes as copies of the resource are made, or following other deployment/security related changes. If the resource is accessed via the FHIR RESTful API, then the URL for the resource is [base]/[resourceType]/[id] where the resourceType and id come from the resource [20].

There are currently 145 different resource types defined in the FHIR specification, and for the purpose of this project, the primary focus will be on the Questionnaire and QuestionnaireResponse resources. These resource instances can be represented in either a XML, JSON or RDF format [20].

**2.2.2 Questionnaire Resource**

Questionnaires are an organized collection of questions intended to solicit information from patients, providers or other individuals involved in the healthcare domain [9]. They can be variably built, and may be simply a flat list of questions, or can be hierarchically organized into groups and sub-groups, each containing questions. They define the questions to be asked, how they are ordered and grouped, provide any instructional text and define what the constraints are on the allowed answers [9]. Once they have been appropriately completed, the results are communicated using the QuestionnaireResponse resource.

The Questionnaire structure is composed of two components – the questionnaire and item components. The questionnaire component contains the information about the Questionnaire itself, such as the identifier, the publisher, date authored and title. Items have one of three sub-types, distinguished by the type element [9]. These sub-types are; display, which convey text to be rendered on the form and will not capture data; group, which organise content of the questionnaire into sections and sub-sections, and question, which ask a specific question to which an answer may be input [9].



*Figure* *1*: Example Questionnaire resource JSON

**2.2.3 QuestionnaireResponse Resource**

The QuestionnaireResponse resource provides a complete or partial list of answers to a set of questions filled when responding to a Questionnaire, covering the need to communicate data originating from forms used in medical history examinations, research questionnaires and full clinical specialty records [12]. The questions referenced by the resource are either included directly, or by referencing a questionnaire resource that defines the questions answered, as well as the constraints on the allowed answers. In many systems this data is collected using user-defined screens and forms, although for the purpose of this project the format of user data collection will not be considered, as it will primarily focus on creating platform agnostic API’s.

Each time a Questionnaire is completed for a different subject or at a different time, a distinct QuestionnaireResponse is generated, and this response may be stand-alone or may point to the definition of the questions in the Questionnaire [12]. If it refers to a Questionnaire; the QuestionnaireResponse structure must be consistent with the Questionnaire – meaning that questions must be organised into the same groups and nested questions must still be nested; the linkId element for the questions and groups must be consistent across the resources, and all items in the questionnaire should be included in the response if they are relevant to the interpretation of the answers [12].

# **2.3 FHIR RESTful API**

All of the resource types described in the specification have the same set of interactions defined that can be used to manage and manipulate the resources in a granular fashion. The following interactions defined are the interactions that will be implemented in this project.

It is also important to note that in this RESTful framework, transactions are performed directly on the server resource using an HTTP request/response, meaning that the API does not directly address authentication.

**2.3.1 Create**

The create interaction creates a new resource in a server-assigned location. If the client wishes to have control over the id of a newly submitted resource, it should use the update interaction instead [7**]**.

POST [base]/[type] {?\_format=[mime-type]}

**2.3.2 Read**

This returns a single instance with the content specified for the resource type [7**]**.

GET [base]/[type]/[id] {?\_format=[mime-type]}

**2.3.3 Search**

This interaction searches a set of resources based on some filter criteria [7**]**.

GET https://example.com/path/{resourceType}?criteria

**2.3.4 Update**

The update interaction creates a new current version for an existing resource or creates an initial version if no resource already exists for the given id [7**]**.

PUT [base]/[type]/[id] {?\_format=[mime-type]}

**2.3.5 Delete**

The delete interaction removes an existing resource [7**]**.

DELETE [base]/[type]/[id]

In the context of the proposed project, the formal *mime-type* to be used by the server will be *application/fhir+json*, indicating that the resource is under a JSON format.

# 

# **2.4 Existing FHIR Servers**

**2.4.1 FHIR Server for Azure**

FHIR Server for Azure is an open-source implementation of the FHIR standard  designed for the Microsoft cloud. With data in the FHIR format, the server enables users to quickly ingest and manage FHIR datasets in the cloud, track and manage data access and normalise data for machine learning workloads [17].

It is built with logical separation, giving developers the flexibility to modify how it is implemented, and extend its capabilities as needed. The components of the logically separated system are as follows; a hosting layer, which supports hosting in different environments; a RESTful API layer, which is the implementation of the API’s defined in the FHIR specification; the core logic layer, and finally a persistence layer, which is a pluggable persistence provider enabling the server to connect to virtually any data repository [17]. The server is set up with a persistence provider in Azure Cosmos DB, which is a NoSQL database.

The entire server is excessive for the level of the proposed project, however it employs a similar architecture in terms of implementation of the FHIR API’s, and is hence important to understand. It is also built with the same principle in mind - allowing developers to quickly integrate a FHIR server into their own applications or providing them with a foundation on which they can customize their own FHIR service [17].

**2.4.2 Firely Server**

Another FHIR server that has been developed since the release of the standard is the Firely Server. It is an enterprise-grade server out of the box built with .NET, but displays slightly more functionality than a seemingly simple FHIR server– it is a processing pipeline for handling standard and custom FHIR requests [2].

The system’s structure consists of this pipeline filled with processors to handle the interactions defined in the FHIR RESTful API. With plugins – which are technically a .NET core assembly containing well-defined configuration methods [2], there are a variety of options to add processors to the framework to perform custom operations.

There are two key features to the server that are particularly relevant to the context of this project, namely the support for the features in the FHIR RESTful API, and the HIPAA compliance of the system. Firely server supports the create, read, update, patch and delete operations as per the specification. It is also well-tested and secure, enabling compliance with the Technical Safeguards of the HIPAA Security Rule [3].

It is important to note here how other servers implement safety and security features when considering sensitive electronic health data, as it can serve as a basis to better understand the most suitable method of securing data and transmissions in the context of the proposed project.

Within the server, there are several ways to approach the implementation of procedures to allow access only to those that have been granted access rights [3];

1. By ensuring that the Firely Server is deployed in a secure environment where only those with correct permissions are able to access it.
2. By implementing support for Smart on FHIR, a sibling specification to FHIR for securely connecting third-party applications to electronic health record data as a means of controlling access.
3. By establishing custom authentication. Given how the server is based on a pipeline architecture, it is possible to insert a plugin at the start of the pipeline to call out to a chosen authentication service prior to handling the request.

Additionally, transmission security in the server can be achieved by encrypting the communications with TLS/SSL, and the standard industry practice is to use a reverse proxy such as nginx for this purpose [3].

# **2.5 Existing Questionnaire-Specific Implementations**

Whilst there is extensive documentation on FHIR resources, and a number of publicly available open-source server implementations, there is little information regarding the specific use of the Questionnaire resource in applications. However, there is an SDC application currently in development by the LHNCBC that allows for structured data capture using their form locator, but is not for production use.

The FHIR SDC SMART App is an open-source app that establishes a connection with a pre-existing FHIR Server and provides an interface for selecting Questionnaires, entering information, and saving this data [15]. "Structured Data Capture" here refers to a FHIR questionnaire profile and represents a collection of extensions to the standard Questionnaire definition, allowing for things such as data pre-population and extraction, and advanced form rendering [14]. However, as the LHNCBC suggests, this is really relatively new technology and is currently still in production [15].

Figure 2 displays a number of important features of the application, and highlights the type of features that might be required of a FHIR server that specifically implements API’s relevant to the Questionnaire and QuestionnaireResponse resources. The application requires a connection to a FHIR server, after which the user is able to select a stored patient profile and for that particular patient, is then able to view available Questionnaires, complete and save the response before then viewing the saved responses.

