SAVITRIBAI PHULE PUNE UNIVERSITY

A PRELIMINARY PROJECT REPORT

ON

“CLOUD BASED DEVOPS SKILL ASSESSMENT APPLICATION”

Submitted toward the partial fulfillment of the Requirement of

BACHELOR OF ENGINEERING
(COMPUTER ENGINEERING)

BY

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DEPARTMENT OF COMPUTER ENGINEERING

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CERTIFICATE

This is certify that the project entitled

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is a bonafide work carried out by students under the Supervision of **Prof. Amar More** and it is submitted towards the partial fulfillment of the requirement of Bachelor of Engineering (Computer Engineering).

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ABSTRACT

Now a days many online tools are available to test the programming knowledge of the person like codechef. But in order to test the knowledge of the DevOps there is no such online tool available. So the aim is to develop the cloud based infrastructure to test the knowledge of DevOps of the examinee. The questions related to the DevOps will be given to the candidate along with the access to the terminal. The candidate has to do all the steps required to solve the problem given. The terminal Provided to the candidate is the communication link between the candidate and the allotted container.

We are using containers rather than VMs, because containers are small,light-weighted and fast, one application can be packed in each container image. The Kubernetes will manage the containerized applications such as database storage and user specific command across a set of containers or hosts and provides mechanisms for deployment, maintenance, and application-scaling. The container runtime packages, instantiates, and runs user commands on containerized application. The output generated will be stored in a temporary file which will be verified with the desired output stored in a database.

Keywords: DevOps, Orchestration, Containerization, Linux, Cloud computing, Parallel Computing, Networking

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Chapter 1

INTRODUCTION

1.1 Introduction

DevOps is a software development methodology that combines software development with information technology operations . The goal of it is to shorten the systems development phases while also delivering fixes, features, and updates frequently in close alignment .The DevOps approach is to include automation and event monitoring at all steps of the software development .The focus on the developer collaboration enables a new approach to managing the complexity of real world problems. I believe the operations complexity breaks down into a few categories: configuration management , infrastructure and deployment automation, log and performance management, and monitoring. Below are some tools we have used to help solve these tasks.

As part of Agile transformations as in the paper"Understanding DevOps & bridging the gap from continuous integration to continuous delivery" in past few years we have seen IT organizations adopting continuous integration principles in their softwares delivery lifecycle, which has improved the efficiency of development teams. With the time it has been realized that this optimization as part of continuous integration alone is just not sufficient to make the entire delivery lifecycle efficient or is not driving the organizations efficiency.

This project tries to cover all aspects of Devops applicable to various phases of SDLC and specifically talks about business need, ways to move from continuous integration to continuous delivery and its benefits. Explores the market opportunities for cloud computing in India. Cloud Computing is a new paradigm in information technology (IT) and IT-enable services(ITES) that transform computing as a resource to computing as a service. It is a disruptive technology with influence pervading across all aspect of a modern economy.

1.2 Motivation

Please mention type either industry sponsored, entrepreneur or internal project

1.3 Problem Definition

To develop a web based application to assess DevOps and Linux administration skills.

1.4 Technical Keywords (As per ACM Keywords)

1. 1. D. Software
   (a) D.2 SOFTWARE ENGINEERING
      i. D.2.6 Programming Environments
         A. Graphical environments
         B. Distributed applications
         C. Integrated environments
         D. Interactive environments
         E. Programmer workbench
         F. Security and reliability issues in distributed applications

Chapter 2

LITERATURE SURVEY

2.1 Literature Survey

Number of literatures pertaining techniques to DevOps and cloud computing published already and are available for public usage.As per Wotif Group used DevOps principles to recover from the downward spirals of manual release activities that many IT departments face. Its approach involved the concept of making it efficient to do the working thing By defining the right things (deployment standards) for developments and operations teams and making it easy to adopt, Wotif drastically and effectively improved the average release cycle time.Containerization is a lightweight virtualization solution.

The paper presented in conference 2017 Seventeenth International Conference on Advances in ICT, DevOps is extended from certain agile practices with a mix of patterns intended to improve collaboration between development and operation teams.

The main purpose of this paper is to conduct a study on how DevOps practice has impacted to software quality. The secondary objective is to find how to improve quality efficiently. Automation is the most critical factor to improve the software quality. As per the results of multiple regression analysis, it has proved culture, automation, measurement and sharing are important factors to consider to improve quality of the software.

In the paper presented in the International Conference on Software Engineering Companion DevOps result in a series of software engineering tactics aimed at shortening the actionable operation of software design changes.

In the paper presented in ”Euromicro Conference on Software Engineering and Advanced Applications” DevOps and continuous practices are attracting steadily growing attentions by both practitioners and researchers in the software engineering community. The terms are often used inconsistently, interchangeably and with unclearmeaning, however. By taking the positions that , this ambiguity and miscommunication renders the community great harm, their effects and interplay between them, reduce ambiguity.

GNU/Linux shell access through a web-browser for an embedded Linux e-learning system represents The internet is growing rapidly and has a more impact on the education sector than it had ever before. This paper aims at describing a novel way toextend the e-Learning techniques used to the area of embedded Linux education. For these techniques, Open Source Software technologies such as AJAX, PHP, Apache have been used in an innovative way to impart embedded Linux education just by use of normal web-browsers which makethe learning system as easy as checking a mail. In this paper, ways of enabling the embedded devices Linux shell access through a web-browser isexplained, which is a key feature of the system. This improves scalability and accessibility for multiple users.

The paper represented in Establish new concept to develop evaluation system of examination questions and examination result. This paper aims to establish a reasonable, objective, quantized evaluation standard of analyzing examination and score, and develop the evaluation index system of examination questions and examination result analyzing. A lot of reasonable and objective ideas such as examination difficulty, estimate score, objective difficulty and so on are risen and defined, and some related quantized calculation methods are given, and the examination result analyzing and examination principle software system which can make a quantized decision is programmed.

” Containerization and the PaaS Cloud ” focus on Containerization is a lightweight virtualization solution. Apart from exhibiting benefits over traditional virtual machines in the cloud, containers are especially relevant for PaaS clouds to manage and orchestrate applications through containers as an application packaging mechanism.

” Task Based Automatic Examination System for Sequenced Test ” represents Computer greatly influences our educational environment. Over the last few years, online automatic computer examination systems have been widely used for computer-based tests, but these systems are based on traditional question-answer examination style which is not fit for the sequenced test. The sequenced test should consider the context of the examinee.ex. the order of questions or the permissions of the examinee, to grade an examinee. This paper propose an effective and practical automatic examination architecturebased on task. The task is to abstract from the examination process and meet the requests of the sequenced test, such as order and dependency.

Our Project is having distributed environment. We are using DevOps Tools such as Kubernetes for generation of master and slave nodes. System will perform task of the evaluation of skills of the candidate.

