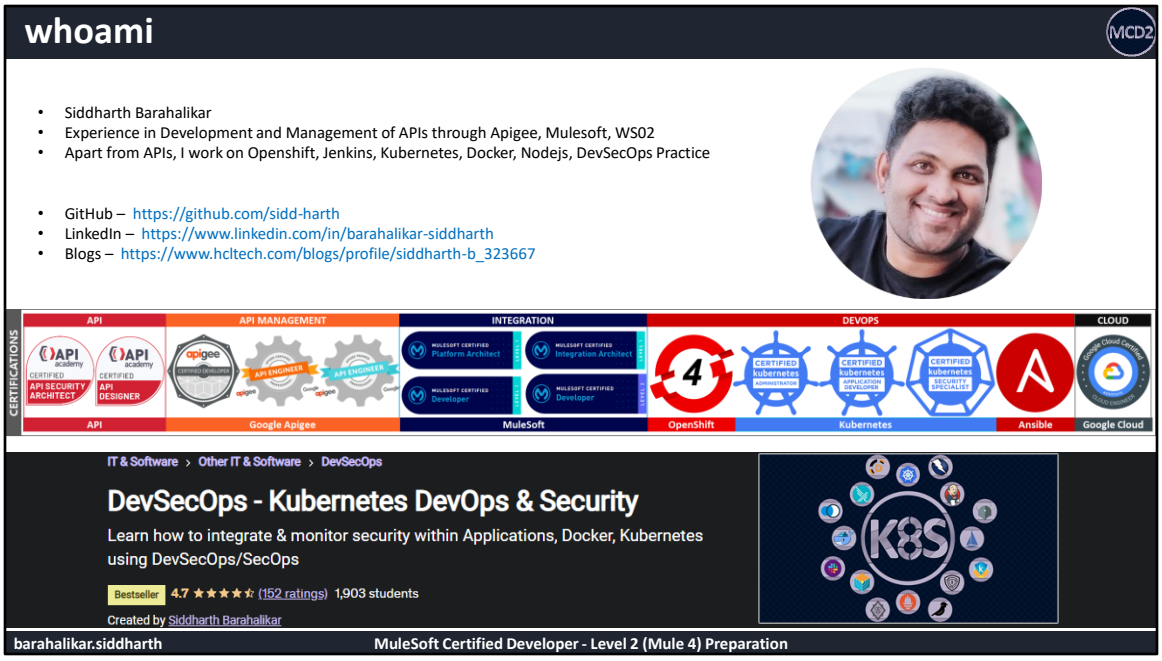
Hello and welcome to the Mulesoft certified developer level 2 preparation Course.
In This course we will go through all the concepts with hands-on exercises



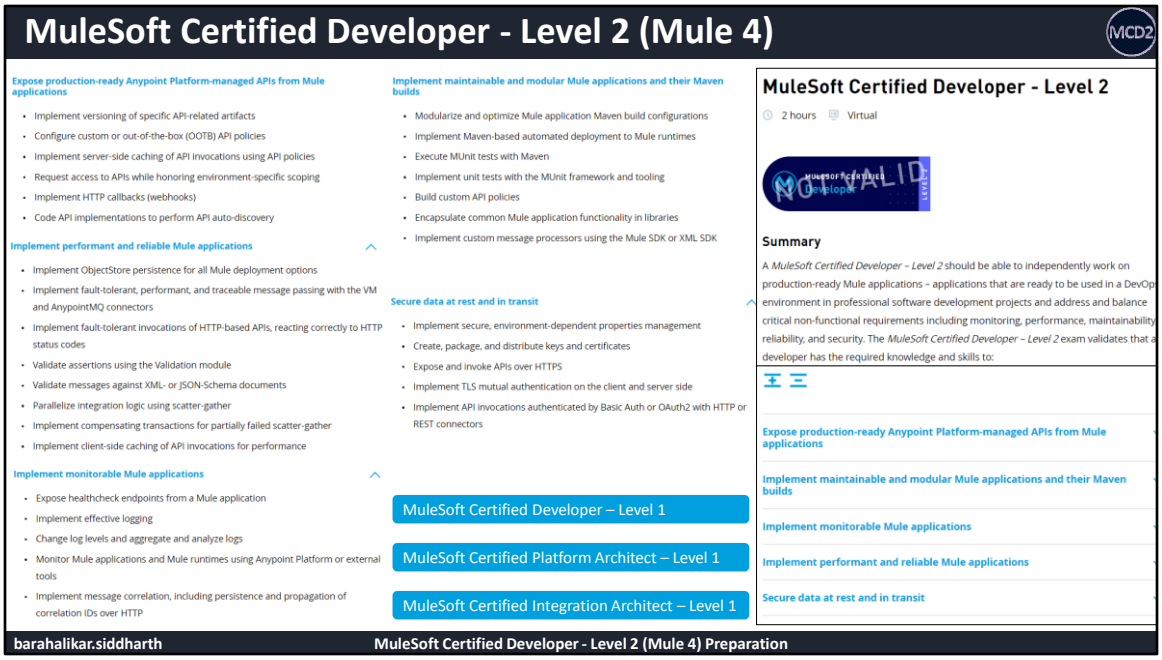
My name is Siddharth and I will be your instructor for this course.

~~So about me?~~

I am a Technical Architect and specialise on API Management and DevOps Technologies. For most part of my career I worked on various API Management tools like Google Apigee, Wso2, Layer7 & MuleSoft. I also work on DevSecOps and Kubernetes.

And these are some of the badges I have acquired in the last few years and the latest one is MCD Level 2 certification.

This is my 2nd online course, my 1st course was on DevSecOps which is one of the best seller and top rated course.



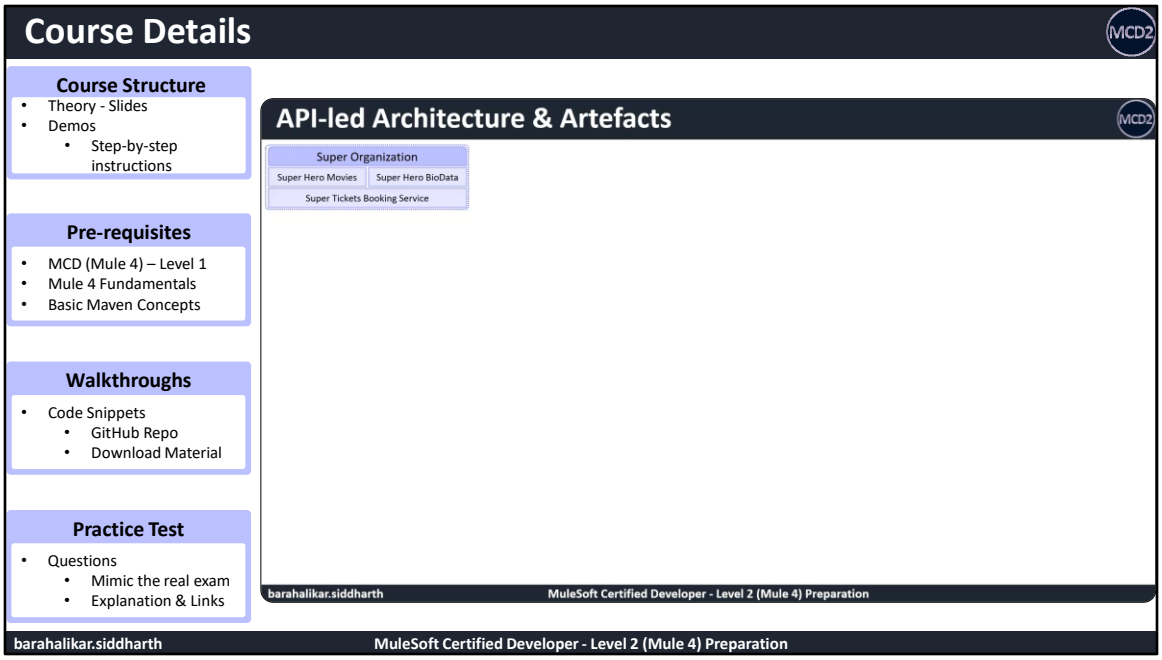
This course doesn't talk about what mulesoft is or what it is used for, because if you are preparing for this Level 2 certification, you already know about it.

As we know, there are 3 major Level 1 Mule certifications, which are MCD L1, MCIA L1, MCPA L1

This course is specifically designed for MCD L2 certification which is all about working independently on production ready mule apps.
It has 5 major topics
And
These 5 topics have around 30+ subtopics

We will dive into each of these topics, by first understand the concept and then implementing it

So how do we do this?



Course Structure –
The course is structured in a way that, I present the topics in a simple and visual way using slides which are followed by hands-on walkthroughs. I would recommend you to do these walkthroughs to get a deeper understanding of the topic

Pre-requisites – Talking about the pre-requisites,
It is highly recommended to complete the Mule 4 level 1 developer certification, before going through these topics.

If not,

It would be great if you have completed the Mule 4 developer fundamentals course, because we will not cover MuleSoft from scratch.

We will cover Maven but Basic Maven knowledge is always good to have.

Walkthroughs
All code snippets and walkthroughs will be provided to you via a Github repository or as a downloadable resource.

Practice Tests
At the end of the course, I had planned to include a couple of practise exam, that helps you assess course content.

For the time being this is kept on hold because MuleSoft's MCD Level2 Practice exam is excellent and that should be sufficient to crack the certification.

To cover all the topics, we have divided this course into 8 Sections starting from 0

Section 0
We will start by setting up the local environment by install JAVA, Maven, Anypoint Studio and deploying the required backend services to CloudhUb after importing and publishing RAML in anypoint platform

Section 1
In Section 1 we will setup the mule project following best practise, add deployment strategy, maven configuration, Modularize Mule app using parent-pom, add secure properties and configure one-way tls

Sections 2
In Section 2 we start adding integration logic, hit multiple APIs in parallel, manage non-functional requiremens, handle errors and cache the data to improve app performance

Section 3
In Section 3 we add HTTP callback and process the messages asynchronously using

VM and Anypoint MQ connectors. We explore circuit breaker, Operational Tracing, Manage correlation id and do schema validations

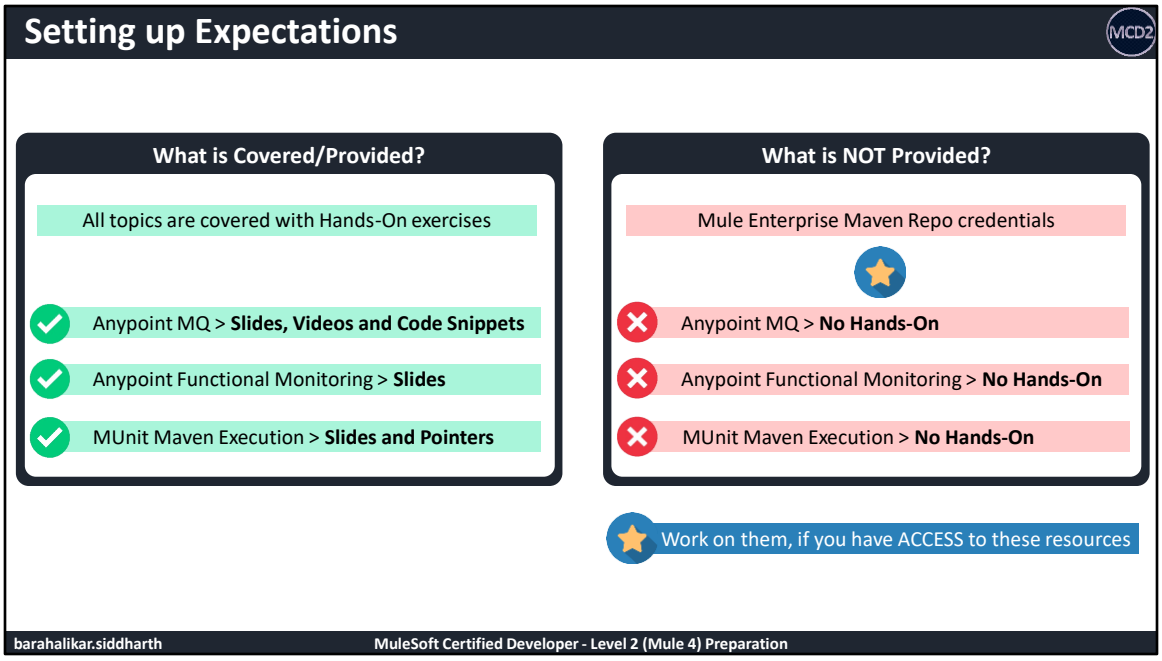
Section 4
In Secton 4 We montion the Mule applicsations using health endpoints. Use Shared library and create new connectors using XML SDK

Section 5
In Section 5 We develop a custom api poloicy from scratch and apply it both offline and online

Section 6
In Section 6 We understand how to using TLS config for SOAP webservice and consume a service using Mutual TLS Authentication.

Section 7
In Section 7 We configure and write Munit test cases for our Mule apps by using various MUNIT Connectors.

We only see a small subset of topics in this slide. We will be covering a lot more topics in detailed within each section.



Before we start, I would like to setup some expectations right at the beginning.

By default all topics are covered with handson excecises, with few exceptions.

Anypoint MQ is not available in Anpoint Platfrom trail accounts. I have used Anypoint MQ in this course but I cannot share it's details and so you will not be able to do Anypointmq HANDSON excercises. We will provide slides, videos, code snippets

and it is the same for Functional Monitoring. So we will be using an external API Monitoring solution to understand the concepts, which is more or less the same.

We do not have and will not provide Mule Enterprise Maven Repo credentials. Munit maven execution depends on this and hence we cover the concept through slides and do Munti testing using Anypoint Studio

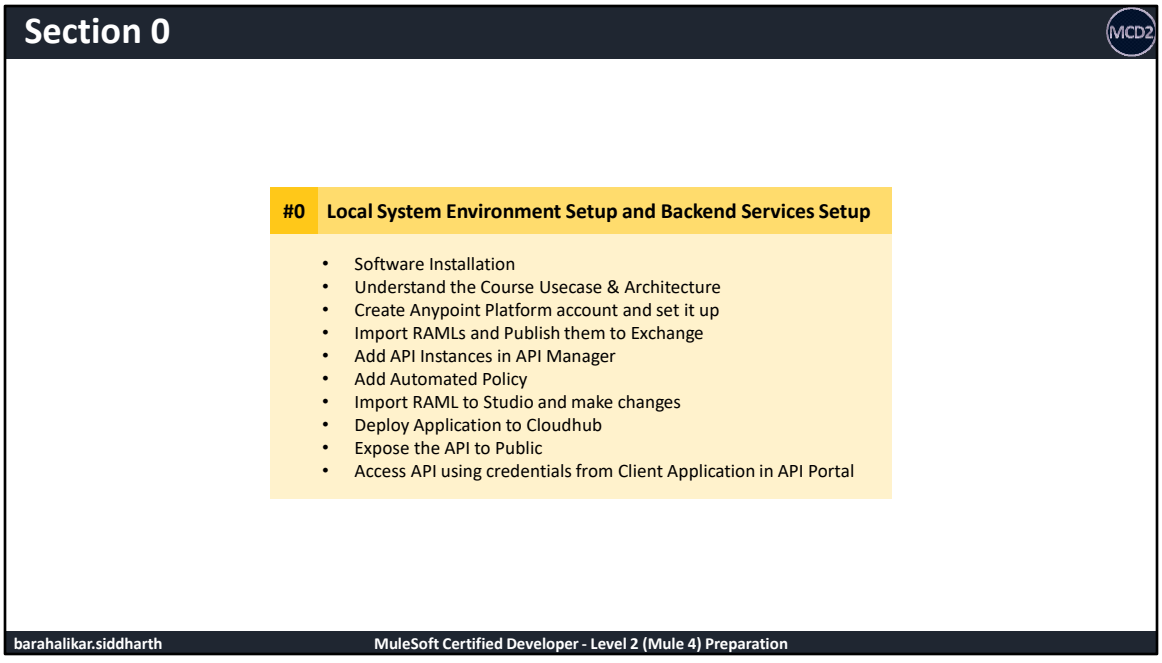
All other hands-on walkthroughs can be done without Enterprise credentials.

If you have access to any of these resources via your partner portal or some other means, you could use them for handson purpose. Please do not use your customer/production account.

Do check out my Linkedin profile and slack workspace for new updates, offers and for any other queries.

Feel free to look at the course description and I look forward to see you inside

~~THANK YOU~~



In Section 0, we will install the software
Understand the course usecase and the architecture
And setup the backend services by

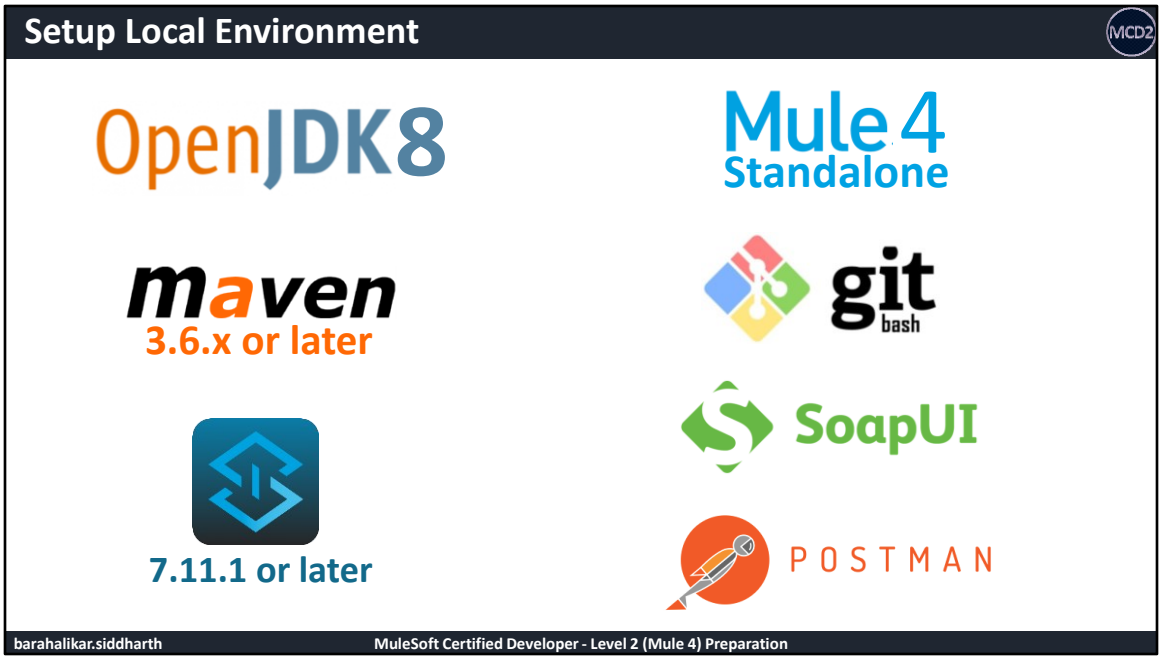
And all these startup files will be provided thorugh a git repository

0.1 Software Installation

- OpenJDK
- Maven
- Anypoint Studio
- Mule 4 Standlaone
- SoapUI
- Postman
- Git Bash

MCD2

In this session we install the softwares



For doing the handson walkthroughs, these softwares needs to be installed and confirgued on your machines.

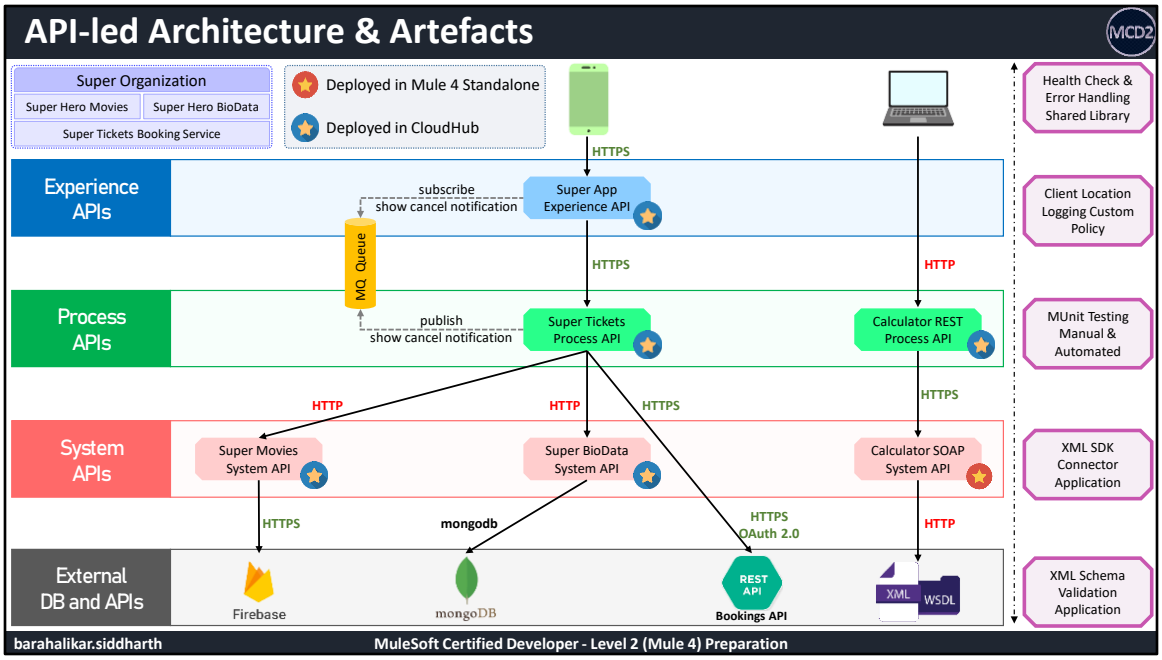
Make sure you dowanlod the correct version.

These installtions are straight forward, so I would leave them to you. In the attached material, I will provde the links and docs for your reference.

Usecase Architecture

- API-led Architecture
- Other Artefacts used in course

In thi ssession, we will have a look at the course usecase followed by it's architecture. We will also see what other artefacts will be developed as par tof this course



Lets assume,
We have a organization named Super Organization, which holds the data for Super hero movies and super hero biodata.
Whenever a new movies releases, they also provide a Ticket Booking Service to the end user via a user application.
The users can book tickets, check the booking status and show cancellation status on this applicaton.

The data is spread across 3 external services – Firebase, MongoDB and a REST API
We develop 2 SAPI (Super Movies and Super BioData) to unlock the data from these core systems
We then develop a Super Tickes PAPI to interact with both the SAPI and the 1 external REST API service
This PAPI is accessed through a EAPI, which also subscribes to the Anypoint MQ Queue to get show cancel notifications published by the PAPI

For mutual authentican topic,
We also have an external WSDL service which is unlocked by SAPI. This SAPI is in turn consumed consumed by a PAAPI using mutual authentication. this use case

showcases Mutual authentication between two Mule Application

For deployments,
The SOAP SAPI is deployed to a Mule 4 standalone server
All others arteafcts are deployd to Cloudhub

For other topics,
We also work on various other application, librareies and connectors in this course

And for the final note – this is a very simple straightboard usecases which covers all the topics of this course,, please do not try to find loophole in it

0.2 Anypoint Platform

- Create a new Account
  - Assign Environments

MCD2

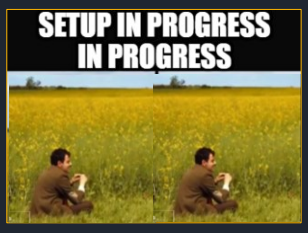
In this session we install the softwares

0.3 API Specification

- Import RAML
- Publish RAML
- Explore Exchange

0.4 Anypoint Platform

- API Manager
  - Create API Instance
  - Add Automated Policy



MCD2

In this session we install the softwares

0.5 Anypoint Studio

- PART A
  - Set up Anypoint Studio
  - Local Maven Repo
- PART B
  - Import Mule Apps
    - Replace ORG ID
    - Replace API ID
    - Add MongoDB Driver
  - Deploy to CloudHub

MCD2

In this session we install the softwares

0.6 Access Applications

- Add CH URL to API Instance
- Expose API to Public
- Get Credentials
- Access Apps

MCD2

In this session we install the softwares

Welcome to Section 1, in this section we will start by adding an Open API Specification to Design center,
Configure API instance for it in API manager and Import it to Studio

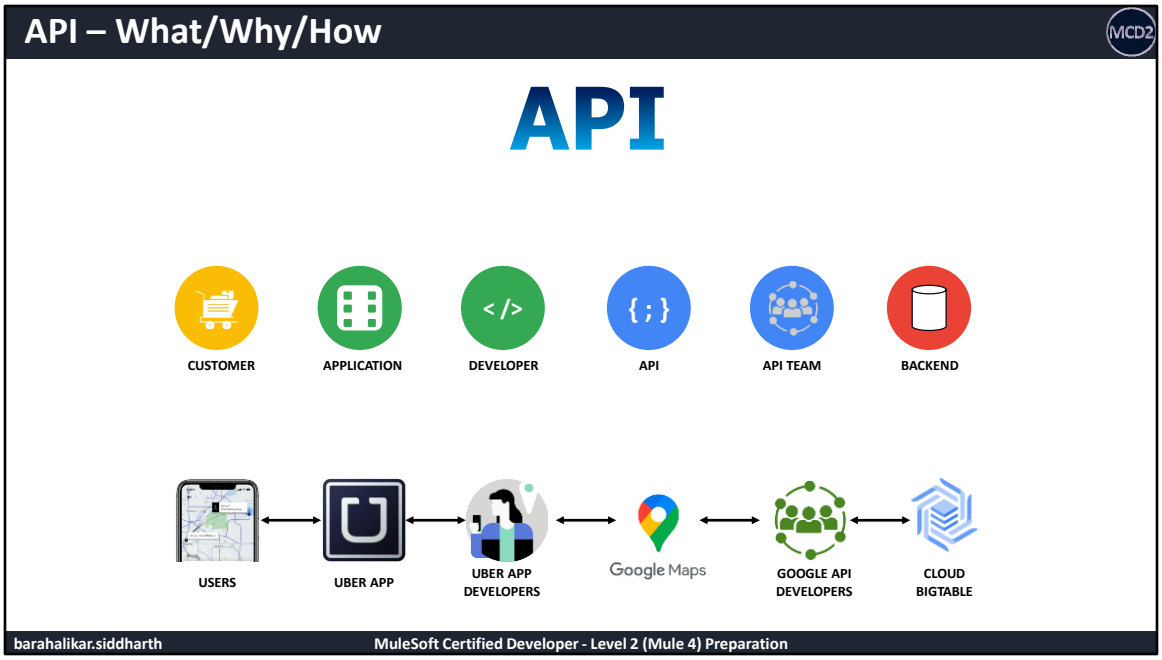
Within Stuido, we will add best coding conventions and setup the project structure.
We will Learn about Cryptogrpahy and how to use it for secureing communicatons/data in transist.
For static data we will use Secure and Hidden properties to encrpt and mask them

We will also understand Cloudhub architecture and setup a Maven based deployment strategy.

We will also modularize mule apps using parent-pom and bill of materials concepts.
We will end this section by visualizing the API interactions within Anypoint Visualizer

API Lifecycle

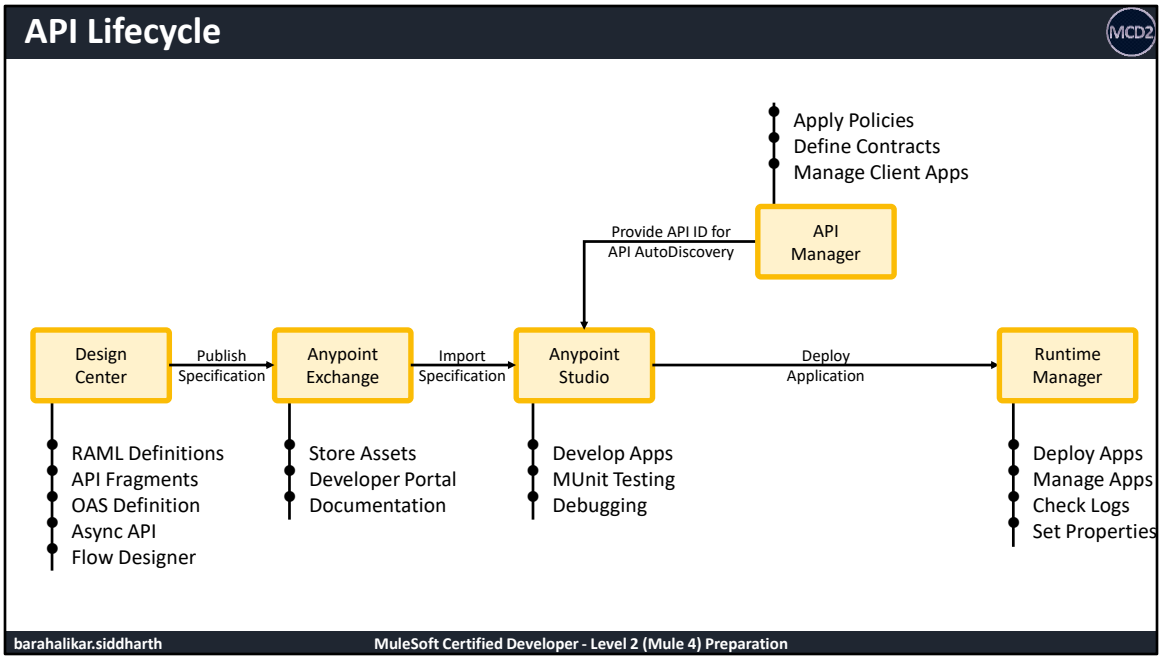
- What/Why/How APIs
- API Lifecycle
- API Specification Options



An API is a set of rules which defines how 2 applications interact with each orher.
In simple terms,
An API is a contract between 2 applications

Generally speaking we have an API/Integration team working on various backends to developer an API
These APIs are then used by APPLication developers to create application, these could internal or external developers.
Then the application is consumed by the user.

A real time example could be of Google Maps,
Google storers the location details like latitiude longitube details within a cloud bigtable
Google api developers work on this data and create google maps api
Now this API can be consumed by some 3rd party application developers like Uber to embed the Maps API within their application
And when the user use the Uber app, they internall make use of the google maps api



A API lifecycle management is the process of overseeing an API from its creation to retirement. This includes everything from designing, publishing, documenting, developing, securing, deploying and monitoring APIs.

Desgin center
The first step is to design API, we make use of Design center to create APIs using RAML/OAS definitons. We Mock them and test them before publishing to Exchange

Anypoint Exhcnage
Is like a repository to hold all your Mule artefacts. We can add documentation to APIs, expose them to Public via a developer portal.

Studio
API Development is done using Anypoint Studio, where all the business logic like orchestration, routing, error handling is done. Once it is build it goes through Munit testing to ensure that it is functioning as expected.

Runtime amanger

Then the application is deployed to Cloudhub and managed via a Runtime Manager to check logs and manage app properties.

API Manager
to ensure your application is following best practices in security we apply policies to them at runtime. And Monito all traffic via an API manager

API Specification

RAML

super-movies-sapi/master

```
#%RAML 1.0
title: Super Heros Movies Data SAPI
description: Super-Movies-SAPI allows you to fetch the basic movies
heros.
version: 1.0
mediaType: application/json

types:
  movies-data: !include movies_dataType.raml

securitySchemes:
  basic-auth: !include exchange_modules/org.mule.examples/basic-auth-
basic-auth-securityscheme.raml

securedBy: basic-auth

/movies/{id}:
  uriParameters:
    id:
      required: true
      example:
        value: MARVEL0001
  get:
    description: This resources fetches bio data based on the unique
Parameter
    responses:
      200:
        description: If **id** exists, returns the bio data
```

Open API Specification

Super Ticket PAPI/master

```
swagger: '2.0'
info:
  title: Super Ticket PAPI
  description: Super Ticket PAPI allows you to check the movie ticket
  version: v1
host: super-ticket-papi.us-e2.cloudhub.io
basePath: /api/v1
schemes:
  - https
paths:
  /tickets/{BID}:
    x-amf-description: Checks the passenger in with given number of ba
    get:
      parameters:
        - name: BID
          description: Unique Booking ID
          required: true
          in: path
          type: string
        - name: CID
          description: Unique Character ID
          required: false
          in: query
          type: string
      responses:
        '200':
          description: If the BID is correct, returns ticket booking d
Super Movies SAPI for the character data will be returned.
```


API specifications can be defined in multiple ways, one of them is RAML

RESTful API Modeling Language (RAML)
- Based on YAML
- Human readable format
- Developer friendly
- you can Reuse code using Fragments

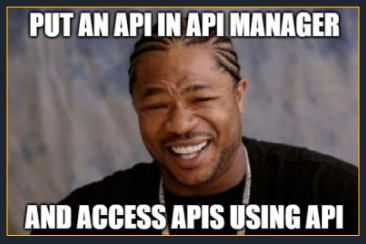
Mulesoft also supports OAS,
- Formerly called Swagger (OAS 2.0)
- Open standard to define RESTful API interfaces in YAML or JSON format
- it has a Wider adoption rate compared to RAML, but
- Files tend to get bigger becuae of Less code sharing options

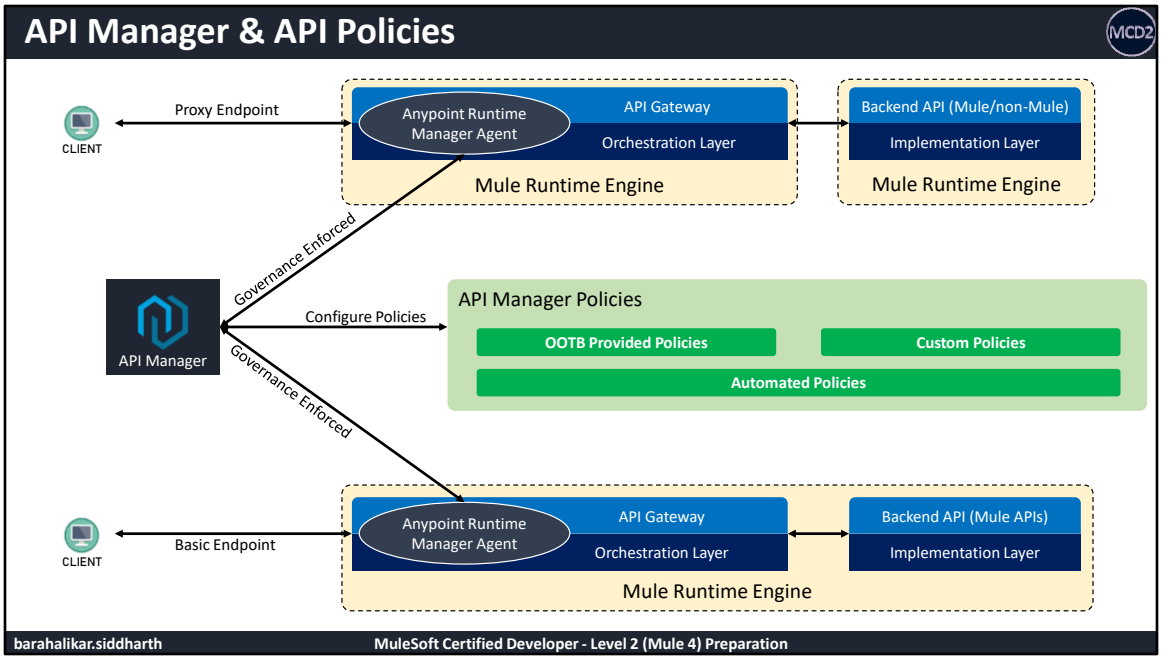
1.1 OAS Definition

- Import OAS to Design Center
- Publish to Exchange

API Manager

- Proxy Endpoint
- Basic Endpoint
- API Gateway





Anypoint API Manager enables you to manage, govern, and secure APIs.