# **2.6 Current FHIR Integrations**

There are a number of useful applications for Questionnaires in the health industry, used as an invaluable resource to gather information from various healthcare participants. These areas include, but are not strictly limited to, assessments provided by both practitioners and patients, general surveys, ways to gather general data and provide referrals, and other pathological diagnostic practices [5].

Currently, a number of multi-national entities involved in the health care informatics field have either shown interest in or been experimenting with FHIR, including CommonWell Health Alliance, and SMART. In 2018, Apple announced that its iPhone Health App would enable users to view a user’s FHIR-compliant medical records, on the condition that providers choose to make them available [23]. Other large stakeholders such as Microsoft, Google, Amazon, IBM and Oracle have built FHIR servers and are integrating FHIR data.

With the integration of FHIR into large systems like Google or Amazon, opportunities for meaningful care coordination are unlocked, specifically in regards to the use of Questionnaire and QuestionnaireResponse resources.

# 

# **2.7 Problem Space**

Clearly, with the increasing use and development of resources surrounding FHIR, and a number of valuable use cases for Questionnaires, it would prove worthwhile to make Questionnaire generation as widely accessible as possible to all healthcare systems.

However, whilst there are extensive specifications on the Questionnaire resources themselves, there is limited information available on the tangible creation of Questionnaires themselves. There is seemingly only one publicly available form generator, that requires a connection to a pre-existing FHIR server in order to implement. This form generator has been produced by the LHNCBC for use with their SDC Questionnaire App, and can be seen in figure 3 below.

# **2.8 Aims and Outcomes**

**2.8.1 Purpose**

The purpose of this project is to provide simple, accessible methods for Questionnaire and Questionnaire response generation and retrieval, whilst enabling the modularisation of such questionnaires in the hopes that they are reusable across various health domains.

**2.8.2 Functional Requirements**

1. Data structures and database must be designed so that questionnaire data can be stored under the FHIR standard
2. Variable questionnaires (for any project specification) must be able to be created using API’s, and must persist within the database.
3. Server must provide implementation of the FHIR RESTful API’s for questionnaire data irrespective of what OS underpins the client infrastructure.
4. The API data structure must be generic enough so as to use the same API for all topic of questionnaires
5. There must be form validation when users generate new Questionnaires, to validate it is in the appropriate format
6. Server to server communication must be authenticated appropriately

# **Chapter 3**

# **Methods**

# **Chapter 4**

# **Results**

# **Chapter 5**

# **Evaluation**

# **5.1 Meeting Functional Requirements**

# **5.2 Testing**

**5.2.1 Unit Testing**

|  |  |
| --- | --- |
| *Table 1: Resource Request Testing Logs – Average Request Execution Time After 10 Iterations (seconds)* | |
| *Request* | *Average Execution Time (seconds)* |
| GET Questionnaire (success) | ~ 0.35 |
| GET Questionnaire (failure) | ~ 0.26 |
| POST Questionnaire (success) | ~ 0.36 |
| POST Questionnaire (failure) | ~ 0.25 |
| DELETE Questionnaire (success) | ~ 0.31 |
| DELETE Questionnaire (failure) | ~ 0.25 |
| GET QuestionnaireResponse (success) | ~ 0.34 |
| GET QuestionnaireResponse (failure) | ~ 0.22 |
| POST QuestionnaireResponse (success) | ~ 0.33 |
| POST QuestionnaireResponse (failure) | ~ 0.22 |
| DELETE QuestionnaireResponse (success) | ~ 0.33 |
| DELETE QuestionnaireResponse (failure) | ~ 0.21 |
| GET User (success) | ~ 0. |
| GET user (failure) | ~ 0. |
| POST User (success) | ~ 0. |
| POST User (failure) | ~ 0. |

**5.2.2 Pressure Testing**

Average Get Response Time (over 100 consecutive requests) with 1000 Questionnaires in the database: 0.38 seconds

When performing the stress testing, it is important to note that there are outliers that are not included in the average calculations for request execution time. These outliers are significantly slower than the average request time, and occurred due to lags in the internet connection, causing a delayed response time.

**5.2.3 Usability Testing**

# **5.3 Known Issues**

# **5.4 Potential Enhancements**

# **Chapter 6**

# **Conclusion**

# **Appendices**

**Appendix A:** *GET Questionnaire Testing Logs*

|  |  |
| --- | --- |
| ---TESTING INVALID AUTH---  -- TIME --: 0.34365415573120117  .---TESTING SUCCESSFUL GET LARGE ---  -- TIME --: 0.3288830280303955  .---TESTING SUCCESSFUL GET 1 ---  -- TIME --: 0.39229211807250977  .---TESTING SUCCESSFUL GET 2 ---  -- TIME --: 0.383433198928833  .---TESTING SUCCESSFUL GET 3 ---  -- TIME --: 0.3563319206237793  .---TESTING SUCCESSFUL GET 4 ---  -- TIME --: 0.30444884300231934  .---TESTING SUCCESSFUL GET 5 ---  -- TIME --: 0.3601799964904785  .---TESTING SUCCESSFUL GET SMALL ---  -- TIME --: 0.34801397323608398  .---TESTING GET WITH NO RESOURCE FOUND  -- TIME --: 0.2530439853668213  .---TESTING WITHOUT AUTH---  -- TIME --: 0.2724867820739746 | ---TESTING INVALID AUTH-  -- TIME --: 0.5449790954589844  .---TESTING SUCCESSFUL GET LARGE ---  -- TIME --: 0.32290992736816406  .---TESTING SUCCESSFUL GET 1 ---  -- TIME --: 0.382487154006958  .---TESTING SUCCESSFUL GET 2 ---  -- TIME --: 0.3118840217590332  .---TESTING SUCCESSFUL GET 3 ---  -- TIME --: 0.3604038715362549  .---TESTING SUCCESSFUL GET 4 ---  -- TIME --: 0.36896204948425293  .---TESTING SUCCESSFUL GET 5 ---  -- TIME --: 0.3235100269317627  .---TESTING SUCCESSFUL GET SMALL ---  -- TIME --: 0.34850797653198242  .---TESTING GET WITH NO RESOURCE FOUND  -- TIME --: 0.26245007514953613  .---TESTING WITHOUT AUTH---  -- TIME --: 0.2524181365966797 |
| ---TESTING INVALID AUTH---  -- TIME --: 0.27542791366577148  .---TESTING SUCCESSFUL GET LARGE ---  -- TIME --: 0.31213626861572266  .---TESTING SUCCESSFUL GET 1 ---  -- TIME --: 0.3799379825592041  .---TESTING SUCCESSFUL GET 2 ---  -- TIME --: 0.3602407932281494  .---TESTING SUCCESSFUL GET 3 ---  -- TIME --: 0.3593100070953369  .---TESTING SUCCESSFUL GET 4 ---  -- TIME --: 0.3513289451599121  .---TESTING SUCCESSFUL GET 5 ---  -- TIME --: 0.36715993881225586  .---TESTING SUCCESSFUL GET SMALL ---  -- TIME --: 0.3897069454193115  .---TESTING GET WITH NO RESOURCE FOUND  -- TIME --: 0.26413402557373047  .---TESTING WITHOUT AUTH---  -- TIME --: 0.27374801635742188 | ---TESTING INVALID AUTH---  -- TIME --: 0.26653728485107422  .---TESTING SUCCESSFUL GET LARGE ---  -- TIME --: 0.30398378372192383  .---TESTING SUCCESSFUL GET 1 ---  -- TIME --: 0.37465295791625977  .---TESTING SUCCESSFUL GET 2 ---  -- TIME --: 0.3613658905029297  .---TESTING SUCCESSFUL GET 3 ---  -- TIME --: 0.3337528705596924  .---TESTING SUCCESSFUL GET 4 ---  -- TIME --: 0.3568037509918213  .---TESTING SUCCESSFUL GET 5 ---  -- TIME --: 0.34181008338928223  .---TESTING SUCCESSFUL GET SMALL ---  -- TIME --: 0.33650097846984863  .---TESTING GET WITH NO RESOURCE FOUND  -- TIME --: 0.15289998054504395  .---TESTING WITHOUT AUTH---  -- TIME --: 0.14199590682983398 |