Chapter 3

SOFTWARE REQUIREMENTS SPECIFICATIONS

3.1 Introduction

3.1.1 Project Scope

This application can be used to assess DevOps skills like configuration ,management etc.The project will demonstrate how containers can be efficiently scheduled and managed to assess Linux administration skills.This provides a user friendly web based platform for assessment.

3.1.2 User Classes and Characteristics

- **Company:**

  Registration : Enter company test details.

  CreateTest : Create test.

  SelectQuestions : Select questions depending on domain.

  GetResult : Get results of candidate.

  Monitor: Monitor candidate live environment test.

- **Admin**

  CreateTestScenario: Create test environment for candidates.

  Monitor : Monitor status of live containers.

  Evaluate : Evaluate and save results of candidates.

- **Candidate**

  Registration: Enter new users details.

Login: Find correct user and allow to login.

Apply :Apply for test.

Result : Get individual result.

3.1.3 Assumptions and Dependencies

- End user can use application from any browser with any operating system.
- Deployed server will be in Linux based operating system.
- Database will be in Redis.
- Application code developed in python .
- Containers deployed through Docker.
- Containers managed using Kubernetes.
- Web based terminal provided by Terminado using Tornado Sockets.

3.2 Functional Requirements

- The application is user friendly.
- It provides an easy interface to user.
- The accessibility or response time of the application should be fast and efficient.
- Performance of the system is appropriate.
- Container deployment should be memory efficient and time efficient.
- Load Balancer must make proper load balancing of requests.

3.3 External Interface Requirements

3.3.1 Company Interface

- Company Registration
- Company Login
- Create Test

- Select Questions
- Get Result

3.3.2 Test Interface

- Test Scenario creation
- Web terminal
- Questions
- Provide Output

3.3.3 User Interface

- User Login
- User Registration
- Apply for test
- Display result

3.3.4 Hardware Interface

Server

- 8 GB RAM
- Intel core i5 processor and above
- Cores 8 or more
- CPU 2.4 GHz or faster
- 80 GB HDD

Slave

- 2 GB RAM
- Intel core i3 processor and above
- Core 1 or more
- CPU 2.4 GHz or faster
- 120 GB HDD

3.3.5 Software Interface

Server

- Linux(ubuntu) Operating System
- YAML Language
- Python Script

Slave

- Linux(ubuntu) Operating System
- Python Script

3.3.6 Communication Interface

- Our Project belongs to web based, so connecting user at online with request and response.
- Since we need to provide terminal access through web based , we have used tornado socket to implement Terminado.
- tornado.websocket Bidirectional communication to the browser. WebSockets allow for bidirectional communication between the browser and server.

3.4 Non-Functional Requirements

3.4.1 Performance Requirements

- System can produce results faster on 16 GB of RAM.
- It may take more time for peak loads at master server.
- The system will be available 100% of the time. Once there is a fatal error, the system will provide understandable feed back to the user.

3.4.2 Safety Requirements

- Only administrators have access to the database of each individual user.
- Containers can be monitored only by system admin.
- Access of containers must be strictly based on users login.

3.4.3 Security Requirements

- For the security purposes and to avoid illegal use of the system, while using this application user must do following things:
  1. At the time of deploying this software user have to register to system.
  2. To use software user have to login and logout each time.
- Our System is being developed in Python . It is an object oriented programming language and shall be easy to maintain. The system is designed in modules where errors can be detected and fixed easily.

3.4.4 Software Quality Attributes

The system considers following non-functional requirements to provide better functionalities and usage of system.

- **Availability** : The system shall be available during 24 hours of a day.
- **Usability** : The system is designed keeping in mind the usability issues considering the end-users who are developers/programmers. It provides detailed help which would lead to better and faster learning. Navigation of system is easy.
- **Consistency** : Uniformity in layout, screens, Menus, colours scheme, format.
- **Performance** : The performance of the system should be fast and as per user requirement. From this system we will get expected outcome in less time and less space since efficiency is higher. Speed is totally depending on the response of the database and connection type.
- **Extendibility** : Prevention in the system should be done in the system by which we make changes in the system later on.
- **Reusability** : Files of any type can be used by the system for any number of times during transformation.
- **Reliability** : Protection of data from malicious attack or unauthorized access.
- **Security** : The system provides security to the randomly generated private key by performing security to it for users confidential data and thus protects from other nodes in the network. The network is free from malicious node and misbehaving node attacks.

3.5 System Requirements

3.5.1 Database Requirements

- **Redis :**
  Redis is an open source (BSD licensed), in-memory data structure store, used as a database, cache and message broker. It supports data structures such as strings, hashes, lists, sets, sorted sets with range queries, bitmaps, hyperloglogs and geospatial indexes with radius queries. Redis has built-in replication, Lua scripting, LRU eviction, transactions and different levels of on-disk persistence, and provides high availability via Redis Sentinel and automatic partitioning with Redis Cluster.

3.5.2 Software Requirements

- **Terminado :**
  This is a Tornado websocket backend for the Xterm.js Javascript terminal emulator library.
  It evolved out of pyxterm, which was part of GraphTerm (as lineterm.py), v0.57.0 (2014-07-18), and ultimately derived from the public-domain Ajaxterm code, v0.11 (2008-11-13) (also on Github as part of QWeb).
  Modules:

  – **terminado.management** : controls launching virtual terminals, connecting them to Tornado's event loop, and closing them down.

  – **terminado.websocket** : Provides a websocket handler for communicating with a terminal.

  – **terminado.uimodule** : Provides a Terminal Tornado UI Module.

  JS: terminado/_static/terminado.js: A lightweight wrapper to set up a term.js terminal with a websocket.

- **Docker :**
  Docker is a platform for developers and sysadmins to develop, deploy, and run applications with containers. The use of Linux containers to deploy applications is called containerization. Containers are not new, but their use for easily deploying applications is.
  Containerization is increasingly popular because containers are:

  – **Flexible:** Even the most complex applications can be containerized.

  - **Lightweight:** Containers leverage and share the host kernel.
  - **Interchangeable:** You can deploy updates and upgrades on-the-fly.
  - **Portable:** You can build locally, deploy to the cloud, and run anywhere.
  - **Scalable:** You can increase and automatically distribute container replicas.
  - **Stackable:** You can stack services vertically and on-the-fly.

- **Kubernetes :**
  Kubernetes is an open source system for managing containerized applications across multiple hosts, providing basic mechanisms for deployment, maintenance, and scaling of applications.
  The open source project is hosted by the Cloud Native Computing Foundation
  - **Planet Scale :** Designed on the same principles that allows Google to run billions of containers a week, Kubernetes can scale without increasing your ops team.
  - **Never Outgrow :** Whether testing locally or running a global enterprise, Kubernetes flexibility grows with you to deliver your applications consistently and easily no matter how complex your need is.
  - **Run Anywhere :** Kubernetes is open source giving you the freedom to take advantage of on-premises, hybrid, or public cloud infrastructure, letting you effortlessly move workloads to where it matters to you.