Using API Manager, we can configure various OOTB and custom polcies in automated or manual way. These policies are

- ○ Applicable to all types of HTTP/1.x APIs , but
  - ○ Does not support WebSocket APIs or HTTP/2 APIs

Lets assume we have an Mule API configured with an corresponding Autodiscovery element. To enforce policies it makes use of API Gateway.
Mule Runtime includes an embedded API Gateway.
An API Gateway allows you to add a dedicated orchestration layer which sits infront of your backend APIs.
API MAanager leverages the capabilities of API Gateway which enforce policies, collect analytics data, manage proxies and authentication.

But how does API Gateway communicate with API Manager?
Anypoint Runtime Manager agent is a Mule plug-in that enables communication with

Mule runtime engine.
API Gateway uses this agent to communicate with registered API instances in API Manager.

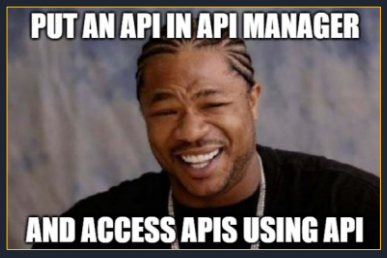
Clients access the app using the BackendAPI Cloudhub URL

Lets assume we have another API that is not based on Mule Runtime, or an Mule app which doesn't have a autodiscovery element. Tto enforce policies on it we can use an API proxy which is a preconfigured Mule application deployed separately. This application is nothing but the API gateway.

Client access the app using the proxy url

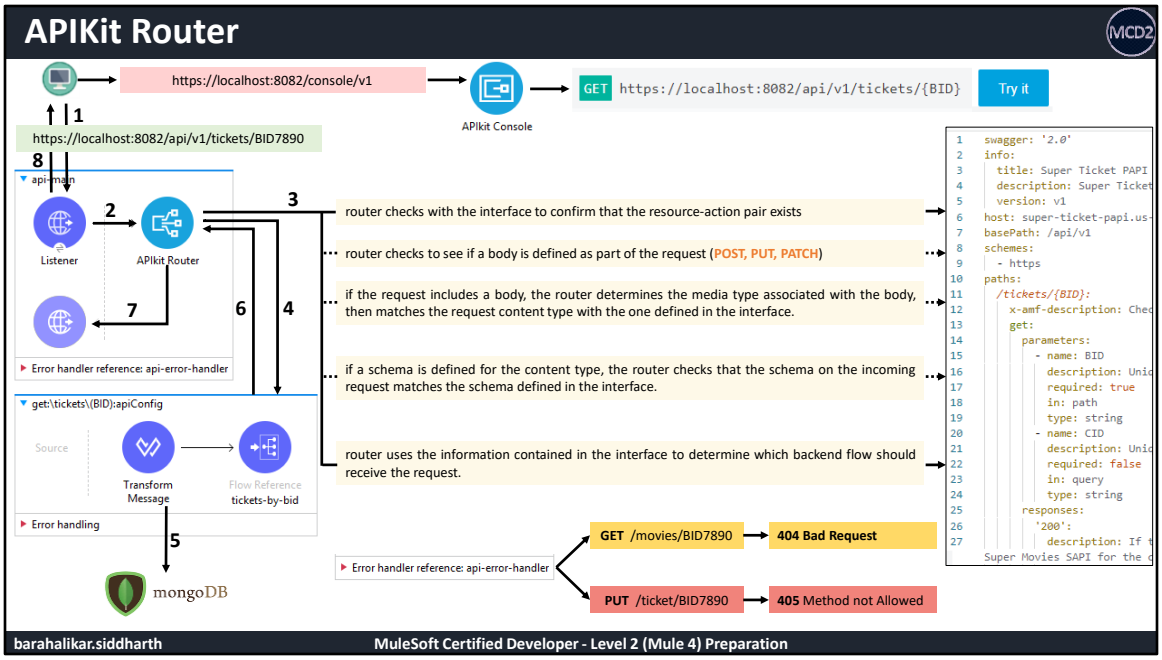
1.2 API Manager

- Create API Instance
- Add Logging Policy



APKit Router

- api-main flow
- api-console flow
- error-handling
- How Routing works



Lets assume we have an RAML or OAS Specification publishde to exchange. When we import it to our Mule Appliction in Anypoint studio, it is going to auto generate flows based on the specification.

We will see how an APIkit router listen for incoming request, do validations, route to flows and returning the response

1. The end user sends an HTTP request to the API.
2. The HTTP endpoint in the main flow receives the request and passes the message to the APIkit Router.
3. The router checks with the interface to confirm that the resource-action pair exists in the interface.

    1. If it is a GET method, the router uses the information contained in the interface to determine which backend flow should receive the request.
    2. If it is a POST/PUT/PATCH method The router checks if a body is defined as part of the request.
    3. If the request includes a body, the router determines the media type of the body, then matches the request content type with the interface.

4. If a schema is defined for the content type, the router checks that the schema on the incoming request matches the schema defined in the interface. If the schema is not valid, the application rejects the request.

5. Once the flow is determined

1. The router sends the request to flow.
2. Flow processes the request, accessing a backend services as required.
3. Flow returns a response to the router.
4. The router pushes the response to the HTTP endpoint.
5. The HTTP endpoint sends the response to the end user.

6. It also has a console endpoint, which can be used to simulate API calls by submitting requests through the Web user interface.
7. Generic error handlers are also generated to handle invalid requests

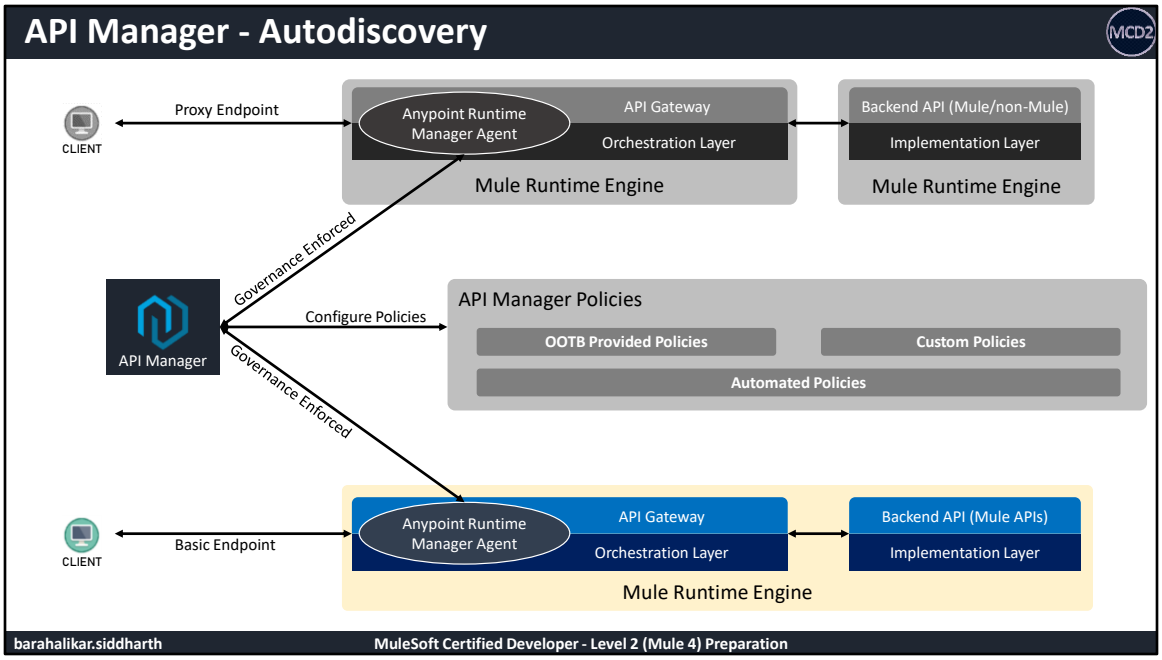
1.3 APIKit Router

- Import API from Exchange to Studio
- Deploy the App

API Autodiscovery

- What is AutoDiscovery
- Steps to achieve it

In an earlier session we talked about API Manager and API Policies. In this video we will talk about Autodiscovery



API Autodiscovery is a mechanism that manages an API from API Manager by pairing the deployed application to the API.

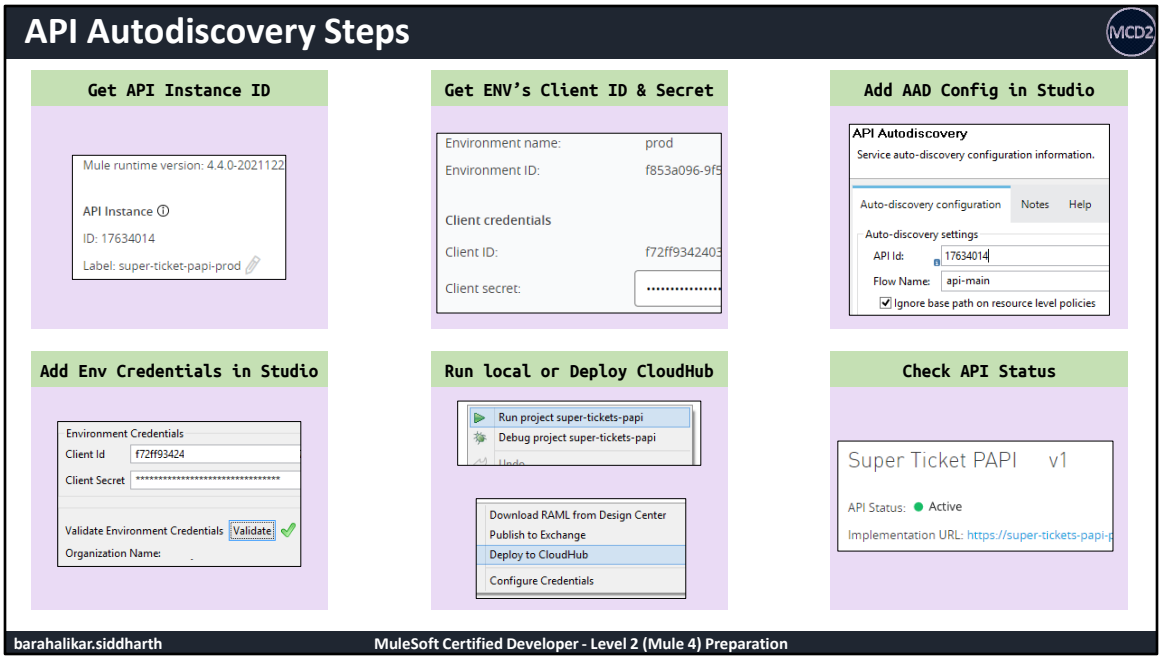
Configuring autodiscovery allows a deployed Mule application to connect with API Manager to download, manage policies and to generate analytics data.

We need to have an unique API Instance ID to map an API with Autodiscovery.

Using API Autodiscovery option, we do not need an extra API Proxy deployed to enforce policies. Mule applications act as their own API proxy.

A couple Point to be noted -
Multiple Autodiscovery elements pointing to an same API instance ID are not supported.

For each Mule runtime version for an API instance, we can have only one Autodiscovery element pointing to it.



These are the steps to enable API AutoDiscovery

1. Get API Instance ID from API in API Manager
2. Get the environment specific client id and secret

Following the principle of least priviledge, it is typically recommended to use the client ID
and secret for a specific environment rather than the entire Anypoint Platform organization:

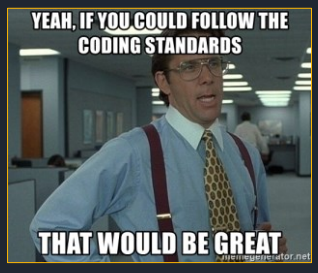
1. Configure Autodiscovery element in Studio, by adding the API ID
2. Add the Environment credentials in Studio
3. Deploy the appluctuon to Cloudhub, once deployed is successful
4. The api status on the API manager changes to Active, this indicates that the Mule App is connected the API in API Manager

1.4 API Autodiscovery

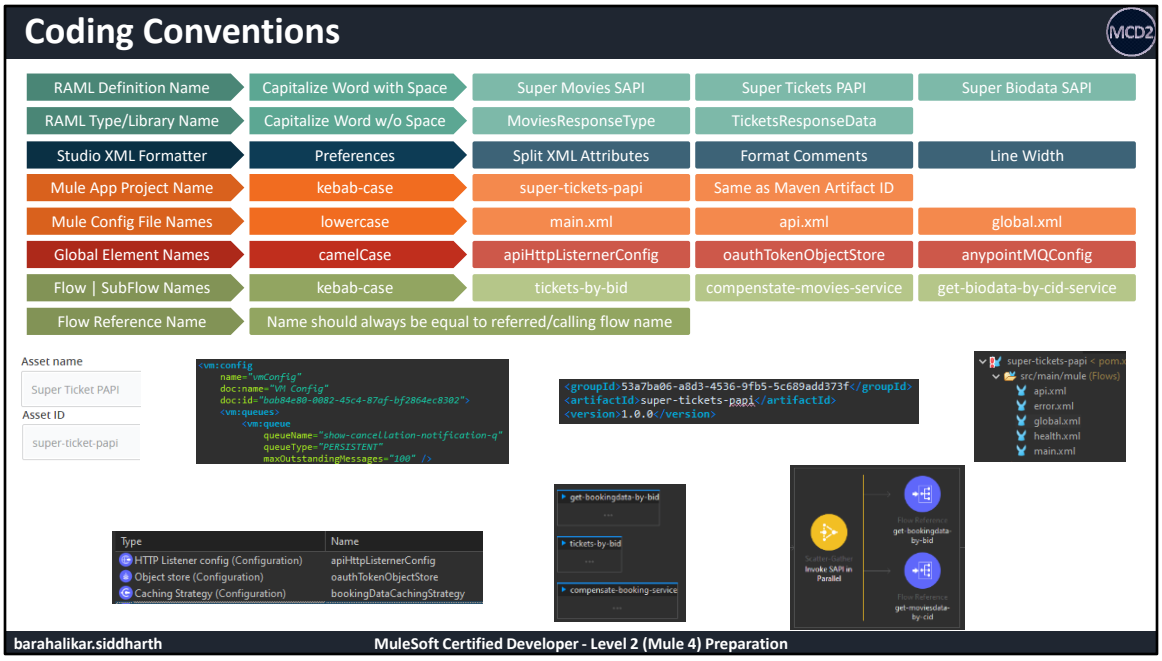
- Steps to achieve it

Coding Conventions

- Naming Conventions
- Project Structure
- Anypoint Studio Settings



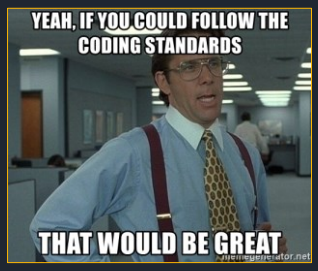
Coding conventions are a set of guidelines for a specific programming language that recommend programming style, practices, and methods for each aspect of a program written in that language.



We will be looking at naming convention of various resources,

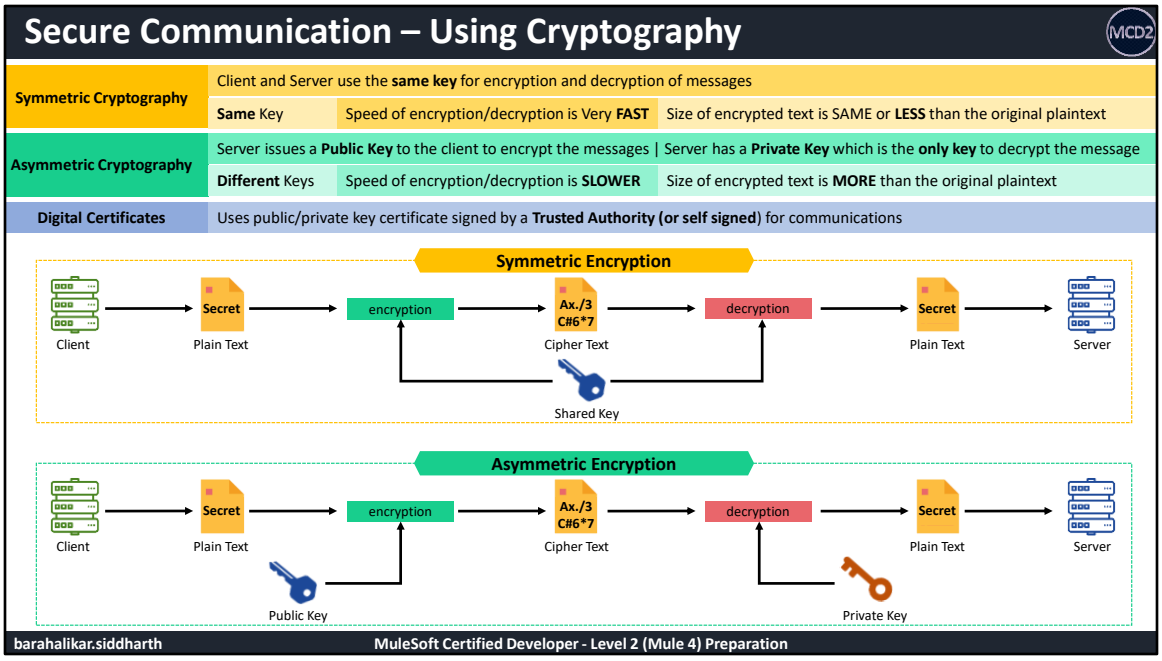
1.5 Coding Conventions

- Naming Conventions
- Project Structure
- Anypoint Studio Settings



Secure Communication

- Using Cryptography
  - Symmetric Encryption
  - Asymmetric Encryption



Secure communication is the safe way of sharing information that cannot be intercepted by a third party users.
It is supported using Cryptography like Symmetric, Asymmetric cryptography and digital certificates

- In **symmetric cryptography**
    - the client and server share the same key to encyprt and decrypt data
    - The key lengths varying between 128 and 256 bits and so the
    - Speed of encryption/decryption is very fast
    - Size of the text is same or less than the original plain text
- In **Asymmetric Cryptography**
    - Server issues a **Public Key** to the client to encrypt the messages | Server has a **Private Key** which is the **only key** to decrypt the message
    - *So 2 different keys are used for encryption and decryption*
    - key length between **1,024 and 4,096 bits** because of which the
    - Speed of encryption/decryption is slower
    - Size of the text is MORE than the original plain text

    - Talking about
- ***Digital Certificate – It us***ses public/private key certificate signed by a **Trusted**

Authority (or self signed) for communications. We will see more about this in the next slide

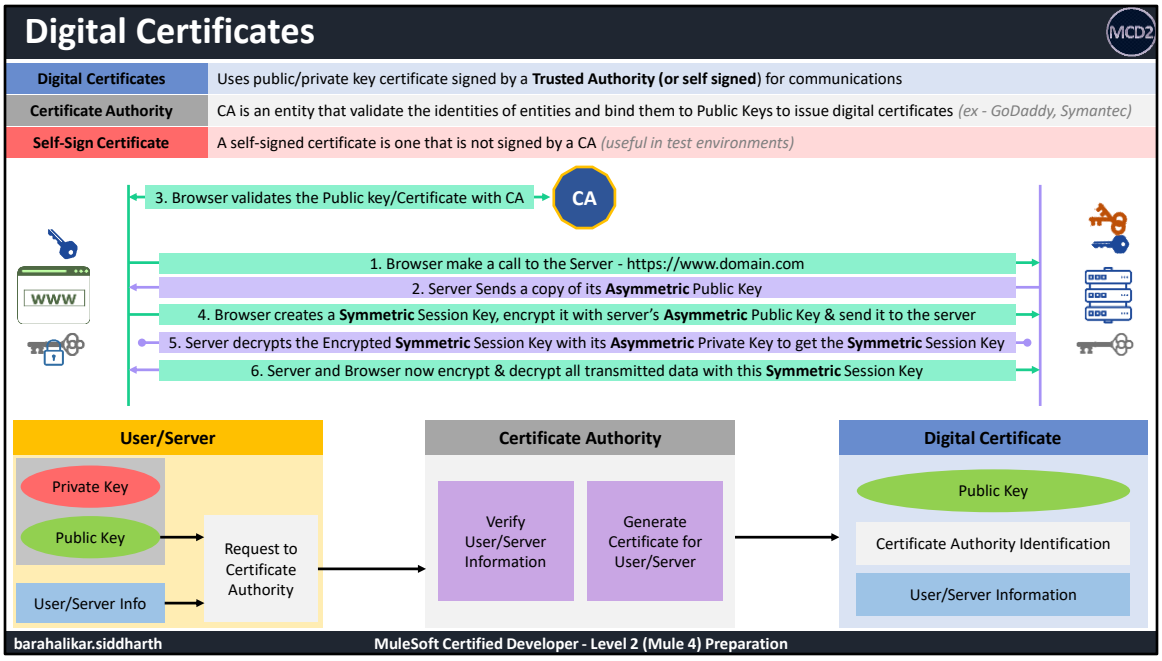
- Lets have a quick look at the **Symmetric** Encryption
    - We have a client and a server
    - The client encrypts a plain text using a shared key which results in a cipher text
    - Ciphertext is **encrypted text transformed from plaintext using an encryption algorithm**
    - **The server** decryptes the cipher text using the same shared key to get the plain text
    - *One disadvantage here is, At some point the client and the server have to exchange this SHARED key for encryotion/decryption. If it get* intercepted by a third party users. Then they will be able to access everything
    - We will see how this can be overcommed in the next slide

- Lets have a quick look at the **Asymmetric** Encryption
    - The flow remains the same
    - Here the client uses a public key to encryo the plain text
    - And Server uses a Private key to decrypt the cipher text

    - I hope you understood the difference between symmetric and asymmetric encryption, in the next session we will look at di

Secure Communication

- Digital Certificates
  - Certification Authority
  - Self-signed Certificate
  - Process Steps



Digital certifiactes are electronic credentials used to assert the online identities of individuals, computers, or applications.
Similar to ID cards like passport, driving license, these certificates contain public keys & identity of the owner

Digital certificates Uses public/private key certificate signed by a **Trusted Authority (or self signed**) for communications

Certificate Authority is an company that validate the identities of entities and bind them to Public Keys to issue digital certificates *(ex - GoDaddy, Symantec)*

If you are testing your application, we can use self-signed certificates, A self-signed certificate is one that is not signed by a CA

What is the process of getting a Digital Certificaiton?
The user generates a Key pair (i.e public & Private key)
The user sends a CSR, certificate signing request to CA by passing the public key and user/server information

The certificate authority verifies the User/Serve info, by contacting/checking them
If everything is correct, CA generates a Certificate foe the Server

This digital Certificate contains the Server Public key, Certificate Authority Identification Information and the Server Information

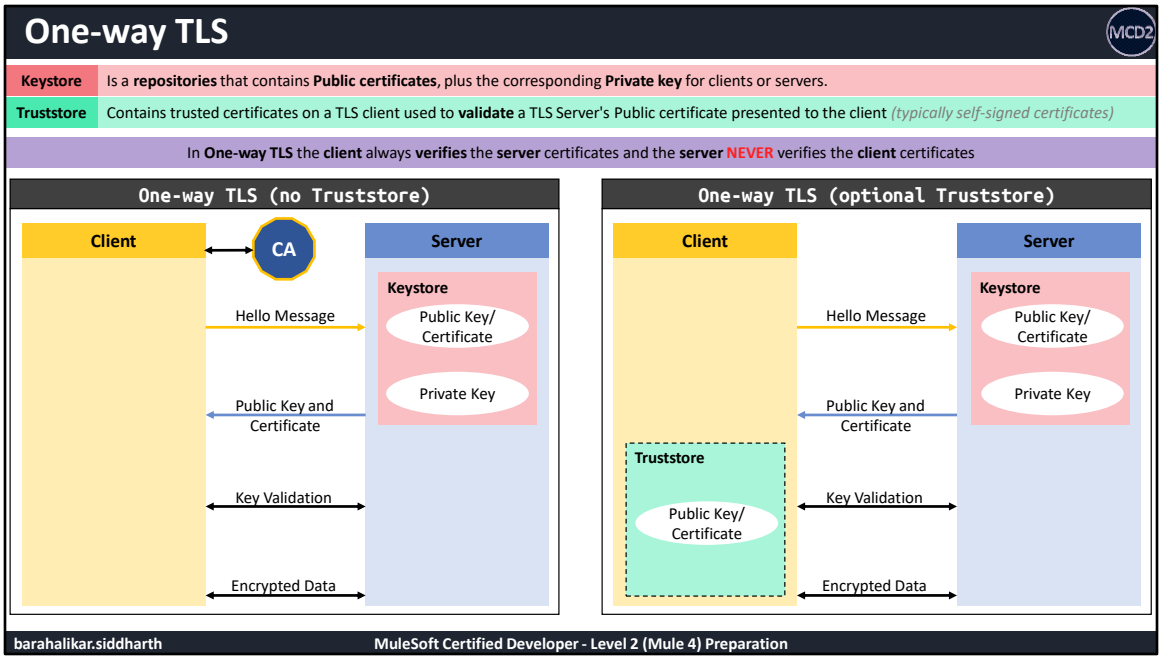
Once the server has the keys, how do they stablish a Secure Connection with the client?

Please note that at the end of the process, both client and server are using a SYMMETRIC KEY to encrypt/decrypt the data. But to exchange this SYMMETRIC KEY securely we have use ASYMMETRIC Keys

I hope this make sense and know you are an expert in SSL. Thank you

SSL/TLS Options

- One-way TLS
- Two-way TLS



Lets understand what are keystores and truststires

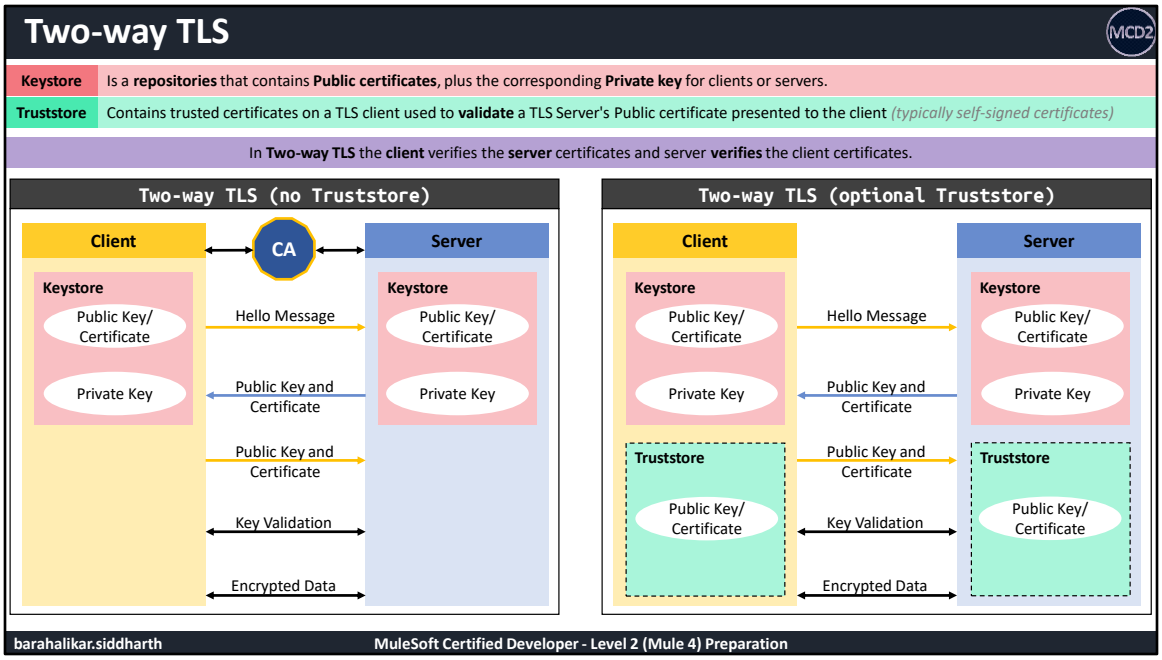
Lets talk about one-way tls with no truststore
We have a client, a CA and a Server with keystore holding keys

- The client issues a session request to the server.
- The server responds with a certificate, which contains its public key.
- This certificate comes from the server's keystore, which also contains the server's private key.
    - The private key is never sent to the client.
- For a signed cert, the client makes a request to the Certificate Authority (CA) to authenticate the certificate.
- If certificate is valid
- The client and server exchange several more messages to validate keys.
- Then the client begins TLS data transfer with the server.

This is an example where client doesn’t use a truststore, it validate certs with the CA

Now Lets talk about one-way tls with truststore

- **TRUSTSTORE**
- **It is the same as before but,**
- If the TLS server uses a self-signed certificate or a certificate that is not signed by a trusted CA, then you create a truststore on the client.
- The client populates its truststore with server certificates and public keys that it trusts.
- When the client receives a certificate, the incoming certificate is then validated against the certificates in its truststore.



Let talk about 2-way-tls following the same example discussed in previous silde

Here both the client and server have there own keystores.
The client issues a session request to the server.
The server and the client both responds with a certificate, which contains its public key.
For a signed cert, the client and server makes a request to the Certificate Authority (CA) to authenticate the individual certificates.
If everything is valid
The client and server exchange several more messages to validate keys.
The client begins TLS data transfer with the server.

Now Lets talk about two-way tls with optional truststore

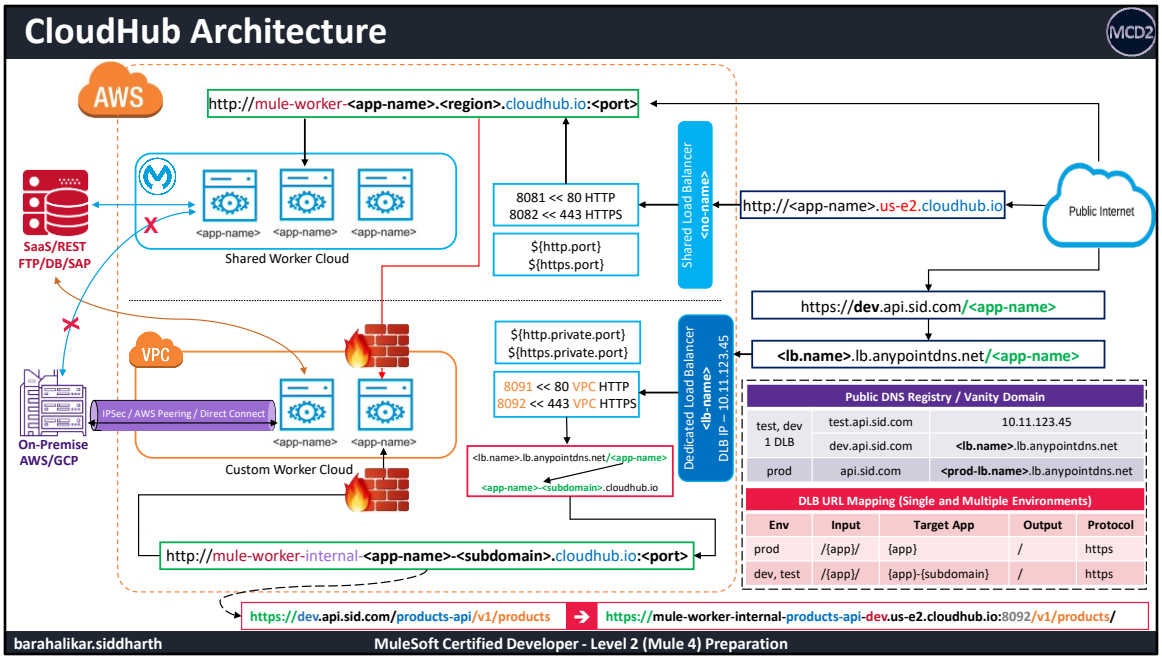
- **TRUSTSTORE**
- **It is the same as before but,**
- If the Client & server uses a self-signed certificate or a certificate that is not signed by a trusted CA, then you create a truststore on both the client & server.
- The client populates its truststore with server public keys and server populates

its truststore with client public key.

- When the client & server share certificates, the incoming certificates are then validated against the certificates in their truststore.

Architecture

- CloudHub Architecture



In your Mule app code, you use api.port instead of the more conventional http.port, https.port,
http.private.port, or https.private.port for the name of the configuration property that holds the
port (8081, 8082, 8091, or 8092, respectively) on which the API is exposed. This is so that an API
implementation can, for example, move from the public CloudHub worker cloud to a VPC by just
changing the value of api.port from 8082 to 8092 in a properties file, while keeping all Mule flow
config files unchanged in using the property name api.port.

