



# INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

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## Lab-As-A-Service

*Computation On-demand*

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**Abstract:** The proliferation of cloud computing and web-based technologies have made it possible for universities to expand their academic networks reaching a wider range of students. In an effort to expand offered services while reducing costs, universities began exploring the use of distributed software platforms and middleware infrastructures to make laboratories accessible over the Internet. Through this framework, which we call Lab-as-a-Service (LaaS), students can remotely execute labs designed by instructors. LaaS incorporates a middleware approach in which it can be used universally across a wide range of experimentation types. Seamless experience of software development and learning can be made easy. The LaaS Framework enables students to engage more actively in courses that need hands-on components. Throughout this paper, we have demonstrated at a small scale how the LaaS framework can be used to transform a traditional learning experience to a remote learning experience that can complement existing MOOCs. This helps to promote courses that require lab facilities to also be incorporated to the online learning environment. For future work, we plan to extend the LaaS framework to take into consideration scalability and complexity of more sophisticated lab equipment that are required for courses in engineering, science, among others.

**Index Terms – Cloud computing, virtual Machines, Kubernetes, Docker, LAAS.**

### I. INTRODUCTION

Virtual Labs will provide to the students the platform to perform assignments and do code in a required environment provided by an instructor. Modeling the required environment on the virtual machine and providing the access of these virtual machine to students so that they can perform assignments. This can, at-the-best, provide an approximate version of the 'real-world' computer environment. Remotely triggering a virtual machine with environment in an actual lab and providing the student the result of the experiment through the computer interface. This would entail carrying out the actual lab experiment remotely. Physical distances and the lack of resources make us unable to perform experiments, especially when they involve sophisticated instruments. Also, good teachers are always a scarce resource. Web-based and video-based courses address the issue of teaching to some extent. Conducting joint experiments by two participating institutions and also sharing costly resources has always been a challenge. With the present-day internet and computer technologies the above limitations can no more hamper students and researchers in enhancing their skills and knowledge. Also, in a country such as ours, costly instruments and equipment need to be shared with fellow researchers to the extent possible. Web enabled experiments can be designed for remote operation and viewing so as to enthruse the curiosity and innovation into students. This would help in learning basic and advanced concepts through remote experimentation. Today most equipment has a computer interface for control and data storage. It is possible to design good experiments around some of this equipment which would enhance the learning of a student. Internet-based experimentation further permits use of resources – knowledge, software, and data available on the web, apart from encouraging skillful experiments being simultaneously performed at points separated in space (and possibly, time). To provide remote-access to Labs in various disciplines of Science and Engineering. These Virtual Labs would cater to students at the undergraduate level, post graduate level as well as to research scholars. To provide a complete Learning Management System around the Virtual Labs where the students can avail the various tools Virtual Labs will be made more effective and realistic by providing additional inputs to the students like accompanying audio and video streaming of an actual lab experiment and equipment. For the 'touch and feel' part, the students can possibly visit an actual laboratory for a short duration. To develop a Lab as Service solution that enhances the learning and assessment experience of learners remotely.

## II. OBJECTIVES

- Accessibility: IaaS aims to provide developers with convenient and on demand access to virtualized software development environments from anywhere and at any time.
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- Collaboration and Teamwork: IaaS promotes collaboration and teamwork among developers by providing shared development environments. Multiple developers or teams can access the same development environment simultaneously, enabling seamless collaboration, code sharing, and real-time communication
- Cost Optimization: IaaS helps organizations optimize their software development costs.

## III. LITERATURE SURVEY

### A. Internet-Accessible Laboratories

**Author:** Eyhab Al-Masri

**Abstract:** The proliferation of cloud computing and web-based technologies have made it possible for universities to expand their academic networks reaching a wider range of students. In an effort to expand offered services while reducing costs, universities began exploring the use of distributed software platforms and middleware infrastructures to make laboratories accessible over the Internet.