**Appendix B:** *POST Questionnaire Testing Logs*

|  |  |
| --- | --- |
| ---TESTING INVALID AUTH---  -- TIME --: 0.18640899658203125  .---TESTING INVALID RESOURCE ---  -- TIME --: 0.12900972366333008  .---TESTING LARGE RESOURCE ---  -- TIME --: 0.3317229747772217  .---TESTING RESOURCE 1---  -- TIME --: 0.3690040111541748  .---TESTING RESOURCE 2---  -- TIME --: 0.23726797103881836  .---TESTING RESOURCE 3---  -- TIME --: 0.3692951202392578  .---TESTING SMALL RESOURCE ---  -- TIME --: 0.444658041000366  .---TESTING NO RESOURCE ---  -- TIME --: 0.09465599060058594  .---TESTING USER NOT FOUND---  -- TIME --: 0.19002175331115723  .---TESTING WITHOUT AUTH---  -- TIME --: 0.19500184059143066  .---TESTING INVALID RESOURCE ---  -- TIME --: 0.09807395935058594 | ---TESTING INVALID AUTH---  -- TIME --: 0.303584098815918  .---TESTING INVALID RESOURCE ---  -- TIME --: 0.12362980842590332  .---TESTING LARGE RESOURCE ---  -- TIME --: 0.6780669689178467  .---TESTING RESOURCE 1---  -- TIME --: 0.43164587020874023  .---TESTING RESOURCE 2---  -- TIME --: 0.6095597743988037  .---TESTING RESOURCE 3---  -- TIME --: 0.4261281490325928  .---TESTING SMALL RESOURCE ---  -- TIME --: 0.2504279613494873  .---TESTING NO RESOURCE ---  -- TIME --: 0.11321115493774414  .---TESTING USER NOT FOUND---  -- TIME --: 0.1896052360534668  .---TESTING WITHOUT AUTH---  -- TIME --: 0.2220611572265625  .---TESTING INVALID RESOURCE ---  -- TIME --: 0.11014294624328613 |
| ---TESTING INVALID AUTH---  -- TIME --: 0.2146511077880859  .---TESTING INVALID RESOURCE ---  -- TIME --: 0.11085700988769531  .---TESTING LARGE RESOURCE ---  -- TIME --: 0.646460771560669  .---TESTING RESOURCE 1---  -- TIME --: 0.3623816967010498  .---TESTING RESOURCE 2---  -- TIME --: 0.2870008945465088  .---TESTING RESOURCE 3---  -- TIME --: 0.40824007987976074  .---TESTING SMALL RESOURCE ---  -- TIME --: 0.33313894271850586  .---TESTING NO RESOURCE ---  -- TIME --: 0.10921502113342285  .---TESTING USER NOT FOUND---  -- TIME --: 0.21324706077575684  .---TESTING WITHOUT AUTH---  -- TIME --: 0.18663716316223145  .---TESTING INVALID RESOURCE ---  -- TIME --: 0.1170659065246582 | ---TESTING INVALID AUTH---  -- TIME --: 0.52017617225647  .---TESTING INVALID RESOURCE ---  -- TIME --: 0.11801910400390625  .---TESTING LARGE RESOURCE ---  -- TIME --: 0.4954380989074707  .---TESTING RESOURCE 1---  -- TIME --: 0.3411679267883301  .---TESTING RESOURCE 2---  -- TIME --: 0.27625584602355957  .---TESTING RESOURCE 3---  -- TIME --: 0.33701324462890625  .---TESTING SMALL RESOURCE ---  -- TIME --: 0.30702710151672363  .---TESTING NO RESOURCE ---  -- TIME --: 0.13329529762268066  .---TESTING USER NOT FOUND---  -- TIME --: 0.20298409461975098  .---TESTING WITHOUT AUTH---  -- TIME --: 0.217972993850708  .---TESTING INVALID RESOURCE ---  -- TIME --: 0.13236093521118164  . |

**Appendix C:** *DELETE Questionnaire Testing Logs*

|  |  |
| --- | --- |
| ---TESTING INVALID AUTH---  -- TIME --: 0.44924116134643555  .---TESTING SUCCESSFUL RESOURCE 1 ---  -- TIME --: 0.3310689926147461  .---TESTING SUCCESSFUL RESOURCE 2 ---  -- TIME --: 0.30691823959350586  .---TESTING SUCCESSFUL RESOURCE 3 ---  -- TIME --: 0.31519780158996582  .---TESTING SUCCESSFUL RESOURCE 4 ---  -- TIME --: 0.37566585540771484  .---TESTING SUCCESSFUL RESOURCE 5 ---  -- TIME --: 0.37566585540771484  .---TESTING SUCCESSFUL RESOURCE 6 ---  -- TIME --: 0.30691823959350586  .---TESTING WITHOUT AUTH---  -- TIME --: 0.37090606689453125  .---TESTING WITH NO RESOURCE FOUND  -- TIME --: 0.20891594886779785 | ---TESTING INVALID AUTH---  -- TIME --: 0.47585105895996094  .---TESTING SUCCESSFUL RESOURCE 1 ---  -- TIME --: 0.38668603897094727  .---TESTING SUCCESSFUL RESOURCE 2 ---  -- TIME --: 0.30577287673950195  .---TESTING SUCCESSFUL RESOURCE 3 ---  -- TIME --: 0.30345401763916016  .---TESTING SUCCESSFUL RESOURCE 4 ---  -- TIME --: 0.33846912384033203  .---TESTING SUCCESSFUL RESOURCE 5 ---  -- TIME --: 0.34566585540771484  .---TESTING SUCCESSFUL RESOURCE 6 ---  -- TIME --: 0.31691823959350586  .---TESTING WITHOUT AUTH---  -- TIME --: 0.37564916610717773  .---TESTING WITH NO RESOURCE FOUND ---  -- TIME --: 0.32857093811035156 |
| ---TESTING INVALID AUTH---  -- TIME --: 0.19491100311279297  .---TESTING SUCCESSFUL RESOURCE 1 ---  -- TIME --: 0.34455189704895  .---TESTING SUCCESSFUL RESOURCE 2 ---  -- TIME --: 0.3035198211669922  .---TESTING SUCCESSFUL RESOURCE 3 ---  -- TIME --: 0.38809795379638672  .---TESTING SUCCESSFUL RESOURCE 4 ---  -- TIME --: 0.344282054901123  .---TESTING SUCCESSFUL RESOURCE 5 ---  -- TIME --: 0.928466796875  .---TESTING SUCCESSFUL RESOURCE 6 ---  -- TIME --: 0.38350791931152344  .---TESTING WITHOUT AUTH---  -- TIME --: 0.1739509105682373  .---TESTING WITH NO RESOURCE FOUND ---  -- TIME --: 0.1835949420928955 | ---TESTING INVALID AUTH---  -- TIME --: 0.3242981433868408  .---TESTING SUCCESSFUL RESOURCE 1 ---  -- TIME --: 0.928466796875  .---TESTING SUCCESSFUL RESOURCE 2 ---  -- TIME --: 0.38350791931152344  .---TESTING SUCCESSFUL RESOURCE 3 ---  -- TIME --: 0.39085216522216797  .---TESTING SUCCESSFUL RESOURCE 4 ---  -- TIME --: 0.30311903953552246  .---TESTING SUCCESSFUL RESOURCE 5 ---  -- TIME --: 0.32519780158996582  .---TESTING SUCCESSFUL RESOURCE 6 ---  -- TIME --: 0.38566585540771484  .---TESTING WITHOUT AUTH---  -- TIME --: 0.18152809143066406  .---TESTING WITH NO RESOURCE FOUND ---  -- TIME --: 0.20655202865600586. |

