



API Testing: Introduction and Testing Planning & Design Micro-Credential

Syllabus

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General Information

KEYWORDS

API application testing, data contract testing, Internet of Things, microservice architecture, risk analysis, setting scope, test approach, test coverage, use cases

LEARNING OBJECTIVES FOR API TESTING: INTRODUCTION AND TEST PLANNING & DESIGN

What is an API

Understand the definition of a Webservice API
Understand the key terms associated with APIs

Expectations from API Testers

Understand the expectations on an API tester

Challenges for Testers

Understand API testing challenges
Explore some possible solutions to the challenges an API tester may face

Requirements for Testing

Understand the Requirements for API testing

Identify Functions and Attributes

To understand some of the nuanced parts of API testing – functions and attributes

Identify and Assess Risks

To understand how to identify and assess API quality risks

Determine Coverage Goals

Consider the coverage goals of API testing
Understand the coverage goals of API testing

Determine a Test Approach

Consider and understand the factors that go into determining the API test approach

Identify Test Conditions and Set Scope

Consider and understand factors that go into identification of test conditions
Setting test scope

Regression Testing

Discuss point of consideration while doing regression testing

Introduction

What is API?

Redhat.com defines API as “API stands for application programming interface, which is a set of definitions and protocols for building and integrating application software.” (Redhat.com, 2022)

In simple terms, API interaction can be looked at much as a game of catch. A sender throws the ball (a request message) to a receiver (an API service). The receiver catches the ball, does some processing, and sends the processed message back to the sender (who is now the new receiver).

To carry this analogy to today’s IT architectures, there are multiple people sending balls to possibly many receivers, with any one receiver possibly passing the ball to several other receivers before throwing the processed ball back to the original sender. When there is a complex architecture

(a lot of balls in the air going what seems like everywhere,) it is best to break the architecture down into individual requests and responses (one ball at a time).

In today’s applications such as Internet of Things (IoT) and machine learning, there may not be a graphical component to the application; the application can simply consist of data gathering and analysis with a graphical component being applied by a different application. In other words, the API endpoints under test might not be seen by an end user until later data analysis is performed – meaning defects can have consequences undetected for some time.

The purpose of this syllabus is to focus on testing API endpoints using different architectures. In simple terms, this syllabus focuses on testing how a process, or service, interfaces with another process or service.

There are three architectures which will be discussed in AT*SQA API Micro-Credential 2 with regards to software testing:

- REST(ful) API
- gRPC
- GraphQL

It will focus predominantly on REST APIs due to REST API's dominance in the market.

The ability to test an API has become a critical tool in the tester's toolbox. API testing is also a valuable skill for security and performance testing. In addition, with emerging Artificial Intelligence (AI) technology, APIs and the testing of APIs will only become more important. For example, to use AI (such as ChatGPT®) in a program, there must be a way to connect to it (via an API).

Expectations of an API Tester

Microservices and distributed systems have become the foundation for many modern business applications and processes. These applications and services use different API architectures to perform the actions that have become critical to daily living. Hence, the services providing 'service to service' or 'service to user' APIs have an expectation to function with near 100% uptime.

A defect impacting an API can have a direct impact to life (i.e., a pharmacy or medical application) or financial implications (i.e., ecommerce search engine). APIs are expected to be available, are expected to handle peak traffic, and are expected to be resilient to a security attack. Organizations can lose customers if a critical API is not fast enough or is not functionally correct. An insecure API can lead to data breaches – exposing customers or company data to negative impacts. As a result, the tester is expected to be knowledgeable about the purpose and use of the API endpoint(s), the traffic the API endpoint(s) are expected to handle, the expected API exposure (internal vs. public), and awareness of API security practices and procedures.

Challenges for Testers

API testing comes with its own unique challenges. It is important that a tester keep in mind the different challenges that may confront them while designing, developing, and executing API tests. Keeping these in mind and communicating the challenges early in the API lifecycle can serve to mitigate or even remove them.