### B. A Component-Based Evolution Model for Service Based Software Architectures

**Author:** Eduardo BerrioCharry, Jeisson Vergara-Vargas and Henry Umaña-Acosta

**Abstract:** Microservices architecture has emerged as an architectural style which focuses on the design and development of software systems as a set of small independent services. Although MSA is inspired by the Service-Oriented Architecture style (both are service-based architectures), it presents important differences

### C. E-Learning System Model for University Education

**Author:** Ayman R. Mohammed, Sally S. Kassem

**Abstract:** High quality education should be the top priority for any nation seeking prosperity. This paper aims to present a conceptual model for an eLearning system for developing countries. This is achieved by adopting an object-oriented approach and Unified Modeling Language (UML). The functional and dynamic views of the system are presented and explained within this framework

### D. Container-Based Lab-as-a-Service Application

**Author:** M. Sanjay Babu, K Sabari Priya, S Padmavati

**Abstract:** Lab setup with diverse requirements restricts the users to depend on the lab facility. In order to allow the users to access the lab environment beyond the working hours and eliminate the dependency on a particular lab facility, number of solutions leveraging virtualization and cloud services have been provided in the past. However, these approaches have few drawbacks. The virtual images are quite heavy. Though portable, it takes quite some time to configure the virtual images. Similarly, cloud-based solutions may not be affordable for every institution and given the scale of usage, the cloud services may be expensive.

### E. Kubernetes-Oriented Microservice Placement with Dynamic Resource Allocation

**Author:** Zhijun Ding Song Wang Changjun Jiang

**Abstract:** Microservices and Kubernetes are widely used in the development and operations of cloud-native applications. By providing automated placement and scaling, Kubernetes has become the main tool for managing microservices. However, existing work and Kubernetes fail to consider the dynamic competition and availability of microservices as well as the problem of shared dependency libraries among multiple microservice instances

### F. Application deployment on the SaaS platform

**Author:** Hong He

**Abstract:** SaaS (Software as a Service) is a kind of application services which is provided via Internet, and customers can order and receive their peculiar types of software application services from the SaaS provider via the Internet according to their actual needs. This paper analysis current development of SaaS, by means of comparing SaaS model with traditional software model, a new engineering method is illustrated. Besides, this paper assays the architecture of SaaS-based software application, what's more, the approach of data separates and the implementation of UI is present. The instance of service outsourcing public technical platform at Weihai illustrates design of SaaS architecture.

## IV. MODULES

### 1) Authentication Module

An authentication (auth) module is a software component that handles the process of identifying and verifying the identity of a user or entity attempting to access a system or application. The primary purpose of an auth module is to ensure that only authorized users or entities can access the system or application, while preventing unauthorized access. An auth module typically consists of a set of APIs and functions that implement various authentication mechanisms, such as passwords, biometrics, multi-factor authentication, etc. The module may also include features such as session management, token validation, and access control. Auth modules are commonly used in web applications, operating systems, and network services to protect against unauthorized access. They are an essential component of security systems, and their effectiveness is critical to maintaining the security of the system.

### 2) Student Module

An authentication (auth) module is a software component that handles the process of identifying and verifying the identity of a user or entity attempting to access a system or application. The primary purpose of an auth module is to ensure that only authorized users or entities can access the system or application, while preventing unauthorized access. An auth module typically consists of a set of APIs and functions that implement various authentication mechanisms, such as passwords, biometrics, multi-factor authentication, etc. The module may also include features such as session management, token validation, and access control. Auth modules are commonly used in web applications, operating systems, and network services to protect against unauthorized access. They are an essential component of security systems, and their effectiveness is critical to maintaining the security of the system.