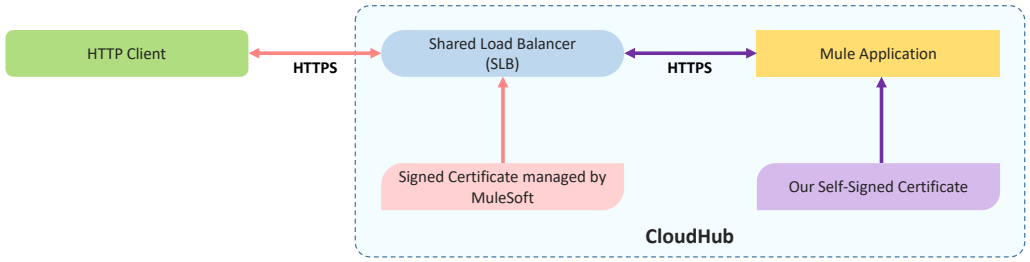
Self-Signed Cert

- Generate a Self-signed certificate
  - JKS vs PKCS12

Create Self Signed Certificate – One-Way-TLS

Create A Private/Public Key Pair - ***server-keystore.jks*** file contains the newly generated public and private key pair

```
keytool -genkey -alias mule-server -keysize 4096 -keyalg RSA -keystore server-keystore.jks
```



Create A Private/Public Key Pair - ***server-keystore.p12*** file contains the newly generated public and private key pair

```
keytool -genkey -alias mule-server -keysize 2048 -keyalg RSA -keystore server-keystore.p12 -storetype pkcs12
```

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In one way tls all we need is a pair of public private key stored in a keystore. We can generate them in multiple ways, one of them is using KEYTOOL cmd.

The default format used for these files is **JKS until Java 8**.
Since Java 9,**the default keystore format is PKCS12**.
The biggest difference between JKS and PKCS12 is that JKS is a format specific to Java, while PKCS12 is a standardized and language-neutral way of storing encrypted private keys and certificates.

We can use any of them based on the preference, I have mentioned both the cmds overs here for you reference.

Within Cloudhub, if we deploy a HTTPS based application behind a Shared Load balancer, then SLB is going to use it's own certificate to tterminate TLS.
In cases where we want to terminate TLS using our certifications, we must deploy the application behind a Dedicated LoadBalancer

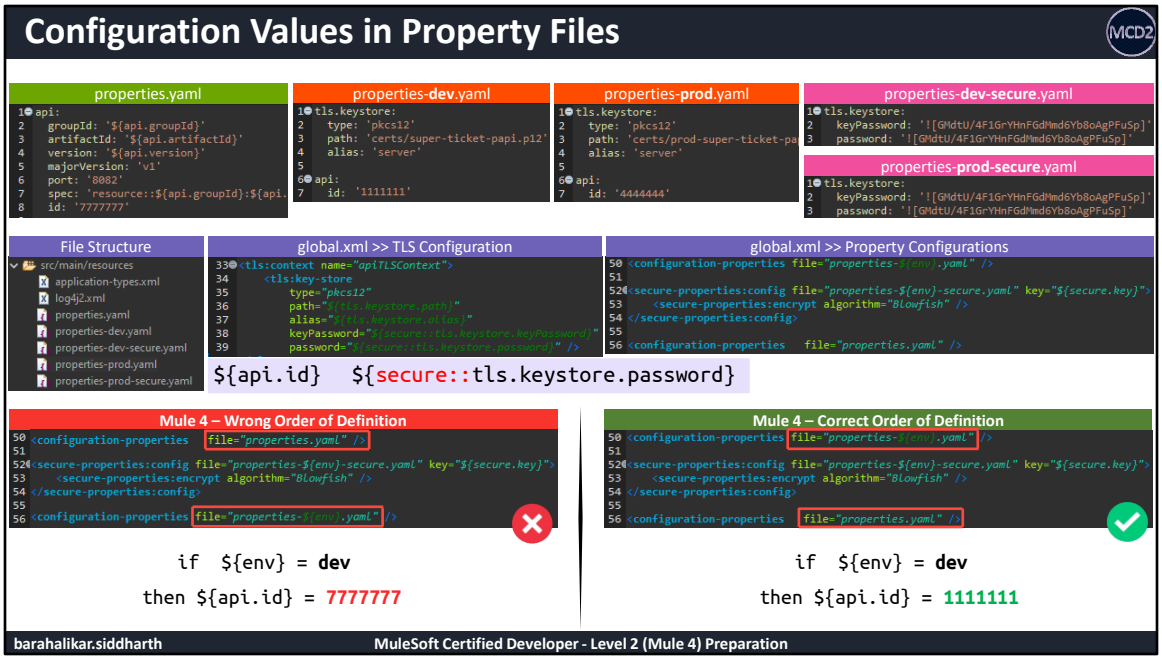
1.6 Self-Signed Cert & CloudHub

- Generate a Self-signed certificate
- Configure it in Mule Application
- Run Locally
- Deploy to CH manually

MCD2

Configuration Properties

- Types of property files
- Naming Convention
- Order of definitions



It is best practice to centralize the management of properties rather than hard code values at the places. This allows for the reuse of values and better maintenance. Instead of changing the property in multiple places you change the value once in the property file.

Applications typically use different values in different environments
We develop a application and deploy or promote the same artifact to different environments
Whenever we change environment, it is not a acceptable to make changes in artefacts.
So we make use of multiple property files each based on a specific environment. If you see here both dev and prod env use different API Instance ID.

Apart from these we also need to encrypt certail sensitive properties like passwords. We use separate property file for them as well. We will see how to encrypt them in a different session.

How do we use these property files?
We use placeholders in the connectors,

To access plain text value we use ${} and
The secure:: prefix is needed to access encrypted values from secure property files
The secure:: prefix is mandatory for all properties in a secure property file, even if one of the property is plain text
We have not used any plain text in our secure properties yaml, but if we had a plain text property, it should have been access using secure:: prefix. To avoid this we are using separate files for plain text and encrypted properties.

Within the global xml we add the CONFIGURATION PROPERTIES, but we have multiple files, so in which order should we define them?

Within Mule 4, it follows TOP 2 DOWN apprioch
The first property processed is PRESERVED
Later definitons cannot OVERRIDE them
This is a complete opposite behaviour compared to MULE 3

So in this example…

1.7 Configuration Properties

- Add properties.yaml

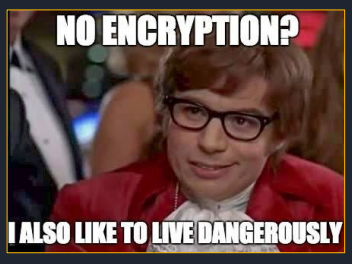
1.8 Configuration Properties

- Add environment specific property files
  - properties-dev.yaml
  - properties-prod.yaml

- Promote APIs to PROD env
  - Deploy to PROD

Secure & Safe Properties

- Encrypting properties
- Safe-Hidden properties



https://docs.mulesoft.com/downloads/mule-runtime/4.2/secure-properties-tool.jar

It is critical to ensure that the sensitive information that a application stores is secure, protected from unauthorized users and malicious attackers. You can encrypt configuration properties as a security level for your applications.

We use the Secure Properties Tool to encrypt or decrypt text strings, values inside a properties file, or all the contents of a properties file.

Mulesoft provide a the tool as a JAR File, we download it and encrypt properties.
*****Example the command********

This example shows a Admin/Ops teams encryption a single Text Strinf using CBC mode of Blowfish algorithm, the value is encrypted and decrypted using a SECRETKEY. Details like the algorithm, mode used and encrypted value are sent to the Developers

---
Developers configure this value in a secure properties file

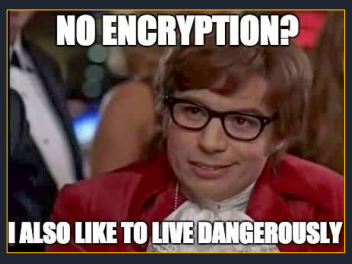
And make use of a Secure properties extensions module to decrypt this value during runtime
Since the developers are unaware of the secret key use, an dynamic placeholder is used in the place.
Finally the secret key is added to a secure-properties field in mule-artefact.json to hide the value in Cloudhub ui.
Developer packages the application and pushes it to a repo

The Admin/Ops or Cicd pipeline picks the app from repo and deployes it to Cloudhub by passing the secretKey as a property.
This key is used by secure properties extension to decrypt the values during runtime
And since we have used secure properties in Mule-artefact json, the secret key is masked in the Cloudhub UI >> this process is called as Hidden Properties.

`These values will be masked and can never be retrieved again via Runtime Manager GUI or API`

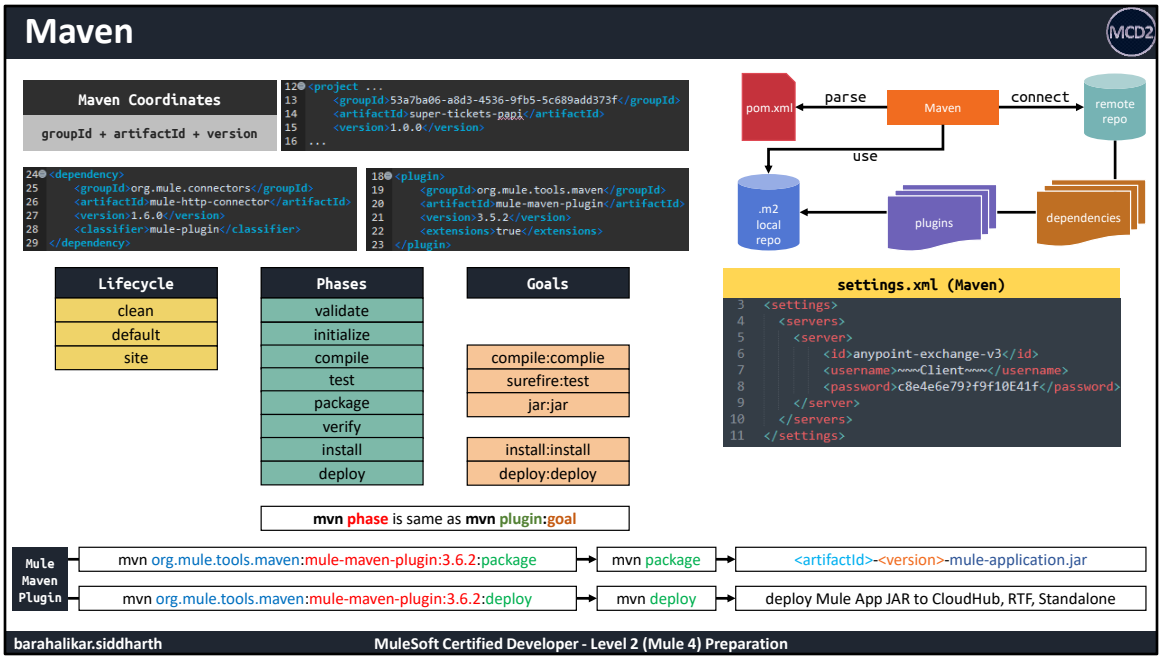
1.9 Secure & Safe Properties

- Encrypting properties
- Configuring them in app
- Safely hide secure keys
- Deploy the app



Maven

- Maven Basics



- We use Maven to avoid writing scripts for building projects and manually downloading the dependencies.
- Dependencies are nothing but libraries or JAR files.

- We need to specify required dependencies within a POM XML file.
- Maven parses the pom xml and checks for the dependencies within the local maven repo,
    - If it doesn't find them, it tries to get them from the central/remote repo
        - And stores them in the local maven repo

How does it find them?

- Maven uses coordinates a combination of groupid artifactid and version, for everything like project, dependencies and plugins defined in the pom xml
- For external credentials, it makes use of Mvn settings .xml to connect with external repos like anypoint exchange or mule maven enterprise repo

There is a specific life cycle that Maven follows to deploy and distribute the target project.

There are three built-in life cycles:
default – This is the main life cycle of Maven as it is responsible for project deployment.
clean – This life cycle is used to clean the project and remove all files generated by the previous build.
site – The aim of this life cycle is to create the project's site documentation

Each life cycle is made up of a sequence of phases.

A Maven phase is nothing but a stage in the Maven build life cycle. Each phase executes a specific task.
Here are a few important phases in the default build life cycle

validate – phase checks if all information necessary for the build is available
compile –phase compiles the source code
test-compile –phase compiles the test source code
test –phase runs unit tests
package –phase packages compiled source code into the distributable format (jar, war)
integration-test –phase processes and deploys the package if needed to run integration tests
install –phase installs the package to a local repository
deploy –phase copies the package to the remote repository

if you run the command mvn deploy, that is, the deploy phase which is the last phase in the default build life cycle, then this will execute all phases prior to the deploy phase as well.

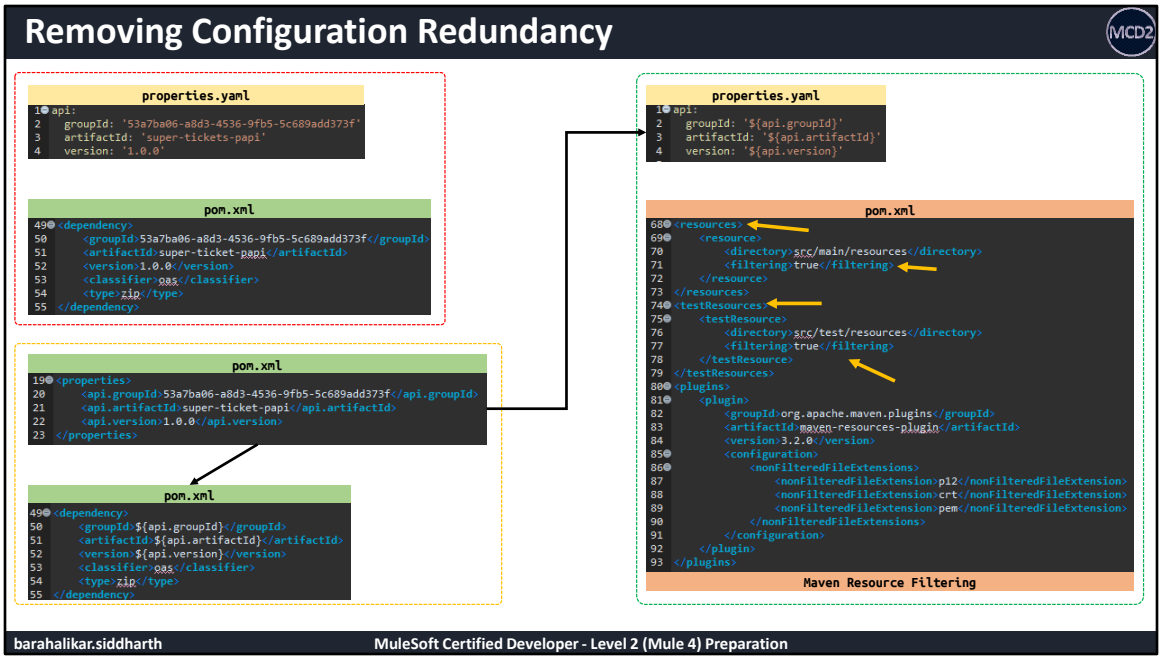
Each phase is a sequence of goals, and each goal is responsible for a specific task.
When we run a phase – all goals bound to this phase are executed in order.
The syntax used is plugin:goal

Here are some of the phases and default goals bound to them:

The Mule Maven plugin enables you to integrate the packaging and deployment of your Mule applications with your Maven lifecycle.

Resource Filtering

- What?
- Why?
- How?



To avoid any duplicate configuration values we have Externalized the properties to a property yaml files in an earlier session

But duplicates arise when working with dependency properties. As we see here, both pom xml and properties yaml file use the same maven coordinates and can rise issues in the future. For example if the version of the api spec is updated, it needs to be changed in 2 places and will raise errors if we miss updating in either of the files

To avoid this we can make use of Maven resources plugin.
Maven Resource Filtering uses placeholders in resource files and replace them with actual value during configuration

This plugin has multiple goals like,
***resources* – goal** which copies resources that are part of the main source code
***testResources* –** goal copy resources that are part of the test source code

In the given configuration, there's a parameter named *filtering* with the value of *true*.
The *filtering* parameter is used to replace placeholder variables in the resource files.

Apart from goals we can also add some configuration to filter some extensions which don't require filtering.

We can make use of properties within pom xml to use the values for filtering.

These values are reffered in depenedency using placeholders,
The same values can also be reffered in properties yaml file

So in the future any changes to coordiantes can be done in pom properties alone and It will be reffered in multiple places

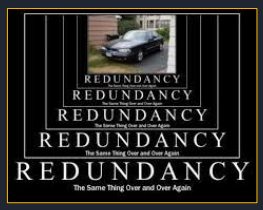
In this way we can avoid duplicate values in multiple files

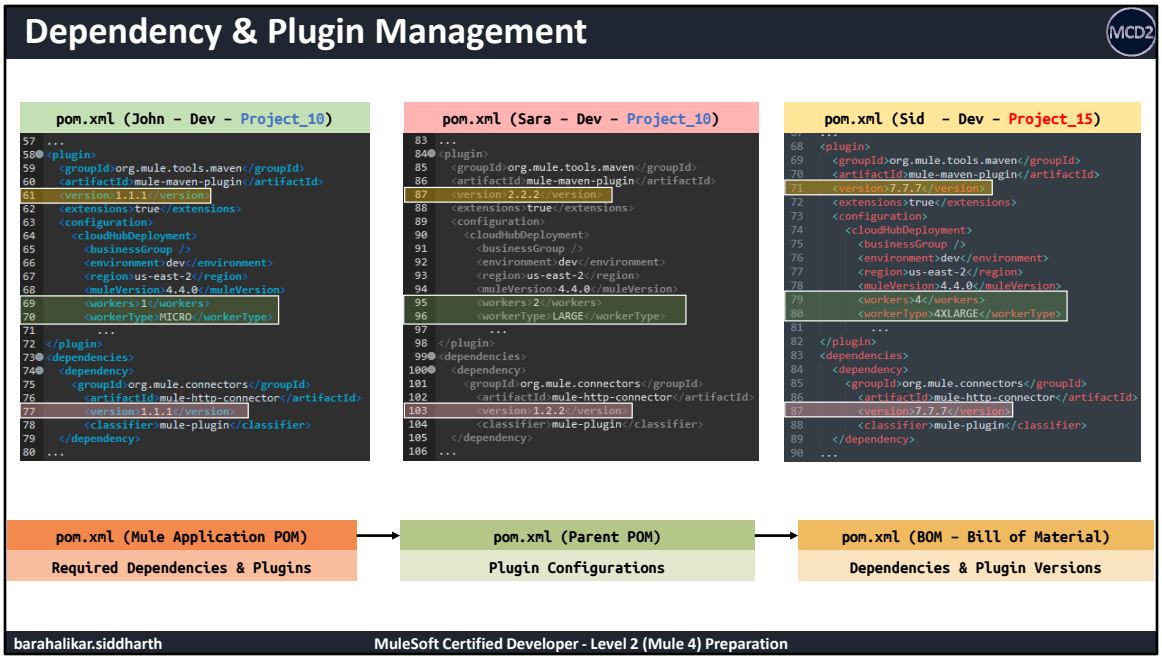
1.10 Resource Filtering

- Configure Plugin
  - Include property file
  - Exclude certain Extensions
- Check /target directory

Build Redundancies & Duplication

- Dependency Management
- POM
  - Parent POM
  - Master BOM





Lets understand why Dependency & Plugin Management is a complex task by taking a simple example,

Lets assume we have a Developer John working on app called Project_10.
His pom xml contains a mule maven plugin of version 1.1.1, using 1 worker of type MICRO and also has a http connector of version 1.1.1
His maven package command is faling and is unable to fix it,
So he connects with his teammate Sara

Sara is also a developer working on the same Project10 app,
Upon discussion they found that Sara's mvn package command is working as expected, but they
Found that they are using different configurations values.
Sara's pom defined mule maven version as 2.2.2 and used 2 workers of type LARGE and use 1.2.2 versoon of http connector.

Now both of them are not sure which configurations is correct.

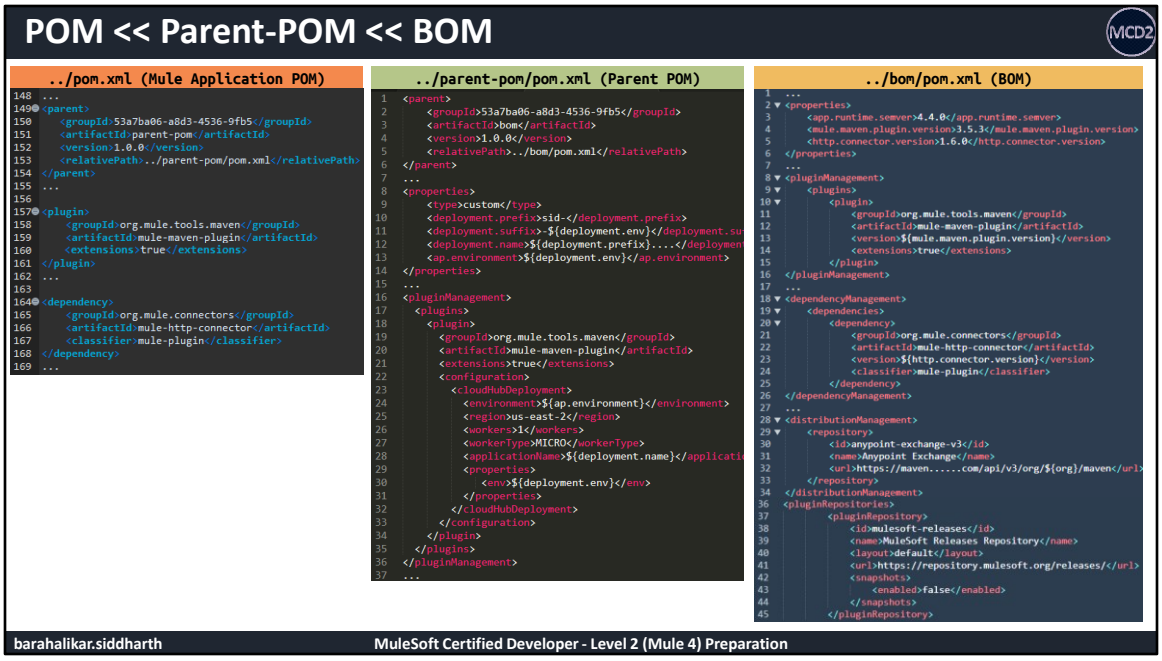
They reach out to another developer Sid working on a different app named

Project_15
Sid's pom configuration uses all latest versions of plugins and dependencies

This issue arises when a organization doesn't have a standard build configuration in place.
This can be avoid by extracting the MAVEN Plugin configurations that are not specific to a mule app to a reusable Parent Pom.
Dependencies management can be extracted into their own parent-pom called as BOM-bill of mareials

The reason we have a separate pom for versions management and pugin management is beacuse it is more common to update the dependency/plugin versions compared to plugin configurations

In this way we can reduce redundance by making all project use a centralized parent-pom and bom. Any changes to these pom's will be reflected in all projects.



Lets understand how this works in a Mule app,

Lets start with the BOM, which manages the versions of both dependencies and plugins

Within Parent-pom we define the plugin configuration for example the Mule maven configuration for Cloudhub deployment

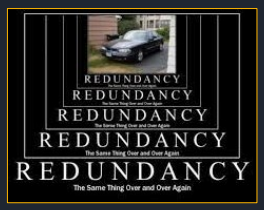
Within Mule app we just define which dependency and plugins are required. If you notice we do not define any versions on mule app pom and parent pom.

As all versions are managed by a BOM
And at the same time mule maven configuration is part of the parent-pom

Any new project can reuse the parent-pom and bom-pom configuration to avoid duplications and redundancies.zz

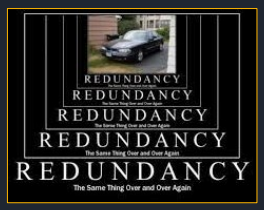
1.11 Parent-POM

- Configure Parent-POM



1.12 Master-BOM

- Configure Master-BOM



1.13 Maven Build

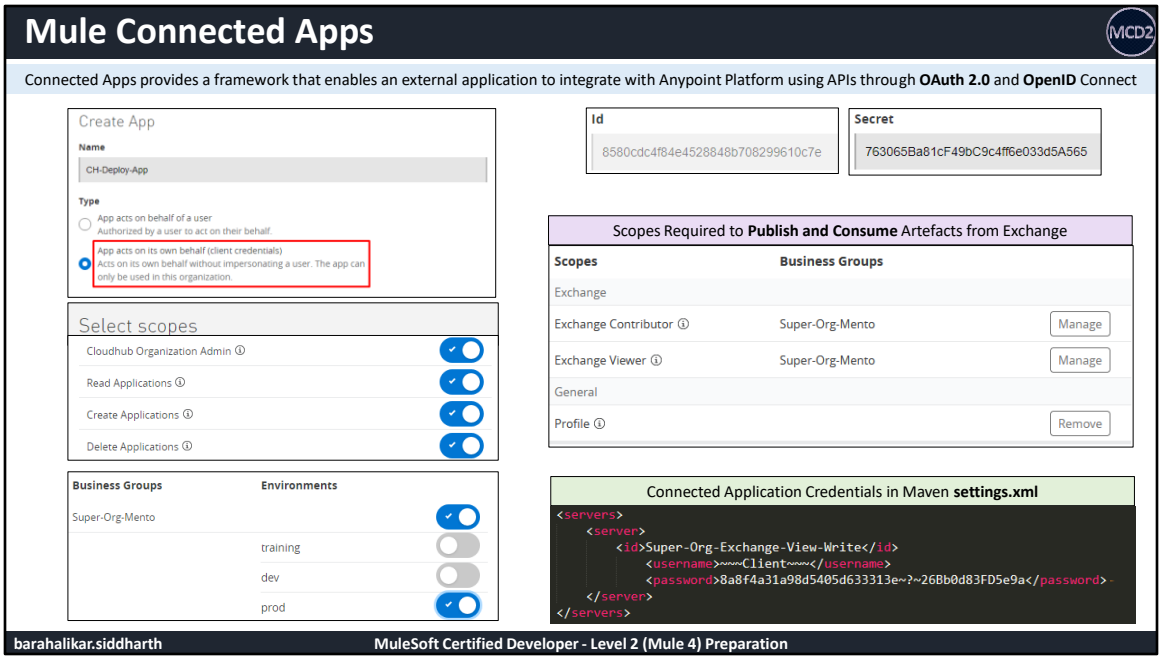
- Use Anypoint Studio **7.12**
  - Update Workspace and Mule App
- Check and Change **local .m2** repository
- **Re-Install** Parent-POM & Master-BOM
- Build Mule Application using **Maven**
  - Understand the **401** Unauthorized Error

MCD2

1.14 Connected App

- What?
- Why?
- How?

- Use credentials in settings.xml
- Build application



The Connected Apps feature provides a framework that enables an external application to integrate with Anypoint Platform using APIs through OAuth 2.0 and OpenID Connect.

Only an organization administrator can view and manage connected apps feature for the entire organization.

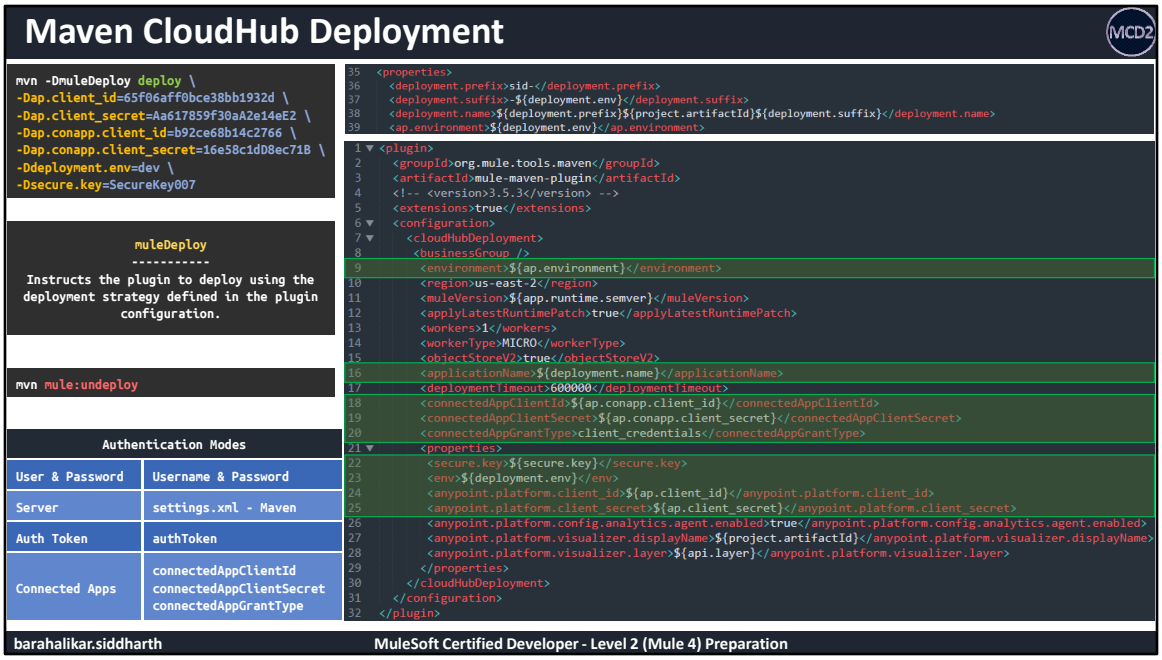
Developers can delegate access to applications that use APIs to interact with Anypoint Platform programmatically. For example while building Mule apps using CICD, the scripts needs appropriate credentials to deploy the application to Cloudhub, the traditional way is to embed users username and password within the maven settings xml.

This is not recommended because, the user credentials moght be exposed and can be use for priviledged anypoint platform access.

To avoid this we can make use of connedted apps.

Maven Deployment

- CloudHub Deployment
- Connected App
  - Scopes



In addition to using Anypoint Studio, Anypoint Runtime Manager, or the Anypoint Platform CLI to deploy applications to CloudHub, you can also deploy, redeploy, or undeploy applications by using the Mule Maven plugin.

To do so, we must add the mule maven plugin and coudhub deployment strategy in the project's pom.xml or parent-pom.

applyLatestRuntimePatch When set to true, the plugin instructs CloudHub to update the worker to the latest available patch for the Mule runtime engine version specified in the deployment configuration, and then deploys the application.

Authentication Methods

When you deploy applications using Mule Maven plugin, you can use different methods to provide your credentials to authenticate against the deployment platform. Depending on the authentication method you use, the parameters to set in the deployment configuration differ

Different mode .. Explain

Here I have use connected apps and hence configured them in the plugin

For deployment we can eother use mvn deploy or pass in an argument –DmuleDeploy
Both of them deploy the app to Cloudhub, but

muleDeploy
Instructs the plugin to deploy using the deployment strategy defined in the plugin configuration. If the muleDeploy parameter is not set, the plugin uploads the artifacts to the repository defined in the distributionManagement section of the application's pom.xml file.

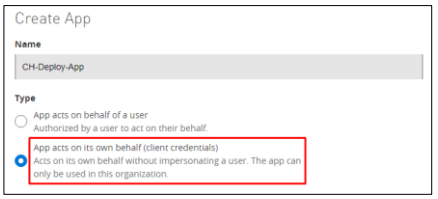
we can use a simple mvn mule:undeploy command to undeploy app from cloudhub

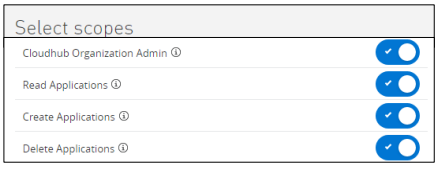
https://docs.mulesoft.com/mule-runtime/4.4/mmp-concept

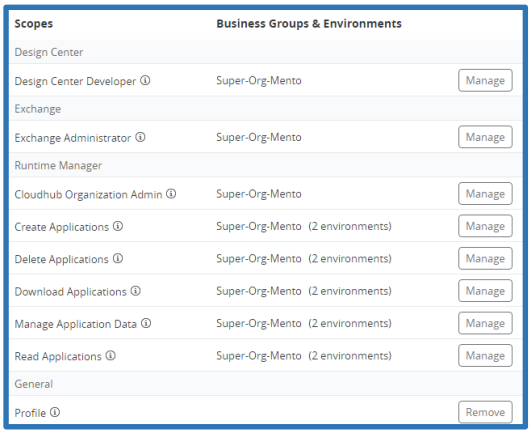
https://docs.mulesoft.com/mule-runtime/4.4/mmp-concept

Mule Connected Apps

Connected Apps provides a framework that enables an external application to integrate with Anypoint Platform using APIs through **OAuth 2.0** and **OpenID** Connect







1.15 Maven Deployment

- CloudHub Deployment
- Connected App
  - Scopes

1.16 Anypoint Visulaizer

- What/Why
- Configure in application
- Deploy and check

Anypoint Visualizer

```
        <api.visualizer.layer>Process</api.visualizer.layer>
    </properties>
```
Mule app pom.xml

```
<anypoint.platform.config.analytics.agent.enabled>true</anypoint.platform.config.analytics.agent.enabled>
<anypoint.platform.visualizer.displayName>${project.artifactId}</anypoint.platform.visualizer.displayName>
<anypoint.platform.visualizer.layer>${api.visualizer.layer}</anypoint.platform.visualizer.layer>
</properties>
</cloudHubDeployment>
```
Parent-pom pom.xml

```
anypoint.platform.config.analytics.agent.enabled=true
anypoint.platform.config.analytics.agent.disabled=true
anypoint.platform.visualizer.displayName=<project-artifactId>
anypoint.platform.visualizer.layer=Process
```

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Anypoint Visualizer provides a real-time, graphical representation of the APIs, and Mule applications that are running and discoverable.

Anypoint Visualizer collects data from Mule applications and APIs to display these graphs.

Anypoint Visualizer has three use cases, or *visualizations*: Architecture, Troubleshooting, and Policies.