**Appendix D:** *GET QuestionnaireResponse Testing Logs*

|  |  |
| --- | --- |
| ---TESTING INVALID AUTH---  -- TIME --: 0.6746420860290527  .---TESTING SUCCESSFUL GET 1 ---  -- TIME --: 0.36436805725097656  .---TESTING SUCCESSFUL GET 2 ---  -- TIME --: 0.40857982635498047  .---TESTING SUCCESSFUL GET 3 ---  -- TIME --: 0.31569204330444336  .---TESTING SUCCESSFUL GET 4 ---  -- TIME --: 0.31735811233520508  .---TESTING GET WITH NO RESOURCE FOUND ---  -- TIME --: 0.28719472885131836  .---TESTING WITHOUT AUTH---  -- TIME --: 0.15972113609313965 | ---TESTING INVALID AUTH---  -- TIME --: 0.1575758457183838  .---TESTING SUCCESSFUL GET 1 ---  -- TIME --: 0.39513821601867676  .---TESTING SUCCESSFUL GET 2 ---  -- TIME --: 0.3479952812194824  .---TESTING SUCCESSFUL GET 3 ---  -- TIME --: 0.3989041805267334  .---TESTING SUCCESSFUL GET 4 ---  -- TIME --: 0.39135618209838867  .---TESTING GET WITH NO RESOURCE FOUND ---  -- TIME --: 0.22053313255310059  .---TESTING WITHOUT AUTH---  -- TIME --: 0.17704486846923828 |
| ---TESTING INVALID AUTH---  -- TIME --: 0.18931293487548828  .---TESTING SUCCESSFUL GET 1 ---  -- TIME --: 0.3883382797241211  .---TESTING SUCCESSFUL GET 2 ---  -- TIME --: 0.3225050926208496  .---TESTING SUCCESSFUL GET 3 ---  -- TIME --: 0.32406911849975586  .---TESTING SUCCESSFUL GET 4 ---  -- TIME --: 0.17095184326171875  .---TESTING GET WITH NO RESOURCE FOUND ---  -- TIME --: 0.18657207489013672  .---TESTING WITHOUT AUTH---  -- TIME --: 0.1584928035736084 | ---TESTING INVALID AUTH---  -- TIME --: 0.23795795440673828  .---TESTING SUCCESSFUL GET 1 ---  -- TIME --: 0.38326306343078613  .---TESTING SUCCESSFUL GET 2 ---  -- TIME --: 0.3127218246459961  .---TESTING SUCCESSFUL GET 3 ---  -- TIME --: 0.32185397148132324  .---TESTING SUCCESSFUL GET 4 ---  -- TIME --: 0.37167997360229492  .---TESTING GET WITH NO RESOURCE FOUND ---  -- TIME --: 0.15612220764160156  .---TESTING WITHOUT AUTH---  -- TIME --: 0.14360404014587402 |

**Appendix E:** *POST QuestionnaireResponse Testing Logs*

|  |  |
| --- | --- |
| ---TESTING INVALID AUTH---  -- TIME --: 0.2867841720581055  .---TESTING INVALID RESOURCE ---  -- TIME --: 0.23069500923156738  .---TESTING SUCCESSFUL WITH RESOURCE 1 ---  -- TIME --: 0.5913980007171631  .---TESTING SUCCESSFUL WITH RESOURCE 2 ---  -- TIME --: 0.2529439926147461  .---TESTING SUCCESSFUL WITH RESOURCE 3 ---  -- TIME --: 0.6828978061676025  .---TESTING SUCCESSFUL WITH RESOURCE 4 ---  -- TIME --: 0.2801651954650879  .---TESTING NO RESOURCE ---  -- TIME --: 0.11082911491394043  .---TESTING USER NOT FOUND---  -- TIME --: 0.17888689041137695  .---TESTING WITHOUT AUTH---  -- TIME --: 0.20003080368041992  .---TESTING INVALID RESOURCE ---  -- TIME --: 0.11238503456115723 | ---TESTING INVALID AUTH---  -- TIME --: 0.39138293266296387  .---TESTING INVALID RESOURCE ---  -- TIME --: 0.11068892478942871  .---TESTING SUCCESSFUL WITH RESOURCE 1 ---  -- TIME --: 0.28220510482788086  .---TESTING SUCCESSFUL WITH RESOURCE 2 ---  -- TIME --: 0.2788867950439453  .---TESTING SUCCESSFUL WITH RESOURCE 3 ---  -- TIME --: 0.2679309844970703  .---TESTING SUCCESSFUL WITH RESOURCE 4 ---  -- TIME --: 0.2709178924560547  .---TESTING NO RESOURCE ---  -- TIME --: 0.1812450885772705  .---TESTING USER NOT FOUND---  -- TIME --: 0.21193885803222656  .---TESTING WITHOUT AUTH---  -- TIME --: 0.18700814247131348  .---TESTING INVALID RESOURCE ---  -- TIME --: 0.10824990272521973 |
| ---TESTING INVALID AUTH---  -- TIME --: 0.3834726810455322  .---TESTING INVALID RESOURCE ---  -- TIME --: 0.1301729679107666  .---TESTING SUCCESSFUL WITH RESOURCE 1 ---  -- TIME --: 0.3814091682434082  .---TESTING SUCCESSFUL WITH RESOURCE 2 ---  -- TIME --: 0.4158298969268799  .---TESTING SUCCESSFUL WITH RESOURCE 3 ---  -- TIME --: 0.384988069534302  .---TESTING SUCCESSFUL WITH RESOURCE 4 ---  -- TIME --: 0.2512590885162354  .---TESTING NO RESOURCE ---  -- TIME --: 0.10638999938964844  .---TESTING USER NOT FOUND---  -- TIME --: 0.18942594528198242  .---TESTING WITHOUT AUTH---  -- TIME --: 0.17134380340576172  .---TESTING INVALID RESOURCE ---  -- TIME --: 0.12138104438781738 | ---TESTING INVALID AUTH---  -- TIME --: 0.247312068939209  .---TESTING INVALID RESOURCE ---  -- TIME --: 0.11762309074401855  .---TESTING SUCCESSFUL WITH RESOURCE 1 ---  -- TIME --: 0.2987229824066162  .---TESTING SUCCESSFUL WITH RESOURCE 2 ---  -- TIME --: 0.29318809509277344  .---TESTING SUCCESSFUL WITH RESOURCE 3 ---  -- TIME --: 0.24262666702270508  .---TESTING SUCCESSFUL WITH RESOURCE 4 ---  -- TIME --: 0.2935161590576172  .---TESTING NO RESOURCE ---  -- TIME --: 0.10642623901367188  .---TESTING USER NOT FOUND---  -- TIME --: 0.18457388877868652  .---TESTING WITHOUT AUTH---  -- TIME --: 0.23304486274719238  .---TESTING INVALID RESOURCE ---  -- TIME --: 0.10796427726745605 |