### 3) Instruction Module

An instructor module is a software component or tool used in educational technology that facilitates the creation and delivery of online learning materials and assessments by instructors or educators. The primary purpose of an instructor module is to provide a platform for instructors to manage and deliver online courses, including creating and organizing course content, managing student enrollment, tracking student progress, and providing feedback and support to students. Instructor modules typically include features such as course creation tools, a learning management system (LMS), communication tools for instructors and students, and assessment tools for quizzes, exams, and assignments. In addition to providing a platform for course management, instructor modules may also include analytics and reporting tools that enable instructors to track student engagement and performance, identify areas of improvement, and adapt their teaching strategies accordingly. Overall, the use of instructor modules in educational technology has revolutionized the way educators create and deliver online courses, providing a more efficient and effective way to manage and deliver learning experiences to students. An instructor module is a software component or tool used in educational technology that facilitates the creation and delivery of online learning materials and assessments by instructors or educators. The primary purpose of an instructor module is to provide a platform for instructors to manage and deliver online courses, including creating and organizing course content, managing student enrollment, tracking student progress, and providing feedback and support to students. Instructor modules typically include features such as course creation tools, a learning management system (LMS), communication tools for instructors and students, and assessment tools for quizzes, exams, and assignments. In addition to providing a platform for course management, instructor modules may also include analytics and reporting tools that enable instructors to track student engagement and performance, identify areas of improvement, and adapt their teaching strategies accordingly. Overall, the use of instructor modules in educational technology has revolutionized the way educators create and deliver online courses, providing a more efficient and effective way to manage and deliver learning experiences to students.

### 4) Main Module

An admin module is a software component or tool used in educational technology that provides a platform for administrators or system managers to manage and monitor online learning systems and resources. The primary purpose of an admin module is to provide administrators with the ability to manage system settings, user accounts, permissions, and roles. This may include features such as user authentication and authorization, access control, and user account management. Admin modules may also include tools for managing and organizing course materials, such as creating course catalogs, assigning instructors to courses, and managing student enrollment. They may also include features for generating reports and analytics on student engagement, performance, and outcomes. In addition to managing learning systems and resources, admin modules may also include tools for managing administrative tasks, such as managing budgets, allocating resources, and handling technical support issues. Overall, the use of admin modules in educational technology has improved the efficiency and effectiveness of managing online learning systems and resources, providing administrators with the tools they need to ensure that these systems operate effectively and efficiently.

## V. Project resources

### FRONTEND

Technologies Used:

- 1) Angular 14
- 2) Rxjs
- 3) NGRX (State Management)
- 4) Bootstrap 5.2 (CSS Framework)
- 5) ACE Editor
- 6) CKEditor

### BACKEND

- 1) Node 18
- 2) Docker
- 3) Docker-Compose
- 4) Docker Swarm
- 5) Express.js
- 6) NGINX (Load Balancer)
- 7) Socket.io
- 8) MongoDB (NoSQL Database)

### Deployment

Infrastructure:

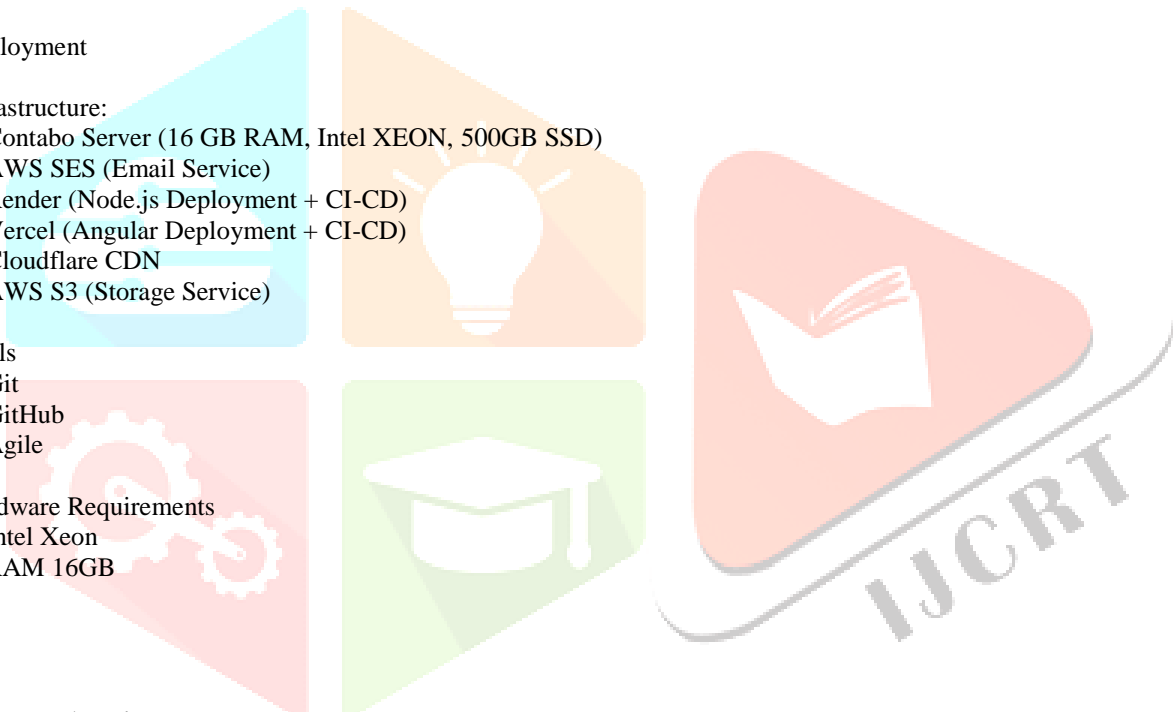
- 1) Contabo Server (16 GB RAM, Intel XEON, 500GB SSD)
- 2) AWS SES (Email Service)
- 3) Render (Node.js Deployment + CI-CD)
- 4) Vercel (Angular Deployment + CI-CD)
- 5) Cloudflare CDN
- 6) AWS S3 (Storage Service)