- The *Architecture visualization* shows the topology of your apps and APIs. This visualization is useful for understanding your system architecture.
- The *Troubleshooting visualization* enables you to view the health of the system and evaluate performance-based metrics.
- The *Policy visualization* enables you to see the policy landscape of your application network at a glance.

to Enable Visulization monitoring we need to add a property to each application deployed to CloudHub. ……

anypoint.platform.config.analytics.agent.enabled=true

To associate an application with a specific layer like Process , System, Experience, Backend a property name…….
anypoint.platform.visualizer.layer=Process

And to use a specific display name, we use
anypoint.platform.visualizer.displayName=<project-artifactId>

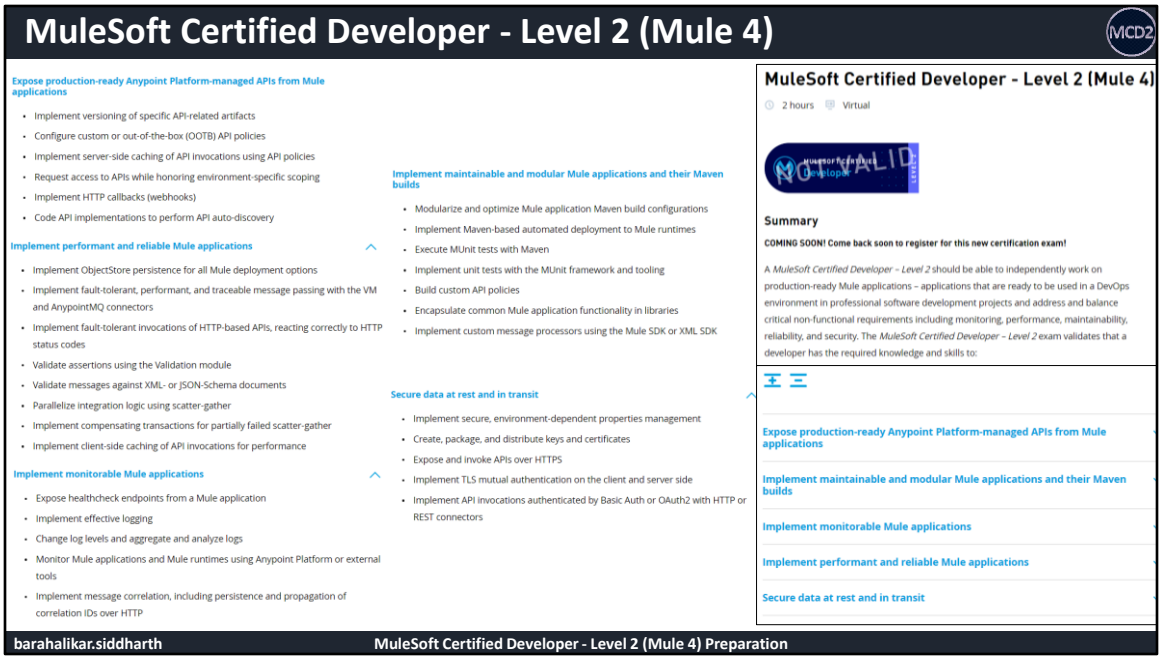
So where do we define these properties?

Welcome to Section 1, in this section we will start by adding an Open API Specification to Design center,
Configure API instance for it in API manager and Import it to Studio

Within Stuido, we will add best coding conventions and setup the project structure.
We will Learn about Cryptogrpahy and how to use it for secureing communicatons/data in transist.
For static data we will use Secure and Hidden properties to encrpt and mask them

We will also understand Cloudhub architecture and setup a Maven based deployment strategy.

We will also modularize mule apps using parent-pom and bill of materials concepts.
We will end this section by visualizing the API interactions within Anypoint Visualizer



This course doesn't talk about what mulesoft is or what it is used for, because if you are preparing for this Level 2 certification, you already know about it.

As we know, there are 3 major Level 1 Mule certifications, which are MCD L1, MCIA L1, MCPA L1

This course is specifically designed for MCD L2 certification which is all about working independently on production ready mule apps.
It has 5 major topics like
Expose production ready anypoiny platform managed apis from Mule applications
Implement monitorable mule apps
Secure data at rest and in transit
And others

These 5 topics have around 30+ subtopics

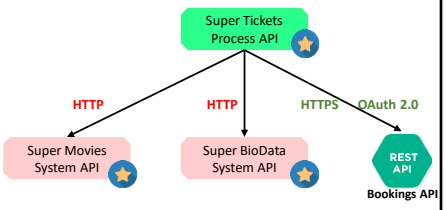
We will dive into each of these topics, by first understand the concept and then implementing it

So how do we do this?

Section 2

#2 Mule Integration - API Development, Error Handling, Caching Strategies

- Add System API REST Connectors to Anypoint Studio
- Get credentials and invoke the SAPI
- Configure HTTP Non-functional requirement
- OAuth 2.0 – Client Credentials Grant Type
- Add DEBUG Async Logging
- Add transformation logic
- Handle custom exceptions
- Parallel execution using Scatter-gather
- Scatter-gather error handling
- Use Until Successful scope to handle HTTP Errors
- Transient vs Permanent HTTP Errors
- Client Side Caching using Object Store/Cache Scope
- Server Side Caching using API Manager's API Caching policy

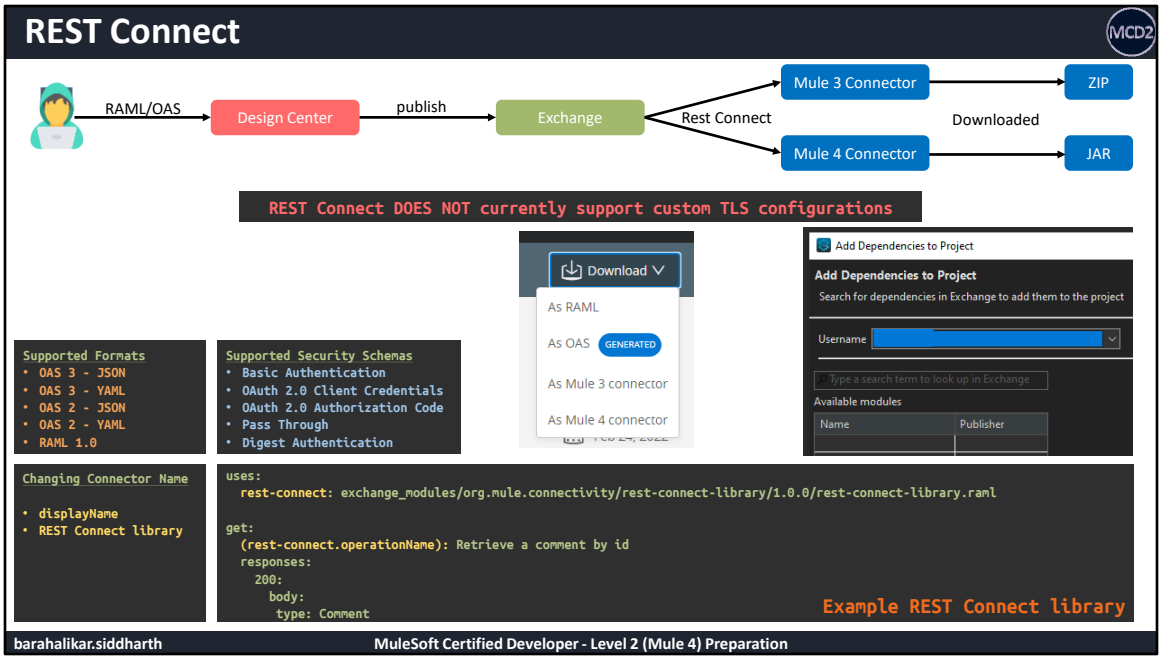


- Welcome to Section2, in this section we will start adding the integration logic to our Super tickets Papi
- We will add system api rest connectors in studio
- Get credentials, apply non functional requirement and invoke SAPI
- We will discuss about Oauth in detail and configure http request connector to call an oauth service to get tokens and use the token in header
- Watch Oauth server interactions using a DEBUG Logger

- TO improve performance we will use Scatter gather for parallel execution of these apis, followed by
- Handling errors for scatter gather and the Mule application following the concepts of transient and permanent http errors
- We will end this section by implemention both Client side and server side caching.

REST Connect

- What?
- How to create?
- How to configure in Mule app?



REST Connect quickly converts an API specification (RAML 1.0, OAS2 or OAS3) to a connector,

How is it done?

A developer writes API Specitiontion in design center and publises it to exchange
The Exchange backend uses REST Connect to transparently convert a REST API specification to a Mule 3 and Mule 4 connector.
REST Connect DOES NOT currently support custom TLS configurations
But supports other security scheams like basic auth, Oauth and others
It can be download or used as a connector in Anypoint Studio.

To add a custom Display name to each resource, we can use display name field or a REST Connect Library
This is th code for the library and if you remember we have used this in one of our earlier RAML

Points to be noted,
REST Connect generates metadata for each operation based on your

schema definition in the request and response for each method in your RAML.
REST Connect cannot generate metadata based on examples in the RAML.

You need to define a schema to generate metadata.

2.1 REST Connect

- How to configure in Mule app?

2.2 REST Connect

- Get Access (client id and secret)
- Configure them in App

2.3 REST Connect

- Add timeouts to follow
  - Non-functional requirement

MCD2

API requirements include functional & non-functional requirements

A functional requirement defines (what your API should do)

example of functional requirement are like,
the api should be accessible in a mobile application.
api should be Servicing financial transactions.
api should provide a self-serve portal.

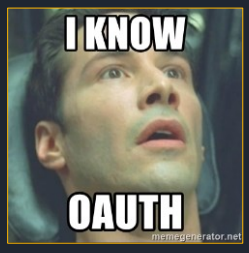
Where as nonfunctional requirements define (how your API should perform in terms of service level agreements).

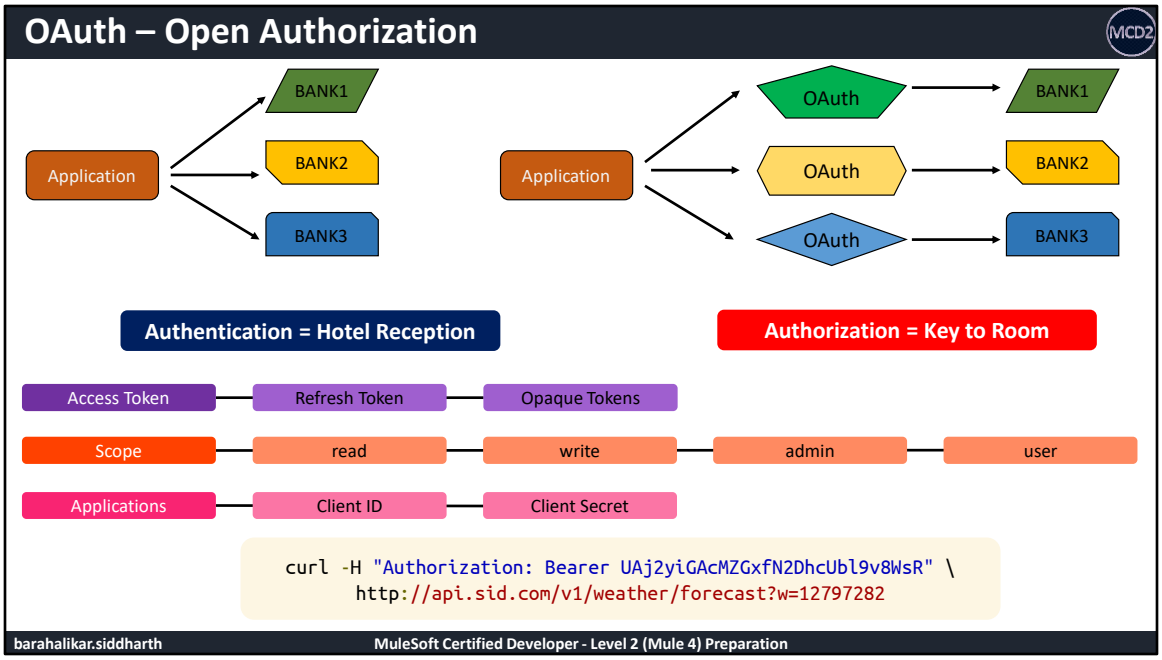
examples of non fucntional requirement could be service Availability, scalability, security policies, response timeouts , latencies and etc
.
Non-functional requirements are essential **to ensure the usability and effectiveness of the entire system**

In this session we will look into response timeouts

OAuth 2.0

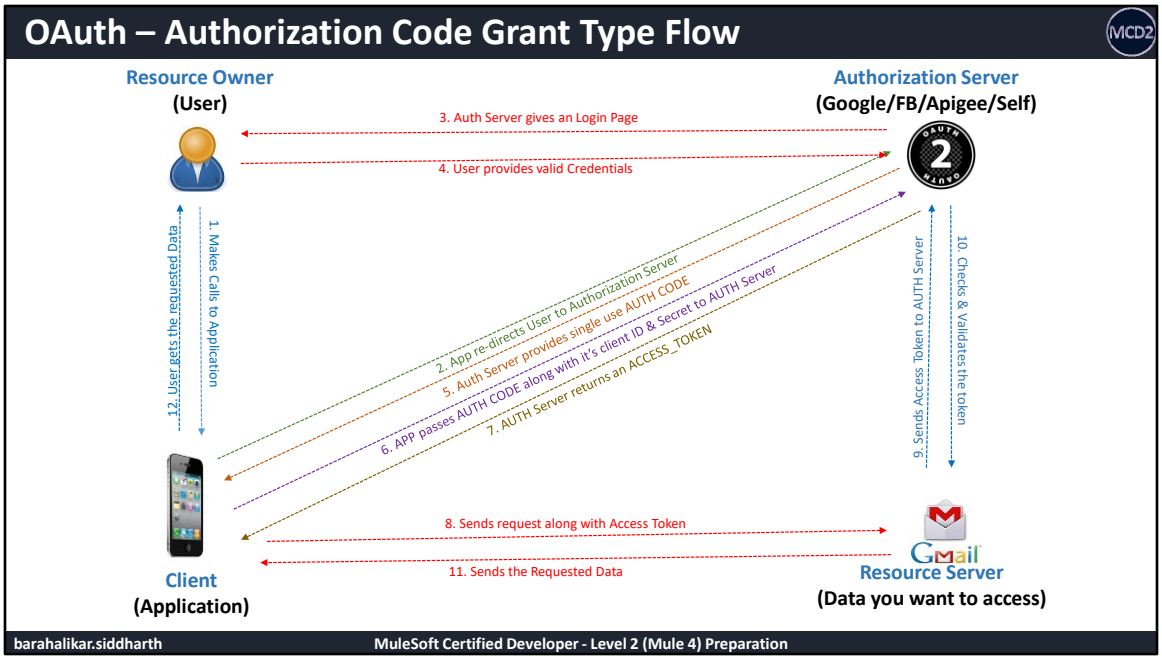
- What/Why/How?
- Authorization Code Grant type steps





The OAuth (open authorization) protocol was developed to **enable secure delegated access**. It lets an application access a resource that is controlled by someone else.

Lets assume we have 3 bank accounts



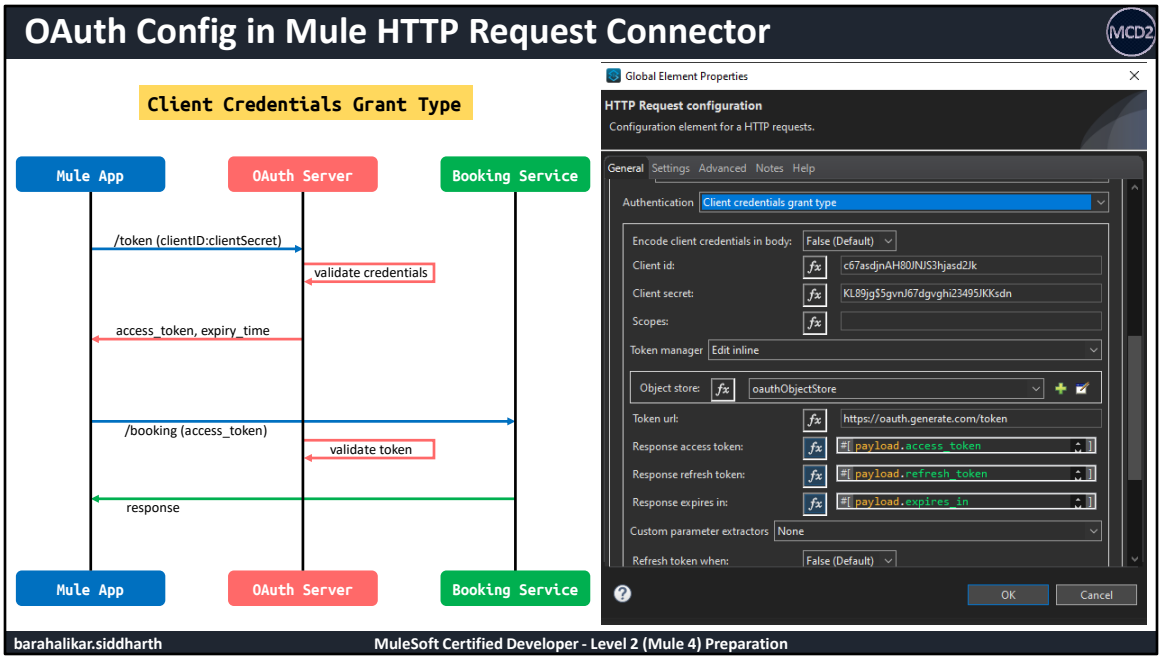
If PKCE is too be used..

Step 2 – Client App re-directs User to Authorization Server along with an **Code_verifier + Code_challenge**

Step 6 – Client makes a call with **Authorization_Code + Code_verifier**

OAuth 2.0

- Configure OAuth in HTTP Request Connector



HTTP Connector) **Request** operation supports connecting a Mule client app to a service that requires any of the following types of authentication,
Basic Authentication
Digest Authentication
NTLM Authentication
OAuth2 Authorization Code Grant Type Authentication
OAuth2 Client Credentials Grant Type Authentication

Mule runtime engine (Mule) uses the credentials configured in the HTTP request connector to configure an authorization header in the HTTP request.

In this example I have configures OAUTH client credentials details in the http connector and this is how the flow works

We have mule app and a booking service secured by a oauth server

- Mule app make a calls to oauth server requesting a token by using the configuration defined in the authentication tab
- The oauth server validates the credentaials and if everything is correct, it generates a token, with some expiry time and send it back to Mule app

- Now mule app will use this token as a authorization header and make a call to the actual booking service,
- The access token is validated by the booking service using the oauth server and if the token is valid
- The response is sent back

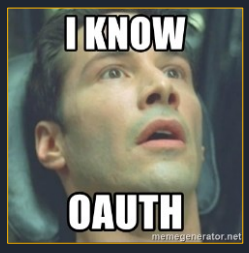
- SO when a client makes a call to the booking service, the Mule engine runs through all these steps to get the response.

2.4 OAuth 2.0

- Understand how Oauth token is retrieved
- Configure OAuth in Mule Application

2.5 OAuth 2.0

- Check Mule App OAuth interaction in LOGs
  - Change log level - DEBUG



MCD2

2.6 Response Modification

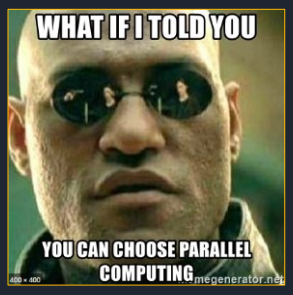
- Add transformation logic

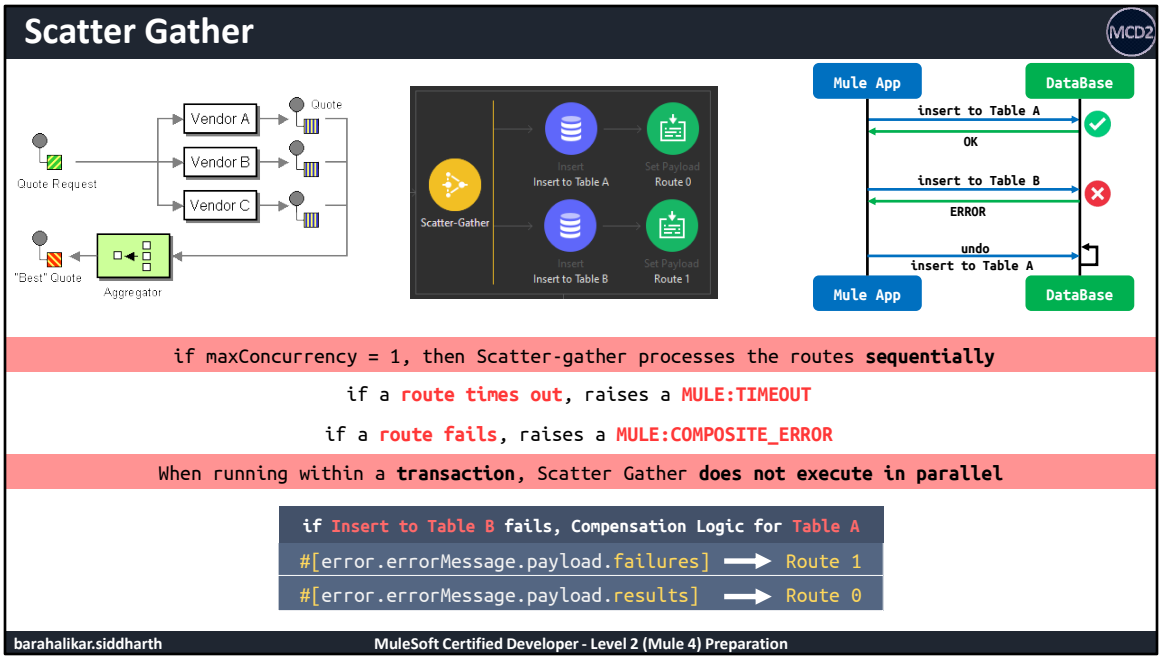
2.7 Error Handling

- Handling custom errors

Parallel Processing

- Use Scatter-Gather
- Error Handling





As per enterprise integration pattern a ***Scatter-Gather*** broadcasts a message to multiple recipients and re-aggregates the responses back into a single message.

The Mule Scatter-Gather component is **a routing event processor that processes a** Mule event through different parallel processing routes that contain different event processors.

Within a scatter gather, if `maxConcurrency = 1, then Scatter-gather processes the routes` **`sequentially`**

Let talk abou this example,

- We have a mule app with scatter gather making parallel calls to two MYSQL tables A and B
- It is going to insert to both tables in parallel and wait for the reponse.
- Lets assume insert to table b failed with an error
    - If a route fails, it raises MULE:COMPOSITE ERROR
    - If it is a timeout, it raises MULE:TIMEOUT
- In this case I want to undo insert to the success route which is TABLE A
- How do we achieve this?

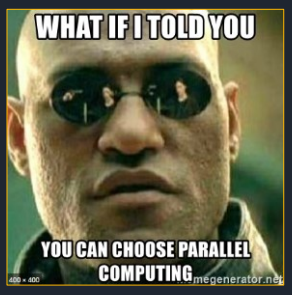
- You may be thinking of putting sctter gather inside a TRY scope with some TRANSACTION BEGIN or JOIN option.
- That may work but, when you run scatter gather within a transaction, scatter gather does not execute in parallel.
    - Well this defeats the whole purpose of using scatter gather in the first place?
- So how do we undo/compensate success route?
- We can make use of the errorMessage find out the successroute and apply some compensaton logic to it

- When we get a mule:composite error, within the errorMessage we get a payload of failures and results, which has the info on the routes
- This info can be used to apply a compensation logic

There is lots more to learn about Scatter gathe, I would recommend you to go to Mule documentation and scan the entire page.

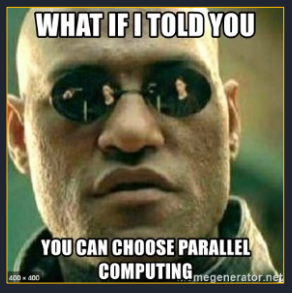
2.8 Parallel Processing

- Use Scatter-Gather



2.9 Parallel Processing

- Use Scatter-Gather
  - Get Failed Routes
  - Get Success Routes

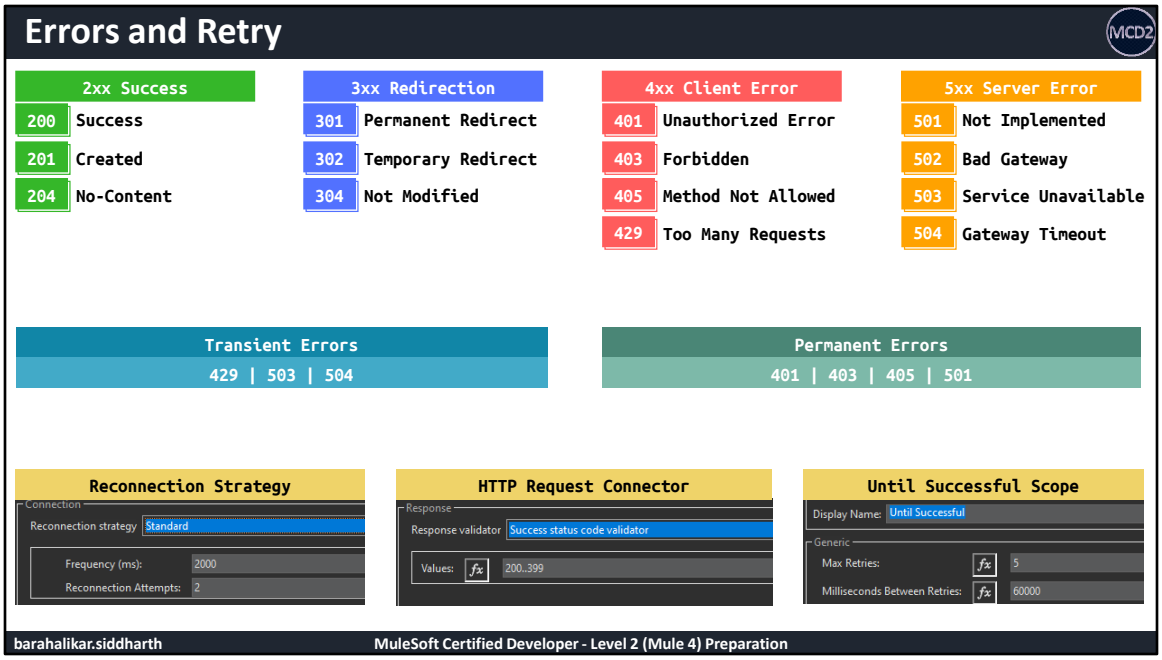


2.10 Parallel Processing

- Use Scatter-Gather
  - Compensation Logic

Errors and Retry

- Using Until Successful Router
- Handle HTTP Errors
  - Transient Errors
  - Permanent Errors



HTTP resonse status codes are three-digit responses that indicate whether a specific HTTP request has been successfully completed. Responses are grouped in five classes:
Informational responses (100–199)
Successful responses (200–299)
Redirection messages (300–399)
Client error responses (400–499)
Server error responses (500–599)

There area about 40 different status code and we will cover the most widely used ones.

Anything from 2xx to 3xx are deemed to be a success.

4xx and 5xx are request breaking error and we need to understand which of them are transient errors and what are permanent errors.

Transient errors are **temporary and usually go away rapidly**. This is why using a Retry Policy to encapsulate code is recommended.

Some examples are 429 too many requests, 503 Service Unavailable and 504 Gateway Timed out

Permanent error will not be resolved even after multiple retries so we raise an error straight way for those status codes
Some examples are 401 403 405 501

In Mule apps for transient error, we could retry the request using options like Reconnection strategy and Until Successful scope
A Reconnection Strategy can Set the number of reconnection attempts and the interval at which to execute them before returning a connectivity error
A Until Successful scope processes the components within it, until they succeed or exhaust the maximum number of retries.

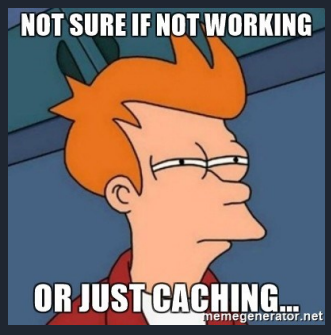
Within Http request connector we can also configure what responses code considered as successful using the response validator option, we will discuss more on this in upcoming sessions

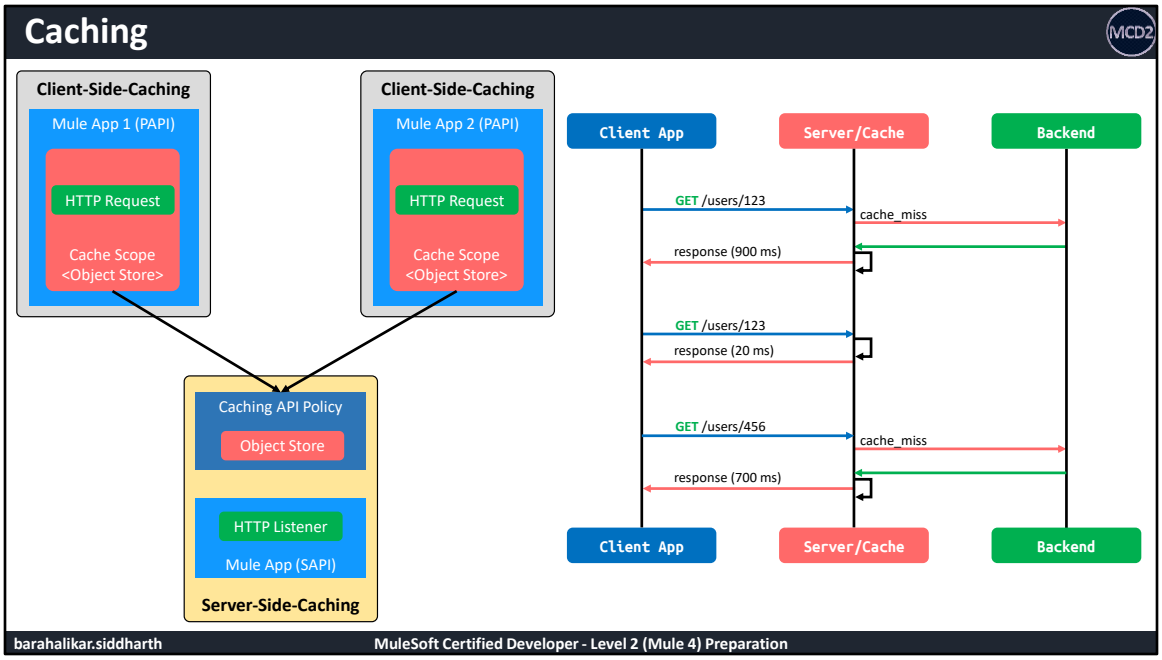
2.11 Errors and Retry

- Using Until Successful Router
- Handle HTTP Errors
  - Transient Errors
  - Permanent Errors

Caching

- What is caching?
- Type of caching
  - Server-side
  - Client-side
- Cache Scope
- Object Store





Caching is the process of storing copies of files in a **cache**, or temporary storage location, so that they can be accessed more quickly. We can also configure TTL for each cache entry. Once expired the cache entry will be deleted.

It's typically only done for HTTP GET requests to
improve speed, because we want to deliver fast content to our consumer and also to **reduce server load,** because we don't want our servers to compute without the need of it

Lets understand how caching works,

- We have a client app, and a backend system which uses a Caching server
- When the client make a GET /users/123 request, the cache server will forward the request to the backend, because this is the very first call and there is nothing there in the cache. It is often denoted by cache_miss
- When the backend responds, a copy of the response is stored on the cache server and the response is sent back to the client
- Notice the response time of 900ms.

When client makes a 2nd call for the same user, now the response will be sent back from the cache server and hence the response time is reduced.
Here the call is never sent/processed by the backend and hence reducing its load

When a client makes a 3rd call for a different user, cache will be missed and call will be forwarded to the backend.

Tthis is how a typical caching works

We have 2 types of cache, lets try to understand them using Mule terminology

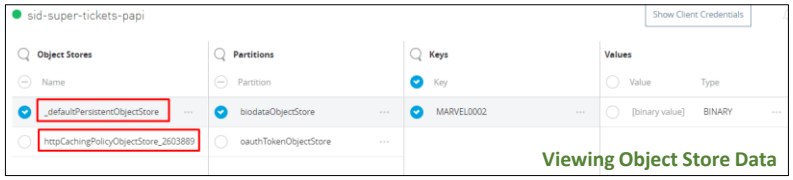
Lets assume we have a System API which listen on a HTTP Listner.
We can use a Caching API Policy infront of it to reduce the SAPI processing load.
This is known as Server side caching

Lets assume we have 2 more Process API with HTTP Request connectors making external calls to the SAPI.
To improve the perforamce of these application and to improve speed, we can encapsulate the HTTP request connectors inside a CACHE SCOPE.
This is know as Client side caching

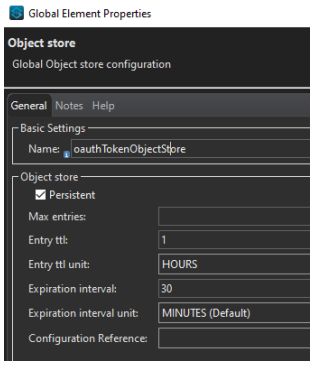
Both cache scope and caching api policy uses object store to persist data.

Object Store

	Anypoint Object Store V2	CloudHub Object Store V1	Mule Object Store
number of entries	Unlimited	100,000 per application	no limit
number of key:value pairs			no limit
key size	n.a	768 byte key size	no limit
value size	**10 MB**	**1 MB**	**no limit**
data per application	Unlimited	1 GB	no limit
Supported by	Object Store Connector | Mule 4	Object Store Connector | Mule 3 & 4	Object Store Connector
API Rate Limit	Standard - 10TPS | Premium - 100TPS	No API Rate limit	n.a



Viewing Object Store Data



If **entryTTL** is not set, **TTL** is rolling and as long as the object is accessed at least once a week, the TTL will extend for another **30 days**

An **expiration thread** runs every 30 minutes and discards the elements that exceed their **time to live (TTL)** or their maxEntries limit.