LACK OF API STANDARDIZATION

Non-standardization for API naming, paths, and call structure is a big challenge to testing. A structural approach between API endpoints could be different between organizations or even groups within an organization. The lack of consistency can be confusing to both the consumer of the API endpoints and the tester. A quality assessment should include an assessment of standardization between API endpoints and products across an organization.

NO GRAPHICAL COMPONENT (NO GUI)

The purpose of APIs is to communicate messages between services; hence, there is not a graphical user interface (GUI) for API endpoints. This may be unfamiliar to testers who are accustomed to testing via a GUI. The lack of a user interface translates into a testing landscape that is free of clicks, screen sizes, browser compatibility, etc. Instead, the test concentrates more on communication protocols, data structure, error handling, performance, and security.

PROLIFERATION OF TOOLS

There is a large selection of tools available for API testing. There are in-OS command line tools such as cURL for Linux and Apple® or PowerShell commands for Microsoft Windows®. There are freeware graphical tools such as Postman®. In addition, there are per license tools such as ReadyAPI®. A tester should create a pro vs. con list comparing the tools' abilities to the requirements and budget of the project before selecting a tool.

UNKNOWN OWNERSHIP AND UNKNOWN REQUIREMENTS

APIs can be developed as a 'let's see' approach from development – expecting the API endpoints to evolve as the requirements become more refined or defined. This approach leads to unknown ownership and/or unknown requirements. In addition, this approach often leads to code churn and an increased risk of quality deterioration over time. It is important for a tester to identify the ownership, audience, and requirements of each endpoint when designing and developing test cases.

LACK OF MANAGEMENT AND CONTROL

REST API testing has its own management and control obstacles. These can be broken into three areas, these are process dependencies, data dependencies, and versioning.

- An API endpoint may have a dependency between one and many other API endpoints or processes. The dependencies may not be

in the scope or control of the API endpoints under test; hence, the API under test may have unpredictable availability or structure (i.e. a dependent API is undergoing changes). For example, an API 'A' may call a dependency API 'B'. 'A' has a dependency on 'B' but 'B' could change without notification to the team supporting 'A'.

- Likewise, APIs may require cross team management of data to allow testing to execute – something the API under test's team may or may not have control over. For example, an API 'A' may call a dependency API 'B'. Testing 'A' may have a dependency on certain test data being available from 'B' or the tests on API 'A' will fail or will be insufficient.
- An API may have more than one version. When there is a change made to an API that will break the current usage of the endpoints, it is expected that a major version number will be updated (i.e., v1 to v2 not v1 to v1.1). Different versions of the API may be active at the same time which introduces a layer of complexity to testing and reporting.

A tester may need to develop a communication plan/channel so changes to dependencies and data are communicated. This will allow the tester to accomplish test repeatability and test strength (non-fragile tests).

RELEASE FREQUENCY

Today's architecture emphasizes decoupled services and releases. This means that a traditional 'big bang' build where the product is built and deployed as one unit is not guaranteed. The tests will need to keep in mind that an API, or even the dependency APIs and services, can be built multiple times per day. As a result, the tester will need to design the test approach such that a test can be run and reported in a traceable and auditable manner. An API under test may need to be tested anytime code on which it is dependent is deployed. For example, if there is a 'main' weather API that gives data for three different cities – each with its own weather API, each city's API might be built and deployed separately. This would imply that the 'main' weather API needs to be retested every time a city's API is deployed as well as any time there is a change to the 'main' weather API.

SYNCHRONOUS/ASYNCHRONOUS APPROACH

As API testing does not have a graphical component, there is not a progress graphical component to show processing progress. The process calling the API may not have a way of identifying progress. An API may respond in a synchronous (the process waits for the response) or asynchronous (the process continues on with other work and is notified when the API response is ready) manner depending on how long processing is expected to take.