Tools

- 1) Git
- 2) GitHub
- 3) Agile

Hardware Requirements

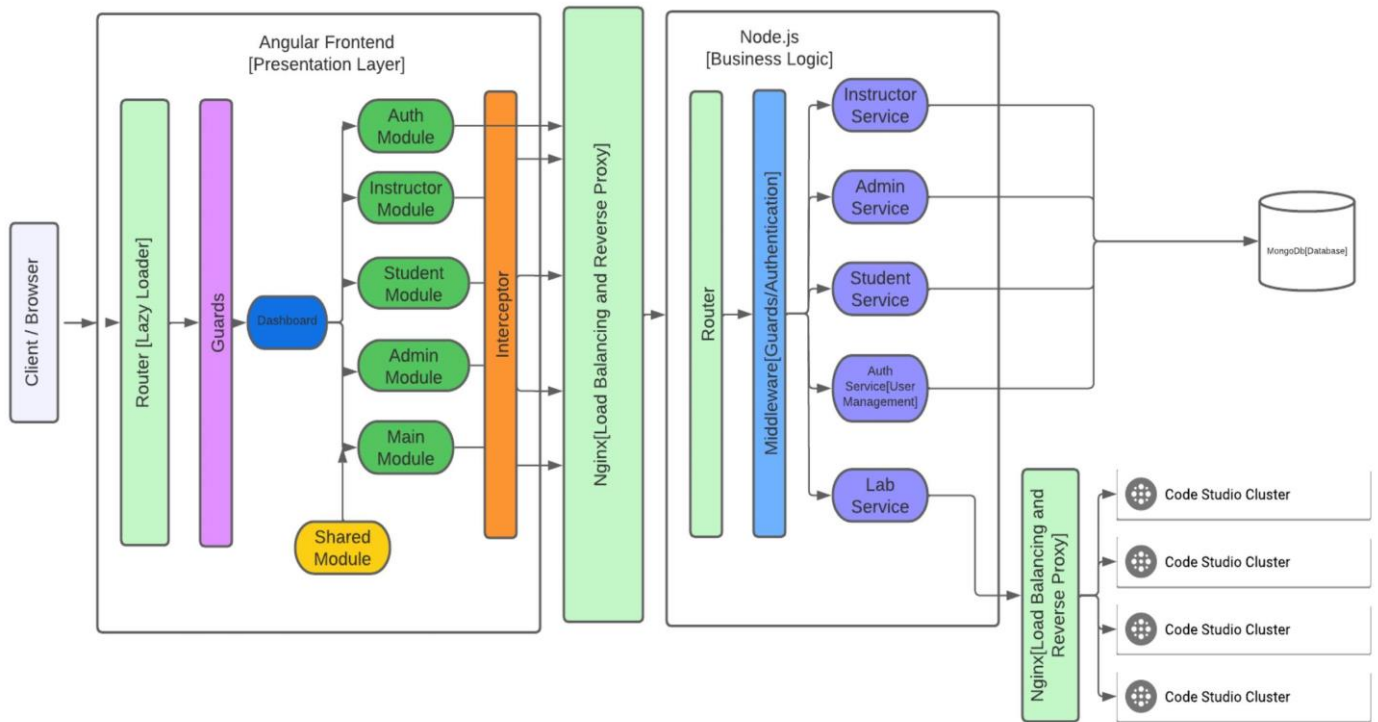
- 1) Intel Xeon