OSv2 can be accessed using **Object Store connector** and/or **OSv2 REST API**

A non-persistent object store does not use the **OSv2** service

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https://docs.mulesoft.com/object-store-connector/1.2/object-store-to-define-a-new-os

Object Store Connector is a Mule component that allows for simple key-value storage. Although it can serve a wide variety of use cases, it is mainly design for:
Storing information such as access tokens.
Storing user information.

Additionally, Mule Runtime uses Object Stores for components, like:
The Cache module uses an Object Store to cached data.
The OAuth module (uses Object Stores to store the tokens.

There are three types of Object Store are:
Anypoint Object Store V2
CloudHub Object Store V1
Mule Object Store

Anypoint Object Store V2

is the latest version of CloudHub Object Store. This is a Cloud Service that is external to the Mule Application. It is only used by CloudHub deployed applications.
We can view the object store data in Cloudhub ui

CloudHub Object Store V1 (OSv1)
is the original Cloud-based Object Store for CloudHub applications. This version is now deprecated

Mule Object Store
is the original on-premise based Object Store that is part of Mule Runtime. this one is fully customisable to user preferences,

Please check out key information regarding each object store

The same Mule Object Store Connector can be used for all three object stores and is the recommended method to write and read key:values to Object Stores.

A custom object store can be configured using Object Store Global elements,
If **entryTTL** is not set, **TTL** is rolling and as long as the object is accessed at least once a week, the TTL will extend for another **30 days**

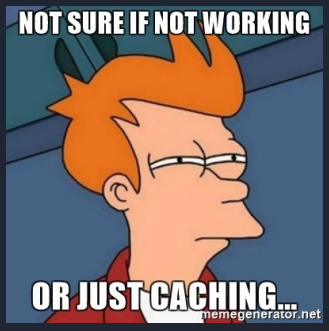
in this image we have set the entry ttl to 1 hour and expiration interval to 30 minutes, So
An expiration thread runs every 30 minutes and discards the elements that exceed their time to live (TTL) or their maxEntries limit.

OSv2 can be accessed using **Object Store connector** and/or **OSv2 REST API**
A non-persistent object store does not use the **OSv2** service

Again I would recommend going through the mule documentation to know ablout object stores

2.12 Client-side Cache

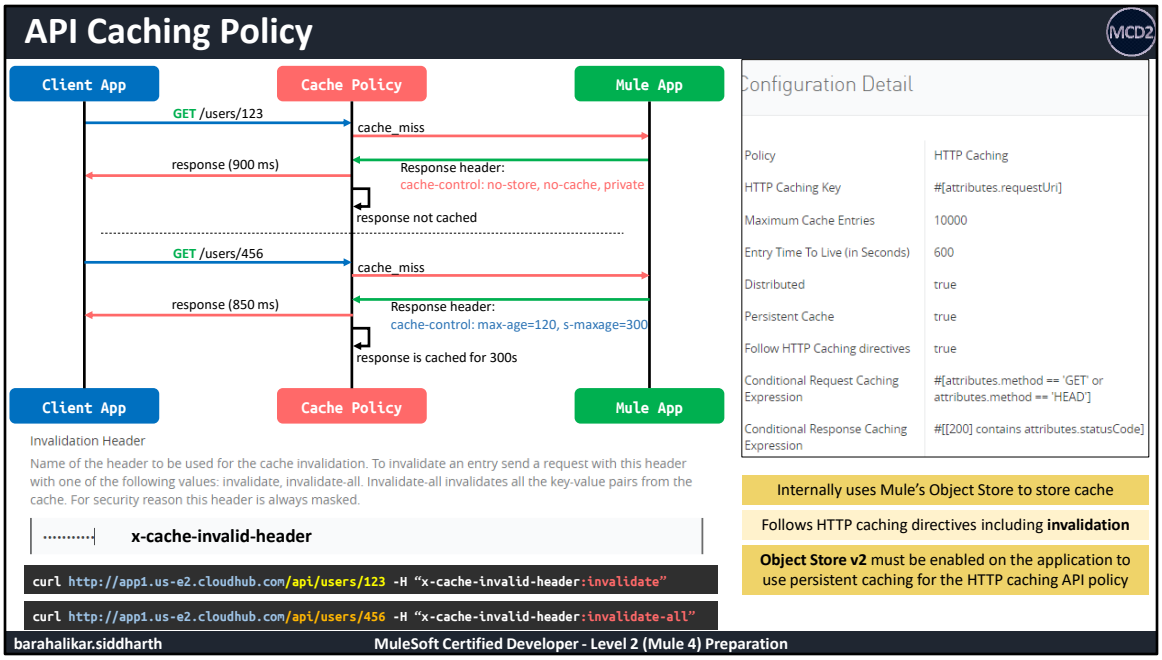
- Cache Scope
- Object Store



MCD2

Sever-Side Caching

- API Caching Policy
- Invalidate Header



So what is api caching policy
Instead of having to write the caching logic inside Mule application code, we can now apply this policy with a single click. With this policy, **users can avoid making multiple calls to a backend system to fetch any data which, in turn, improves API performance by reducing any expensive data processing.**

The API Policy
Internally uses Mule's Object Store to store cache
Follows HTTP caching directives including **invalidation**
Requeries Object Store v2 to be enabled on the application

Within the policy we get options to define the
Cache key
TTL
Persistent
Distributed > so that multiple mule workers share same cache
Conditional request and response expression
The policy also supports an INVALIDATION Header, which can be configured to invalidates the entries in the cache.

We need to define a unique header name, and can be used to either invalidate a single entry or the entire cache

In this curl cmd we use a header value invalidate which removes a single entry
If we use invalidate-all as a header value, the entore cache will be removed

Lets understand what are HTTP CACHING DIRECTIVES, and how it works
The **Cache-Control** HTTP header field holds *directives* which are (instructions) — in both requests and responses — that control caching in shared caches

Lets assume we have a client app, making calls to a Mule application sitting behind a Caching policy

When the client make a GET /users/123 request, the cache server will forward the request to the mule app, because this is the very first call and there is nothing there in the cache.
The Mule app responds back with payload and a response header – cache-control : no-cache, no-store, private
Cache policy will check this response header and will not cache the response

When the client make a 2nd call to GET /users/456 request, the cache server will forward the request to the mule app
Mule app responds back with payload and a cache-control header of max-age=120 and s-maxage=300, both these value are used to define TTL and if both are present, the s-maxage will take precedence
So based on the response header the cache policy will cache the data for 300s

2.13 Sever-Side Caching

- API Caching Policy
- Invalidate Header
- Visulaizer

Section 2 - Completed

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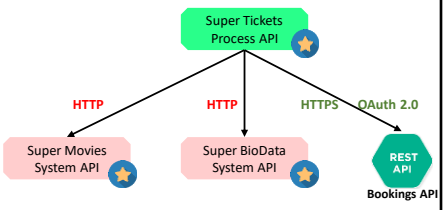

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- Handling errors for scatter gather and the Mule application following the concepts of transient and permanent http errors
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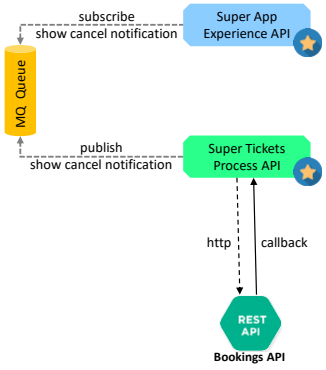
Section 3

#3 Asynchronous Message Processing, Logging Options, Tracing, Correlation IDs and Content Validation

- Configure HTTP Callback
- Register HTTP Callback with external service
- Configure VM module and add Publish Messages
- Listen to messages by adding a Transaction
- Add redelivery policy using correlation id
- Forward error messages to DLQ
- Configure Anypoint MQ module
- Publish messages to MQ
- Create new App and subscribe Anypoint MQ messages
- Publish messages to external system
- Configure a circuit breaker
- Check Correlation ID across HTTP and VM protocols
- Trace correlation id using MQ publish operation
- Operational logging and tracing
- Use Mapped Diagnostic Context
- Configure Validation Module
- Validate Input request
- Validate XML/JSON Schemas



barahalikar.siddharth MuleSoft Certified Developer - Level 2 (Mule 4) Preparation

Welcome to Section 3, in this section we will discuss about asynchromous message processing

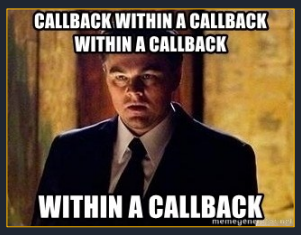
Configure http callabcks and register them with external services
We will configure VM connectors to process messages asynchronously by using DLQs, transactions and redelivery policies.
We will then configure Anypoint mq to publish messages, which will be subscribed by an EAPI
We will improve the performance by configuring a circuit breaker.

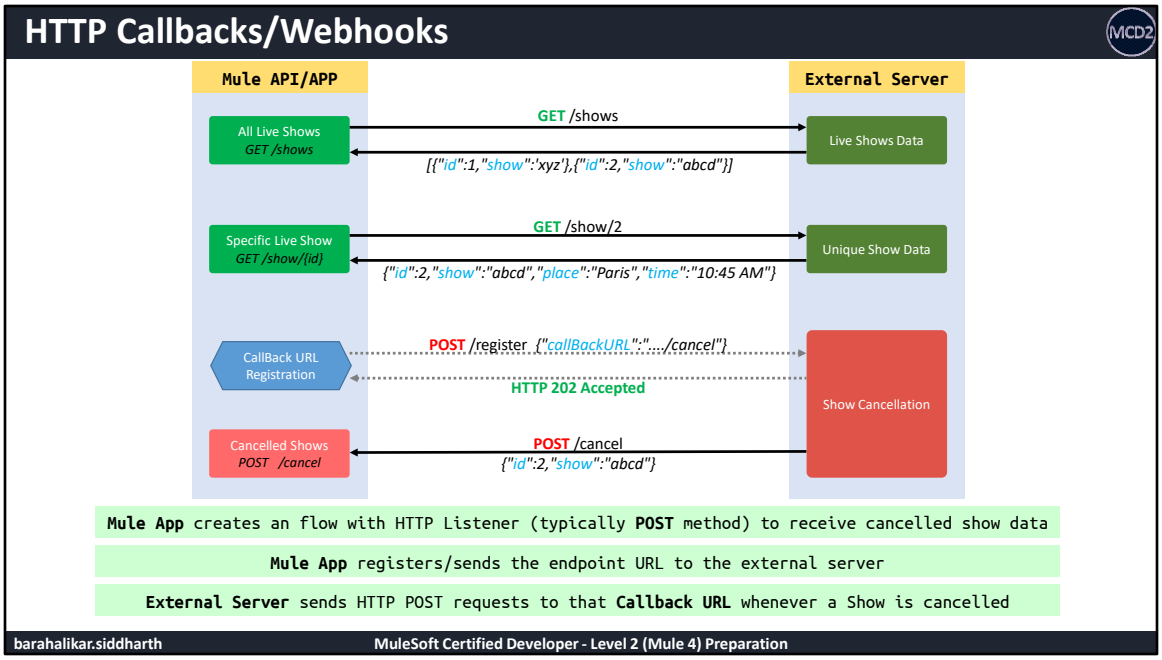
We will also looking into CorrealtionIDs, Operational logging, Mapped diagnostic context using Tracing and

End the section with validation modules

HTTP Callback

- What/Why?





What is HTTP Callback?
In Simple terms,
A callback function is like a **Employee** who "calls back" to his **Manager** when he has completed a **Task**.
A **webhook** is a fancy name for an **HTTP callback**.

Lets assume we have a Mule APP and a external server

- The mule app makes calls to the external server to fetch the data about Live Shows
    - The server responds with a JSON Array
- The Mule apps make another call to external server endpoint to fetch unique show details based on a id.

These are regular HTTP GET calls.

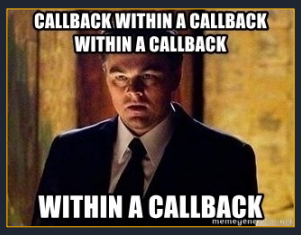
- Whenever a show gets cancelled the external server has all the details about it.
- We do not want the mule application to keep on polling the external server to get the show cancellaton events, because no one knows when a show will be cancelled.
- Polling can be avoided by using HTTP callbacks.

- **Mule App** creates an flow with HTTP Listener (typically **POST** method) to receive cancelled show data
- **Mule App** registers/sends the endpoint URL to the external server
    - External server responds with a 202 Accepted
- Whenever a show gets cancelled the **External Server** sends HTTP POST requests to that **Callback URL**
- **In** this way the mule app receives cancelled show data

- And that’s how an http callback works

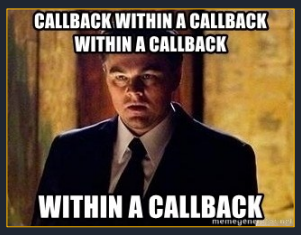
3.1 HTTP Callback

- Configure in Mule Application



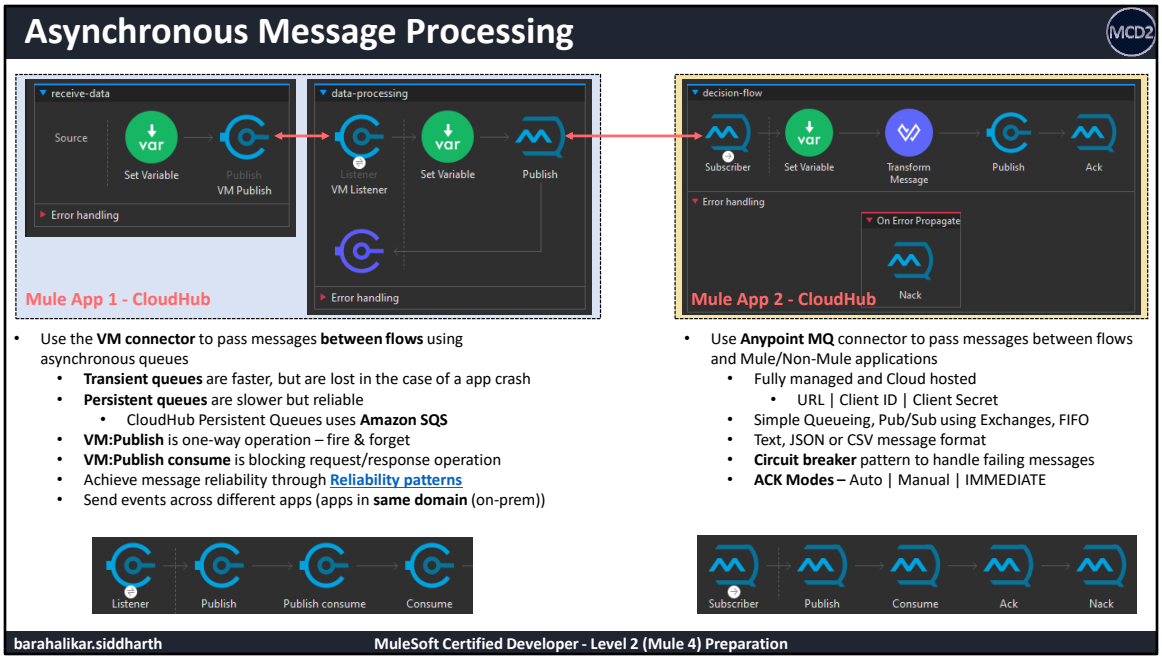
3.2 HTTP Callback

- Register Callback with external service
- CloudHub Reserved Properties



Asynchronous Processing

- What/Why?
- VM vs Anypoint MQ



- Asynchronous processing is the opposite of synchronous processing, as **the client does not have to wait for a response after a request is made, and can continue other forms of processing**.
- This process is referred to as ***non-blocking*** because the execution thread of the client is not blocked after the request is made.

- In a mule app a Flow Reference passes events **synchronously** between flows

- If data needs to be asynchronously passed between flows within the same application we can make use of VM connector.
- A (VM Connector) manages intra-app and inter-app communication through either transient or persistent asynchronous queues
    - **Transient queues** are faster, but are lost in the case of a app crash
    - **Persistent queues** are slower but reliable
        - CloudHub Persistent Queues uses **Amazon SQS**
- By using VM queues we can
    - Achieve message reliability

- Distribute work across multiple CloudHub workers and
- Communicate with another application running in the same Mule domain

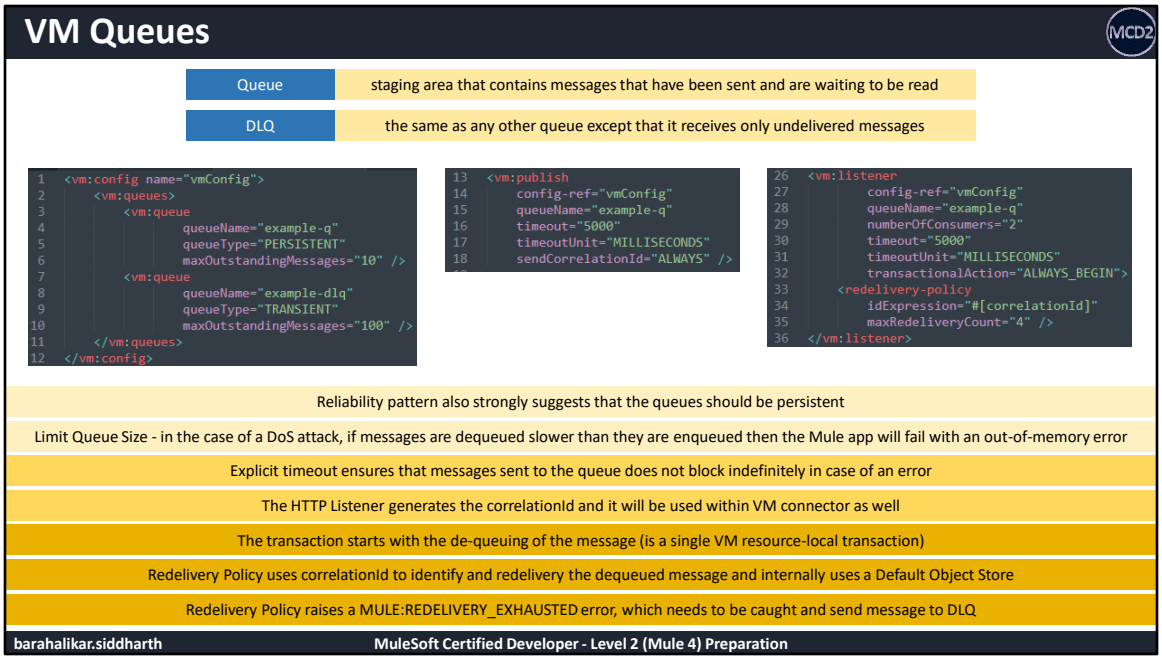
- VM module has

•**VM:Publish** is one-way operation – fire & forget
•**VM:Publish consume** is blocking request/response operation

- Okay, now lets says the message has been persisted in a queue and processed. As a next step this processed message needs to be used/consumed by another app. How can this be achieved?

- We can make use of JMS or **Anypoint MQ** connector to pass messages between flows and Mule/Non-Mule applications.
- Anypoint MQ is fully managed cloud messaging system
- To access it all we need is a,
    - URL, client id and secret
- Anypoint MQ includes features:
    - **Queues and Message Exchanges – to send** messages to queues, pull messages from queue
    - This can be done using Simple queuing, pub/sub using exhcnage and FIFO

- In anypoint mq, The payload format could be JSON,CSV, TEXT
- TO handle failing message we can make use of a circuit breaker and
- It provides various options to Acknowedge the events.



Talking about VM queue
A **queue** is a staging area that contains messages that have been sent and are waiting to be read
A **DLQ** – Dead Letter Queue is the same as any other queue except that it receives only undelivered messages

We can configure a queue to be transient or persistent, Reliability pattern strongly suggests that the queues should be persistent
It is always recommended to Limit Queue Size - in the case of a DoS attack, if messages are dequeued slower than they are enqueued then the Mule app will fail with an out-of-memory error

Explicit timeout ensures that messages sent to the queue does not block indefinitely in case of an error
The HTTP Listener generates the correlationId and it will be used by DEFAULT within VM connector as well

We can start a TRANSACTION in VM listener, The local transaction starts with the de-

queuing of the message
If any message fails, the Redelivery Policy uses correlationId to identify and redelivery the dequeued message and internally uses a Default Object Store
Redelivery Policy raises a MULE:REDELIVERY_EXHAUSTED error, which needs to be caught and send message to DLQ

3.3 Asynchronous Processing

- Reliability Pattern
- VM Configuration
- VM Connector
  - Publish Payloads

3.4 Asynchronous Processing

- VM Connector
  - Listen for Payloads
  - Add transaction
  - Check for error

3.5 Asynchronous Processing

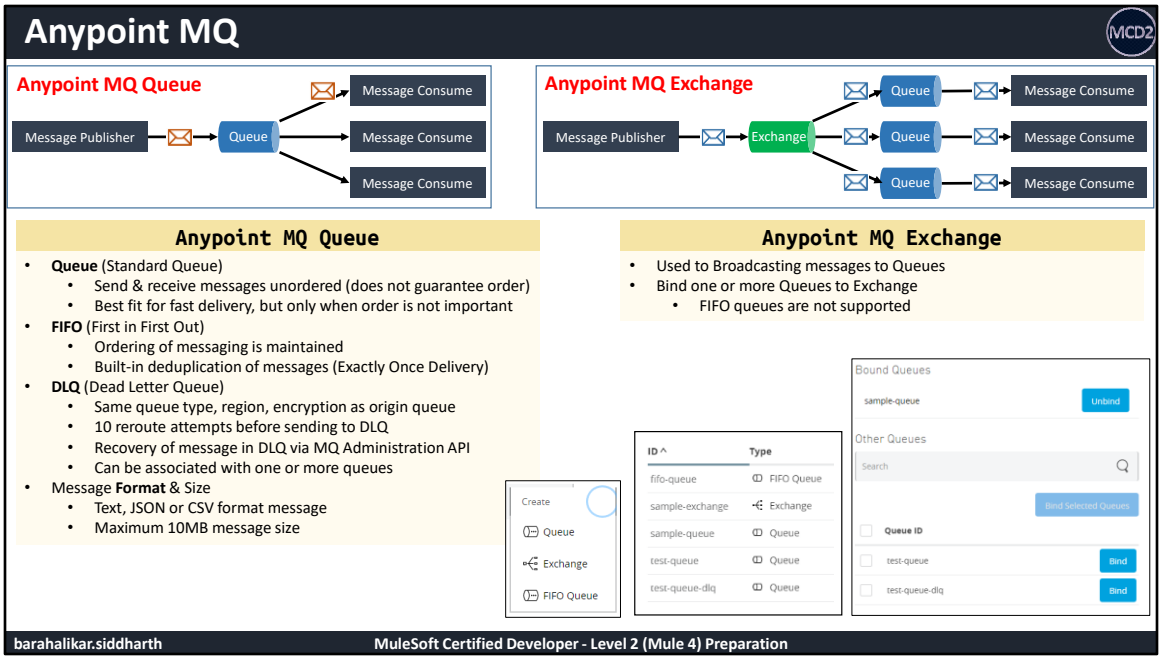
- VM Connector
  - Re-delivery Policy

3.6 Asynchronous Processing

- VM Connector
  - Add a DLQ
  - Error Handling

Anypoint MQ

- What/How?
- Queue vs Exchange
- Steps



https://www.youtube.com/watch?v=Uz5S20NHpIs&ab_channel=MuleSoft-TechZone

As discussed earlier an **Anypoint MQ** connector can pass messages between flows and Mule/Non-Mule applications.

In **Anypoint MQ Queue**
A Publishers can publish messages into queues, and any one consumer can receive messages from queue.

There are multiple options,
A Standard queue can

- Send & receive messages unordered (does not guarantee order)
- It is a Best fit for fast delivery, but only when order is not important

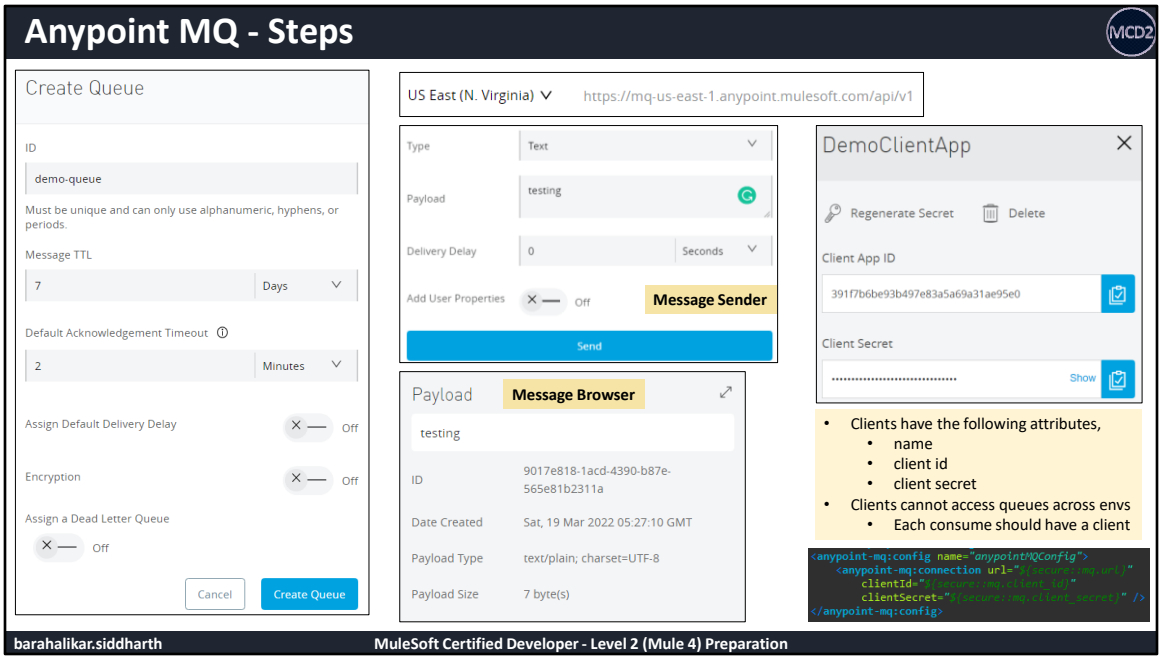
- **In FIFO** (First in First Out)
  - Ordering of messaging is maintained

    - It has a Built-in deduplication of messages (Exactly Once Delivery)
- **Then we have the DLQ** (Dead Letter Queue)
    - It has the Same queue type, region, encryption as origin queue
    - Anypoint MQ does 10 reroute attempts before sending payload to DLQ
    - Recovery of message in DLQ is done via MQ Administration API
    - A dlq Can be associated with one or more queues
- Message **Format** & Size
    - Text, JSON or CSV format message
    - Maximum 10MB message size

With **message exchanges** you can distribute a single message to multiple consumers.

- Used to Broadcasting messages to Queues
- Bind one or more Queues to Exchange
    - FIFO queues are not supported

    These images show how we can create queue, exchange, FIFO queues
    And how to Bound queues to a message exhcnage



Anypoiny Mq standard and FIFO queues are available in 10 regions at the time of this recording.
We can select any one of them.

Create a queue by giving it a id, configure Message TTL and ACK timeout, default is 2mins
We can also configure delivery delay, encrypt the data and assign a DLQ

Within the UI we have the option to send and browser messages. We can also make use of Anypoint MQ REST APIs for all these operations.

TO access MQ, we need to create a Client app, and use the credentials.
Clients cannot access queues across different environments
Within each enviruonment a new client should be created

In Anypoint Studio we can configure URL, Client id and secret to access the queues.

3.7 Anypoint MQ

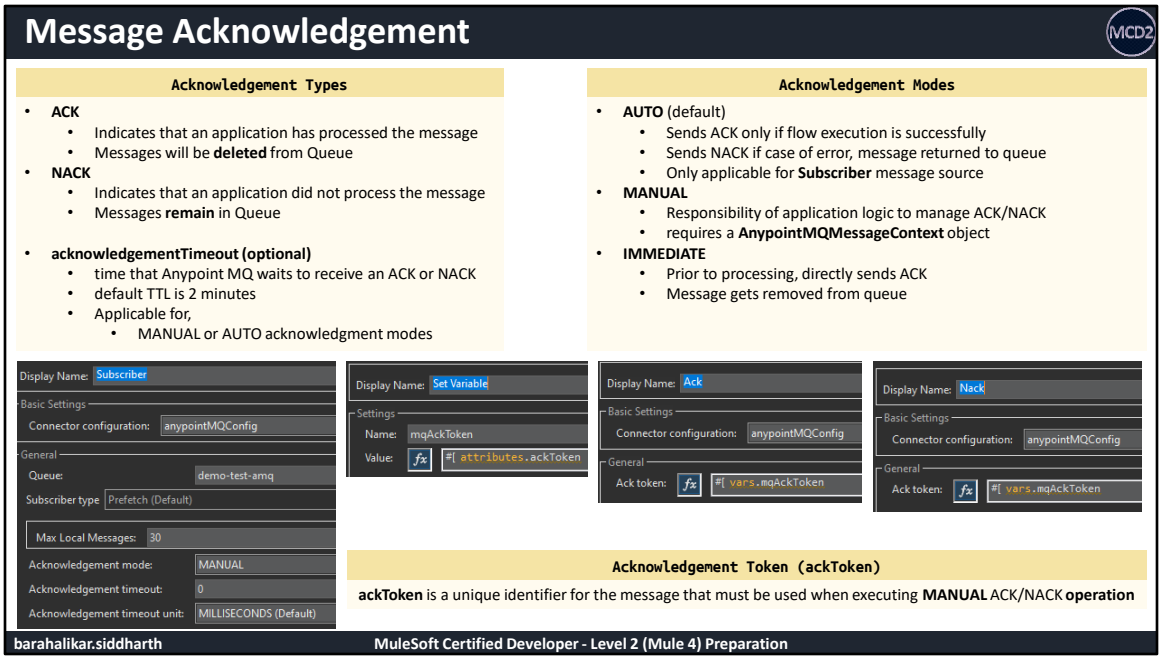
- Configure Anypoint MQ in Mule app

3.8 Anypoint MQ

- Publish Messages to Anypoint MQ

Anypoint MQ

- Message Acknowledgement
  - Acknowledgement Types
    - ACK
    - NACK
  - Acknowledgement Modes
    - AUTO
    - IMMEDIATE
    - MANUAL



Anypoint MQ lets you determine how to process messages in Anypoint Studio using the Anypoint MQ connector.

Two acknowledgment responses can occur:

- Acknowledgment (**ACK**)
    - Indicates that an application has processed the message
    - Messages will be **deleted** from Queue

- Negative acknowledgment (**NACK**)
    - Indicates that an application did not process the message
    - Messages **remain** in Queue
- There is another option, **acknowledgementTimeout (optional)**
    - It is the time that Anypoint MQ waits to receive an ACK or NACK
    - default TTL is 2 minutes
    - Applicable for,
        - MANUAL or AUTO acknowledgment modes

- It also has **Acknowledge modes**
- **AUTO** (default)
  - Sends ACK only if flow execution completes successfully
  - Sends NACK if error occurs in flow, message returned to queue
  - Only applicable for Subscriber message source
- **MANUAL**
  - Responsibility of application logic to manage ACK/NACK
  - requires a **AnypointMQMessageContext** object
- **IMMEDIATE**
  - Direct ACK when message is consumed, prior of any processing
  - Message gets removed from queue

  - All these can be configured using anypoint mq connectors in studio

  - We also have an **`Acknowledgement Token (ackToken)`**
  - **ackToken** is a unique identifier for the message that must be used when executing **MANUAL** ACK/NACK **operation**

3.9 Anypoint MQ

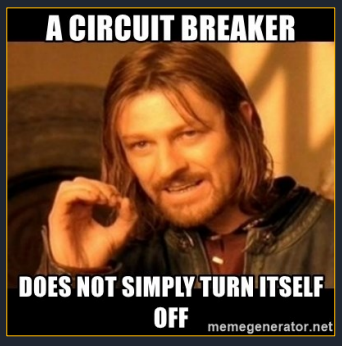
- Create new EAPI
- Subscribe to Anypoint MQ Queue
- Manual ACK

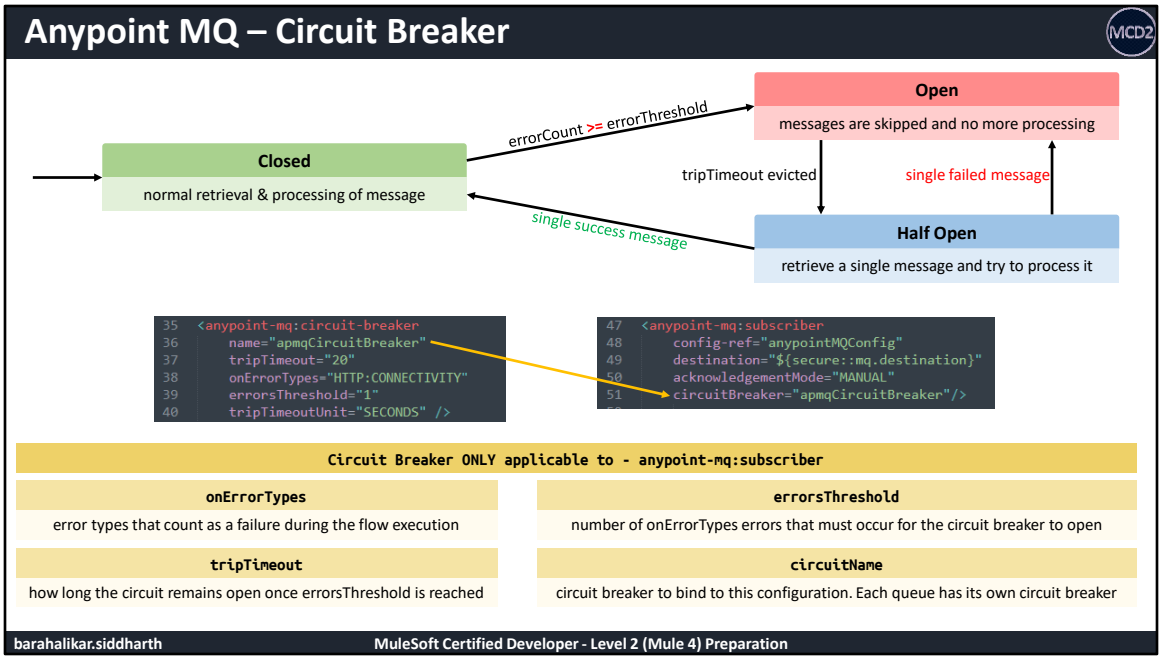
3.10 Anypoint MQ

- Publish events to external system
- Manually Raise an error
- Handle error using NACK

Anypoint MQ

- Circuit Breaker
  - Configuration





A circuit breaker is an electrical switch designed **to protect an electrical circuit from damage caused by overcurrent/overload or short circuit**.