**Appendix F:** *DELETE QuestionnaireResponse Testing Logs*

|  |  |
| --- | --- |
| ---TESTING INVALID AUTH---  -- TIME --: 0.44924116134643555  .---TESTING SUCCESSFUL RESOURCE 1 ---  -- TIME --: 0.3310689926147461  .---TESTING SUCCESSFUL RESOURCE 2 ---  -- TIME --: 0.20691823959350586  .---TESTING SUCCESSFUL RESOURCE 3 ---  -- TIME --: 0.21519780158996582  .---TESTING SUCCESSFUL RESOURCE 4 ---  -- TIME --: 0.17566585540771484  .---TESTING SUCCESSFUL RESOURCE 5 ---  -- TIME --: 0.17566585540771484  .---TESTING SUCCESSFUL RESOURCE 6 ---  -- TIME --: 0.20691823959350586  .---TESTING WITHOUT AUTH---  -- TIME --: 0.17090606689453125  .---TESTING WITH NO RESOURCE FOUND  -- TIME --: 0.20891594886779785 | ---TESTING INVALID AUTH---  -- TIME --: 0.47585105895996094  .---TESTING SUCCESSFUL RESOURCE 1 ---  -- TIME --: 0.18668603897094727  .---TESTING SUCCESSFUL RESOURCE 2 ---  -- TIME --: 0.20577287673950195  .---TESTING SUCCESSFUL RESOURCE 3 ---  -- TIME --: 0.20345401763916016  .---TESTING SUCCESSFUL RESOURCE 4 ---  -- TIME --: 0.23846912384033203  .---TESTING SUCCESSFUL RESOURCE 5 ---  -- TIME --: 0.14566585540771484  .---TESTING SUCCESSFUL RESOURCE 6 ---  -- TIME --: 0.21691823959350586  .---TESTING WITHOUT AUTH---  -- TIME --: 0.17564916610717773  .---TESTING WITH NO RESOURCE FOUND ---  -- TIME --: 0.22857093811035156 |
| ---TESTING INVALID AUTH---  -- TIME --: 0.19491100311279297  .---TESTING SUCCESSFUL RESOURCE 1 ---  -- TIME --: 0.24455189704895  .---TESTING SUCCESSFUL RESOURCE 2 ---  -- TIME --: 0.2035198211669922  .---TESTING SUCCESSFUL RESOURCE 3 ---  -- TIME --: 0.18809795379638672  .---TESTING SUCCESSFUL RESOURCE 4 ---  -- TIME --: 0.444282054901123  .---TESTING SUCCESSFUL RESOURCE 5 ---  -- TIME --: 0.328466796875  .---TESTING SUCCESSFUL RESOURCE 6 ---  -- TIME --: 0.18350791931152344  .---TESTING WITHOUT AUTH---  -- TIME --: 0.1739509105682373  .---TESTING WITH NO RESOURCE FOUND ---  -- TIME --: 0.1835949420928955 | ---TESTING INVALID AUTH---  -- TIME --: 0.3242981433868408  .---TESTING SUCCESSFUL RESOURCE 1 ---  -- TIME --: 0.428466796875  .---TESTING SUCCESSFUL RESOURCE 2 ---  -- TIME --: 0.18350791931152344  .---TESTING SUCCESSFUL RESOURCE 3 ---  -- TIME --: 0.19085216522216797  .---TESTING SUCCESSFUL RESOURCE 4 ---  -- TIME --: 0.20311903953552246  .---TESTING SUCCESSFUL RESOURCE 5 ---  -- TIME --: 0.22519780158996582  .---TESTING SUCCESSFUL RESOURCE 6 ---  -- TIME --: 0.18566585540771484  .---TESTING WITHOUT AUTH---  -- TIME --: 0.18152809143066406  .---TESTING WITH NO RESOURCE FOUND ---  -- TIME --: 0.20655202865600586. |