- **Python :**
  A high-level taken programing language for all-purpose programming. Pythons design philosophy emphasizes code readability, especially when using large amounts of white space. It provides a structure that allows for clear programming on a small scale and on a large scale.
  Python contains a dynamic sort system and automatic memory management. It supports a variety of programming paradigms, including object-oriented, imperative, functional, and procedural, and has a large and complete standard library.
  The Python interpreter can be used with many operating systems.Python can be used as a scripting language for web applications, for example,for Apache web servers. Through the web server gateway interface, standard APIs have evolved to facilitate these applications.

- **Django :**
  Django is a high-level Python Web framework that encourages rapid develop-

ment and clean, pragmatic design. Built by experienced developers, it takes care of much of the hassle of Web development, so you can focus on writing your app without needing to reinvent the wheel. Its free and open source.

- **Ridiculously fast :**Django was designed to help developers take applications from concept to completion as quickly as possible.
- **Reassuringly secure :**Django takes security seriously and helps developers avoid many common security mistakes.
- **Exceedingly scalable :**Some of the busiest sites on the Web leverage Djangos ability to quickly and flexibly scale.

3.5.3 Hardware Requirements

Server

- 8 GB RAM
- Intel core i5 processor and above
- Cores 8 or more
- CPU 2.4 GHz or faster
- 80 GB HDD

Slave

- 2 GB RAM
- Intel core i3 processor and above
- Core 1 or more
- CPU 2.4 GHz or faster
- 120 GB HDD

3.6 Analysis Model

We are using Agile methodology to implement our project. AGILE methodology is a practice that promotes continuous iteration of development and testing throughout the software development lifecycle of the project. Both development and testing activities are concurrent unlike the Waterfall model.

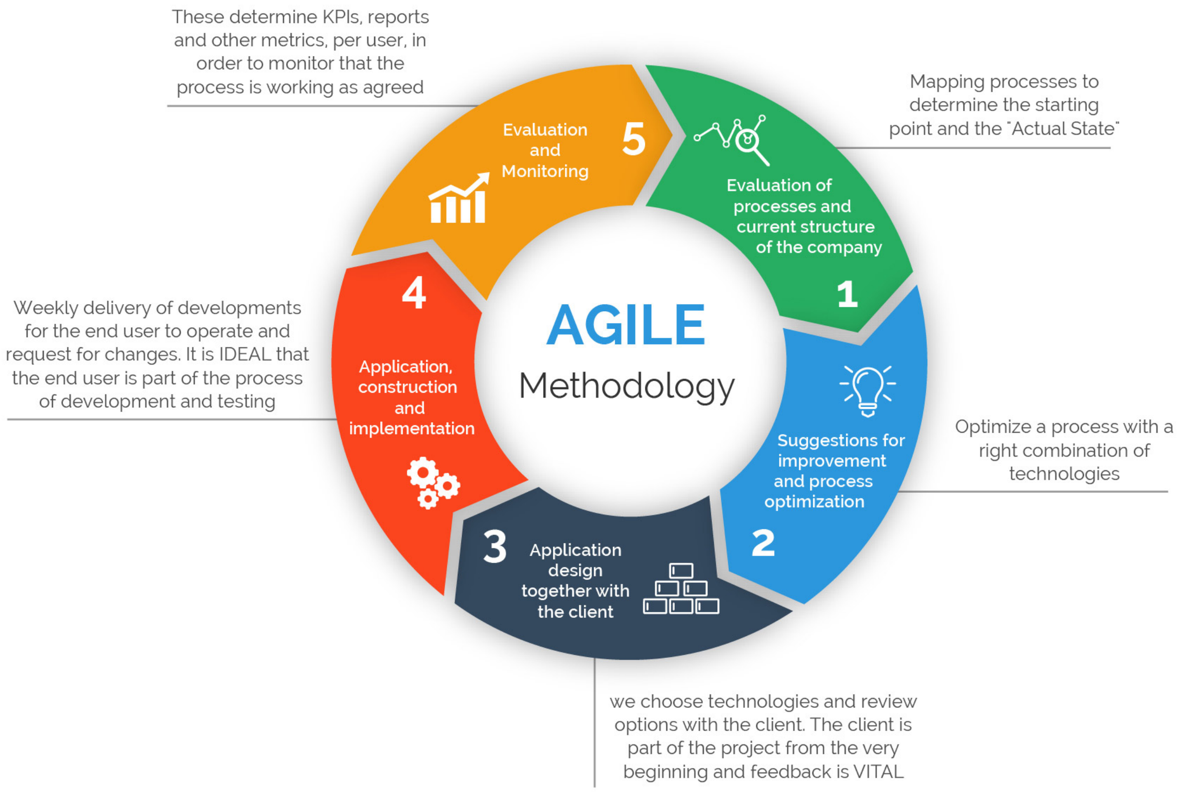
These determine KPIs, reports and other metrics, per user, in order to monitor that the process is working as agreed
Mapping processes to determine the starting point and the "Actual State"
Evaluation and Monitoring
5
Evaluation of processes and current structure of the company
1
AGILE
Methodology
4
Application, construction and implementation
Weekly delivery of developments for the end user to operate and request for changes. It is IDEAL that the end user is part of the process of development and testing
Suggestions for improvement and process optimization
2
Optimize a process with a right combination of technologies
3
Application design together with the client
we choose technologies and review options with the client. The client is part of the project from the very beginning and feedback is VITAL

Figure 3.1: Agile methodology

- **Scope out and prioritize projects :**
  During the first step of the agile software development life cycle, the team scopes out and prioritizes projects. Some teams may work on more than one project at the same time depending on the departments organization.

- **Diagram requirements for the initial sprint :**
  Once you have identified the project, work with stakeholders to determine requirements. You might want to use user flow diagrams or high-level UML diagrams to demonstrate how the new feature should function and how it will fit into your existing system.

- **Construction/iteration :**
  Once a team has defined requirements for the initial sprint based on stakeholder feedback and requirements, the work begins. UX designers and developers begin work on their first iteration of the project, with the goal of having a working product to launch at the end of the sprint. Remember, the product will undergo various rounds of revisions, so this first iteration might only include the bare minimum functionality. The team can and will have additional sprints to expand upon the overall product.

- **Release the iteration into production :**
  Test the system.
  Your quality assurance (QA) team should test functionality, detect bugs, and record wins and losses.
  Address any defects.
  Finalize system and user documentation.

- **Production and ongoing support for the software release :**
  This phase involves ongoing support for the software release. In other words, your team should keep the system running smoothly and show users how to use it. The production phase ends when support has ended or when the release is planned for retirement.