A request that gives the processed results back quickly is often a synchronous result (the processing occurs fast enough that the results can be given in the response). A request that requires processing that may take some time may use an asynchronous approach. An asynchronous API workflow is often broken down into the following three requests:

1. An acknowledgement that the initial request (or job) was received
2. A request for the status of the processing (somewhat equivalent to a progress bar)
3. Retrieval of the results of the processed request (or job).

Testers will need to keep in mind the API's approach (synchronous or asynchronous) when designing, planning, and executing tests.

PERFORMANCE REQUIREMENTS

API performance can be as important as functionality. An API that cannot meet the performance requirements can result in crashes, lost revenue, or lost functionality.

A tester should keep in mind the audience (the user of the API), the number of concurrent users expected (capacity performance testing), the expected message size to be processed, the time to process each message both large and small (volume performance testing), the expected peak traffic (spike performance testing), the expected normal traffic (soak performance testing), and the result of traffic well above the expected peak (stress performance testing).

Setting performance expectations early with the product team (between the product owner, developers, operations, testers, and support team) sets a foundation for the APIs' performance quality. Early performance test planning (e.g., when tests will be performed, what environment will be used, and what users or test data will need to be created) sets the expectation for the performance test execution in each release cycle.

TEST DATA REQUIREMENTS

Unlike solutions with a graphical user interface, an API may need test data to pre-exist to exercise the API properly. A test data plan for CRUD operations

(Create, Read, Update, Delete) may be required to perform API tests. Some APIs may have a tight data coupling with multiple dependent APIs to execute properly. For example, a call to get the weather forecast for a region may include a call to a dependency API for each city or sub-region to give the required data for a region.

Testing may need to include the scenario where test data is not available (i.e., a dependent service is not available). Such testing where dependent data is not available might fall under fault tolerance, failure recovery, disaster recovery (DR) testing or negative testing.

Requirements for Testing

Functional testing is required for API testing. The tester must have the skills necessary for manual functional testing tasks including requirements analysis, test design, test implementation, test execution, and results recording and reporting. These skills are covered in the ISTQB Foundation Level syllabus [ISTQB_FL_SYL].

In addition to the standard testing skills that are always needed, API testing also

requires capabilities for testing specific quality characteristics such as security, performance, compatibility, and reliability.

Test automation development, though not required, is a valuable skill for API testing. Proficiency in the same language in which the API is developed is helpful for understanding the API and conducting static testing. Where test automation development is implemented with a third-party tool, the tester must have proficiency in the development, execution, and reporting of API tests with that tool.

Unlike other types of testing, such as mobile and GUI testing, API testing often does not need special equipment such as a particular device. Different API architectures are designed to have no dependency on a particular operating system. However, the tools used for testing (such as ReadyAPI) may only be installable on particular operating systems (i.e., Microsoft Windows).

The requirements for fast development and deployment have pushed the software development lifecycle toward the iterative models, including Agile. AI and API code scaffolding have resulted in faster development. Rapid prototyping

is often used to quickly develop, gain feedback and successfully deploy a new product. A rapid prototype may end up being the production released product.

Testers need to employ testing that will not substantially slow the progress of delivering the product to market but will help reduce the risk of a failure. Risk-based testing approaches are critically important to build quality confidence in the short testing cycle. The amount of risk and corresponding testing are correlated to the usage and criticality of the product. It is important to evaluate each API endpoint individually for its risk factors. Once a proper risk analysis has been conducted, testing can be allocated to mitigate the risk to achieve the desired level of confidence.

API endpoints tend to be developed incrementally. An initial, simple version of the application is developed and deployed. Additional endpoints or parameters are then added as they become ready and as the market demands. The intention of modern development approaches is to allow

the product to be introduced quickly without compromising quality while additional features are developed and tested for later deployment.

Sequential lifecycle models (e.g., V-model, waterfall) can be applied to API development but are less frequently used due to the need to get a product to market quickly. Documentation tends to be minimal. Testing also tends to have less documentation. Safety-critical applications still tend to follow sequential models as do other applications that are under regulatory control.