- 2) RAM 16GB



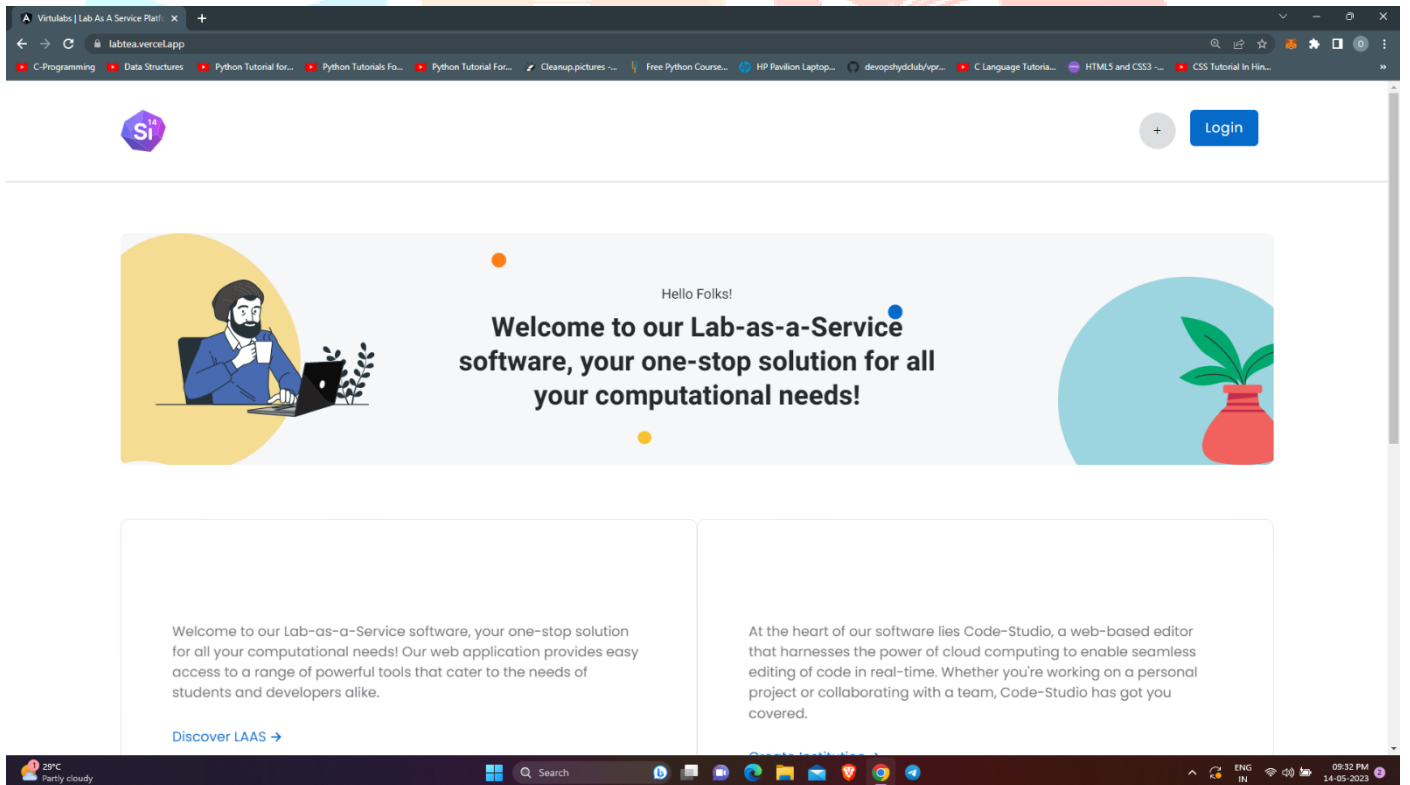
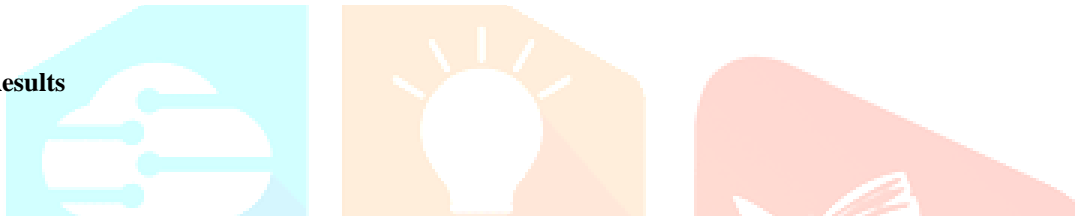
## VI. System Architecture