In software, a Circuit breaker is used to detect failures and to prevent a failure from constantly recurring, during temporary external system failure.

Anypoint Mq circuit breaker is only applicable to MQ Subscriber operation

In circuit breaker terminology we have 3 states closed, open and half-open
- **Closed** state is When everything is normal, the circuit breakers remained closed, and all the request passes through to the services
- in **Open state** circuit breaker returns an error immediately without even invoking the services. .
- **in Half Open state**, the circuit breaker allows a 1 requests from the client to passthrough and invoke the external service. If the requests are successful, then the circuit breaker will go to the closed state. However, if the requests continue to fail, then it goes back to Open state.

In Studio we configure a circuit breaker to respond to certain error types like HTTP

CONnectivity or NOT FOUND and add it to the MQ Subscriber
When a error occurs the CB checks if the errorCount **>=** errorThreshold. If it is true then it goes into Open state

OnErrortypes defines error types that count as a failure during the flow execution

`errorsThreshold - is` number of **onErrorTypes** errors that must occur for the circuit breaker to open

`tripTimeout configuration is` how long the circuit remains open once errorsThreshold is reached
Once the trip timeout is evicted, the CB goes into Half open state

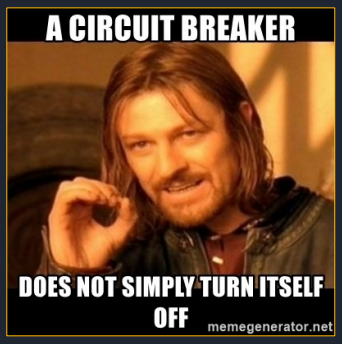
When it is in half open state the CB sends a single event to the external service and if fails, the CB goes into a OPEN state,
If it is success it goes into a Closed state.

After configuring the circuit breaker, we need to configure MQ Subscriber with the circuitbreaker config
It is always recommended for each queue to have it own circuit vbreaker.

In the next hands on session we will implement this.

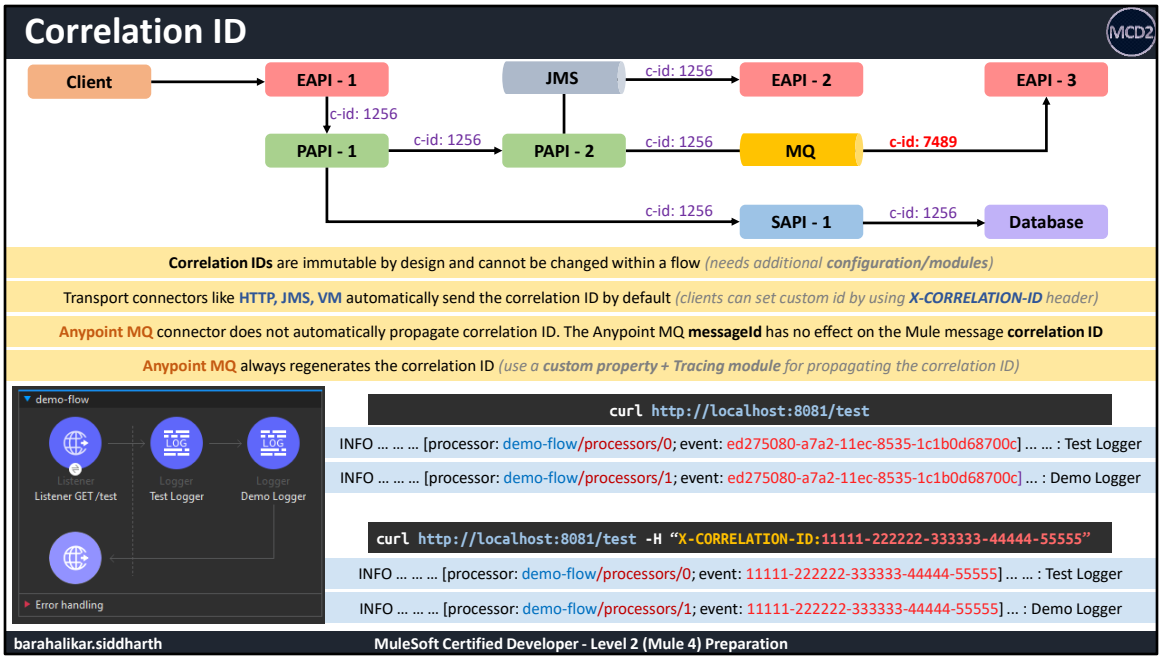
3.11 Anypoint MQ

- Circuit Breaker



Correlation ID

- What?
- How?



In a distributed system architecture, it is highly difficult to understand a single end to end customer transaction flow through the various components.

To solve this we use a Correlation Pattern, It is a well documented Enterprise Integration Pattern.
This pattern depends on the use of Correlation ID.

A Correlation ID is a unique identifier that is added to the very first interaction (incoming request) to identify the context and is passed to all components that are involved in the transaction flow. Correlation ID becomes the glue that binds the transaction together and helps to draw an overall picture of events.

- *In this image we have a set of EAPI, PAPI and SAPI, communication through HTTP, JMS and MQ connectors.*
- *Since the client is not sending any correlation id,*
- *Mule application's HTTP Listerner automatically generates a correlation ID for the Mule event and propagates it across the calls.*

- **Correlation IDs** is a simple **UUID but** immutable by design and cannot be changed within a flow *(it needs additional **configuration/modules to do so**)*
- Transport connectors like **HTTP, JMS, VM** automatically send the correlation ID by default

- When a correlation ID has been set, Mule will preserve it across transport. This means that Mule will propagate the correlation ID alongside the message payload.

- *But what about Anypoint MQ connector*
- **Anypoint MQ** connector does not automatically propagate correlation ID. The Anypoint MQ **messageId** has no effect on the Mule message **correlation ID**
- **Anypoint MQ** always regenerates the correlation ID *(we can use a **custom property + Tracing module** for propagating the correlation ID, we will see more on this in another session)*

- *So if you notice the image, only MQ connector uses a new corealtion id compared to others*

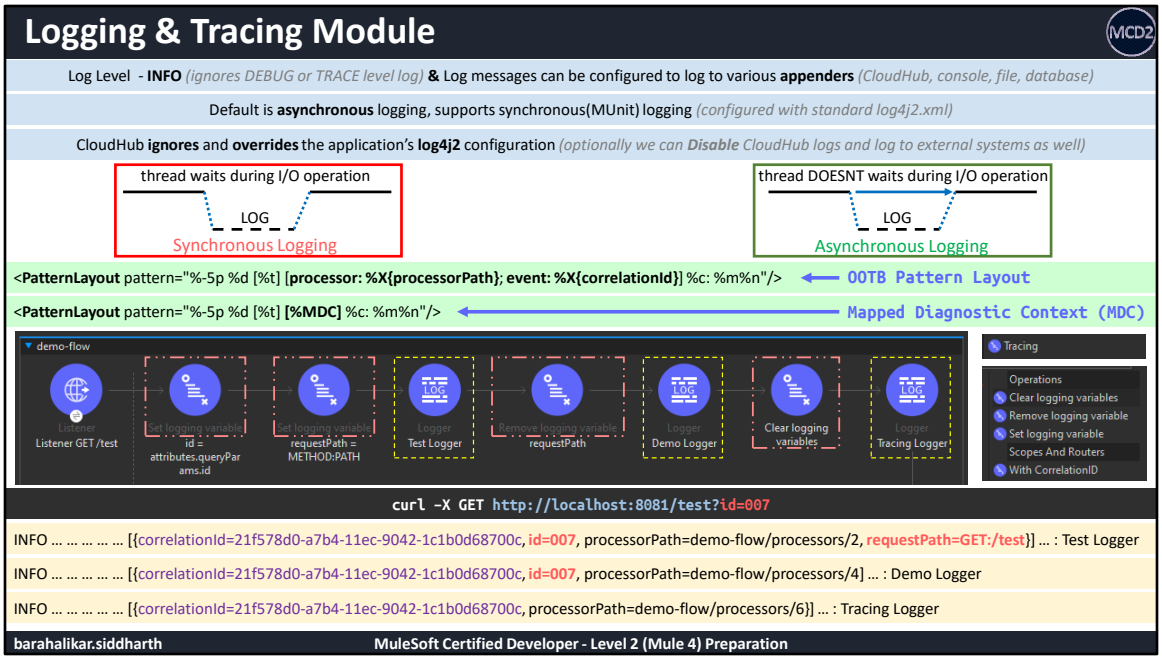
- *In the bottom image we have a simple Mule flow listening on HTTP GET /test endpoint with 2 logger,*
- *When we hit it without any correlation header, Mule http connector will automatically generate and use a correlation id.*
    - *This can be seen on the log message event details*
    - *It used a same correaltionId id for both loggers*
- *If required the client can set a custom correlation id in the header and mule will preserve and propogate that id across the flows*
    - *The header name could be -* **`X-CORRELATION-ID`**

3.12 Correlation ID

- Trace correlation ID
  - across HTTP Listener
  - across VM
  - across Anypoint MQ

Logging & Tracing

- What/Why/How?
- Log
  - PatternLayout
- Tracing Module
  - MDC



- Mule runtimes and Mule applications use standard log4j2 logging
- Logs help to debug and track processing of Mule applications, such as details from Mule events
- Logging component creates log messages with various log levels, such as INFO, WARN, ERROR, and DEBUG
    - By default, Mule runtimes show the INFO log level, and ignore DEBUG or TRACE level log messages
- Log messages can be configured to log to various appenders – like system console, a file, a database, the CloudHub logging service
    - CloudHub **ignores** and **overrides** the application's **log4j2** configuration *(optionally we can **Disable** CloudHub logs and log to external systems as well)*

- It Supports both synchronous or asynchronous logging
    - By default, logging in Mule is done asynchronously
- In Synchorunus logging
    - The execution of the thread processing event is interrupted to wait for the

log message
    - It degrades application Performance and
    - It is used in logging CRITICAL messages
- In aynschronous logging
    - The logging operation occurs in a separate thread
    - So improve apps performance, but
    - Log may be lost in case of application crash

- The standard log4j2 patternlayout logs the processerPath and the correlation id in the log context. This is the out of the box pattern layout
- We can use Mapped Diagnostic Context (MDC) to enrich logging and improve tracking by providing more context or information in the logs for the current Mule event.

- But how do we use MDC?
- It is done using Tracing Module?

- What is Tracin module?
- Tracing module enables you to enhance your logs by adding, removing, and clearing variables from the logging context for a given Mule event.
- It also enables you to modify the correlation ID during flow execution.

- Lets take a example, in this image we have a flow with 3 loggers, Test, Demo, Tracing Logger
- We are also making use of tracing opertions to provide more information in the logs,
    - We have added 2 set logging variable operations to set some info in the log context
        - Like the querparamter valye and the reqestPath
    - Then we use a remove logging context to remove one of the set logging variable
    - Finally we use a Clear logging variable to removes all variables set by the tracing module

- When we hit the app with a GET method on /test endpoint with a ID queryparameter, this is how logs looks like

- The 1st logger logs TEST Logger message, but see the log context it also includes id and requestPath along with correaltionId and processpath
- Similarly in the 2nd log message we see DEMO LOGGER message and in the log

context we only see id=007, because we have removed the requestPath

- In the final log, we don't see any special variable because we cleared all logging variables

- This is how a tracing module can be used to enrich the logging context

3.13 Logging & Tracing

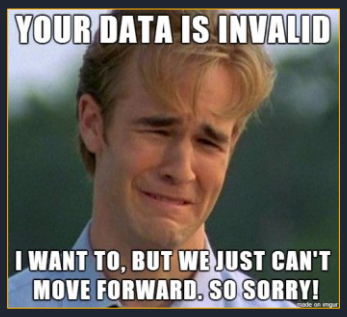
- Tracing Correlation ID across Anypoint MQ

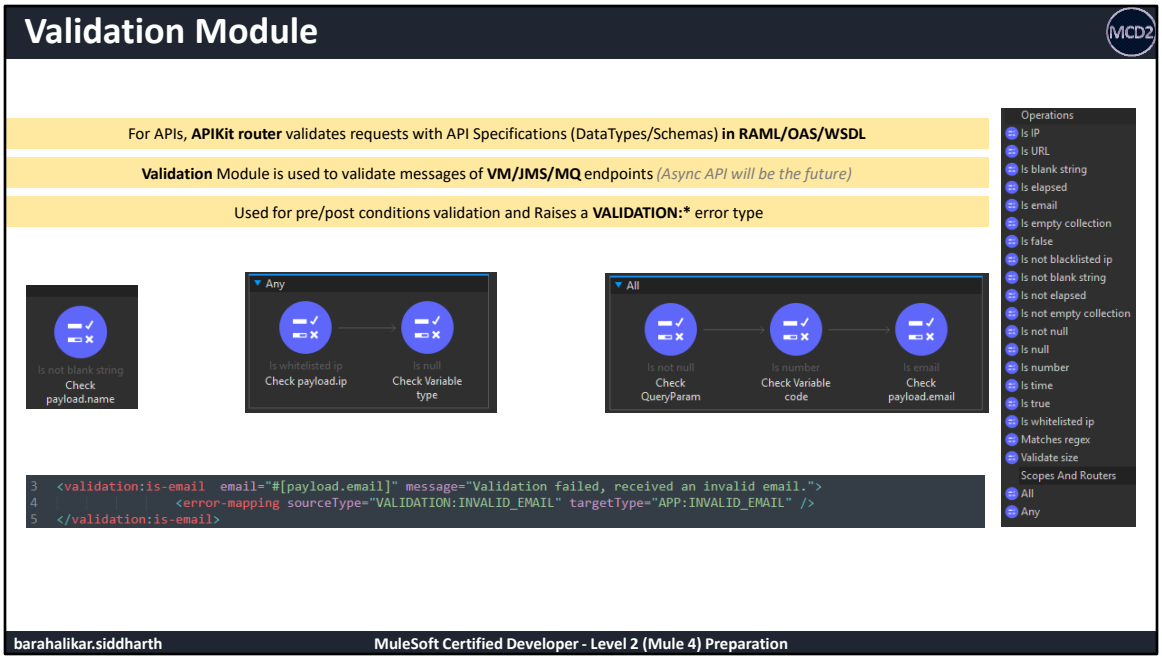
3.14 Logging & Tracing

- Mapped Diagnostic Context

Validation Module

- What/Why/How?
- JSON Schema Validation
- XML Schema Validation





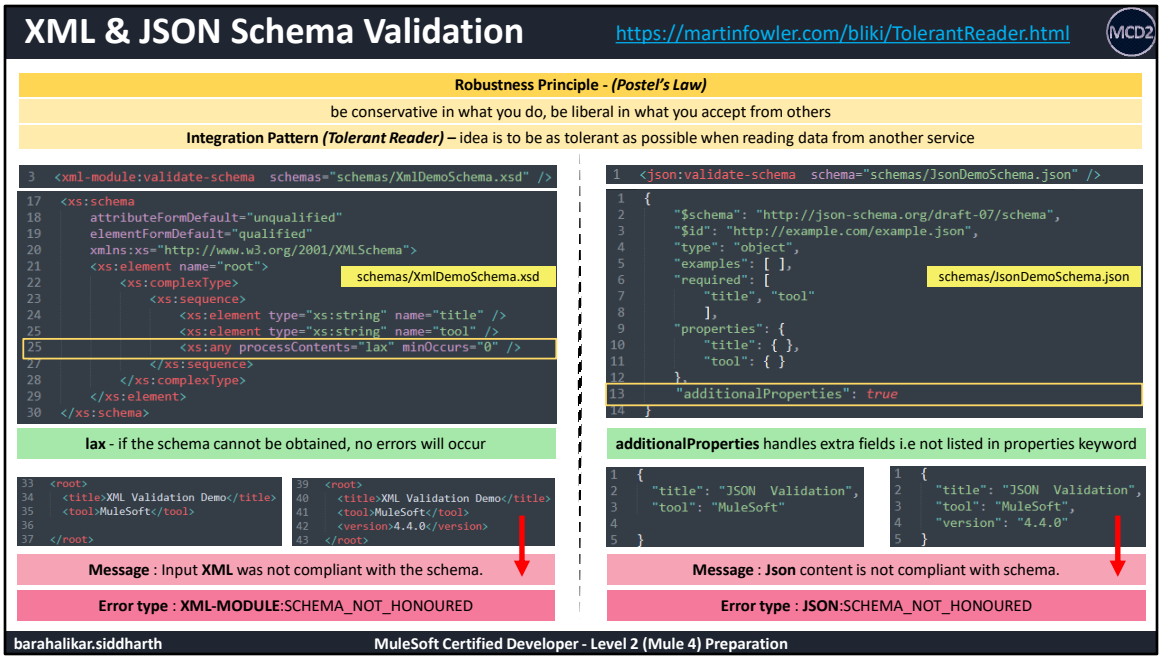
Validation module verifies that the content of a message in a Mule flow matches specific criteria. If a message does not meet the defined validation criteria, the validation fails and returns a validation error.

Why use a validation module?
For APIs we have a **APIKit router** which validates requests with API Specifications (DataTypes/Schemas) **in RAML/OAS/WSDL**

Any endpoint *which is not part of the API specification like* ***JMS,VM,MQ endpoint, we use the*** **Validation** Module to validate messages.
It can be Used for pre/post conditions validation and raises standard validations error or custom errors as well

In the future we will be using the *Async APIs.*

The validation module has a rich set of operations.
Which can be used individually or as part of a scope
If used within a All scope, all opeations must pass to proceed futher
If used within a Any scope, than at least one operation should *pass to proceed futher*



In mulesoft, we can use XML module to **Validate schema**, it validates that the input content is compliant with a given XSD schema.

In this example we have xsd which accepts 2 xml elements title and tool of type string When the user sends a payload, the xml module validates it againsts the schema and allow it because it is complaint.

When the user sends a payload which has a extra element that is not defined in the schema, XML module raises an error.

- This is where we talk about an **integration pattern called as** a Tolerant Reader, which **helps creating robust communication systems**.
- The idea is to be as tolerant as possible when reading data from another service.
- We only validate required fields to make integrations more resilient to changes from other systems

It has been explained in depth by Martin Flower in one of his blog, I have added a link here, please go ahead and read it.

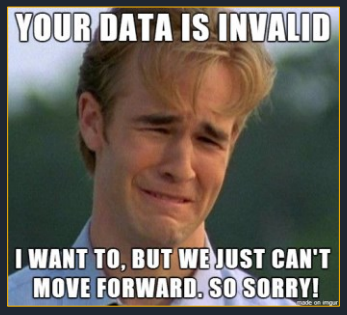
To acheivee this, within xml xsd, we can add a lax element, which will not raise an error if schema cannot be obtained for a particular element

==========

- On similar grounds we can also validate JSON payloads using a JSON schema,
- In JSON schema, we make use of the additionalProperties field to allow extra properties in a JSON Payload
- If additonalProperties is set to false, the schema wont allow any additional properties and will raise an Error

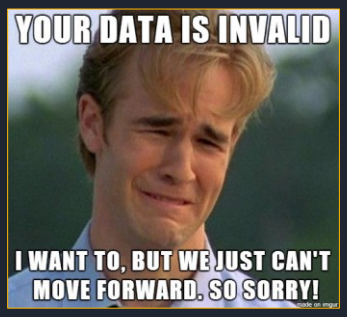
3.15 Validation Module

- Configure module
- Validate Payload and Content type
- Handle Errors
- Test



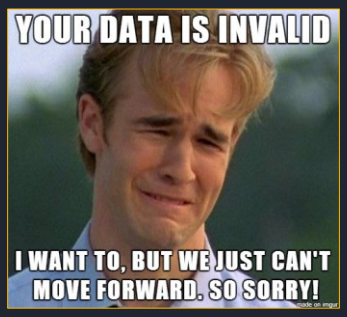
3.16 JSON Schema Validation

- Configure module
- Validate JSON Payload
- Add additional properties
- Handle Errors
- Test



3.17 XML Schema Validation

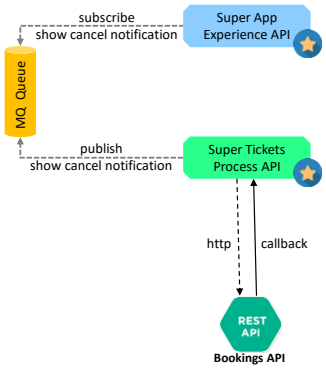
- Configure module
- Validate XML Payload
- Add lax
- Handle Errors
- Test



Section 3 - Completed

#3 Asynchronous Message Processing, Logging Options, Tracing, Correlation IDs and Content Validation

- Configure HTTP Callback
- Register HTTP Callback with external service
- Configure VM module and add Publish Messages
- Listen to messages by adding a Transaction
- Add redelivery policy using correlation id
- Forward error messages to DLQ
- Configure Anypoint MQ module
- Publish messages to MQ
- Create new App and subscribe Anypoint MQ messages
- Publish messages to external system
- Configure a circuit breaker
- Check Correlation ID across HTTP and VM protocols
- Trace correlation id using MQ publish operation
- Operational logging and tracing
- Use Mapped Diagnostic Context
- Configure Validation Module
- Validate Input request
- Validate XML/JSON Schemas



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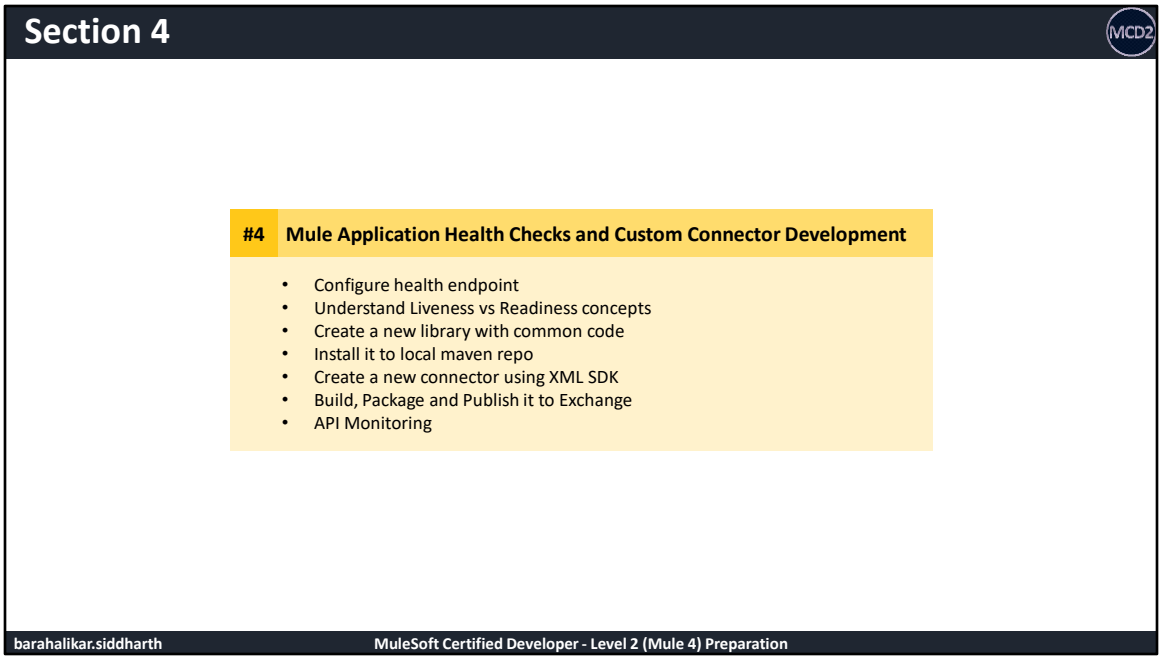
Welcome to Section 3, in this section we will discuss about asynchromous message processing

Configure http callabcks and register them with external services
We will configure VM connectors to process messages asynchronously by using DLQs, transactions and redelivery policies.
We will then configure Anypoint mq to publish messages, which will be subscribed by an EAPI
We will improve the performance by configuring a circuit breaker.

We will also looking into CorrealtionIDs, Operational logging, Mapped diagnostic context using Tracing and

End the section with validation modules



- Welcome to Section 4
- This is a small but exicting section where

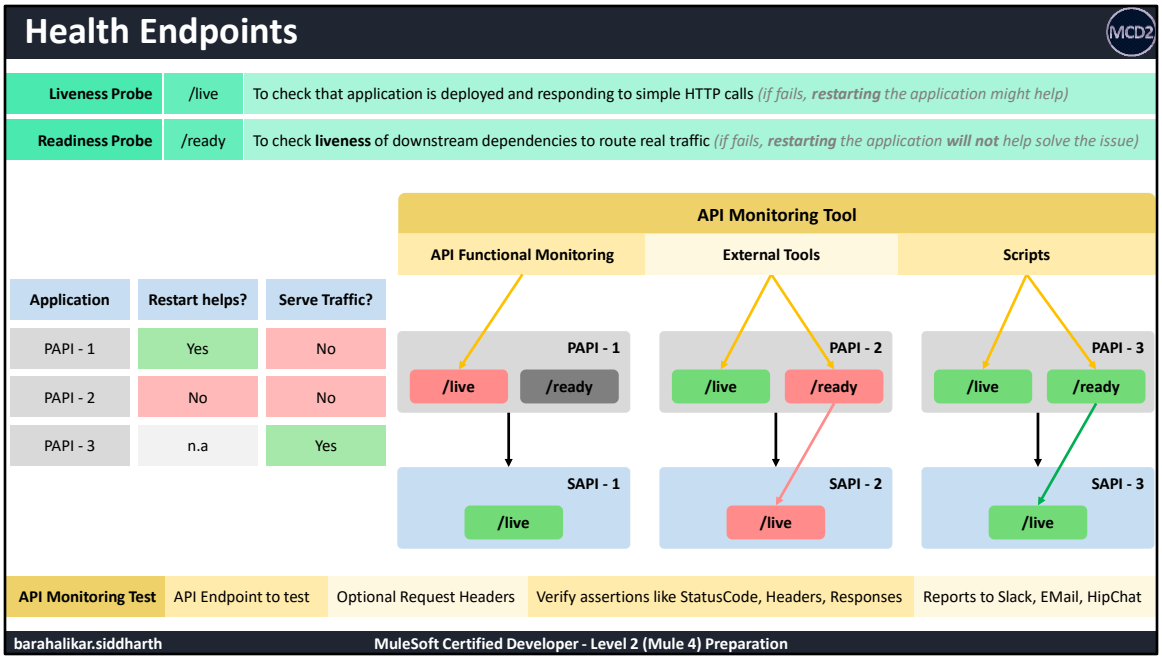
- we will configure health endpoint for our Mule application
- Understand liveness and readiness concepts
- Create a new mule library with common application logic
- Install it to local maven repo

- We will also create a new mule connector using XML sdk,
- Build and publish it to exchange

- And end the section by monitoring the APIs using health endpoints

Health Endpoints

- Liveness Probe
- Readiness Probe
- API Monitoring



Health Endpoint is a common practice in building APIs. It is **a special REST API implementation** that you can use to validate the status of a application and its dependencies. It responds back with **the HTTP status that defines whether the service is "Up or Down"**

We use a liveness probe with a /live endpoint
To check that application is deployed and responding to simple HTTP calls *(if fails, **restarting** the application might help)*

We use a rediness probe with /ready endpoint
To check **liveness** of downstream dependencies to route real traffic *(if fails, **restarting** the application **will not** help solve the issue)*

These endpoints are monitoring by an API Monitoring tool
API monitoring is the process of **observing the functional, availability, and performance metrics of an API**. It can Optionally sends out reports about whether tests pass or fail.

We can setup a simple api monitor using
Anypoint Functional monitoring or any other external tool/scripts by

- defining the endpoint to monitor,
- adding option request detaisl,
- Verifying assertions like statuscode, responses
- Optionally sending reports to email, slack channels

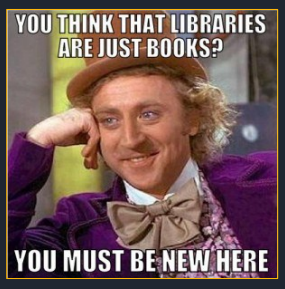
- Lets assume we have a process api which depends on SAPI.
    - All apis should have these health endpoint defined
    - An api monitor first checks the liveness of PAPI,
    - If it fails, PAPI will not able to server traffic even if the SAPI is live
    - restarting the PAPI might help in this case
- In the 2nd example,
    - The PAPI liveness check has passed but
    - The downstream SAPI liveness check failed
    - In this case restarting the PAPI will not help and
    - PAPI cannot server traffic
- In the 3d example,
    - All the health checks pass for both PAPI and SAPI
    - PAPI will be able to server traffic

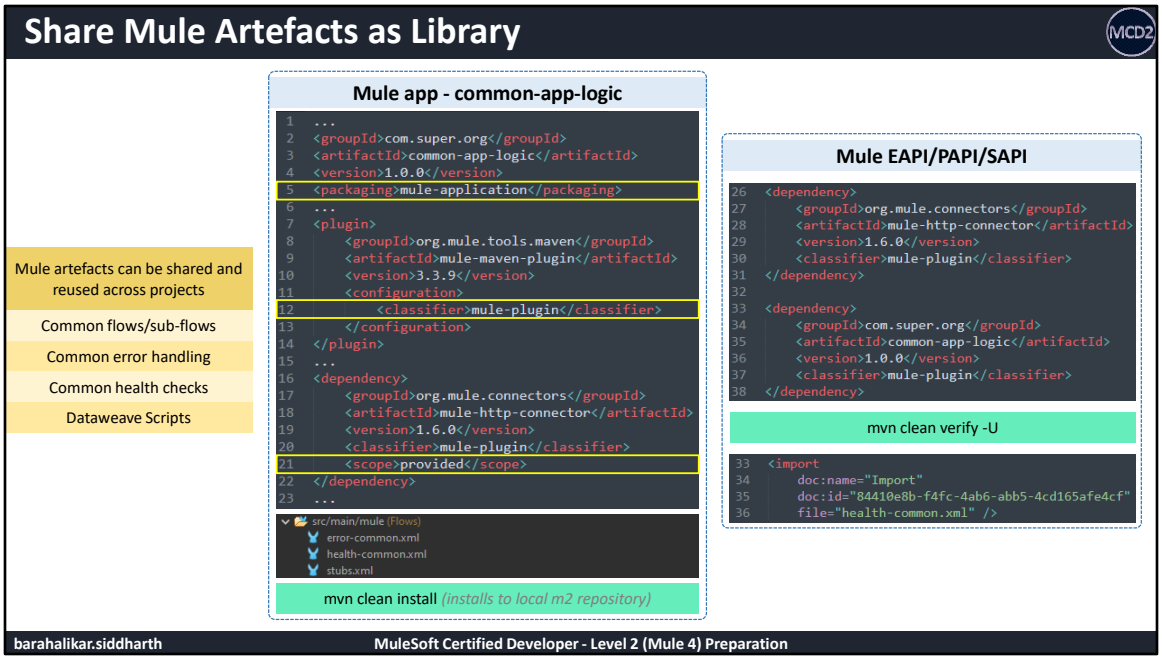
4.1 Health Endpoints

- Liveness Probe
- Readiness Probe
- HTTP Status Code Validator

Shared Libraries

- Common Mule Artefacts/Logic
- Naming convention
- Local installation





Reusability is extremely important to deliver functionality quicker and in a more consistent manner.
Within Mulesoft we can create a shared library which contains flows, sub-flows,, which can be re-used across the Mule projects. For example, common sub-flows can be used for logging, error-handling, shared business logic, etc.

To create a shared library, We start of by creating a normal mule app,
in pom xml we must make sure that the mule maven plugin classifier is of type **mule-plugin**

If the application/library depends upon any connector, we can define the scope as provided
This means that the dependency should be provided by the application using this library

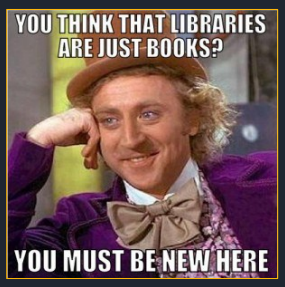
Then we can add the common business logic and build the application
It can be installed to local maven repo or deployed to exchange as well

Any application can now use this library by defining it in the dependencies section

And use the common functionality using the IMPORT feature.

