School of Computing
Final Year Engineering Project

Project Initiation Document

Matthew Gaynor

A Web Driven SDN Orchestrator For The Provisioning of ACI Fabric and Lab Infrastructure

1. Basic details

Student name:	Matthew Gaynor
Draft project title:	A Web Driven SDN Orchestrator For The Provisioning of ACI Fabric and Lab Infrastructure
Course and year:	Computer Networks BSc 2023
Project supervisor:	Dr Shikun Zhou
Client organisation:	Cisco - CX Labs UK
Client contact name:	David Smith

2. Degree suitability

This project will aim to solve a problem that has arisen due to a lack of automation and an ever-aging infrastructure that is failing to keep up with the times.

The project will be centred around Cisco ACI, which is Cisco's datacentre software defined networking (SDN) solution. ACI manages the network devices which interconnect to form a fabric, that can be managed from one web UI and via a REST API. This ties together both software and networking to form one solution that is highly scalable and ready for the current need to be application centric.

ACI utilises VXLAN and IS-IS under the hood, so it is required to have an understanding as to how this works for troubleshooting.

There will also be a heavy use of APIs, with a custom backend being required to interact and store data from ACI, as well as vCenter for virtualisation automation.

3. Outline of the project environment and problem to be solved

The client is CX Labs within Cisco Systems. Due to the nature of Cisco being a large multi-national company, the company is split up into different business units. These business units specialise in different fields and provide different services. CX Labs provides lab space mainly to internal customers, including over divisions of CX (Customer Experience) Common use of lab space includes testing and validation services, proof of concepts and replications of client's networks for testing. In some cases, customers can host equipment directly in the labs and have remote access to the stored equipment via the means of a VPN connection to the lab.

Over the years, CX Labs has conventionally had more isolated lab space compared to DMZ space. Whilst the isolated environment is good, it is only accessible to employees of Cisco. Because of this limitation, demand for DMZ space has increased, meaning lab space that has connectivity to the internet. Customers increasingly want access to the testbeds they are paying for to carry out their own testing. The nature of this DMZ space means physical separation from the rest of the network to prevent accidental bridges between un-protected internet and the corporate network. Due to the increasing demand, more lab space is being converted to DMZ space, this has resulted in the need for new infrastructure to support the additional space.

The existing DMZ lab space uses an old approach using Nexus 9K switches at the core, and old Catalyst 2960 switches for Top of Rack. Whilst solidly reliable, to deploy a new project, it is a very involved process, with VLANs, trunks, access ports, vCenter Port Group creation, routing and VPN all having to be configured and provisioned manually.
This environment commonly results in configuration mistakes which can result in extra time required for troubleshooting, and in some cases, inter-project communication which should not be possible. It is also very time consuming which stretches the limited time availability when onboarding new projects to the limit.
Another issue that arises when this creates is that when a project is terminated, the same work is then required in reverse to free infrastructure up for the next project in the lab. Again, this resulting in configuration errors, and in some cases, the project infrastructure is never properly decommissioned due to time constraints. This leads to more unexpected work when a new project comes in and requires the lab space.

4. Project aim and objectives

The aim of the project is to deliver a web dashboard that will allow the lab team to deploy projects into the lab space with minimal involvement in configuring the networking equipment. The dashboard will be powered by NextJS for the frontend and Laravel for the backend. The Laravel backend will interact with the vCenter and ACI APIs to provide the network and service automation. Laravel will also store the state of the lab and keep track of IP addressing and IDs to improve ease of use and response times. It will serve as an overall orchestration master for the lab.

- Web UI for management of rack space and infrastructure
- Automated routing deployment using the CSR1000v virtual router platform
- Automated EPG, BD and VRF deployment using ACI.
    - ToR port allocation also automated
- Terminal Server automation to place terminal server in correct network
- Ability to manage the space from the Web UI, including the provisioning of additional racks, Terminal Servers and ToR switches.

5. Project constraints

Equipment is being loaned and hosted by Cisco, could be affected by organisation changes and restructuring. Members of staff leaving could also impact the project.
Not able to test at scale, only able to simulate 3 racks, with a collapsed spine and leaf architecture.

6. Facilities and resources

All resources required for this project are provided by myself and Cisco. I have a testbed of equipment that will be necessary to complete the project with dedicated external IP addresses and VPN access.