Versioning is used as a reference of support for older versus newer versions of the API. When an API has a breaking change, the version will change from one major version to another (i.e., v1 to v2). Old versions of an API may be supported for a period of time that overlaps with test support of a newer version. For example, if an API v1 has a breaking change that results in the release of v2, testing may need to support v1 for a month (in addition to supporting v2) to allow users to update to v2.

Test Planning and Design

Identify Functions and Attributes

It is important to focus on the functions and attributes that are within scope for the testing effort.

API requirements tend to be brief. There may be a specification, a requirements document, use cases, or user stories. In general, the tester should not expect comprehensive requirements and should instead plan to work at the use case level or even the child level of a use case - where usage scenarios are identified. If the use cases are not available, the tester should seek them out to understand the expected usage and to focus the testing accordingly.



Where use cases are unknown or lack definition, Behaviour-Driven Development (BDD) may be used to identify the use case (given, when, then) as well as provide use case test verification. However, this approach moves the use case documentation responsibility from the product owner to the tester.

In order to scope the testing, it is important for the tester to understand the attributes of each endpoint that are important to the product or service and to prioritize them appropriately. Security and performance must be prioritized along with functionality to identify the risks and determine the amount and type of testing that will be needed in each area. The stakeholders must understand that each attribute desired to be tested will require an investment in people (with the appropriate skills), tools and environments.



Identify and Assess Risks

APIs often form the backbone of an application or distributed system; yet there is often little time allocated for implementation and testing. Also, requirements tend to be brief and informal and lacking in critical non-functional attributes such as performance and security. As a result, the tester will need to keep risks in mind both on the use case level as well as the overall product level.

If the API or endpoint is new, the tester will need to assess the functionality of the API or endpoint, any security threats, boundary conditions, and so forth. A security test pass and performance test pass should be scheduled before the new API is released allowing any issues to be identified and fixed before release.

If the API or endpoint is not new, a new security or performance test pass might not automatically be scheduled before release. Hence, the tester will need to assess the risk of each change to the functionality, security, and performance. Changes that share code with a previous API version might introduce security vulnerabilities or performance bottlenecks to the released API endpoint as well as new endpoints.

It is important for the tester to adapt the risk identification and assessment process to fit within the timelines of the project. Heavyweight risk assessment methods usually are not successful in this environment and tend to delay the testing.

It may also be useful to consider production metrics (i.e., how the API or endpoint is currently used in production,) when defining risk areas. For example, the following metrics could be used:

- **Usage metrics** – provides the ratio of endpoint usage to other metrics or the ratio of optional parameter usage to non-optional parameter usage
- **Number of application users** – indicates how many people use the application
- **Message size** – provides the average and peak API request message and response message
- **Response times** – provides an average and peak API response to a request

These metrics can be used to identify high risk areas that can be addressed by testing or development. For example, the application user rates can be used to develop realistic performance testing goals.

Determine Coverage Goals

It is important to consider all the areas to be tested and get agreement with the team that the coverage goals are realistic and will accomplish the testing goals for the project. The following areas should be considered, and the desired coverage determined before starting testing on the project:

- Requirements/Acceptance Criteria – If there are requirements or acceptance criteria, coverage should be used as one of the testing guidelines. Traceability from the tests back to the requirements is useful because API requirements can grow as new features are added and existing features are updated or modified. Traceability will help the tester know which test cases need to be re-executed as a priority when changes occur.
- Risks – The identified risks must be addressed by testing. Traceability may be needed between the test cases and the risk items.
- Endpoints – The capabilities of the software will be tested but should also be tested in accordance with the risk and usage associated with each endpoint. A complete list of endpoints will help to set the risk levels as well as to track coverage of each of these items.
- Code – Because of the speed of the development of APIs, unit testing is very important and code coverage goals should be stated before development starts. Automated unit testing, particularly when employed with continuous integration and delivery, will help to improve the quality as the same tests can be run each time without significant manual time and effort. Fault metrics and technical debt measures can be used to track the quality of the software.
- Error handling – Depending on the API architecture or resources given to API execution, error handling can be a common occurrence with APIs. Hence, the different error conditions will need to be covered in testing.