- **Retirement**
  During the retirement phase, you remove the system release from production, typically when you want to replace a system with a new release or when the system becomes redundant, obsolete, or contrary to your business model.

3.7 System Implementation Plan

- **PERT Chart/Grant chart :**

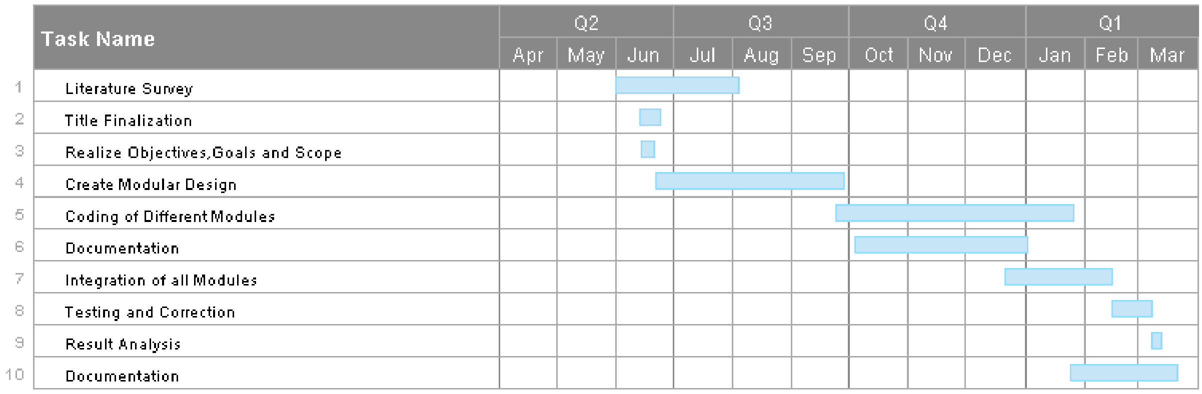

Figure 3.2: Plan

- **Project Estimate :**
  Estimating is figuring out how much time and money is required for completion. Usually developer will not really know the requirement. Usually management will have a number in mind when they ask for your estimate.

- **Cost Estimation :**
  As we need to deploy application on cloud ,cost for cloud services is incurred.

- **Time of Project :**
  The time required for the project is 15 months.

Chapter 4

System Design

4.1 System Architecture

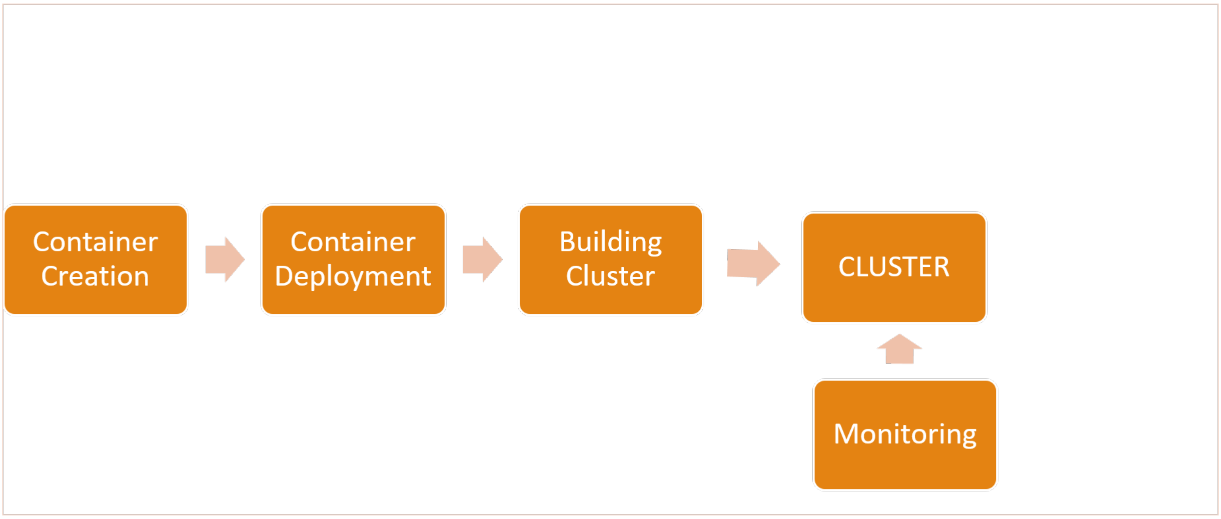

Figure 4.1: System Architecture

4.2 Mathematical Model

Let S = {U, N, T, S, status, result, F}
Where,

- U = { u1, u2, u3, .., ui.} Finite set of users (Candidates).
- N = { Master, Slave }
  Where,
  Master = Kubernetes master node.
  Slave = Kubernetes worker node.

- Slave = { slave1, slave2, ., slavei }
- T = { t1, t2, t3, ., ti } Finite set of test Scenarios.
- S = { s1, s2, s3, ., si } Finite set of scores of a user.
- status = { status1, status2, .., satatusi } Test status.
- Functionalities:
  Yes/No = authenticate (uname, passwd)
  Interface Candidate Web Brower (Wi)
  Si = get test Scenario Score(ti)

  Rank = apply ranking algorithm (ti, si)
  Result = generate test result.