The architecture diagram consists of the following components:

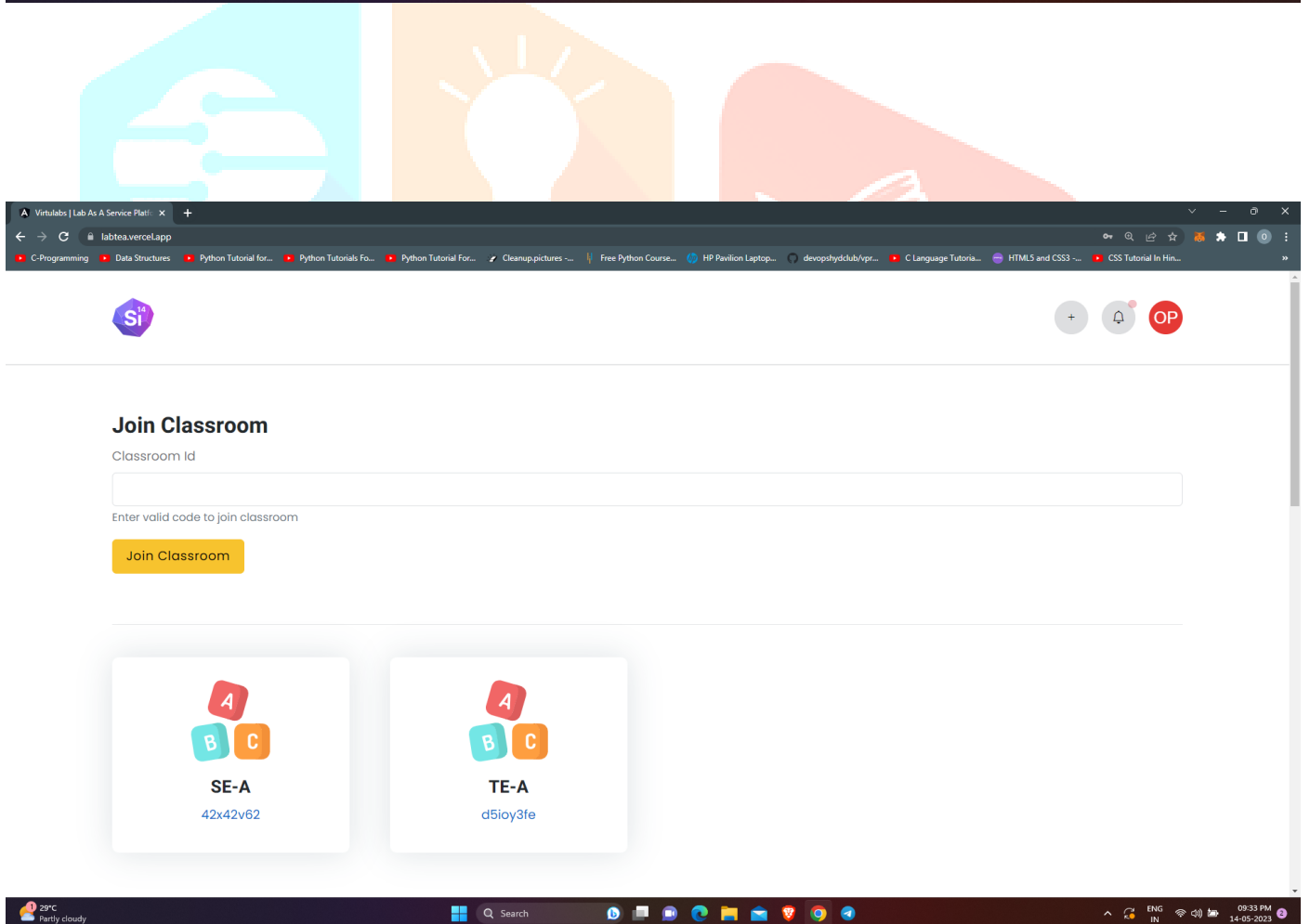
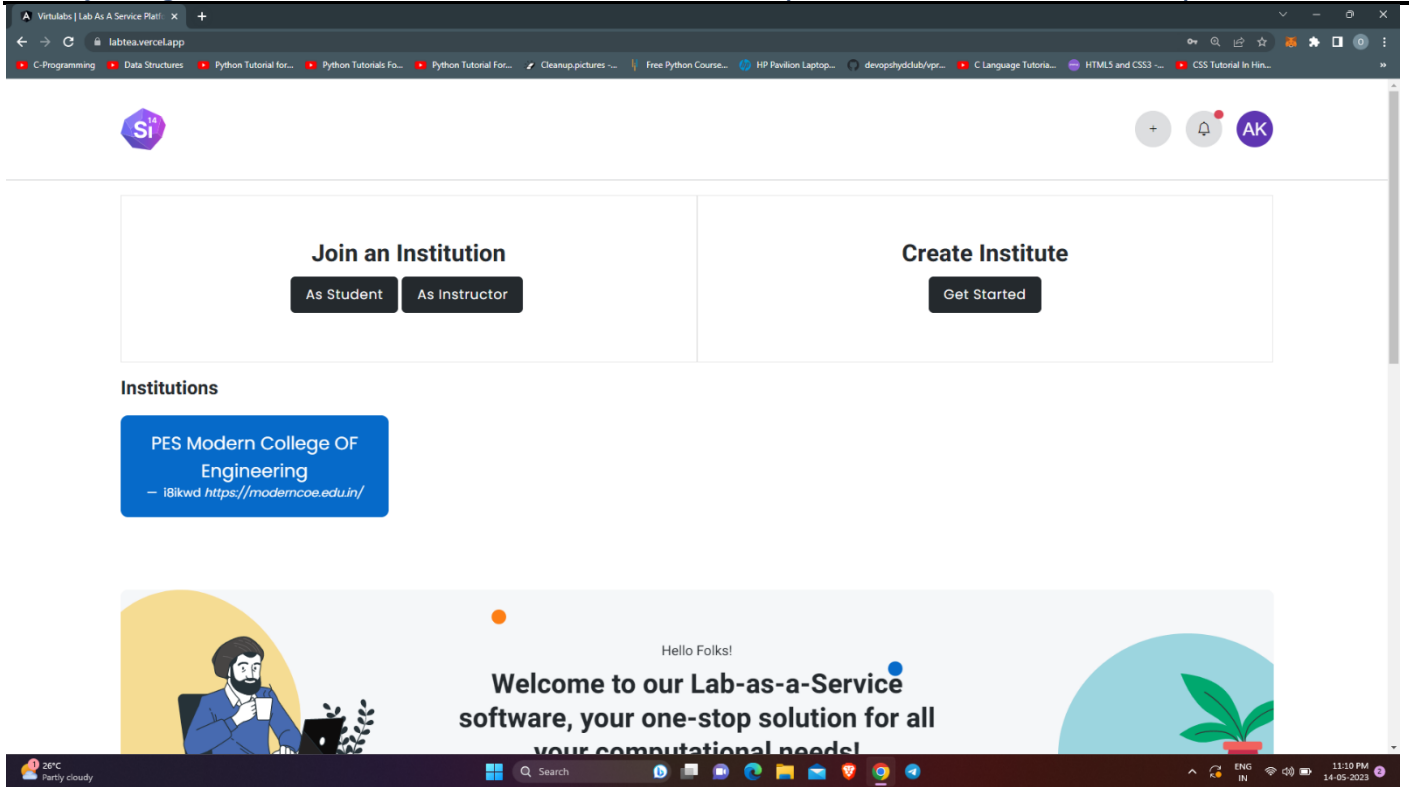
- User Interface: The front-end of the platform built using React, responsible for rendering and user interactions.
- Application Backend: The back-end built with Node.js, which handles the logic and APIs to interact with the database and the docker containers.
- Database: Student data is stored in database in the form of collections, the database used is MongoDB.
- NginX: Here NginX is used as both load balancer and the web engine.
- Code Studio Clusters: Multiple clusters are present for the code studio which are present in docker containers.