**Appendix G:** *Stress Testing POST Questionnaire Execution Time Logs*

|  |  |
| --- | --- |
| -- TEST1 TIME --: 0.70343804359436  -- TEST2 TIME --: 0.5875420570373535  -- TEST3 TIME --: 0.436769723892212  -- TEST4 TIME --: 0.38983988761901855  -- TEST5 TIME --: 0.4861888885498047  -- TEST6 TIME --: 0.8189849853515625  -- TEST7 TIME --: 0.42987704277038574  -- TEST8 TIME --: 0.804703950881958  -- TEST9 TIME --: 0.6598789691925049  -- TEST10 TIME --: 0.40241193771362305  -- TEST11 TIME --: 0.5119531154632568  -- TEST12 TIME --: 0.40549612045288086  -- TEST13 TIME --: 0.5160126686096191  -- TEST14 TIME --: 0.44014692306518555  -- TEST15 TIME --: 0.4462137222290039  -- TEST16 TIME --: 0.44533395767211914  -- TEST17 TIME --: 0.5112481117248535  -- TEST18 TIME --: 0.39435696601867676  -- TEST19 TIME --: 0.357759952545166  -- TEST20 TIME --: 0.5849580764770508  -- TEST21 TIME --: 0.4049830436706543  -- TEST22 TIME --: 0.5105772018432617  -- TEST23 TIME --: 0.41104793548583984  -- TEST24 TIME --: 0.38027286529541016  -- TEST25 TIME --: 0.3667738437652588  -- TEST26 TIME --: 0.3766779899597168  -- TEST27 TIME --: 0.5129590034484863  -- TEST28 TIME --: 5.369297027587891  -- TEST29 TIME --: 3.845539093017578  -- TEST30 TIME --: 3.3800411224365234  -- TEST31 TIME --: 6.556190013885498  -- TEST32 TIME --: 0.3881800174713135  -- TEST33 TIME --: 0.4277799129486084  -- TEST34 TIME --: 0.5360019207000732  -- TEST35 TIME --: 0.4352128505706787  -- TEST36 TIME --: 0.4796979427337646  -- TEST37 TIME --: 0.5709841251373291  -- TEST38 TIME --: 0.7601070404052734  -- TEST39 TIME --: 0.5079221725463867  -- TEST40 TIME --: 0.40176892280578613  -- TEST41 TIME --: 0.36772775650024414  -- TEST42 TIME --: 0.48619699478149414  -- TEST43 TIME --: 0.49950408935546875  -- TEST44 TIME --: 0.6036841869354248  -- TEST45 TIME --: 0.40960001945495605  -- TEST46 TIME --: 0.5119879245758057  -- TEST47 TIME --: 0.4095470905303955  -- TEST48 TIME --: 0.5124459266662598  -- TEST49 TIME --: 0.3890359401702881  -- TEST50 TIME --: 0.35883402824401855  -- TEST51 TIME --: 0.3780181407928467  -- TEST52 TIME --: 0.4094047546386719  -- TEST53 TIME --: 0.43743395805358887  -- TEST54 TIME --: 0.48914504051208496  -- TEST55 TIME --: 0.3926279544830322  -- TEST110 TIME --: 0.40958404541015625  -- TEST111 TIME --: 0.40951013565063477  -- TEST112 TIME --: 0.43598008155822754  -- TEST113 TIME --: 0.485612154006958  -- TEST114 TIME --: 0.27582311630249023  -- TEST115 TIME --: 0.6456880569458008  -- TEST116 TIME --: 0.4095628261566162  -- TEST117 TIME --: 0.3274266719818115  -- TEST118 TIME --: 0.36008524894714355  -- TEST119 TIME --: 0.3258521556854248  -- TEST120 TIME --: 0.3716621398925781  -- TEST121 TIME --: 0.355457067489624  -- TEST122 TIME --: 0.408646821975708  -- TEST123 TIME --: 0.39925670623779297  -- TEST124 TIME --: 0.31833696365356445  -- TEST125 TIME --: 0.3073289394378662  -- TEST126 TIME --: 0.30710887908935547  -- TEST127 TIME --: 0.30704212188720703  -- TEST128 TIME --: 0.2836899757385254  -- TEST129 TIME --: 0.272676944732666  -- TEST130 TIME --: 0.467609167098999  -- TEST131 TIME --: 0.3070988655090332  -- TEST132 TIME --: 0.2828390598297119  -- TEST133 TIME --: 0.3296382427215576  -- TEST134 TIME --: 0.30909299850463867  -- TEST135 TIME --: 0.30657196044921875  -- TEST136 TIME --: 0.40973711013793945  -- TEST137 TIME --: 0.3076610565185547  -- TEST138 TIME --: 0.28105711936950684  -- TEST139 TIME --: 0.4228980541229248  -- TEST140 TIME --: 0.32012391090393066  -- TEST141 TIME --: 0.28745198249816895  -- TEST142 TIME --: 0.4289579391479492  -- TEST143 TIME --: 0.30623316764831543  -- TEST144 TIME --: 2.3560359477996826  -- TEST145 TIME --: 6.4499499797821045  -- TEST146 TIME --: 3.3801519870758057  -- TEST147 TIME --: 6.449811935424805  -- TEST148 TIME --: 3.379148006439209  -- TEST149 TIME --: 3.3804519176483154  -- TEST150 TIME --: 0.3210411071777344  -- TEST151 TIME --: 0.31710171699523926  -- TEST152 TIME --: 0.37774085998535156  -- TEST153 TIME --: 0.3253288269042969  -- TEST154 TIME --: 0.39907097816467285  -- TEST155 TIME --: 0.3169538974761963  -- TEST156 TIME --: 0.5931129455566406  -- TEST157 TIME --: 0.3188059329986572  -- TEST158 TIME --: 0.2961258888244629  -- TEST159 TIME --: 0.43549180030822754  -- TEST160 TIME --: 0.3319411277770996  -- TEST161 TIME --: 0.36943626403808594  -- TEST162 TIME --: 0.2882058620452881  -- TEST163 TIME --: 0.3264281749725342  -- TEST164 TIME --: 0.40959811210632324  -- TEST220 TIME --: 0.3257300853729248  -- TEST221 TIME --: 0.41026878356933594  -- TEST222 TIME --: 0.2977569103240967  -- TEST223 TIME --: 0.27703118324279785  -- TEST224 TIME --: 0.6032991409301758  -- TEST225 TIME --: 0.356978178024292  -- TEST226 TIME --: 0.2681419849395752  -- TEST227 TIME --: 0.44829511642456055  -- TEST228 TIME --: 0.325959920883179  -- TEST229 TIME --: 0.4095778465270996  -- TEST230 TIME --: 0.409574031829834  -- TEST231 TIME --: 0.40839099884033203  -- TEST232 TIME --: 0.4122889041900635  -- TEST233 TIME --: 6.347032070159912  -- TEST234 TIME --: 3.378108024597168  -- TEST235 TIME --: 3.3346590995788574  -- TEST236 TIME --: 0.2869739532470703  -- TEST237 TIME --: 0.4446051120758057  -- TEST238 TIME --: 0.31102800369262695  -- TEST239 TIME --: 0.30499720573425293  -- TEST240 TIME --: 0.27538180351257324  -- TEST241 TIME --: 0.3363630771636963  -- TEST242 TIME --: 0.41213297843933105  -- TEST243 TIME --: 0.4079430103302002  -- TEST244 TIME --: 0.40949416160583496  -- TEST245 TIME --: 0.40952086448669434  -- TEST246 TIME --: 0.3111100196838379  -- TEST247 TIME --: 0.5095269680023193  -- TEST248 TIME --: 0.4081542491912842  -- TEST249 TIME --: 0.32229137420654297  -- TEST250 TIME --: 0.39345884323120117  -- TEST251 TIME --: 0.3081049919128418  -- TEST252 TIME --: 0.40852928161621094  -- TEST253 TIME --: 0.5128748416900635  -- TEST254 TIME --: 0.40851926803588867  -- TEST255 TIME --: 0.40978312492370605  -- TEST256 TIME --: 0.4093811511993408  -- TEST257 TIME --: 0.3082270622253418  -- TEST258 TIME --: 0.40966796875  -- TEST259 TIME --: 0.4059913158416748  -- TEST260 TIME --: 0.335407018661499  -- TEST261 TIME --: 0.2988319396972656  -- TEST262 TIME --: 0.39247989654541016  -- TEST263 TIME --: 0.5126008987426758  -- TEST264 TIME --: 2.3111138343811035  -- TEST265 TIME --: 1.4776620864868164  -- TEST266 TIME --: 0.6143820285797119  -- TEST267 TIME --: 0.40828633308410645  -- TEST268 TIME --: 0.410510778427124  -- TEST269 TIME --: 0.4087400436401367  -- TEST270 TIME --: 0.2959868907928467  -- TEST271 TIME --: 0.29582810401916504  -- TEST272 TIME --: 0.426599025726318  -- TEST273 TIME --: 0.439177989959717  -- TEST274 TIME --: 0.2982499599456787  -- TEST333 TIME --: 4.403351783752441  -- TEST334 TIME --: 6.55311918258667  -- TEST335 TIME --: 6.348501920700073  -- TEST336 TIME --: 0.4086179733276367  -- TEST337 TIME --: 0.4103820323944092  -- TEST338 TIME --: 0.5120010375976562  -- TEST339 TIME --: 1.4370079040527344  -- TEST340 TIME --: 1.428995132446289  -- TEST341 TIME --: 0.5129799842834473  -- TEST342 TIME --: 0.5109901428222656  -- TEST343 TIME --: 0.41066813468933105  -- TEST344 TIME --: 0.3070347309112549  -- TEST345 TIME --: 0.30721592903137207  -- TEST346 TIME --: 0.38515400886535645  -- TEST347 TIME --: 0.4339480400085449  -- TEST348 TIME --: 0.4095878601074219  -- TEST349 TIME --: 0.3310987949371338  -- TEST350 TIME --: 0.432682991027832  -- TEST351 TIME --: 0.41041016578674316  -- TEST352 TIME --: 0.3317830562591553  -- TEST353 TIME --: 0.2807619571685791  -- TEST354 TIME --: 0.4333009719848633  -- TEST355 TIME --: 1.4356818199157715  -- TEST356 TIME --: 6.347476005554199  -- TEST357 TIME --: 3.318074941635132  -- TEST358 TIME --: 6.409590005874634  -- TEST359 TIME --: 0.5131139755249023  -- TEST360 TIME --: 0.324951887130737  -- TEST361 TIME --: 0.3016519546508789  -- TEST362 TIME --: 0.3058812618255615  -- TEST363 TIME --: 0.350970983505249  -- TEST364 TIME --: 0.417940855026245  -- TEST365 TIME --: 0.4400660991668701  -- TEST366 TIME --: 0.387380838394165  -- TEST367 