4.3 Data Flow Diagram

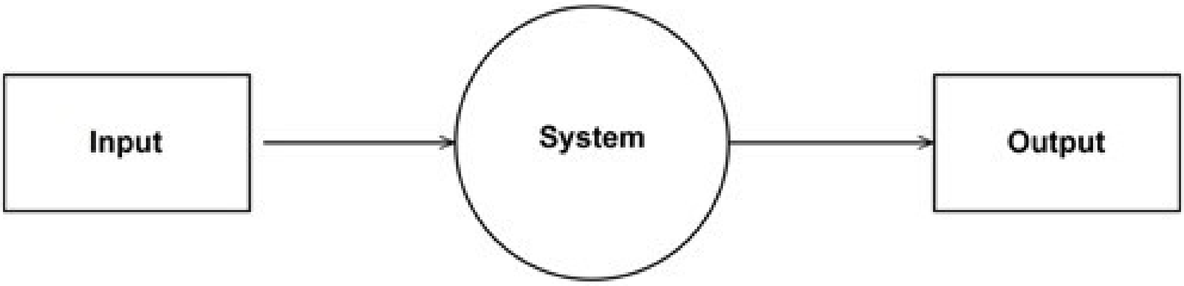

Figure 4.2: DFD Level 0

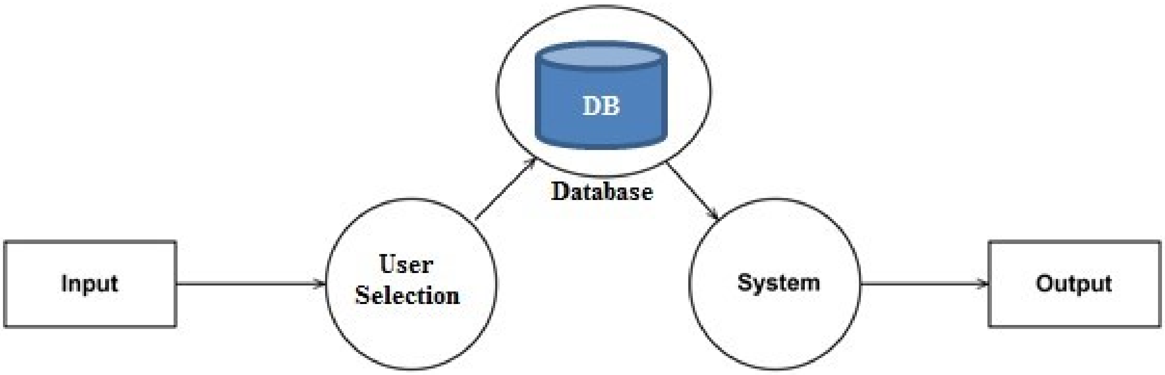

Figure 4.3: DFD Level 1

4.4 UML Diagram

4.4.1 Use Case Diagram

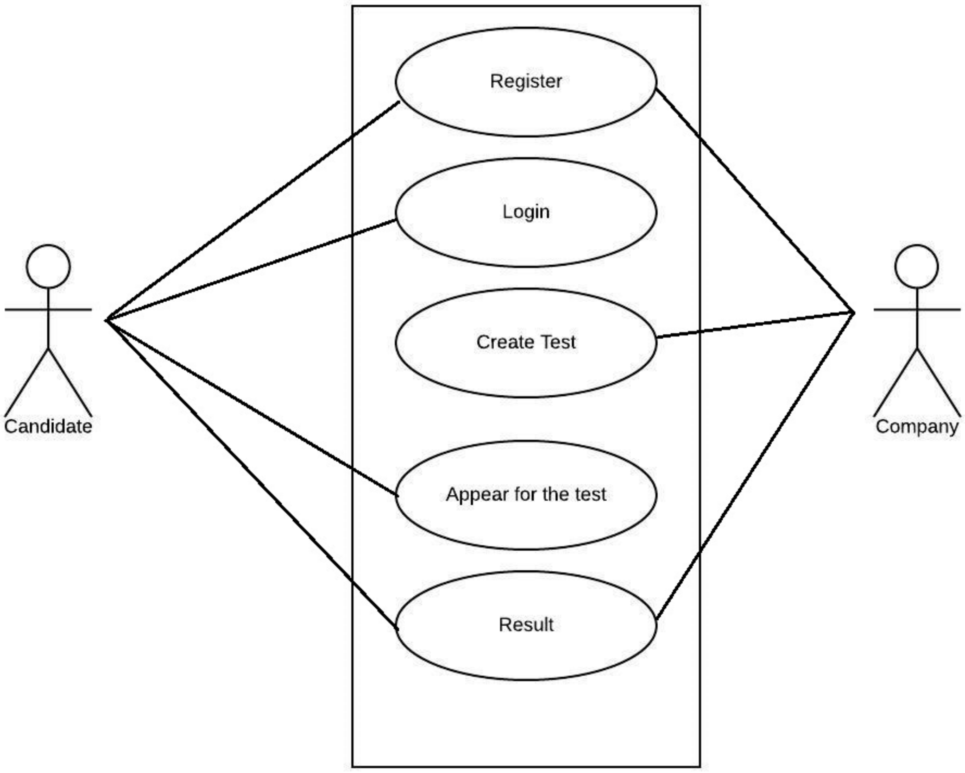

Figure 4.4: Use Case Diagram

4.4.2 Class Diagram

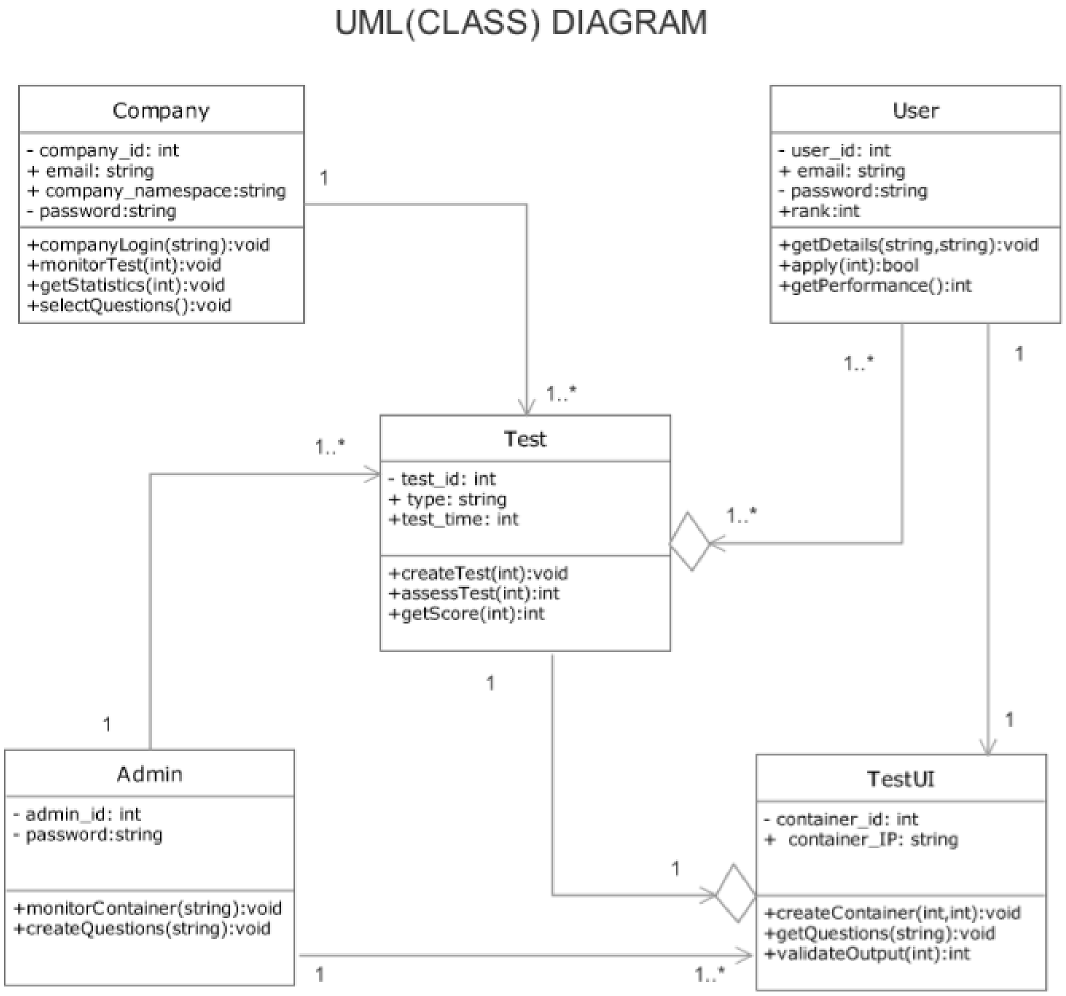

Figure 4.5: Class Diagram

4.4.3 Object Diagram

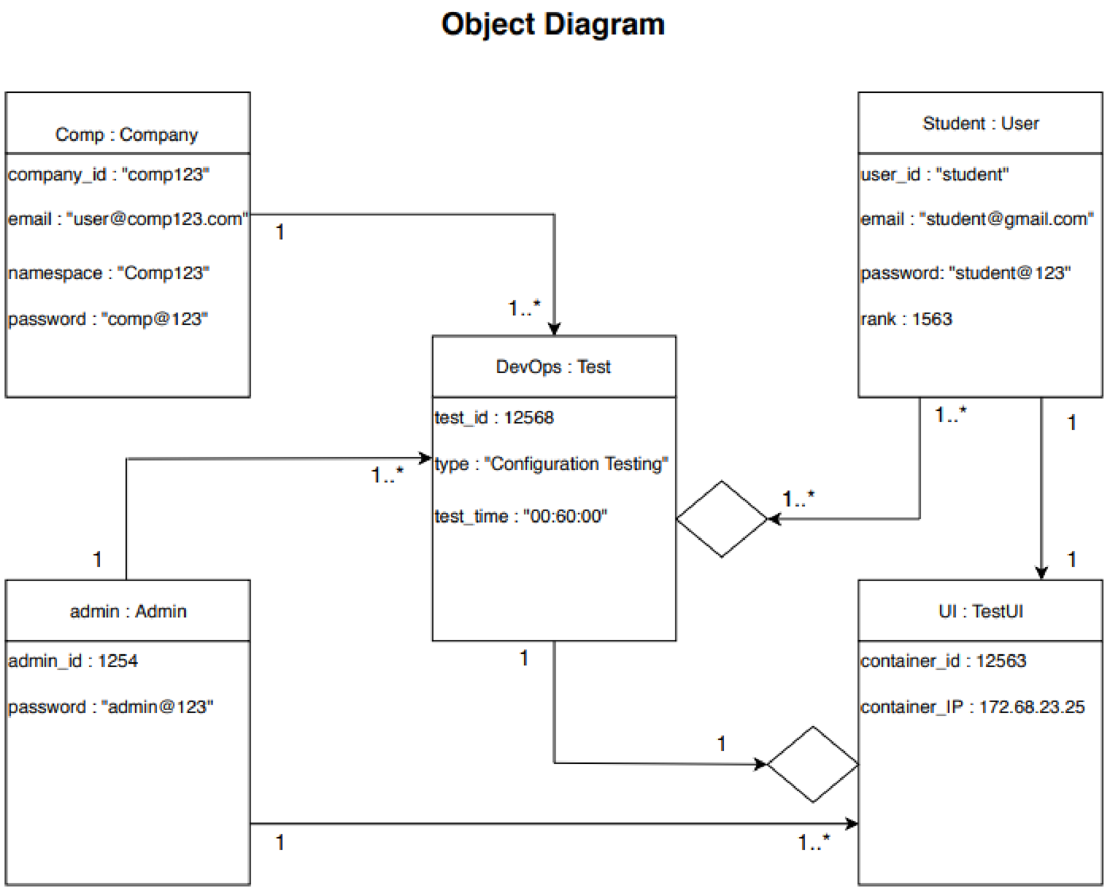

Figure 4.6: Object Diagram

4.4.4 Deployment Diagram

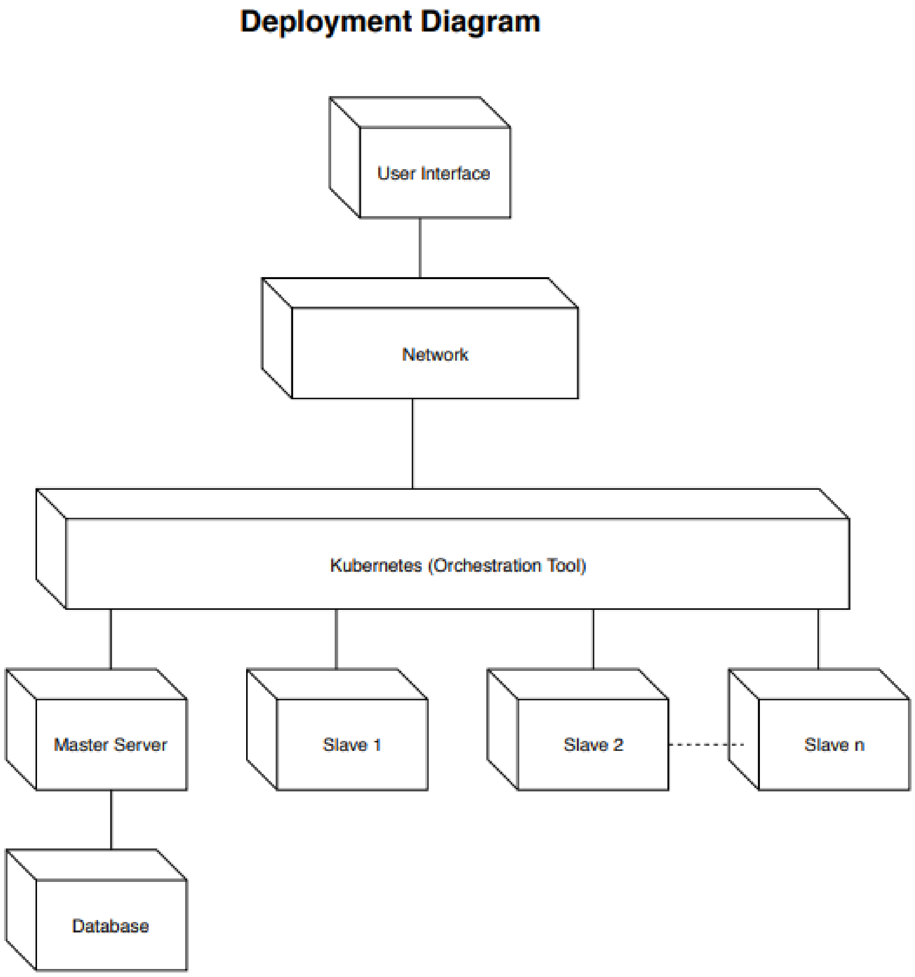

Figure 4.7: Deployment Diagram

4.4.5 Component Diagram

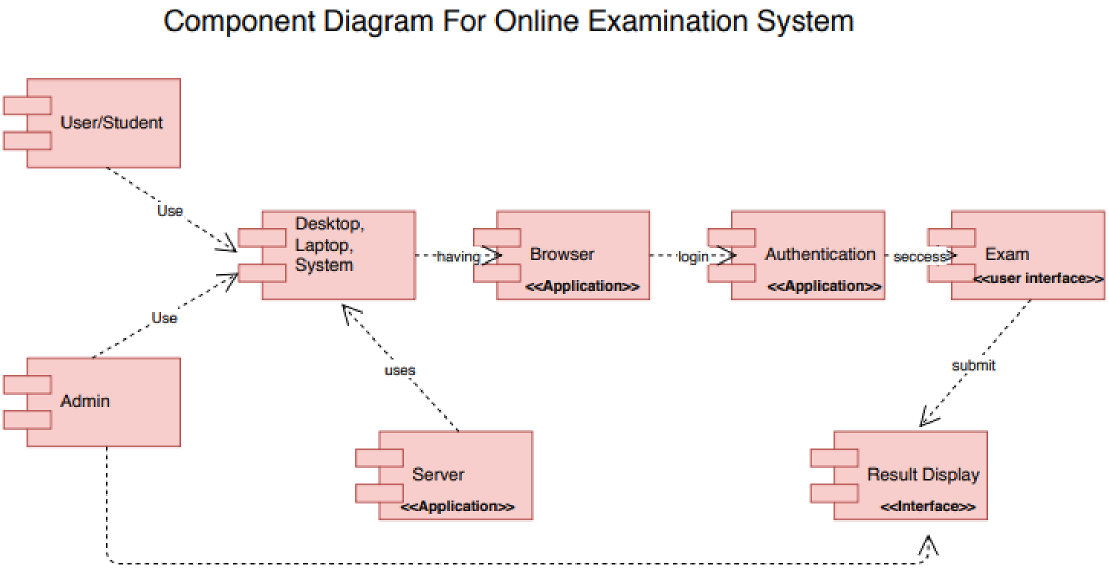

Figure 4.8: Component Diagram

4.4.6 Communication Diagram

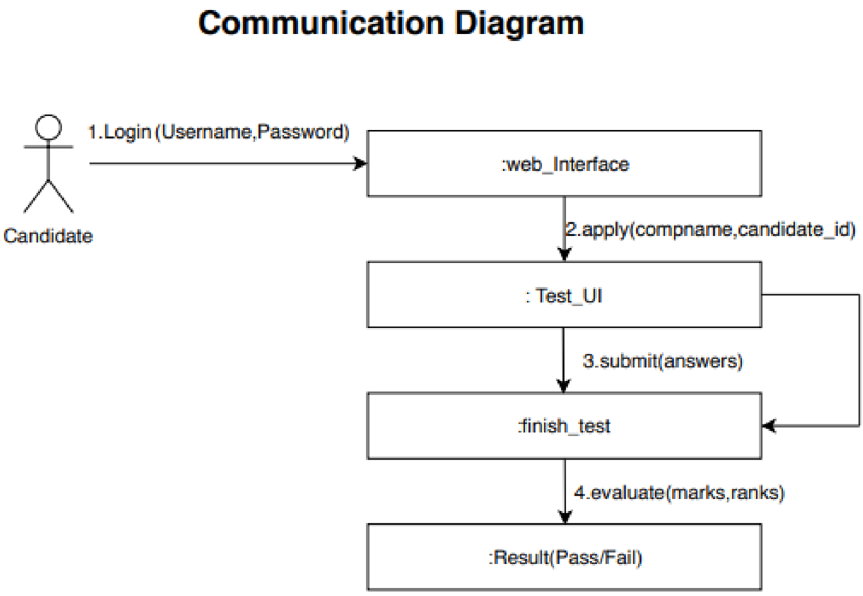

Figure 4.9: Communication Diagram

4.4.7 Sequence Diagram

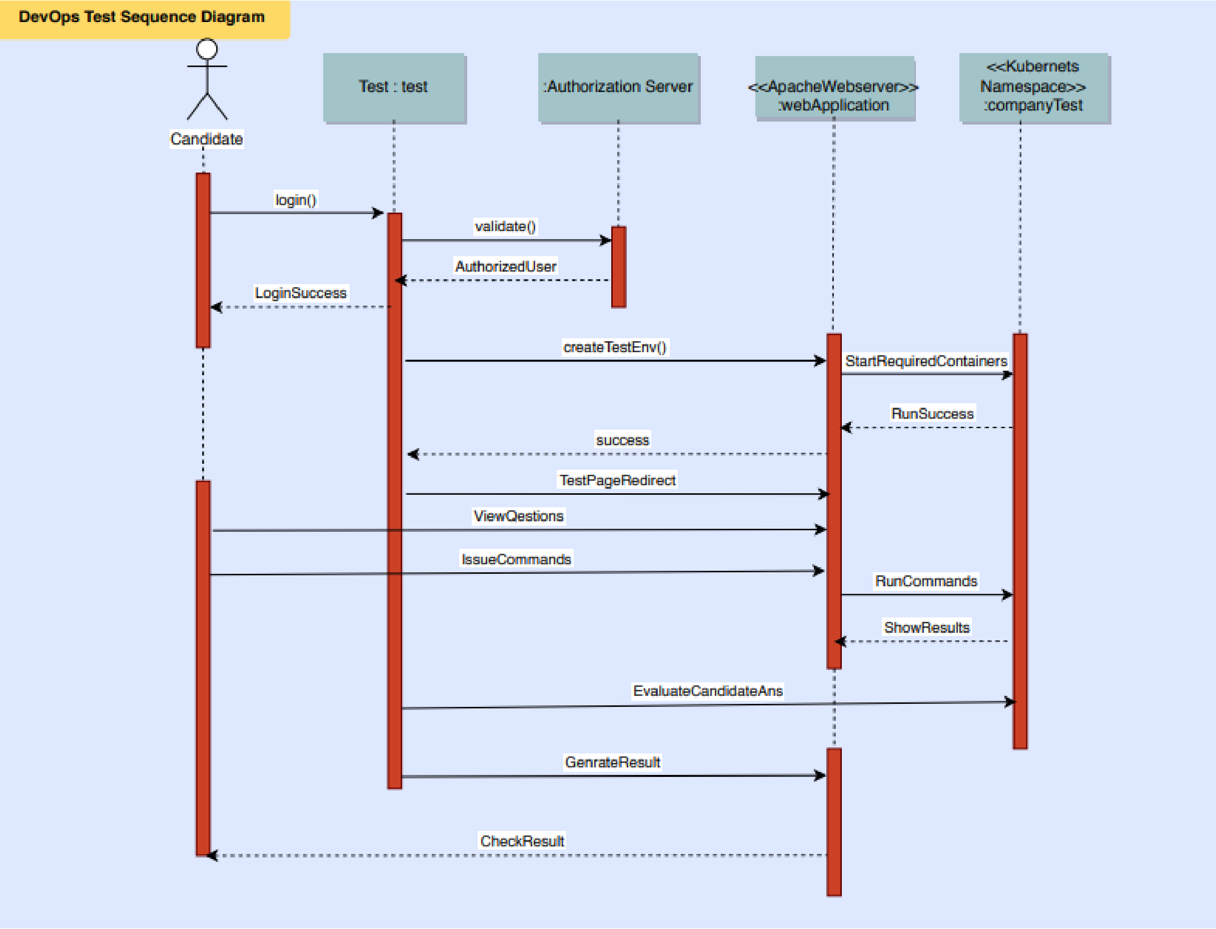

Figure 4.10: Sequence Diagram

4.4.8 State Diagram

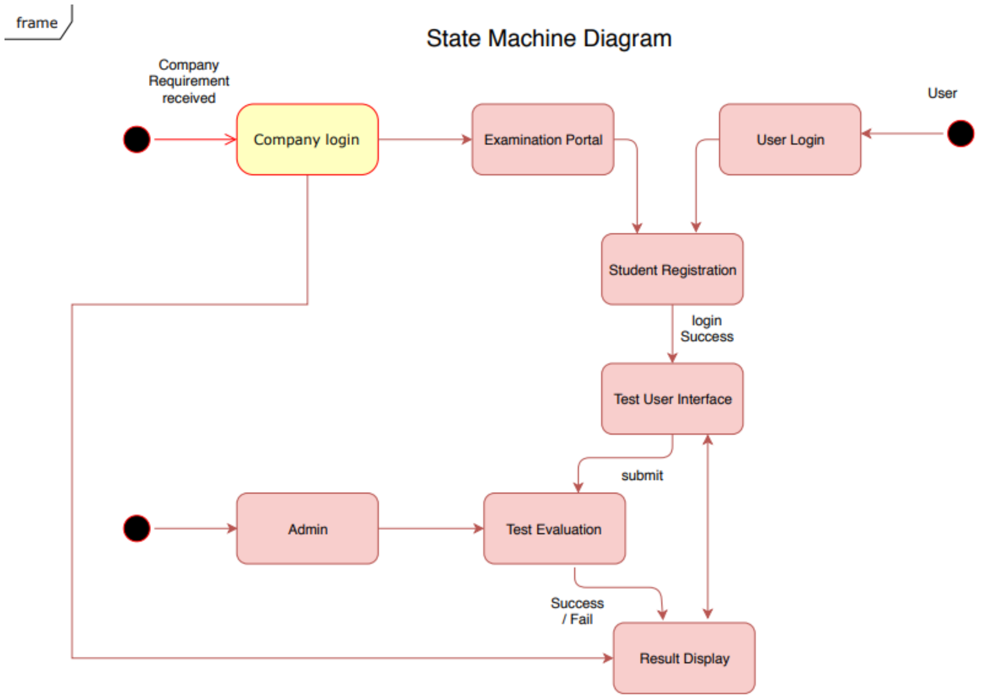

Figure 4.11: State Diagram

Chapter 5

OTHERS SPECIFICATIONS

5.1 Advantages

- User friendly.
- Unlimited storage.
- Easy to use.
- Time saving.
- Highly Scalable
- Continous Availability
- Low Cost

5.2 Limitations

- Outsourcing a DevOps infrastructure requires a specific level of software development expertise, including an in-depth understanding of integration, infrastructure, and orchestrating workflow. You need the experts along with the tools for DevOps as a Service to succeed.