- Geography – The geographic location of expected use can influence the testing. An API can be hosted in different geographic regions resulting in different performance depending on the physical distance. Depending on the projected user audience location, performance based on geographic location will need to be covered.
- Performance – The baseline expectation for the API performance will need to be cited. Depending on the environment under test, the baseline may need to reflect the hardware constraints in each environment.
- Security – There is a growing number of resources available for API security testing. Depending on the API user audience and risk of API exploitation, a penetration testing effort may need to be included in test coverage.

Understanding the coverage requirements for testing is important for setting the scope and timelines of the testing effort as well as to help determine the types of equipment and environments that will be needed.

Determine a Test Approach

Once the coverage goals are determined, the proper test approach can be decided. The test approach must consider the following:

- Environments – The tests must be conducted in certain environments and those environments may also have associated conditions (i.e., different data dependencies and different dependency services).
- Industry context – The target industry can influence the required test approach (e.g., safety-critical, mission-critical, COTS (Commercial Off the Shelf), games, business applications, social network).
- Schedules – The reality of the schedule (development, test, deployment, release, etc.) must be considered when determining the test approach, with the highest priority (highest risk) tests being conducted first.

- Scope – The testing scope must be clearly stated to set the expectations for the coverage to be achieved and the risk mitigation goals.
- Evaluation – Evaluation of test results tends to be different for API projects from other projects given there is not a graphical front-end component to APIs. A test may need to be executed from the beginning to the end to evaluate and triage any failures. Timing issues may require the test to run several times before the failure reproduces.

Depending upon the formality and criticality of the project, the test approach may be documented in a traditional test plan or may be informally documented in a brief project document. Either way, the approach should be documented because agreement on the approach is critical within the project.

Identify Test Conditions and Set Scope

The time needed to create traditional test cases may not exist in a fast-paced project. In this case, identifying the test conditions and assigning risk-based priorities to each test, and conducting testing to address each of the identified conditions may be the most efficient method for testing within the limited timeframe.

API test automation should result in artifacts that show the scope and test coverage. Manual API test execution using a tool (i.e., Postman) can create test artifacts (i.e., the Postman collection). Where there is little time for requirement and test documentation, the artifacts can be used to identify the test conditions and the test scope. Test artifacts may not include test reports; however, saving test artifacts (e.g., the automation code, Postman collection) can be leveraged to show what testing has occurred and what data was used in the testing.

Identifying and prioritizing the test conditions sets the scope for the testing. With limited time, priority/risk-based testing will ensure the most important items are tested to some level of coverage. When time runs out and the coverage is deemed sufficient, testing is complete.

Regression Testing

Regression testing an API may or may not be more straightforward than GUI or mobile testing. Environmental configuration, data dependencies, and performance will need to be kept in mind when performing regression testing (i.e., in the development environment, a test might require user “Smith”, but user “Smith” does not exist in the test environment). As stated in the “Release Frequency” section of this syllabus, there may be multiple process dependencies that will require regression testing. It is important for a tester to capture the API versions, test execution time, solution build, test environment, and dependency process versions when reporting on API regression test results in order to understand failure origins and failure frequency.

References

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AI (such as ChatGPT) was not used to create content for this document.

Purpose of this Document

This syllabus forms the basis for the Association for Software Testing and Quality Assurance (AT*SQA) Micro-Credential for API Testing. This particular syllabus is focused on the Introduction and the Test Planning and Design areas.

AT*SQA provides this syllabus as follows:

1. To training providers, to produce courseware and determine appropriate teaching methods.
2. To credential candidates, to prepare for the exam (as part of a training course or independently).
3. To the international software and systems engineering community, to advance the profession of software and systems testing, and as a basis for books and articles.

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