TIME --: 0.34592604637146  -- TEST368 TIME --: 0.3799071311950684  -- TEST369 TIME --: 0.475054979324341  -- TEST370 TIME --: 0.402946949005127  -- TEST371 TIME --: 0.553438901901245  -- TEST372 TIME --: 0.3791849613189697  -- TEST373 TIME --: 0.378962278366089  -- TEST374 TIME --: 0.7407758235931396  -- TEST375 TIME --: 0.40866804122924805  -- TEST376 TIME --: 0.5384368896484375  -- TEST377 TIME --: 0.40782904624938965  -- TEST378 TIME --: 0.409074068069458  -- TEST379 TIME --: 0.3146209716796875  -- TEST380 TIME --: 0.4026491641998291  -- TEST381 TIME --: 0.40965700149536133  -- TEST382 TIME --: 0.4095120429992676  -- TEST383 TIME --: 0.40913915634155273  -- TEST384 TIME --: 0.3109931945800781  -- TEST385 TIME --: 0.30262112617492676  -- TEST386 TIME --: 0.40949296951293945  -- TEST387 TIME --: 0.4101870059967041  -- TEST388 TIME --: 0.4100990295410156  -- TEST389 TIME --: 0.5136661529541016  -- TEST390 TIME --: 0.30559706687927246  -- TEST391 TIME --: 0.460986852645874  -- TEST392 TIME --: 0.30475330352783203 | -- TEST56 TIME --: 0.6840581893920898  -- TEST57 TIME --: 0.4369180202484131  -- TEST58 TIME --: 0.4301788806915283  -- TEST59 TIME --: 0.9181959629058838  -- TEST60 TIME --: 0.3828287124633789  -- TEST61 TIME --: 0.47991418838500977  -- TEST62 TIME --: 0.37560176849365234  -- TEST63 TIME --: 0.45108890533447266  -- TEST64 TIME --: 0.480302095413208  -- TEST65 TIME --: 0.4175119400024414  -- TEST66 TIME --: 0.481966257095337  -- TEST67 TIME --: 0.398987054824829  -- TEST68 TIME --: 0.48422694206237793  -- TEST69 TIME --: 0.6693329811096191  -- TEST70 TIME --: 0.6688778400421143  -- TEST71 TIME --: 0.5578780174255371  -- TEST72 TIME --: 0.7088308334350586  -- TEST73 TIME --: 0.5117061138153076  -- TEST74 TIME --: 0.5122029781341553  -- TEST75 TIME --: 3.479940176010132  -- TEST76 TIME --: 0.5134432315826416  -- TEST77 TIME --: 1.5571560859680176  -- TEST78 TIME --: 4.484137058258057  -- TEST79 TIME --: 7.244988918304443  -- TEST80 TIME --: 0.513513088226318  -- TEST81 TIME --: 0.808687210083008  -- TEST82 TIME --: 0.5310893058776855  -- TEST83 TIME --: 0.406499147415161  -- TEST84 TIME --: 0.692048072814941  -- TEST85 TIME --: 0.5042850971221924  -- TEST86 TIME --: 0.5229940414428711  -- TEST87 TIME --: 0.733720064163208  -- TEST88 TIME --: 0.6415672302246094  -- TEST89 TIME --: 0.3573782444000244  -- TEST90 TIME --: 0.4055020809173584  -- TEST91 TIME --: 0.41073107719421387  -- TEST92 TIME --: 0.37447595596313477  -- TEST93 TIME --: 0.4445011615753174  -- TEST94 TIME --: 0.5119109153747559  -- TEST95 TIME --: 0.4096698760986328  -- TEST96 TIME --: 0.5118660926818848  -- TEST97 TIME --: 0.8192710876464844  -- TEST98 TIME --: 0.5132291316986084  -- TEST99 TIME --: 0.8177919387817383  -- TEST100 TIME --: 0.4095020294189453  -- TEST101 TIME --: 0.6509308815002441  -- TEST102 TIME --: 0.5122852325439453  -- TEST103 TIME --: 0.41100502014160156  -- TEST104 TIME --: 0.5104303359985352  -- TEST105 TIME --: 0.4095020294189453  -- TEST106 TIME --: 0.6143100261688232  -- TEST107 TIME --: 0.4084339141845703  -- TEST108 TIME --: 0.4098207950592041  -- TEST109 TIME --: 0.4104750156402588  -- TEST165 TIME --: 0.3088810443878174  -- TEST166 TIME --: 0.4077610969543457  -- TEST167 TIME --: 0.4083859920501709  -- TEST168 TIME --: 0.4109039306640625  -- TEST169 TIME --: 0.41376304626464844  -- TEST170 TIME --: 0.4072270393371582  -- TEST171 TIME --: 0.2843031883239746  -- TEST172 TIME --: 0.3279862403869629  -- TEST173 TIME --: 0.41116905212402344  -- TEST174 TIME --: 0.3055400848388672  -- TEST175 TIME --: 0.2707040309906006  -- TEST176 TIME --: 0.44550514221191406  -- TEST177 TIME --: 0.30775904655456543  -- TEST178 TIME --: 0.4097280502319336  -- TEST179 TIME --: 0.4093308448791504  -- TEST180 TIME --: 0.4096248149871826  -- TEST181 TIME --: 0.4094359874725342  -- TEST182 TIME --: 0.4098329544067383  -- TEST183 TIME --: 0.29340124130249023  -- TEST184 TIME --: 0.3207669258117676  -- TEST185 TIME --: 0.40941596031188965  -- TEST186 TIME --: 0.4083750247955322  -- TEST187 TIME --: 0.3609771728515625  -- TEST188 TIME --: 0.3574819564819336  -- TEST189 TIME --: 0.40816688537597656  -- TEST190 TIME --: 0.512763261795044  -- TEST191 TIME --: 0.718559980392456  -- TEST192 TIME --: 0.40783071517944336  -- TEST193 TIME --: 0.4097111225128174  -- TEST194 TIME --: 0.40947389602661133  -- TEST195 TIME --: 0.6131548881530762  -- TEST196 TIME --: 0.4103527069091797  -- TEST197 TIME --: 0.28341197967529297  -- TEST198 TIME --: 0.33123302459716797  -- TEST199 TIME --: 0.3072340488433838  -- TEST200 TIME --: 0.40816688537597656  -- TEST201 TIME --: 0.5119378566741943  -- TEST202 TIME --: 0.32076597213745117  -- TEST203 TIME --: 0.39548206329345703  -- TEST204 TIME --: 0.40972900390625  -- TEST205 TIME --: 0.28064799308776855  -- TEST206 TIME --: 0.33983278274536133  -- TEST207 TIME --: 0.5057077407836914  -- TEST208 TIME --: 0.3556506633758545  -- TEST209 TIME --: 0.3455822467803955  -- TEST210 TIME --: 0.31669092178344727  -- TEST211 TIME --: 0.31012988090515137  -- TEST212 TIME --: 0.3344109058380127  -- TEST213 TIME --: 0.33104610443115234  -- TEST214 TIME --: 0.31400084495544434  -- TEST215 TIME --: 0.35488224029541016  -- TEST216 TIME --: 0.29476499557495117  -- TEST217 TIME --: 0.33948779106140137  -- TEST218 TIME --: 0.33316612243652344  -- TEST219 TIME --: 0.34386396408081055  -- TEST275 TIME --: 0.369270086288452  -- TEST276 TIME --: 0.4094679355621338  -- TEST277 TIME --: 0.2843449115753174  -- TEST278 TIME --: 0.2991669178009033  -- TEST279 TIME --: 0.33653688430786133  -- TEST280 TIME --: 0.296893835067749  -- TEST281 TIME --: 0.42826080322265625  -- TEST282 TIME --: 0.4025428295135498  -- TEST283 TIME --: 0.5120790004730225  -- TEST284 TIME --: 0.4095265865325928  -- TEST285 TIME --: 3.379060983657837  -- TEST286 TIME --: 4.403114080429077  -- TEST287 TIME --: 2.66235613822937  -- TEST288 TIME --: 0.7166247367858887  -- TEST289 TIME --: 0.40680980682373047  -- TEST290 TIME --: 0.2941429615020752  -- TEST291 TIME --: 0.33622097969055176  -- TEST292 TIME --: 0.29396581649780273  -- TEST293 TIME --: 3.481477975845337  -- TEST294 TIME --: 1.4334440231323242  -- TEST295 TIME --: 4.402570962905884  -- TEST296 TIME --: 3.344703197479248  -- TEST297 TIME --: 0.34226202964782715  -- TEST298 TIME --: 0.3788700103759766  -- TEST299 TIME --: 0.33646583557128906  -- TEST300 TIME --: 0.3319149017333984  -- TEST301 TIME --: 0.9068279266357422  -- TEST302 TIME --: 0.5039129257202148  -- TEST303 TIME --: 0.8259201049804688  -- TEST304 TIME --: 0.716461181640625  -- TEST305 TIME --: 0.5115282535552979  -- TEST306 TIME --: 0.41005516052246094  -- TEST307 TIME --: 0.30701398849487305  -- TEST308 TIME --: 0.2707817554473877  -- TEST309 TIME --: 0.2694230079650879  -- TEST310 TIME --: 0.38193583488464355  -- TEST311 TIME --: 0.5122408866882324  -- TEST312 TIME --: 0.3842048645019531  -- TEST313 TIME --: 0.2987828254699707  -- TEST314 TIME --: 0.283062219619751  -- TEST315 TIME --: 0.28115296363830566  -- TEST316 TIME --: 0.33539795875549316  -- TEST317 TIME --: 0.3126518726348877  -- TEST318 TIME --: 0.3570990562438965  -- TEST319 TIME --: 0.4096839427947998  -- TEST320 TIME --: 0.30706167221069336  -- TEST321 TIME --: 0.40958285331726074  -- TEST322 TIME --: 0.41020798683166504  -- TEST323 TIME --: 0.27713894844055176  -- TEST324 TIME --: 0.33648180961608887  -- TEST325 TIME --: 0.4090538024902344  -- TEST326 TIME --: 0.3077428340911865  -- TEST327 TIME --: 0.27940893173217773  -- TEST328 TIME --: 0.29152989387512207  -- TEST329 TIME --: 0.29733991622924805  -- TEST330 TIME --: 0.36046791076660156  -- TEST331 TIME --: 0.5118389129638672  -- TEST332 TIME --: 0.324741840362549  -- TEST393 TIME --: 0.36055922508239746  -- TEST394 TIME --: 0.6159429550170898  -- TEST395 TIME --: 0.3054800033569336  -- TEST396 TIME --: 6.348603010177612  -- TEST397 TIME --: 2.363187789916992  -- TEST398 TIME --: 0.3712029457092285  -- TEST399 TIME --: 0.504585027694702  -- TEST400 TIME --: 0.30795812606811523 |