7. Log of risks

Description	Impact	Mitigation/Avoidance
Moving equipment around may result in injury	Cause delays to the project timeline	Follow the appropriate safety and manual handling guidance when lifting equipment.
Changing in Cisco policy may mean I am no longer able to access lab	Cause delays to the project and result in the inability to complete testing	Take backups of virtual machines and keep in contact with managers at Cisco. Worst case, all of lab can be simulated and done virtually.
Hardware Failure	Inability to continue testing using the testbed	Take config backups and arrange for replacement devices to be installed or move to virtualised devices. Use Git for version control to keep codebase backed up to GitHub.

8. Project deliverables

The result will be a web UI with a backend that handles the interactions with the networking equipment. The web UI will be easy to use and have a good UX design to allow for a minimal learning curve and be easy for someone with limited networking knowledge to use.
The backend will take care of automation and the only manual input from the user will be the IP addresses of the relevant equipment, such as the APIC and terminal servers.

Documentation including a proposed network topology and user guide will be included. As well as basic installation instructions, although Docker will be used to simplify this as much as possible.

9. Project approach

As this will be a software development project, I will be using Trello to manage my development. Trello is a web application that provides a way to manage a Kanban SDLC. As it is just me developing the software, there is no need for a full agile methodology to be implemented and doing so would result in wasted time, so Kanban is the perfect choice.
I will also follow the waterfall model as a guide to the overall development cycle.

As I will be utilising the vCenter and ACI REST APIs, the appropriate documentation for these must be consulted in order to implement them. Elements such as schema and authentication

will vary from API to API, so the documentation is required for this. Both VMware and Cisco provide detailed documentation on their APIs.

As I am building my own REST API, it will be best practise to follow the OpenAPI specification. Whilst there is no one specific REST standard, the OpenAPI standard is widely regarded as the most optimal when creating REST APIs.

10. Project plan

The first step is to carry out a literature review to determine existing solutions and work out their advantages and shortcomings. This will allow me to put together some best practises to follow and allow me to make the most optimal solution.

The next step will then be performing a detailed requirement analysis to determine the exact requirements of the project. I will then be able to create a success criteria which will outline the key functionality that is required from the project.

The next phase will then be taking the success criteria and designing how the artefact will work from a technical standpoint. This will include designing the UI/UX and how the database will store information. An API design will also help determine the models required to handle the data. I will also need to research the ACI and vCenter APIs which I have used briefly in the past, but more in-depth knowledge will be required for this.

After the design phase is complete, the artefact can be created which will involve writing all the code and documenting the process.

The application can then be tested by the end users and by also using traffic generation to ensure that the automation aspect has carried out its intended functions.

11. Supervisor Meetings

We have agreed that a weekly sync-up would be a good frequency for us. Supervisor input shouldn’t be needed too frequently, so periods of leave won’t be a problem and I can plan upcoming questions accordingly. Meetings will take place face-to-face.

12. Legal, ethical, professional, social issues (mandatory)

As the artefact will be automating the network infrastructure that will be supporting sensitive testbeds, it is important the security of the platform is taken deeply into consideration. As such, authentication will be required against authentication servers to ensure that only authorised users have access to the dashboard. Testing of the provisioned network policy must also be tested to ensure that no cross-communication between projects occurs. This is very important as ARP leaking and communication could result in sporadic issues and hard to troubleshoot problems. However, as the environment is not production and is purely for testing, security is not as crucial as a production piece of software would required to be.

As the platform will be automating network device configuration, it will remove the need for as much time to be spent by an engineer, which has the potential to devalue their skill sets and appear to higher management like their role is no longer required.

Appendix A: Ethics certificate

Certificate of Ethics Review

Project title: A Web Driven SDN Orchestrator For The Provisioning of ACI Fabric and Lab Infrastructure

Name:	Matt Gaynor	**User ID**:	922830	**Application date**:	10/10/2022 11:18:58	**ER Number**:	TETHIC-2022-103684

You must download your referral certificate, print a copy and keep it as a record of this review.

The FEC representative(s) for the **School of Computing** is/are **Haythem Nakkas, Dalin Zhou**

It is your responsibility to follow the University Code of Practice on Ethical Standards and any Department/School or professional guidelines in the conduct of your study including relevant guidelines regarding health and safety of researchers including the following:

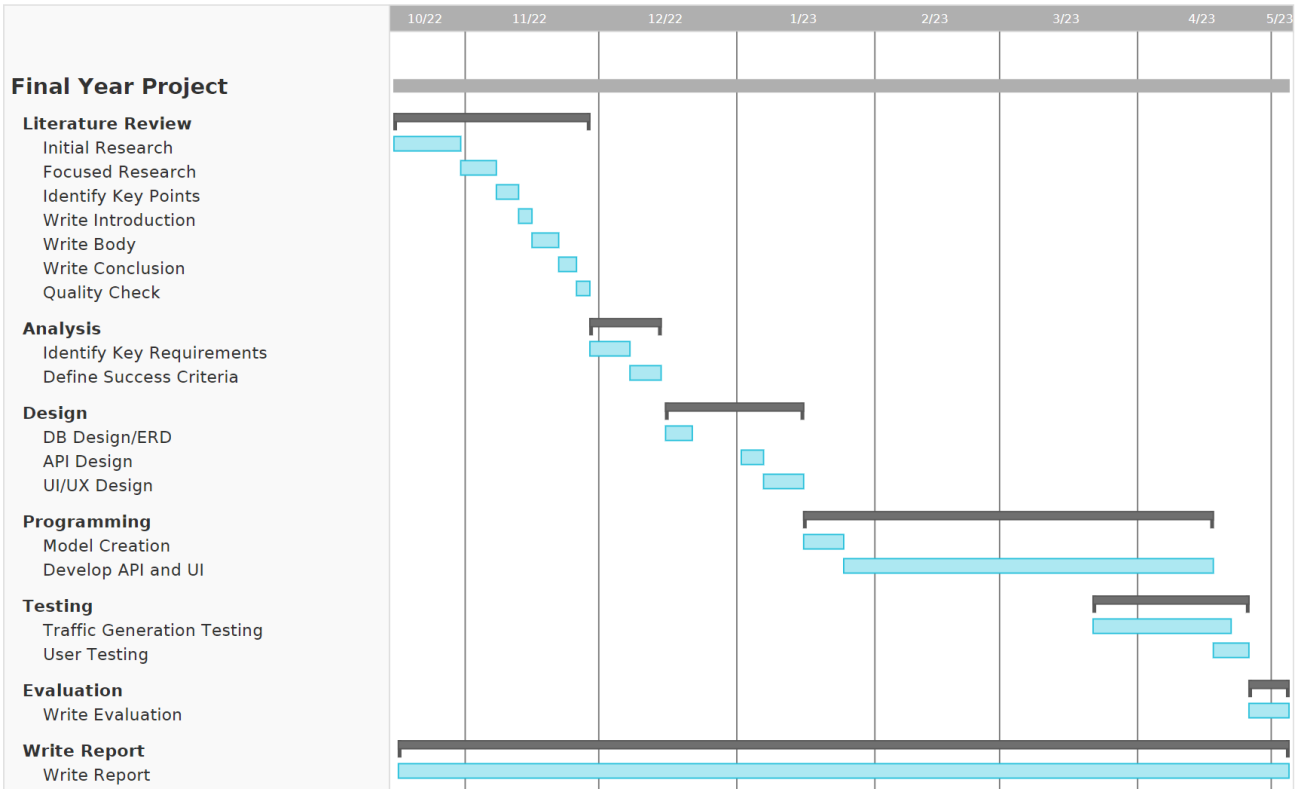
- University Policy
- Safety on Geological Fieldwork

It is also your responsibility to follow University guidance on Data Protection Policy:

- General guidance for all data protection issues
- University Data Protection Policy

Which school/department do you belong to?: **School of Computing**
What is your primary role at the University?: **Undergraduate Student**
What is the name of the member of staff who is responsible for supervising your project?: **Dr Shikun Zhou**
Is the study likely to involve human subjects (observation) or participants?: No
Will financial inducements (other than reasonable expenses and compensation for time) be offered to participants?: No
Are there risks of significant damage to physical and/or ecological environmental features?: No
Are there risks of significant damage to features of historical or cultural heritage (e.g. impacts of study techniques, taking of samples)?: No
Does the project involve animals in any way?: No
Could the research outputs potentially be harmful to third parties?: No
Could your research/artefact be adapted and be misused?: No
Will your project or project deliverables be relevant to defence, the military, police or other security organisations and/or in addition, could it be used by others to threaten UK security?: No

Appendix B: Gantt chart


10/22
11/22
12/22
1/23
2/23
3/23
4/23
5/23
Final Year Project
Literature Review
Initial Research
Focused Research
Identify Key Points
Write Introduction
Write Body
Write Conclusion
Quality Check
Analysis
Identify Key Requirements
Define Success Criteria
Design
DB Design/ERD
API Design
UI/UX Design
Programming
Model Creation
Develop API and UI
Testing
Traffic Generation Testing
User Testing
Evaluation
Write Evaluation
Write Report
Write Report