PRESIDENCY UNIVERSITY
Private University Estd. in Karnataka State by Act No. 41 of 2013
Itgalpura, Rajankunte, Yelahanka, Bengaluru – 560064

Smart Multilingual Chatbot for PGRKAM Platform

A PROJECT REPORT

Submitted by

SHREE SAI PAVAN E - 20221CSE0458

PRAJWAL A - 20221CSE0355

SRUJAN S - 20221CSE0457

Under the guidance of,

Ms. Tintu Vijayan

BACHELOR OF TECHNOLOGY

IN

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PRESIDENCY SCHOOL OF COMPUTER SCIENCE AND ENGINEERING

BONAFIDE CERTIFICATE

Certified that this report "**Smart Multilingual Chatbot for PGRKAM Platform**" is Bonafide work of "SHREE SAI PAVAN E ID: 20221CSE0458, PRAJWAL A ID: 20221CSE0355, SRUJAN S ID: 20221CSE0457", who have successfully carried out the project work and submitted the report for partial fulfilment of the requirements for the award of the degree of BACHELOR OF TECHNOLOGY in COMPUTER SCIENCE ENGINEERING during 2025-26.

Ms. Tintu Vijayan
Project Guide
PSCS
Presidency University

Dr. Jayavadivel Ravi
Program
Project Coordinator
PSCS
Presidency University

Dr. Sampath A K
Dr. Geetha A
School Project
Coordinators
PSCS
Presidency University

Dr. Asif Mohamed H B
Head of the Department
PSCS
Presidency University

Dr. Shakkeera L
Associate Dean
PSCS
Presidency University

Dr. Duraipandian N
Dean
PSCS & PSIS
Presidency University

Examiners

Sl. no.	Name	Signature	Date
1			
2			

PRESIDENCY UNIVERSITY

PRESIDENCY SCHOOL OF COMPUTER SCIENCE AND ENGINEERING

DECLARATION

We the students of final year B-Tech in COMPUTER SCIENCE ENGINEERING at Presidency University, Bengaluru, named SHREE SAI PAVAN E ID: 20221CSE0458, PRAJWAL A ID: 20221CSE0355, SRUJAN S ID: 20221CSE0457, hereby declare that the project work titled **"Smart Multilingual Chatbot for PGRKAM Platform"** has been independently carried out by us and submitted in partial fulfilment for the award of the degree of B-Tech in COMPUTER SCIENCE ENGINEERING during the academic year of 2025-26.

SHREE SAI PAVAN E	USN: 20221CSE0458	Signature 1
PRAJWAL A	USN: 20221CSE0355	Signature 2
SRUJAN S	USN: 20221CSE0457	Signature 3

PLACE: BENGALURU

DATE: 03-12-2025

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SHREE SAI PAVAN E

PRAJWAL A

SRUJAN S

Abstract

The PGRKAM (Punjab Ghar Ghar Rozgar and Karobar Mission) platform serves as an essential resource for employment facilitation in Punjab, connecting job seekers with opportunities provided by the state government The much-needed analytics is missing in the PGRKAM platform that significantly depends on it to demonstrate user behavior and platform performance.

The project is the answer to this problem and an innovation of a complex analytics tool related to the PGRKAM web and Android applications. The technique was to survey the finer user-event data, including page interactions, referral to the adverts, and demographic profile. The system provides individual job suggestions using machine learning algorithms (Collaborative Filtering and Genetic Algorithms). The data is processed and presented through interactive dashboards, simultaneously, allowing the officials to make a decision supported by data so that to boost the number of users and employment rates.

PGRKAM analytics tool was integrated and tried on the local network of PGRKAM, which demonstrates better insights and real-time monitoring capacity. There were security measures in place to ensure that the data was handled in line with privacy laws. The results indicate that the platform can become an excellent tool in the specific employment services where the fit of skill and opportunity by job seekers is maximized. The project also aligns with the SDGs in that it will lead to sustained, inclusive and sustainable economic growth, full and productive employment as well as decent work to all.

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Abbreviation

Abbreviation	**Full Form**
API	Application Programming Interface
CRUD	Create, Retrieve, Update, Delete
CSS	Cascading Style Sheets
DBMS	Data Base Management System
Django ORM	Django Object Relational Mapper
DRF	Django Representational State Transfer Framework
HTML	Hypertext Markup Language
HTTP	Hypertext Transfer Protocol
IP	Internet Protocol
JSON	JavaScript Object Notation
LLM	Large Language Model
LMS	Learning Management System
MVC	Model View-Controller
NLP	Natural Language Processing
ORM	Object Relational Mapping
OS	Operating System
PLFS	Periodic Labour Force Survey
PGRKAM	Punjab Ghar Ghar Rozgar and Karobar Mission
REST	Representational State Transfer
SDG	Sustainable Development Goal

SQL	Structured Query Language
SSID	Service Set Identifier
UI/UX	User Interface / User Experience
URL	Uniform Resource Locator
UUID	Universally Unique Identifier
JWT	JSON Web Token
CI/CD	Continuous Integration / Continuous Deployment

Chapter 1
Introduction

Background of the Project

The PGRKAM web and Android applications from the Government of Punjab represent the platforms through which employment data is maintained and job opportunities are facilitated for the candidates. These applications are used by various users to receive timely updates on job opportunities, skill development programs, and employment news. However, the platforms lack tools that can be integrated with analytics to provide administrators with accurate insights regarding how users interact with the applications, their behavioral patterns, and the effectiveness of the employment advertisements.