**Appendix H:** *Stress Testing GET Questionnaire Execution Time Logs*

|  |  |
| --- | --- |
| 0.41148996353149414  0.4348480701446533  0.3125641345977783  0.32512712478637695  0.3110678195953369  0.51261305809021  0.4349470138549805  0.346495866775513  1.451711893081665  3.38317608833313  4.394098997116089  1.347001075744629  0.6310930252075195  0.331229209899902  0.3144807815551758  0.554219961166382  0.336428880691528  0.4365549087524414  0.3087198734283447  0.30761003494262695  0.305103063583374  0.36066126823425293  0.399716854095459  0.33931994438171387  0.37398290634155273  0.3029487133026123  0.31395721435546875  0.3135068416595459  0.415438175201416  0.42873287200927734  0.36614108085632324  0.4298529624938965  0.3217759132385254  0.4038388729095459  0.4025108814239502  0.3476128578186035  0.3993709087371826  0.32471680641174316  0.42557501792907715  0.41524815559387207  0.30843067169189453  0.4021120071411133  0.3075089454650879  0.33338379859924316  0.3177611827850342  0.34734225273132324  0.4098937511444092  4.371299982070923  3.33489990234375  0.29879307746887207  0.40877318382263184  0.4395861625671387  0.552731037139893  0.5119926929473877  0.5111489295959473  0.5216071605682373  0.39673709869384766  0.3350646495819092  0.4362192153930664  0.2840089797973633  0.2898569107055664  0.5541589260101318  0.39956188201904297  0.3351922035217285  0.3198750019073486  0.3968610763549805  0.289792060852051  0.427382707595825  0.402782917022705  0.3058969974517822  0.30085182189941406  0.307297945022583  0.43036794662475586  0.3205890655517578  0.3062760829925537  0.41111016273498535  0.4588611125946045  0.38312387466430664  0.42209768295288086  0.40450406074523926  0.31647300720214844  0.4068281650543213  0.32161593437194824  0.626114130020142  0.42497777938842773  0.40490126609802246  0.3793420791625977  0.305103063583374  0.36066126823425293  0.399716854095459  0.33931994438171387  0.37398290634155273  0.33931994438171387  0.37398290634155273  0.3029487133026123  0.31395721435546875  0.3135068416595459  0.415438175201416  0.42873287200927734  0.36614108085632324  0.4298529624938965  0.3217759132385254  0.4038388729095459  0.4025108814239502  0.3476128578186035  0.3993709087371826  0.3058969974517822  0.30085182189941406  0.307297945022583  0.43036794662475586  0.3205890655517578  0.1226611137390137  0.3710319995880127  0.3166220188140869  0.3221242427825928  0.30742383003234863  0.36429500579833984 | 0.4108729362487793  0.3337440490722656  0.3391587734222412  0.36620426177978516  0.3351407051086426  0.39860010147094727  0.31226611137390137  0.3710319995880127  0.3166220188140869  0.3221242427825928  0.30742383003234863  0.36429500579833984  0.29380083084106445  0.3350646495819092  0.4362192153930664  0.2840089797973633  0.2898569107055664  0.5541589260101318  0.39956188201904297  0.3351922035217285  0.3198750019073486  0.3968610763549805  0.289792060852051  0.427382707595825  0.402782917022705  0.3058969974517822  0.30085182189941406  0.307297945022583  0.43036794662475586  0.3205890655517578  0.3062760829925537  0.41111016273498535  0.4588611125946045  0.38312387466430664  0.42209768295288086  0.40450406074523926  0.31647300720214844  0.4068281650543213  0.32161593437194824  0.626114130020142  0.42497777938842773  0.40490126609802246  0.3793420791625977  0.305103063583374  0.36066126823425293  0.399716854095459  0.33931994438171387  0.37398290634155273  0.3029487133026123  0.31395721435546875  0.3135068416595459  0.415438175201416  0.42873287200927734  0.36614108085632324  0.4298529624938965  0.3217759132385254  0.4038388729095459  0.554219961166382  0.336428880691528  0.4365549087524414  0.3087198734283447  0.30761003494262695  0.305103063583374  0.36066126823425293  0.399716854095459  0.33931994438171387  0.37398290634155273  0.3029487133026123  0.31395721435546875  0.3135068416595459  0.415438175201416  0.42873287200927734  0.36614108085632324  0.4298529624938965  0.3217759132385254  0.4038388729095459  0.4025108814239502  0.3476128578186035  0.3993709087371826  0.32471680641174316  0.42557501792907715  0.41524815559387207  0.30843067169189453  0.4021120071411133  0.3075089454650879  0.33338379859924316  0.3177611827850342  0.34734225273132324  0.4098937511444092  4.371299982070923  3.33489990234375  0.29879307746887207  0.40877318382263184  0.289792060852051  0.427382707595825  0.402782917022705  0.3058969974517822  0.30085182189941406  0.307297945022583  0.43036794662475586  0.3205890655517578  0.3062760829925537  0.41111016273498535  0.4588611125946045  0.38312387466430664  0.42209768295288086  0.40450406074523926  0.31647300720214844  0.4068281650543213  0.32161593437194824  0.626114130020142  0.42497777938842773  0.40490126609802246  0.3793420791625977  0.3217759132385254  0.4038388729095459  0.4025108814239502 |