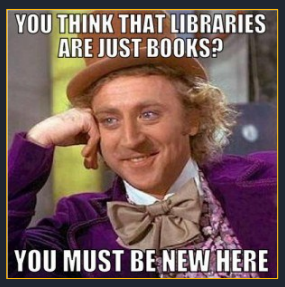
4.2 Shared Libraries

- Create a new app
- Add common mule flows
- Install to local maven repo



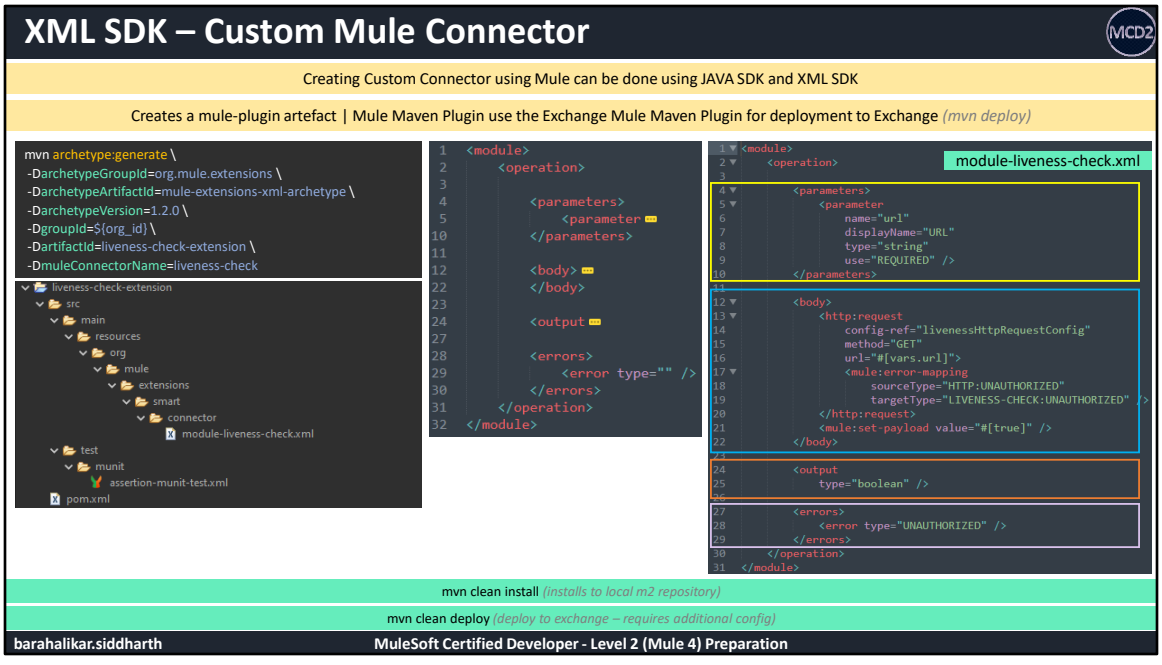
4.3 Using Shared Library

- Configure it in a Mule app
- Test



Custom Connector Development

- XML SDK
- Generating the skeleton
- Project Structure
- Build & Install to Maven repo



MuleSoft XML SDK lets developers write custom connectors and is actually easier than using the Java-based Mule SDK.

XML SDK Creates a mule-plugin artefact and the Exchange Mule Maven Plugin is used for deployment to Exchange *(mvn deploy)*

We will be developing a custom connector for the Dependency/Downstream API Liveness Check.

To create an XML SDK module:
We start the process by Add the MuleSoft repository to your Maven (mvn) settings file
And use mvn archetype command to generate the Mule Project Skeleton

Lets see what attributes are deined in this command
archetypeGroupId
The GroupId in the Mule repository where the skeleton of the XML SDK is defined.
archetypeArtifactId
The ArtifactId of the archetype in the Mule repository.

archetypeVersion
A version of the archetype.
groupId
The GroupId for your application or module. Generally, it should be an AnypointOrganizationId.
artifactId
The ArtifactId for your project or module.
muleConnectorName
The name of your Mule custom connector.

The module-liveness-check.xml file Defines the XML SDK root element and all connector logic is defined here

An XML SDK module has an operations elements.

An <operation> element defines parameter, body, output and error mapping options Within the operation element

- a set of **input** parameters defines data which is the only data the message processors in the <body> scope can access.
- A **body** defines a chain of components to be executed, similar to a mule flow.
- Operation elemenet also has a single **output** which Declares the output type of your XML SDK module and
- if any error from body should not be propagated as it is, we can do **Error** mapping as well

- Can we use mvn cmds to install this to local maven repo or deployinf to exchange

Talking about Limitations

- XML SDK only provides outbound operations, it cannot have sources (such as a <scheduler>) or routers.
- There is No graphical editor and all xml namespaces must be prefixed
- To prevent errors it is recommeneded to Use the kebab case naming convention to name parameters and operations in any XML SDK project

There is a lot more XML SDK, Please chec the mule documentation for more info and examples

XML SDK – Catalog

Standard Data Types for <property> and <parameter> are primitive – *boolean, number, date, datetime, time, localdatetime, string, timezone, binary, any, regex*

For Data Types with **complex** structure we can create a **CATALOG** of data type and inject them into the **MODULE**

module-liveness-catalog.xml

```
<catalogs xmlns="http://www.mulesoft.org/schema/mule/types">
    <catalog
        name="UserJsonType"
        format="application/json">
        <schema
            format="application/json+schema"
            location="./user-schema.json" />
    </catalog>
</catalogs>
```

module-liveness.xml

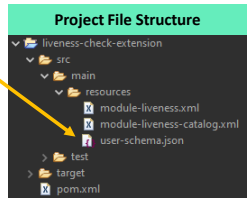
```
<module>
    <operation>
        <parameters>
            <parameter
                name="name"
                displayName="Name"
                type="string"
                use="REQUIRED" />
            <parameter
                name="age"
                displayName="Age"
                type="integer" />
        </parameters>

        <body>
            <ee:transform>
                <ee:set-payload><![CDATA[
          %dw 2.0
          %output application/json encoding='UTF-8'
          ---
          {
            "name" : upper(vars.name),
            "age" : vars.age as Number
          }
          ]]></ee:set-payload>
            </ee:transform>
        </body>
        <output type="UserJsonType" />
    </operation>
</module>
```

user-schema.json

```
{
  "type": "object",
  "properties": {
    "age": {
      "type": "integer"
    },
    "name": {
      "type": "string"
    }
  },
  "additionalProperties": false
}
```

Project File Structure



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What is a Catalog within XML SDK?

- The standard data types for <property> and <parameter> are primitive types: string, boolean, number, date, datetime, localdatetime, time, localtime, tim ezone, binary, any, regex.
- For Data Types with **complex** structure we can create a **CATALOG** of data type and inject them into the **MODULE**

This example creates a catalog file for JSON schema
The catalog file can reference XSD and JSON schema files

Once the catalog and schemas are ready, you use **types** in the output of a operations
The type is nothing but the name of the catalog

4.4 Custom Connector Development

- XML SDK
- Generating the skeleton
- Make few changes

4.5 Custom Connector Development

- XML SDK
  - Add business logic
  - Add error handling
  - Install to local Maven repo

4.6 Custom Connector Development

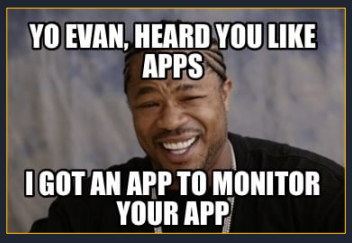
- Add the new custom connector as a Dependency
- Use the new operation

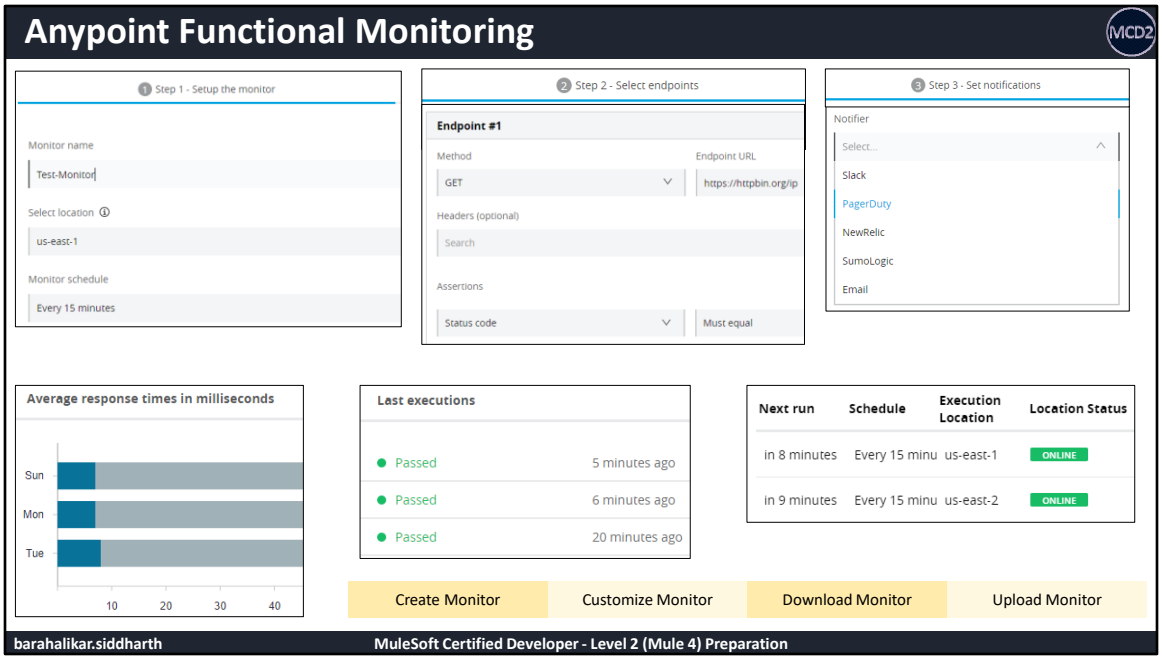
4.7 Custom Connector Development

- Check Custom Error Mapping
- Talk about Catalog
- Deploy it to Exchange

Monitoring

- Anypoint Functional Monitoring Steps





As dicussed earlier an API monitoring is the process of **observing the functional, availability, and performance metrics of an API**. Optionally sends out reports about whether tests pass or fail.

For using Anypoint functional monitor we follow these steps

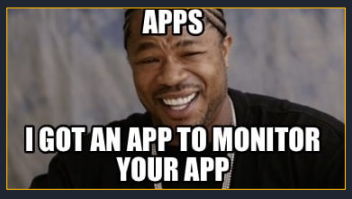
- We create a monitor by giving it a name, select a location to run the tests from and configure a schedule
- In 2nd step we add the endpoints that needs to be monitor and add assertions to check status code and others
- In 3rd step we set the notificaitons to notify a user when a monitor fails.

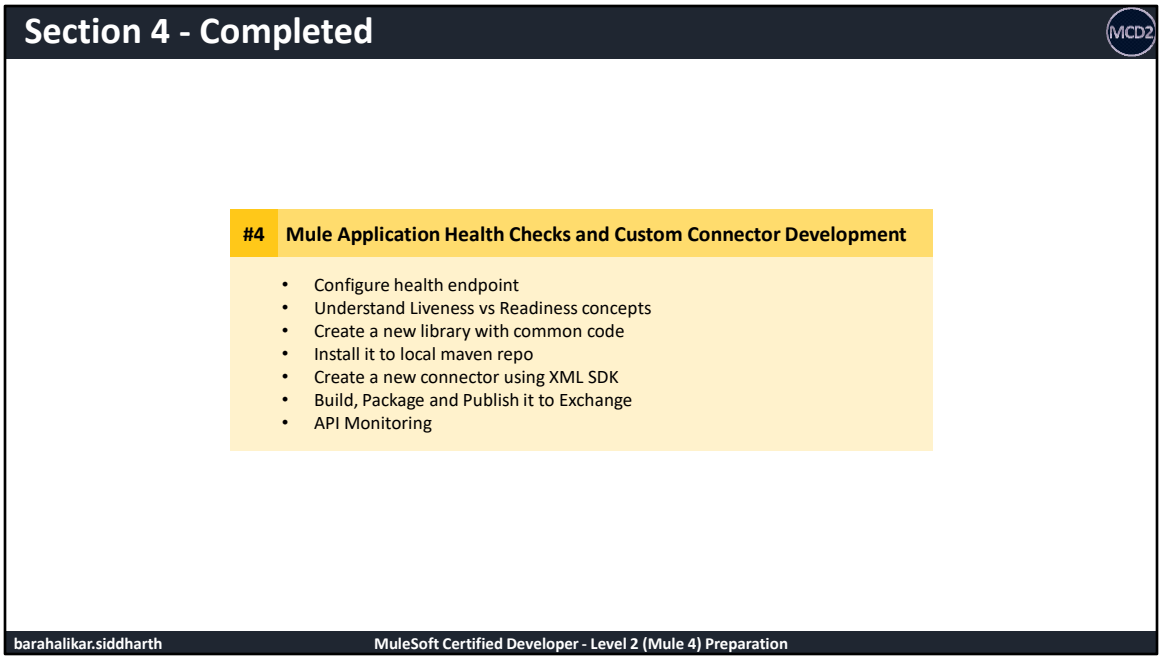
We can review the details of past test runs. By accessing the **View Monitor History option**

We have the options to
Customize monitors
Dowanlod and upload monitors

4.8 Monitoring

- Monitoring using an External system
- Validate Status Code
- Schedule it every 1 minute
- Send Failure reports





- Welcome to Section 4
- This is a small but exicting section where

- we will configure health endpoint for our Mule application
- Understand liveness and readiness concepts
- Create a new mule library with common application logic
- Install it to local maven repo

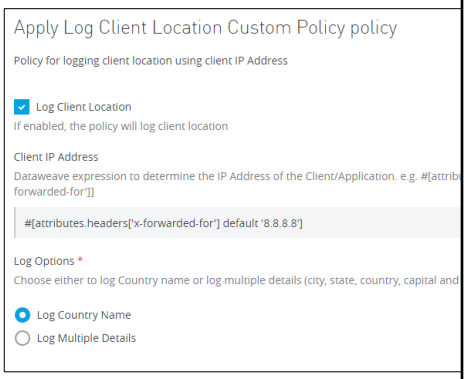
- We will also create a new mule connector using XML sdk,
- Build and publish it to exchange

- And end the section by monitoring the APIs using health endpoints

Section 5

#5 Custom API Policy Development, Offline Policies Management

- Generate Custom API Policy template
- Build the policy
- Package and deploy to Exchange
- Apply policy using API Manager
- Apply policy Offline
- Use Handle Bar to create complex policies



Welcome to Section 5
In this section
We develop a custom api poloicy from scratch and apply it using API Manager and also within Anypoint Studio

Custom API Policy

- What/Why/How?
- Project Structure
- Development options
- Handlebars

Custom Policies are policies which can be developed and applied to their APIs, to extend the functionality of Mule application or existing API Polciies.

Policies can be applied/deployed locally as offline policies.
For applying online, policies should be deployed to Anypoint Exchange

- First step to develop a custom policy consists in setting up a project with the required files.
- The easiest way to gather all your required files is by using the maven archetype.
- This archetype creates all the necessary files for you.

Lets see what attributes are deined in this command

archetypeGroupId

defines the GroupId in the Mule repository where the skeleton of the Mule custom policy is defined.

archetypeArtifactId

defines the ArtifactId of the archetype in the Mule repository.

archetypeVersion

A version of the archetype.

groupId
defines the GroupId for your application or module. Generally, it should be an AnypointOrganizationId where the policy will be deployed
artifactId
defines name of your policy.

We mainly work on 3 files, one is

- **XML template** where the actual logic of the policy and Mule configuration are defined.
    - Here we are logging a message using vars.msg dataweave expression, this message value should be provided by the user
    - So how does a user provide this value?
- It is done using a
- **YAML file** which renders the policy configuration UI in Anypoint API Manager.
    - If this yaml file is not provided, the policy won't be able to be applied through Anypoint API Manager.
- In pom.xml ---

Packaging type as
mule-policy , so packager plugin can successfully build the JAR,
distributionManagement section is defined pointing to user's Exchange.
mule-maven-plugin is responsible of packaging the policy into a deployable jar
maven-deploy-plugin is configured to deploy both the resulting jar and the YAML when uploading the policy to Exchange

Basicis of XML template

- Within the **http-policy:proxy** element contains a **http-policy:source, this** block contains the actual logic to implement the policy.
- Any Mule Event operation that is defined before the **execute-next element** will be executed before the start of a flow with an HTTP Listener.
- The **http-policy:execute-next** element is required to continue the Mule Event processing.
    - The **http-policy:execute-next** element can trigger other **policies** or the **application** flow.
    - Any policy can stop the Mule Event processing chain by not executing http-policy:execute-next.

    - HIHGHLY recommended to check out the mule documentation for more info the processing chain

<<show docs to **Understanding execution order >>**

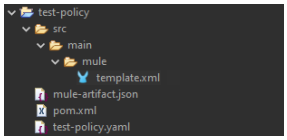
For applying policy using API Manager

We can deploy the policy to exchange using mvn deploy

Custom API Policy – Handlebars

Handlebar is a templating framework and can access config values from YAML file

Using **if conditions**, it decides which section of policy is executed based on user input



template.xml

```
...
<http-policy:proxy name="{{{policyId}}}-policy">
        <http-policy:source>

            <set-variable
                variableName="msg"
                value="{{{message}}}" />

            <logger
                message="#[vars.msg]" />

            <http-policy:execute-next/>

            {{#if upperCase}}
            <logger
                message="#[upper(vars.msg)]" />
            {{/if}}

        </http-policy:source>
</http-policy:proxy>
...
```

test-policy.yaml

```
id: custom-log-message
name: Custom Log Message
description: Policy for logging
category: Custom
type: custom
resourceLevelSupported: true
encryptionSupported: false
standalone: true
requiredCharacteristics: []
providedCharacteristics: []
configuration:
  - propertyName: message
    name: Enter Message
    description: Enter value to Log
    type: string
    optional: true
    sensitive: false

  - propertyName: upperCase
    name:Enable Upper Case
    description: Logs message in upper case.
    type: boolean
    optional: true
    defaultValue: false
```

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Lets understand what are HandleBars,

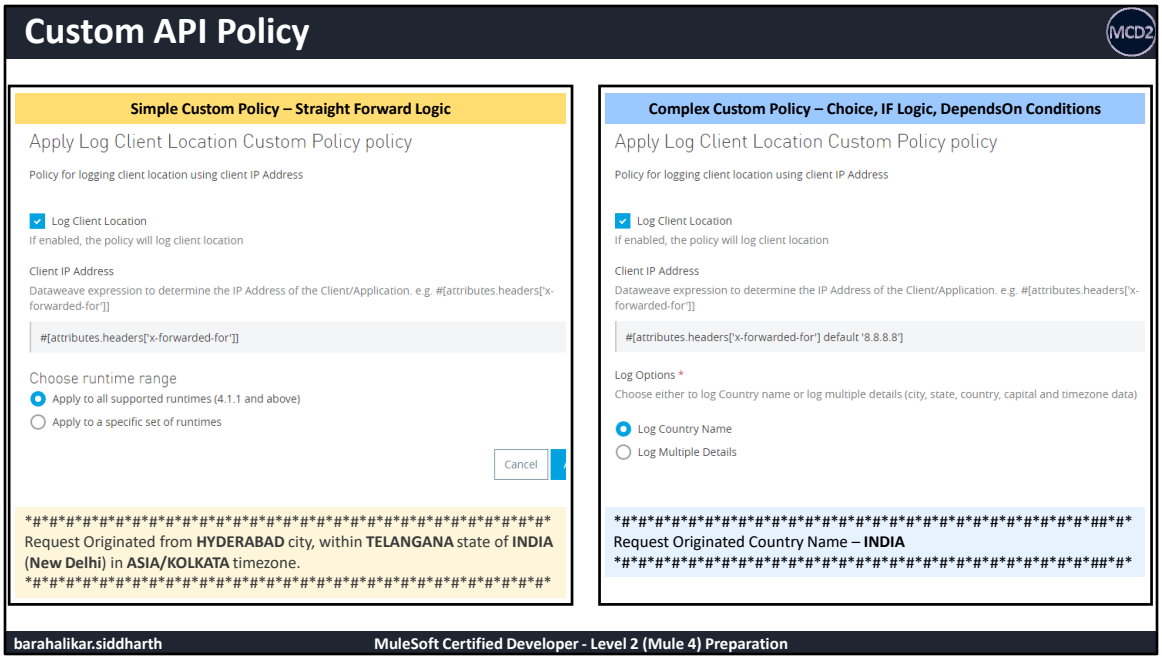
Handlebars is a templating framework that allows users to create more complex policies.

Each policy parameter defined in a YAML Configuration file will be available as a HandleBar variable

Using handlebars we can conditionally decide which sections of the policy are applied depending on the user configuration.

- Lets assume we have aPolicy Yaml, which takes user input to Log messages in UPPER case
- If it is selected, we need to have a logic in the policy to log messages in upper case
- Here we can make use of Handle bars,
- Within the Template xml, we can use a IF condition to execute a section of policy
- This section gets executed only if the condition is true.
- If the condition is false, this section is ignored

In this way we have multiple if conditions for a more complex policy



We will be creating a custom policy to log the user/client's Location Detail.

Within the API policy, the users should define where the policy will find the Client-IP address within the request.

This is done using a dataweave expression

The policy will log the CITY, STATE, COUNTRY, CAPITAL and TIMEZONE details of the client.

Futhermore we will modify this policy using HANDLEBARS to give users an option to log either the COUNTRY NAME or all the details

5.1 Custom API Policy

- Generate skeleton
- POM Modifications

5.2 Custom API Policy - Development

- Understand Client IP Logging
- Add Business Logic to Policy
- Add UI Properties
- Package the policy

5.3 Custom API Policy - Deployment

- Deploy to Exchange
- Configure in API Manager

Custom API Policy - Offline

- Pre-requisites
- Applying Offline Custom Policy
- Removing Offline Custom Policy

Managing Offline Custom Policy – Apply & Remove

Prerequisites Before applying an offline custom policy	API Gateway Capabilities enabled in Mule Runtime Engine
	API configured with a basic or proxy endpoint exists in API Manager
	Mule application is linked with API Autodiscovery & deployed with a HTTP(s) flow
Applying Offline Custom Policy	**mvn clean package** >>>> Copy the **JAR** >>>> ***MULE_HOME_DIR/policies/policy-templates***
	Create JSON file >>>> ***MULE_HOME_DIR/policies/offline-policies***
Removing Offline Custom Policies	Delete JSON file >>>> ***MULE_HOME_DIR/policies/offline-policies***

```json
{
  "template" : {
    "groupId" : "c738e3c8-08cf-462d-bb9a-1553ebf5008e",
    "assetId" : "log-client-location-custom-policy",
    "version" : "1.1.0"
  },
  "api": [
    {
      "id": "17719055"
    }
  ],
  "order": 1,
  "configuration" : {
    "ipAddress" : "1.1.1.1"
  }
}
```

log-client-location-custom-policy-definition.json

```json
{
  "id" : "log-client-location-custom-policy-definition",
  "template" : {
    "groupId" : "c738e3c8-08cf-462d-bb9a-1553ebf5008e",
    "assetId" : "log-client-location-custom-policy",
    "version" : "1.1.0"
  },
  "api" : [ {
    "id" : 17719055
  } ],
  "online" : false,
  "order" : 1,
  "configuration" : {
    "ipAddress" : "1.1.1.1"
  }
}
```

policy-definition.json

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An offline policy is applied directly to the runtime and not through API Manager.

But how do we do that?

First we need to satisfy few prerequisties like,

- The API Gateway Capabilities should be enabled in Mule Runtime Engine
- The API should be configured with a basic or proxy endpoint exists in API Manager
- The Mule application should be linked with API Autodiscovery & deployed with a HTTP(s) flow

To apply the policy,

- We need to package the policy into a deployable JAR
- Copy the JAR to MULE_HOME/Polciies/policy-tempaltes directory
- Wee need to create a JSON file in %MULE_HOME%/policies/offline-policies directory to define the configuration
    - API instance ID
    - Order of the policy in which it should be executed if we have multiple

offline policies and
- User input Parameters

- To **remove** an offline policy, you need to delete the JSON file you created in the offline-policies directory.

5.4 Custom API Policy - Offline

- Copy artefacts to Mule_Home Directories
- Deploy App
- Test
- Remove Policy

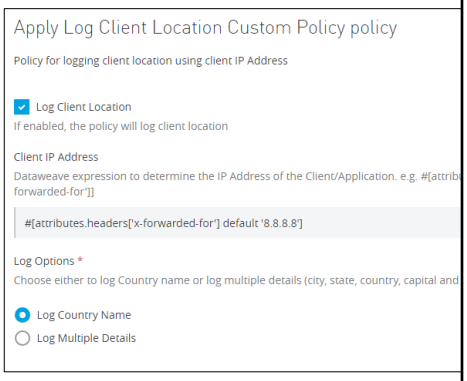
5.5 Custom API Policy - Complex

- Add handlebar logic
- Package the policy
- Deploy to Exchange
- Apply in API Manager
- Check in CloudHub Logs

Section 5 - Completed

#5 Custom API Policy Development, Offline Policies Management

- Generate Custom API Policy template
- Build the policy
- Package and deploy to Exchange
- Apply policy using API Manager
- Apply policy Offline
- Use Handle Bar to create complex policies

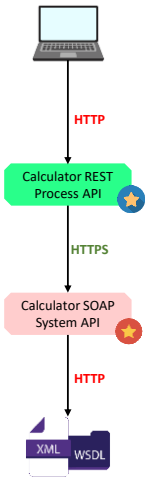


Welcome to Section 5
In this section
We develop a custom api poloicy from scratch and apply it using API Manager and also within Anypoint Studio

Section 6

#6 Consuming SOAP Web Services using TLS Certificates (one-way and two-way)

- Consume SOAP Service over plain HTTP Protocol
- Consume SOAP Service using one-way-tls
- Consume SOAP Service using two-way-tls
- Configure TLS Certs for a SOAP WebConsumer connector
- Deploy application to Mule 4 Standalone server



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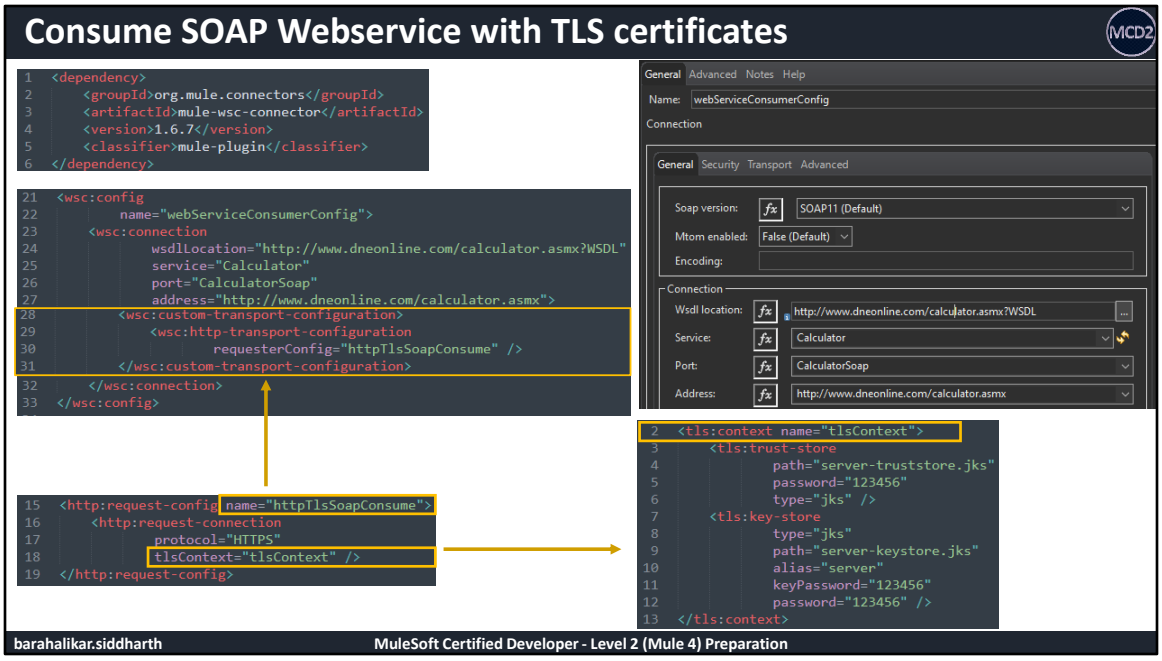
Section 6

In Section 6 We understand how to using TLS config for SOAP webservice and consume a service using Mutual TLS Authentication.

SOAP WebService

- Add Module
- Configure TLS Certs



Web Service Consumer Connector) consumes a SOAP web service from a Mule app to fetch data from an external source.

We can add the module to Mule app and configure the WSDL in the connector config.

This is enough for accessing the Webservice over HTTP

What if we want to consume a Webservice which has mutual authentication enabled?

Where in the connector do we mention the TLS certification for TLS communication?

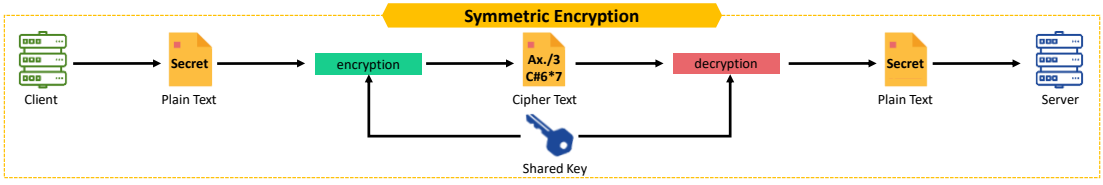
Here we rely on the HTTP Request connector to configure TLS certs and use that configuration within Webservice connector

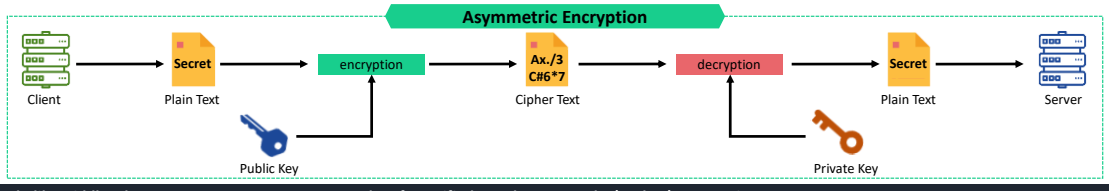
Secure Data in Transit

- Secure Communication – Using Cryptography
- Digital Certificates
- One-way TLS
- Two-way TLS
- Create Keys & Certificates (JKS) 2-Way-TLS
- Create Keys & Certificates (PKCS12) 2-Way-TLS

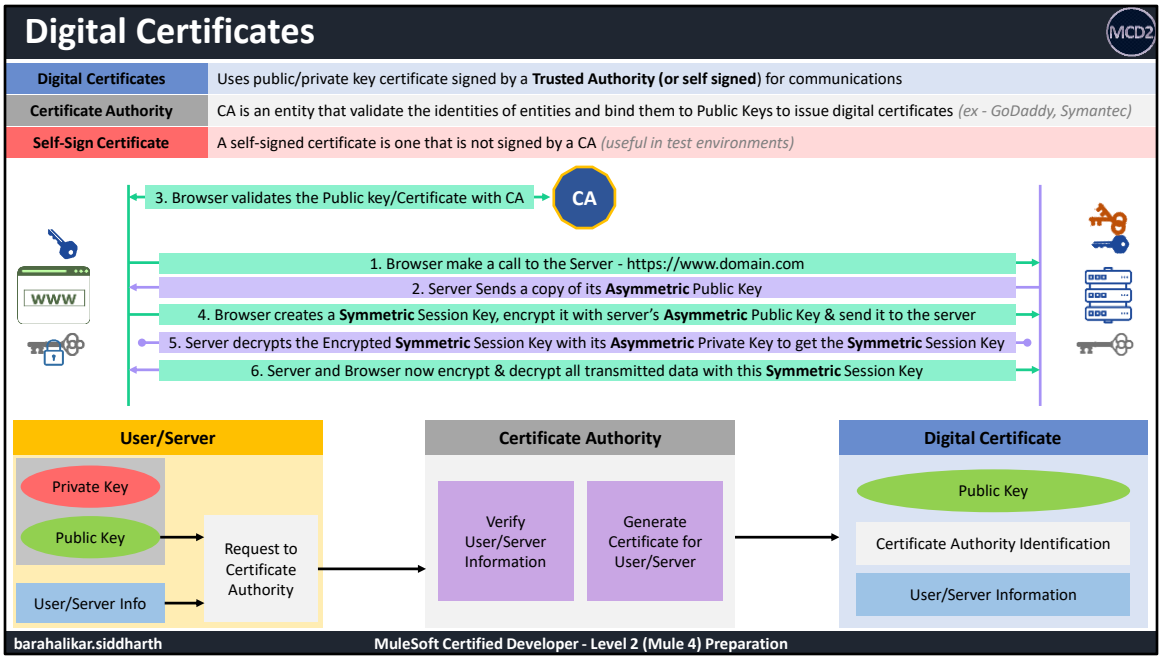
Secure Communication – Using Cryptography

Symmetric Cryptography	Client and Server use the **same key** for encryption and decryption of messages		
	Same Key	Speed of encryption/decryption is Very **FAST**	Size of encrypted text is SAME or **LESS** than the original plaintext
Asymmetric Cryptography	Server issues a **Public Key** to the client to encrypt the messages | Server has a **Private Key** which is the **only key** to decrypt the message		
	Different Keys	Speed of encryption/decryption is **SLOWER**	Size of encrypted text is **MORE** than the original plaintext
Digital Certificates	Uses public/private key certificate signed by a **Trusted Authority (or self signed)** for communications		



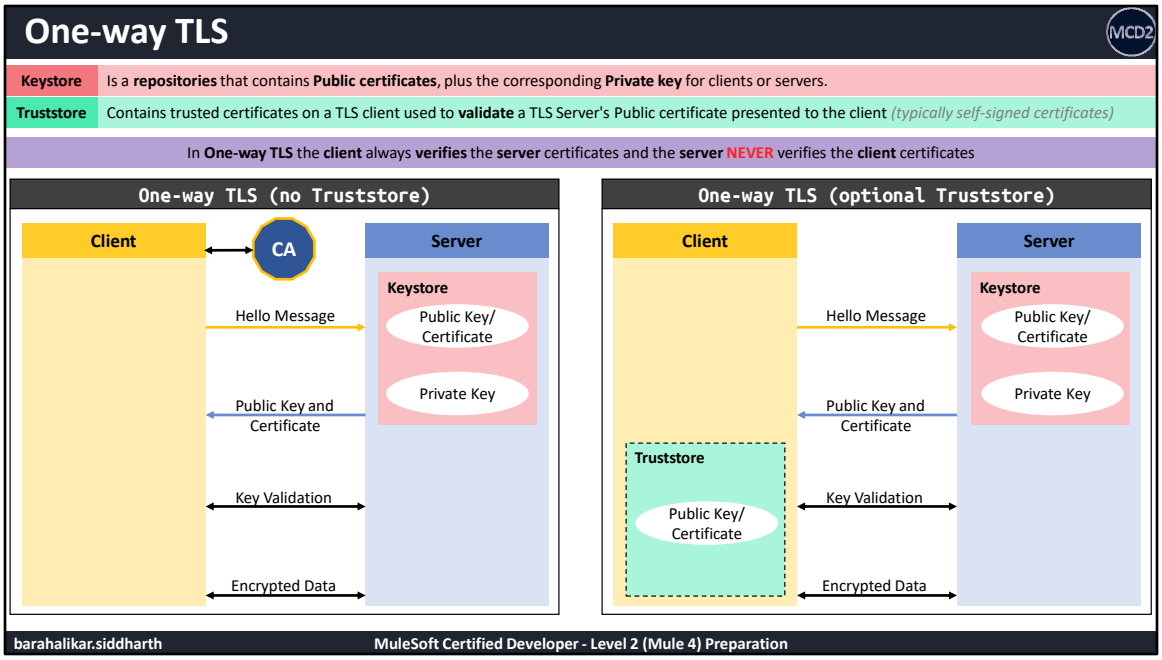


Within secure communication, we understood the differences between Symmetricc and Asymmectric encryption