- Can you really clone a production environment in the cloud? Cloning an enterprise infrastructure for test purposes is complex and can lead to unforeseen compatibility problems. Of course, if our objective is to create a production environment, we cant use the cloud to clone something our dont have.
- Security is always a concern. The security team is usually not part of DevOps, and the DevOps team tends to choose speed over security when developing

software. Using cloud services can create unnecessary risks and exposure, especially since its the transport layer that is usually left unsecured; cyber criminals tend to use the transport layer for spoofing and man in the middle attack.

- Lack of domain knowledge. This could be a problem if serious integration work will be involved in automation projects.
- Pushing their favorite products and processes, which might not fit very well with customers env. This could be avoided if customer has knowledgeable leadership.
- More lasting dependency than you plan. DevOps driven automation projects are normally complex. If customer has incompetent team or not team, they will end up with consulting company for continued support.

5.3 Applications

Asessment of

- Linux Skills
- DevOps Skills
- Configuration Testing

Chapter 6

CONCLUSION

A cloud-based devOps skill assessment tool, which integrates containers and their orchestration , will be developed for the assessment of linux skills and configurations skill along with DevOps skills. This project presents computational issues of accessing terminal through web.

Companies that incorporate the DevOps operations to get more done, plain and simple. With a single team composed of cross-functional members all working in collaboration, DevOps systems can deliver the maximum speed, functionality, and innovation.Companies that uses this application will be easily able to create test depending on their specific requirements. This test scenarios will help company to easily evaluate candidate knowledge and thus they can find a right candidate for the desired post.

Chapter 7

References

[1] Cloud Computing Innovation in India: A Framework and Roadmap - White Paper 2.0, in Cloud Computing Innovation in India: A Framework and Roadmap - White Paper 2.0

[2] Understanding DevOps & bridging the gap from continuous integration to continuous delivery, Fifth International Conference on the Innovative Computing Technology (INTECH 2015), Pontevedra, 2015