## VII. Results











## Lab Studio

### Create Assignment

≡ Assignment Name

🔍 Problem Statement

📄 Assignment Description

Paragraph ▾

**B** *I*

🏠 Lab Environment

📏 Required RAM: 40 MB

📄 Preferred Programming Language

📄 Dependencies Installation Scripts

Eg. pip3 install numpy

📅 Due Date

Create Assignment

Assignment Name	Date Created	Problem Statement	Due Date	Environment	Action
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- key outcomes of Software Lab as a Service (LaaS):
- Increased productivity through ready-to-use development environments.
- Cost savings by eliminating the need for physical infrastructure investment.
- LaaS platforms are designed to scale resources up or down based on project requirements. This scalability allows organizations to easily accommodate fluctuations in development needs, ensuring optimal performance and efficient resource utilization.
- Streamlined workflows with seamless integration of development tools and services.
- Faster time to market with rapid provisioning and agile development processes.
- These outcomes collectively contribute to enhanced efficiency, cost-effectiveness, and accelerated software delivery for developers and organizations utilizing LaaS.

## VIII. Conclusion

It will allow users to access the lab environment beyond working hours. It will eliminate the dependency on particular lab facilities. It will readily provide an integrated development environment for students without worrying about development setup and dependencies. Through this framework, which we call Lab-as-a-Service (LAAS), students can remotely execute labs designed by instructors. It will reduce the gap between high and low computation. It can incorporate a middleware approach in which it can be used universally across a wide range of experimentation types. This helps to promote courses that require lab facilities to also be incorporated to the online learning environment. For future work, we plan to extend the LaaS framework to take into consideration scalability and complexity of more sophisticated lab equipment that are required for courses in engineering, science, among others.

**IX. References**

- [1] Liyanagunawardena, T., Adams, A., Williams, S. (2019). MOOCs: A Systematic Study of Published Literature. *International Review of Research in Open and Distance Learning*, 14(3), pp. 202-227.
- [2] Mendes, L., Li, L., Bailey, P., DeLong K., del Alamo, J., (2016). Experiment lab server architecture: A web services approach to supporting interactive LabVIEW-based remote experiments under MIT's iLab shared architecture. *13<sup>th</sup> International Conference on Remote Engineering and Virtual Instrumentation*, pp. 293-305.
- [3] Coursera, [www.coursera.org/](http://www.coursera.org/) (Last Accessed April 25, 2023)
- [4] W. Linzhang, Y. Jiesong, Y. Xiaofeng, H. Jun, L. Xuandong, and Z. Guoliang, "Generating Test Cases from UML Activity Diagram based on Gray-Box Method," *11th Asia-Pacific Software Engineering Conference*.
- [5] G. Mazlami, J. Cito, and P. Leitner, "Extraction of Microservices from Monolithic Software Architectures," in *Proceedings 2017 IEEE 24<sup>th</sup> International Conference on Web Services, ICWS 2017*, 2017, pp. 524–531.
- [6] B. Selic, "Using UML for modeling complex real-time systems," *Lecture Notes in Computer Science Languages, Compilers, and Tools for Embedded Systems*, pp. 250–260, 1998.