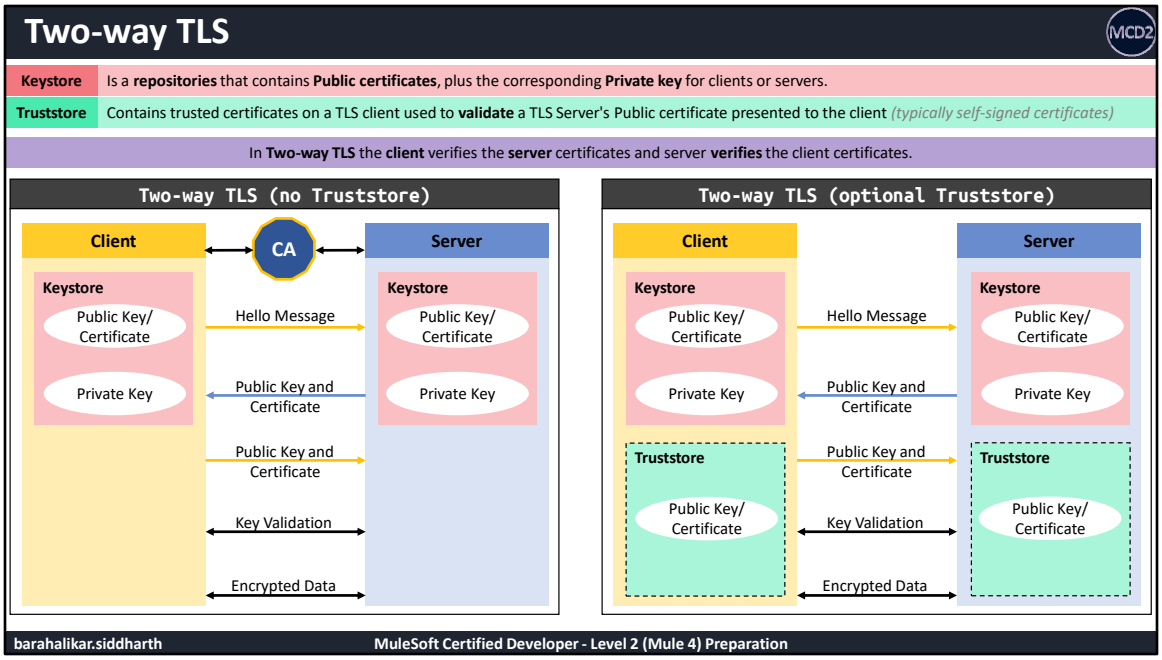


Here we understood what are digital certificates and these are obtained b y the server/user

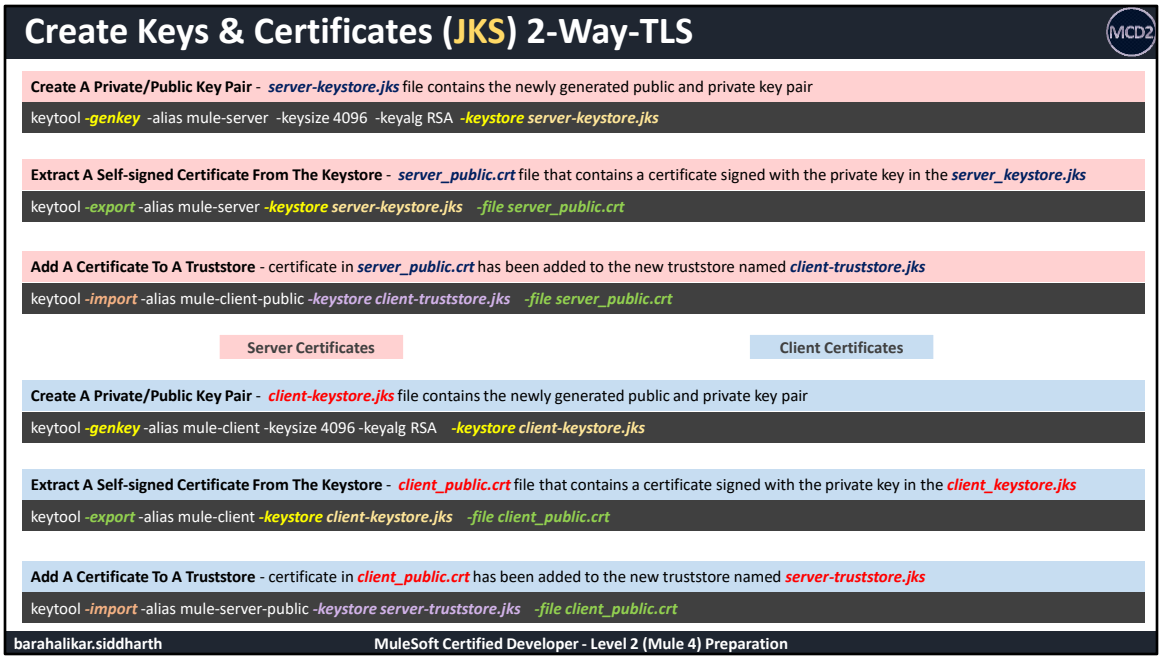
We also saw the interaction between a client and server exchanging keys to secure the data transmission



Then we talked about one way tls and how it works with and without a truststore



Finally we talked about 2 way tls and how it works with and without a truststore.



We also talked about JKS vs PCKS formats and generated a keystore which was used for 1 way tls.

Here we will see how to generate jeystore and trsutsore using JKS format

Create Keys & Certificates (PKCS12) 2-Way-TLS

Create A Private/Public Key Pair - ***server-keystore.p12*** file contains the newly generated public and private key pair

```
keytool -genkey -alias mule-server  -keysize 2048 -keyalg RSA -keystore server-keystore.p12 -storetype pkcs12
```

Extract A Self-signed Certificate From The Keystore - ***server_public.pem*** file that contains a certificate signed with the private key in the ***server_keystore.p12***

```
keytool -export -alias mule-server -keystore server-keystore.p12   -file server_public.pem
```

Add A Certificate To A Truststore - certificate in ***server_public.pem*** has been added to the new truststore named ***client-truststore.p12***

```
keytool -import -alias mule-client-public -keystore client-truststore.p12   -file server_public.pem
```

Server Certificates

Client Certificates

Create A Private/Public Key Pair - ***client-keystore.p12*** file contains the newly generated public and private key pair

```
keytool -genkey -alias mule-client  -keysize 2048 -keyalg RSA -keystore client-keystore.p12 -storetype pkcs12
```

Extract A Self-signed Certificate From The Keystore - ***client_public.pem*** file that contains a certificate signed with the private key in the ***client_keystore.p12***

```
keytool -export -alias mule-client -keystore client-keystore.p12   -file client_public.pem
```

Add A Certificate To A Truststore - certificate in ***client_public.pem*** has been added to the new truststore named ***server-truststore.p12***

```
keytool -import -alias mule-server-public -keystore server-truststore.p12   -file client_public.pem
```

6.1 Soap WebService – Plain HTTP

- Import SOAP **SAPI**
- Run & Test
- Deploy to Standalone Server

- Import REST **PAPI**
- Consume SOAP **SAPI**
- Test

6.2 Soap WebService > One-way TLS

- Generate server keystore and client truststore
- Package them in Mule App
- Configure keystore in SOAP **SAPI**
- Deploy to Standalone Server

- Configure client truststore in REST **PAPI**
- Deploy & Test

6.3 Soap WebService > Two-way TLS

- Generate client keystore and server truststore
- Package them in Mule App
- Configure keystore in REST **PAPI**
- Deploy

- Configure server truststore in SOAP **SAPI**
- Deploy to Standalone server
- Test

Section 6 - Completed

#6 Consuming SOAP Web Services using TLS Certificates (one-way and two-way)

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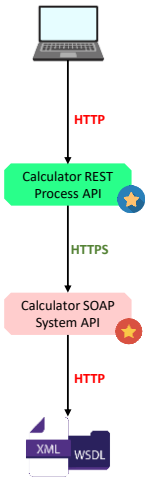

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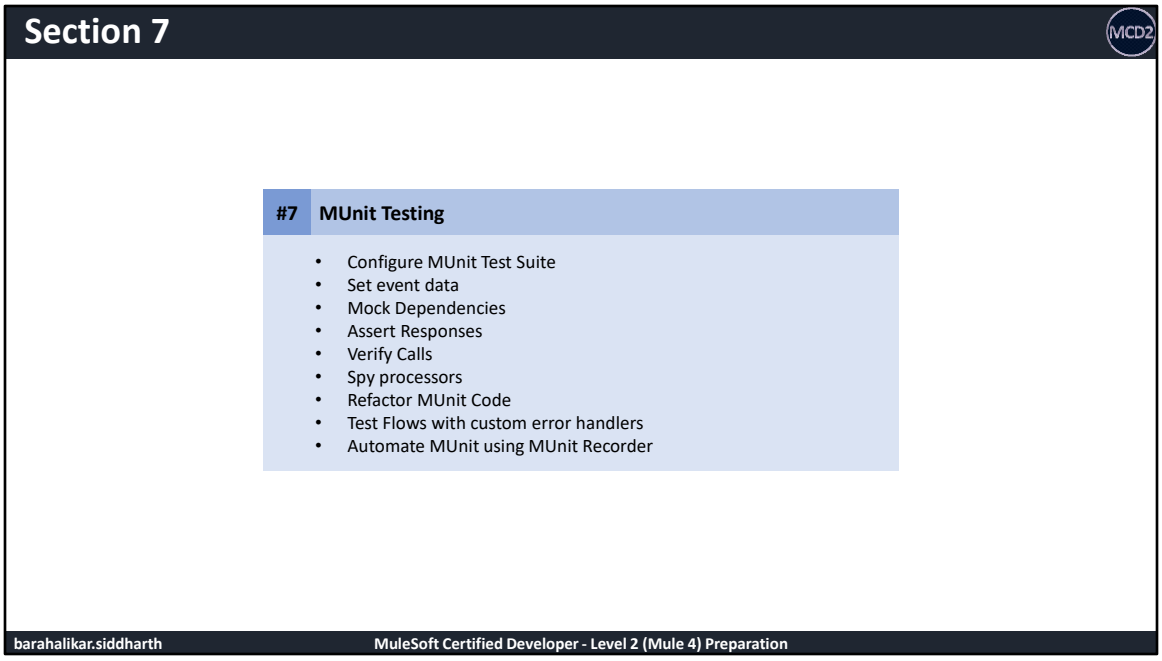


Welcome to Section 7
In this section we will work on Munit testing.

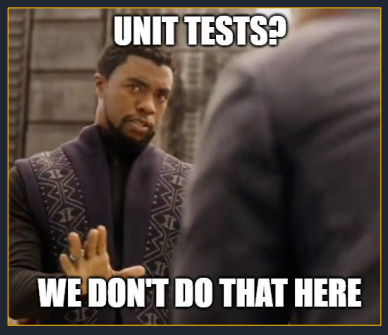
We will start bu configuring Munit test suite for a Mule application

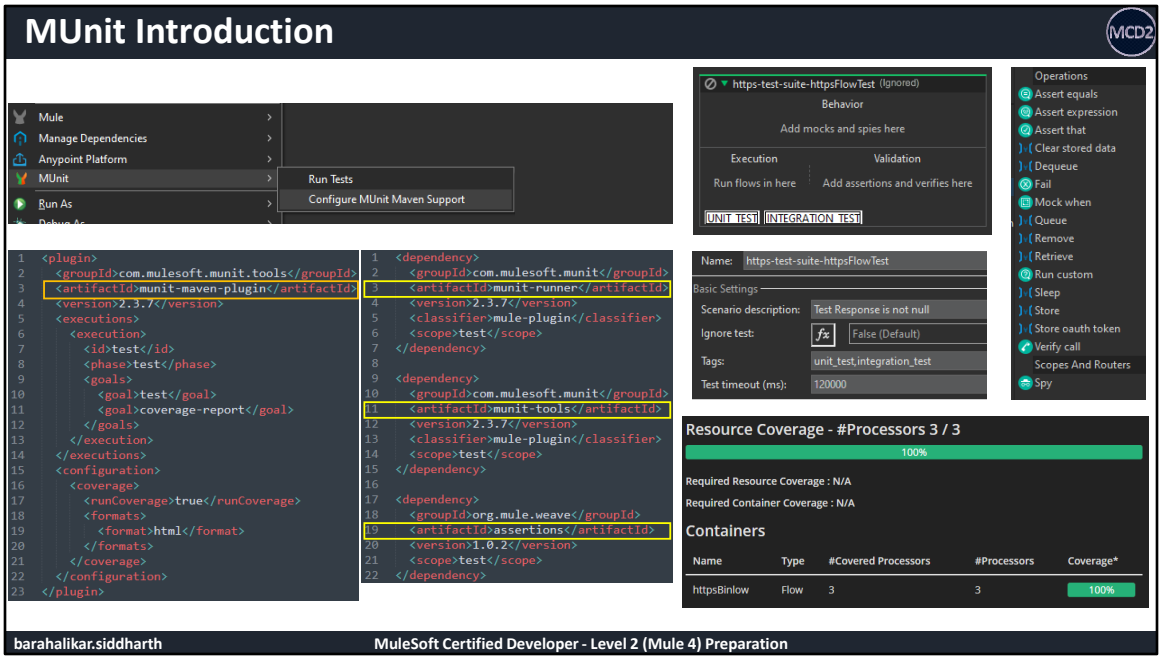
Write Munit test cases by
- Setting the event data
- Mocking dependencies
- Asserting the response
- Verifying the calls and processors data
- Refactor Munit code and
- Test flows with custom error handler

We will end this section by automating Munit usin Munit recorder

MUnit Testing

- MUnit Basics





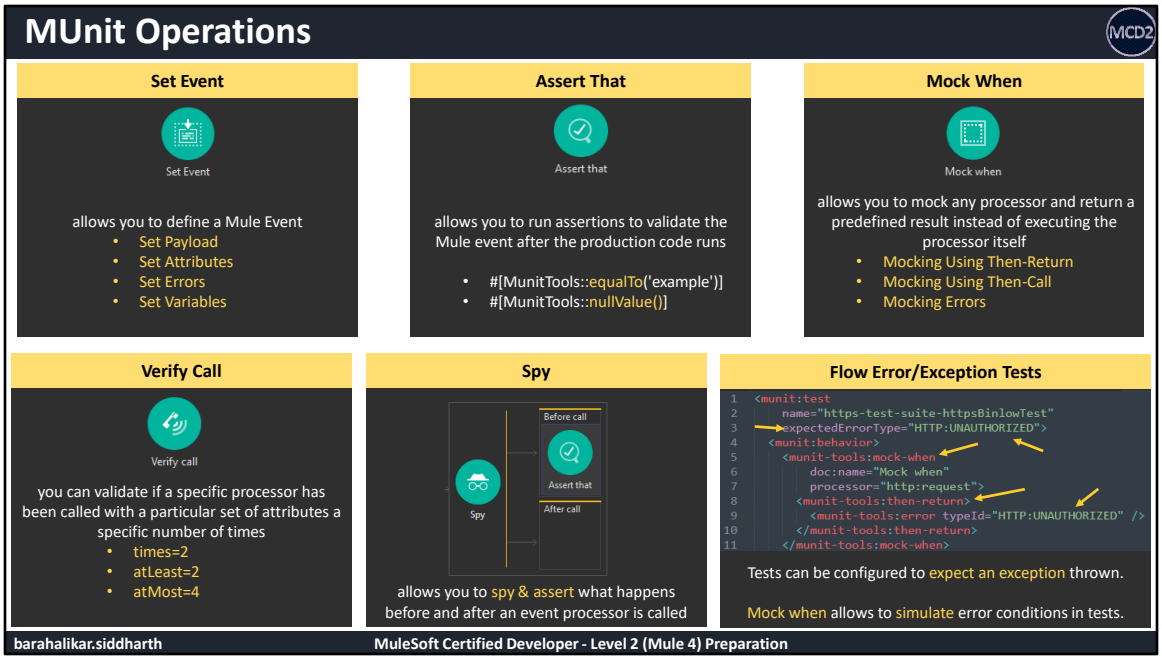
The main objective of unit testing is **to isolate written code to test and determine if it works as intended**.
Unit tests helps to find problems early in the development and fix them quickly

- MUnit is a Mule application testing framework which allows you to build automated tests for your Mule integrations and API's.
- MUnit is very well integrated with Anypoint Studio.
- Each Munti test is essentially a Mule flow
- Tests are executed in a Mule runtime and reports are generated

- We can configure Munti maven support for each application,
- It modifies the application pom to include munit dependencies like munit-runner, munit-tools, & assertions module
- A Munit ttest flow is divided in three scopes and all are optional.
    - the Behavior scope is ■ where all preconditional before execution are set, like mocks, spys
    - The Execution scope ■ is where we have testing logic, references to the Mule flow and setting event data
    - The Validation scope ■ is the place where we do assertions

- Each test flow has multiple configurations options like,
    - tags which can be used in maven commands
    - Timeouts and the option to
    - Ignore the tests etc

- Finally it also gives a detailed coverage report on the mule flows and its processors being tested.



Within the Munit operations, we will be exploring the following operations.

We will use set event data operation to define the mule event like

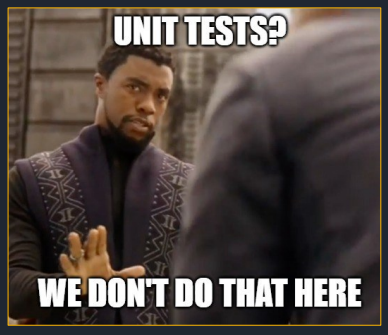
- Set Payload
- Set Attributes
- Set Errors
- Set Variables

We will use assert that operation which allows you to run assertions to validate the Mule event after the code run

- #[MunitTools::equalTo('example')]
- #[MunitTools::nullValue()]

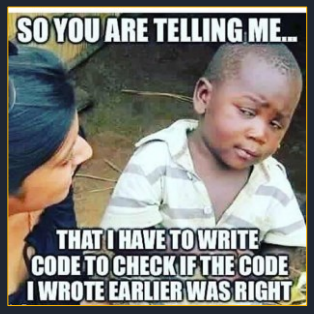
7.1 MUnit Testing

- Import new app
- Deploy & Test



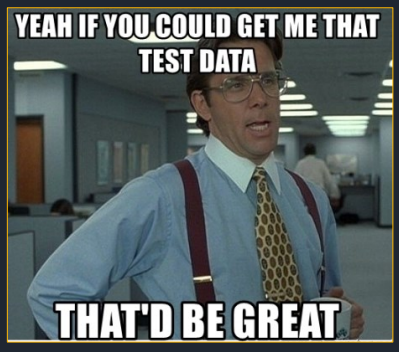
7.2 MUnit Testing

- Configure MUnit Support
- Add a sample test
- Run & Test



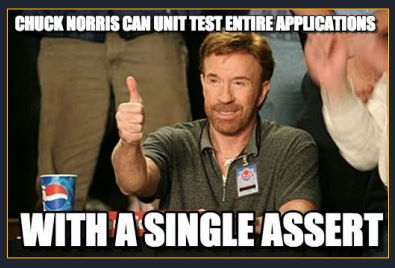
7.3 MUnit Testing

- Set Event Data
  - Set Input Payload
  - Set Query Parameters
- Run & Test



7.4 MUnit Testing

- Add Assertions
  - Check Payload is not null
  - Check Payload name field
- Run & Test

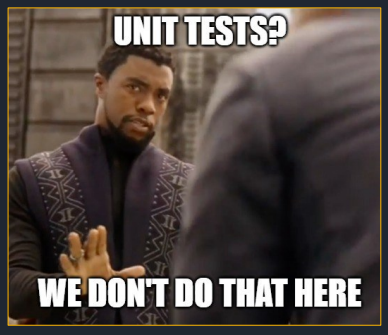


7.5 MUnit Testing

- Mock Dependencies
  - Mock payloads
  - Mock all external services
- Add a new Payload Assert
- Run & Test

7.6 MUnit Testing

- Verify
  - All external services are called once
- Run & Test



7.7 MUnit Testing

- Spy
  - Assert the payload
    - before invoking external service
    - after invoking external service
- Run & Test

7.8 MUnit Testing

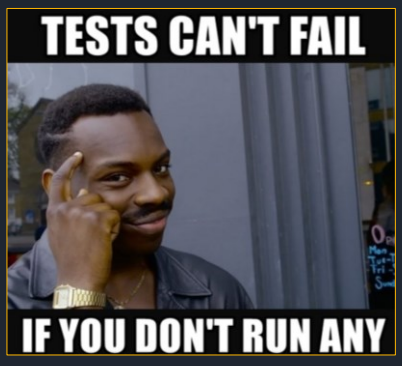
- Refactoring Munit Tests and Data

7.9 MUnit Testing

- Tests Flow with custom error handler
- Mock Errors

MUnit Testing

- Maven MUnit Testing
- Maven Commands
- Various Configurations
- Coverage reports



MUnit provides a Maven plugin that enables you to run your MUnit tests as part of your continuous integration environment.

This is a sample Munit maven pom configuration

Talking about Coverage
These configurations only apply when you execute your MUnit tests using the Maven plugin.
They do not apply when running tests from Studio.

One of the features of MUnit Coverage is to fail the build if a certain coverage level is not reached.

- MUnit Coverage handles three different levels:
    - **Application** level coverage of all your application.
    - **Resource** level coverage of each individual Mule configuration file.
    - **Flow**: level coverage of event processors in each flow.

- Fail Build - if **false**, and the coverage levels are not reached, the build will not fail, but will give a warning

The reports can be generated in 4 formats >> console, html, json and sonar

>>

- Another feature is the ability to ignore either a flow or a file.
- This way, the ignored resource:
    - Does not count as coverage data. And it also
    - Does not cause a build to fail if the flow is not tested or if the flow does not reach coverage metrics

You can specify the type of runtime in which your applications being tested will run.
We add the runtimeProduct tag , it could e:

- MULE for community edition. But
- if app has enterprise connectors/config we need to use MULE_EE for MUnit testing *(example – Mule Secure Properties Config) we use* MULE_EE for enterprise edition.

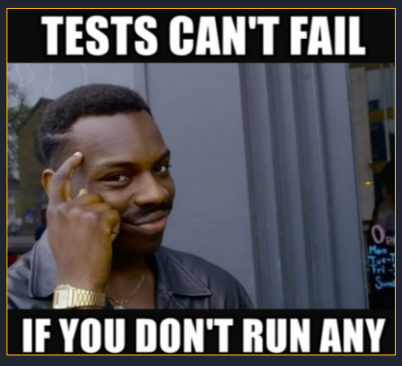
To test we can use these cmds
Mvn test for testing
-DskipTest to skip testing
For –Dmunit.tags - Only tests tagged with these names will run.

We can have multiple test suite in the app,
We can select running all tests defined in the test suites or
We can also mention the test name which should be executed in the test suite

There is a lot moe to Munit Maven Plugin, please refer the documentation page for more info

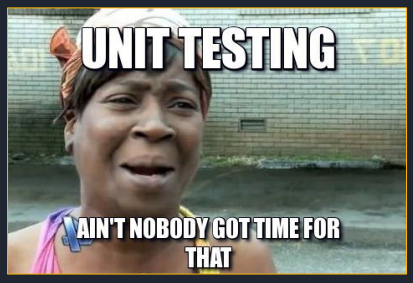
7.10 MUnit Testing

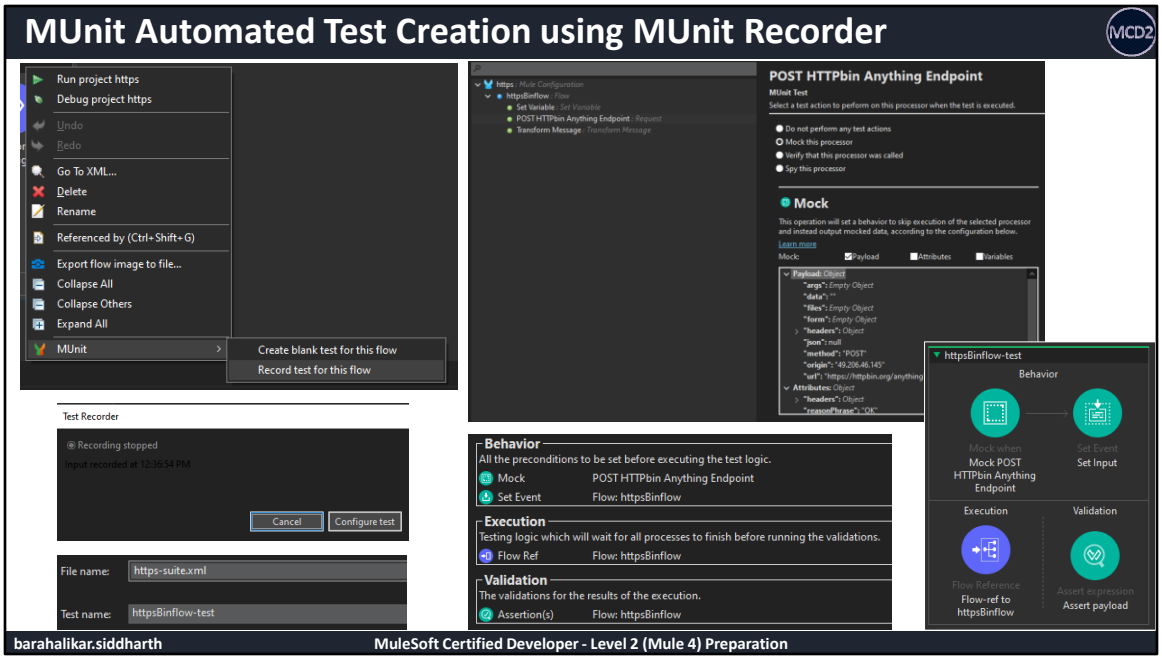
- Maven MUnit Tests
  - Failure



MUnit Testing

- Automated MUnit Recorder
- Configuration





MUnit Test **Recorder** is a tool to automate the creation of **Munit test cases** in MuleSoft.

The test recorder enables you to record a processing flow and then configure a unit test based on the captured event.

The test recorder captures real data as it goes through your application in Anypoint Studio.

By capturing the flow execution, MUnit can automatically generate an MUnit test so that you can configure the necessary mocks and assertions for your test.

Steps to achieve this are,

- We can right click on any flow and select Record test for this flow
- It will deploy the app and wait for the request call.
- Once the flow gets executed, we can configure the test
- It will capture everything from the request and response like payload, attributes and variable
- We can decide which components needs to mocked/verified/spied based on the

requirement and select the options

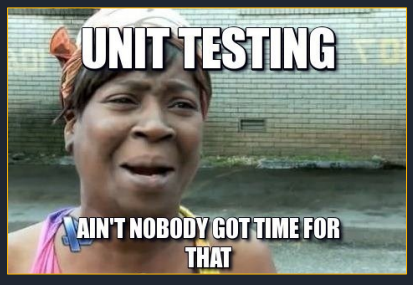
- It is going to automatatically generate the tests based in our input.

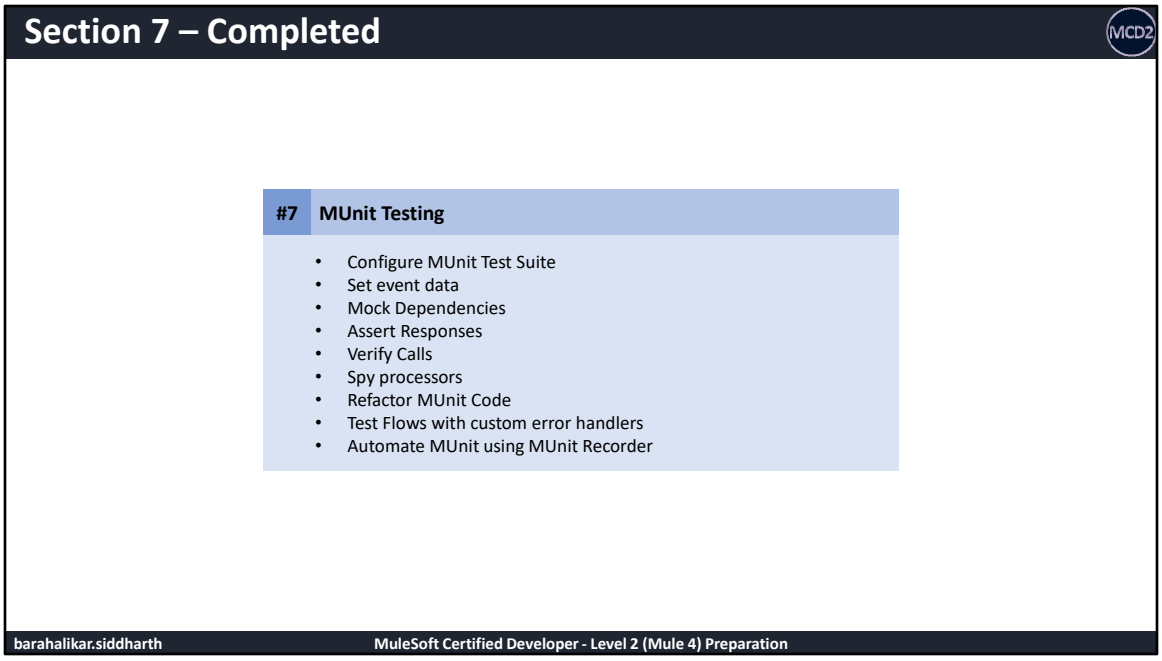
- It has few Limitations –
- You cannot create tests for flows with Mule errors raised inside the flow
- The recorder does not support mocking a message before or inside a Foreach processor.

- For more information please refer Mule documentation

7.11 MUnit Testing

- Record MUnit Tests
- Check out the configurations
- Run & Test





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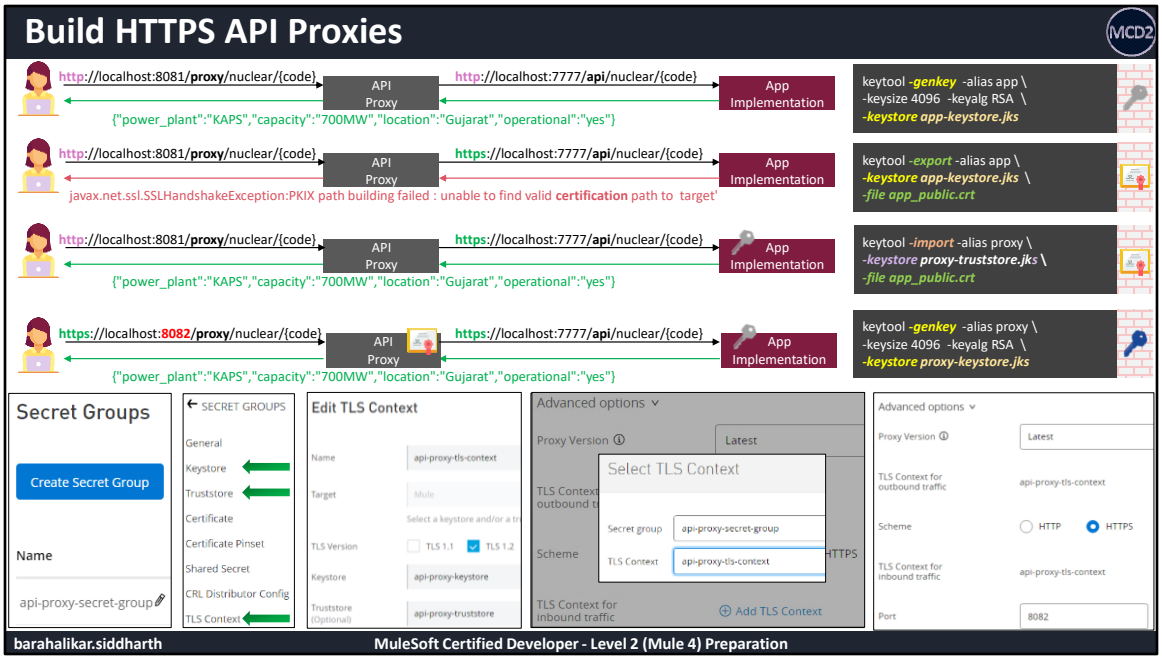
HTTPS API Proxies

- API Proxies
  - TLS
    - Inbound Traffic
    - Outbound Traffic
- Secret Groups
  - TLS Context
  - KeyStore
  - TrustStore



https://self-signed.badssl.com/

Create proxy >> add url
Deploy
Get error ssl engine failure
Export .cer >> add to truststore
Add truststore to Seret group >>> create tls
Redeploy >> test
Generate a keystore >> add to secret group
CREATE ANOTHER TLS to use KEYSTORE
Redeploy >> test

Use on-prem to deploy app and proxy api

Add server to runtime manager

App >> nuclear app >> one flow >> one https listerner with KEYSTORE >> port

anything other than 8082/8081 >> path /api/code

Proxy >> basePath /proxy >>
>> without tls
>> with outbound tls
>> plus inbound tls

Secret Manger >> one for truststore >> one for keystore

A-1 HTTPS API Proxies

- API Proxies
  - TLS
    - Inbound Traffic
    - Outbound Traffic
- Secret Groups
  - TLS Context
  - KeyStore
  - TrustStore