[3] DevOps: Introducing Infrastructure-as-Code, 2017 IEEE/ACM 39th International Conference on Software Engineering Companion (ICSEC), Buenos Aires, 2017

[4] Improve software quality through practicing DevOps, 2017 Seventeenth International Conference on Advances in ICT for Emerging Regions (ICTer), Colombo, 2017

[5] Improve software quality through practicing DevOps, 2017 Seventeenth International Conference on Advances in ICT for Emerging Regions (ICTer), Colombo, 2017

[6] Continuous practices and devops: beyond the buzz, what does it all mean?, 2017 43rd Euromicro Conference on Software Engineering and Advanced Applications (SEAA), Vienna, 2017

[7] GNU/Linux shell access through a web-browser for an embedded Linux e-learning system, 2011 3rd International Conference on Electronics Computer Technology, Kanyakumari, 2011

[8] Establish new concept to develop evaluation system of examination questions and examination result, 2011 2nd International Conference on Artificial Intelli-

gence, Management Science and Electronic Commerce (AIMSEC), Dengleng, 2011

[9] Task Based Automatic Examination System for Sequenced Test, 2009 International Conference on Electronic Computer Technology, Macau, 2009

[10] Containerization and the PaaS Cloud, in IEEE Cloud Computing, vol. 2, no. 3, pp. 24-31, May-June 2015.