Aim of the Project

The primary goal of this project is to conceive, build, and implement an integrated analytics platform in the PGRKAM web and Android applications. Once this instrument is integrated, management will be able to see the users' activities, behavior, and other types of engagement in real-time. The proposed analytics tool will facilitate the advertiser to pinpoint the exact locations where users saw PGRKAM adverts. Besides, the demographic profiles of the users, pages or services accessed and suggesting personalized job recommendations through sophisticated algorithms are some other examples of actionable insights. These activities would then be linked to enhancing user experience, which is the ultimate goal of decision-makers and datadriven administrators.

The Digital Transformation and User Engagement

Understanding the user's behavior is of great importance in the present digital world. Any e-service platform, especially one that is at the government level and has millions of users, should not only be successful but should also be continuously improved. To get there, analytics tools must be used, which will reveal the ways users absorb information, point out the particular features that are most attractive, and let the user know where he is having problems. As a matter

of fact, the most recent data suggest that government online employment portals experience millions of user sessions on a monthly basis, however, they do not generate enough detailed data on user engagement, thus, losing the opportunity to increase the platform and the efficiency of service provision. Moreover, the embedded analytics would solve the skill-job mismatch problem gradually by enabling advertiser targeting and personalized job matching.

Prior Existing Technologies

There are several commercial and open-source analytics instruments designed to help the understanding of user behaviour and engagement in web and mobile platforms. Examples of such tools include Google Analytics, Mix panel, and Kiss metrics. These platforms offer features like event tracking, funnel analysis, user segmentation, as well as real-time reporting. However, they are general, and therefore, may not provide comprehensive answers required by employment platforms like PGRKAM, which need in-depth insights on job matching algorithms and specialized demographic analytics. This project aims at either the creation of a tailored analytics solution or the modification of existing technologies in such a manner that they will be compatible with the PGRKAM platform.

1.1 Background

• PGRKAM stands out as one of the major initiatives of the Government of Punjab, designed to not just alleviate the issue of unemployment but also, through an all-encompassing employment generation program, facilitate skill development and self-employment across the entire region. The mission operating on an online platform (www.pgrkam.com) along with mobile applications was initiated in 2018. These apps provide access to work, skill development courses, overseas employment guidance, and local jobs where the user lives. Its primary goal is to create a detailed database of unemployed families in Punjab so that targeted employment programs can be launched and the government can make informed policy decisions.

• The PGRKAM app, in spite of its extensive reach and the number of its users, has no integrated analytics system that would enable the comprehension of user interactions,

preference, and engagement levels on the platform by tracking user behaviour. Present-day commercial analytics tools such as Google Analytics and mix panel facilitate user activity tracking; nevertheless, they may not entirely address all requirements of a government employment portal devoted to personalized job matching and demographic insights (Drish Infotech Limited, 2025)[2]. For that reason, a specially designed/customized analytics tool is urgently needed to obtain detailed information regarding user behaviour, including advertisement channels, demographics, service usage, and success in job recommendations.

• Consequently, the project on hand is about providing an analytics solution that would permit the Punjab government to observe user behaviour in real-time not only through the web but also the Android applications of the PGRKAM. Besides that, it can help administrators to make various decisions by the insights, which are experiential, found, and observed, thus leading to website usability improvement and employability service enhancement, which at the end of the day contributes to socioeconomic development by the employability rate of the workforce in the state of Punjab going up and consequent reduction of unemployment International Journal of Research Publication and Reviews, 2024

1.2 Statistics

- Punjab continues to face significant challenges related to unemployment, especially among its youth population. According to the latest Periodic Labor Force Survey (PLFS) data from April to June 2025, the youth unemployment rate (ages 15-29) in Punjab stood at 20.2%, which is notably higher than the national average of 14.6% (Ministry of Statistics and Programmer Implementation, 2025). Rural areas in Punjab experience even higher unemployment rates at 22.1%, compared to 17.8% in urban regions, indicating a disparity in job availability and accessibility (Times of India, 2025).[1]

- This elevated unemployment rate poses serious socio-economic challenges in the state, emphasizing the need for effective and user-friendly employment platforms like PGRKAM. Despite providing employment-related information and services, PGRKAM currently lacks detailed analytics to understand user behavior, preferences,

and engagement with the platform. Such data is vital for improving outreach, customizing job recommendations, and optimizing resource allocation.

- Moreover, a gap persists between the skills possessed by job seekers and the requirements of available jobs, making targeted job matching essential. Enhanced analytics integration in PGRKAM would enable real-time tracking and analysis of user profiles and interactions, assisting policymakers and administrators in designing better interventions. Consequently, this will aid in reducing the unemployment rate and improving employment quality in Punjab, driving sustainable economic growth (International Journal of Research Publication and Reviews, 2024).

1.3 Prior existing technologies

- Several advanced user behavior analytics platforms exist today that provide insights into how users interact with digital applications. These technologies serve as a foundation or reference point for developing or integrating customized analytics solutions like the one proposed for the PGRKAM platform.
- **Mixpanel** is a leading product analytics software used globally for tracking user interactions on web and mobile applications. It allows organizations to monitor events (specific user actions), segment users based on properties, and create interactive visual reports without complex queries. Mix panel's key features include event tracking, cohort analysis, funnel visualization, and user engagement metrics, enabling businesses to understand user behavior deeply and optimize features accordingly (Mixpanel Docs, 2025; Craft.io, 2023).

- **Kissmetrics** focuses on person-based behavioral analytics, tying user actions to their profiles to assess customer journeys comprehensively. It offers tools such as funnel reports, retention tracking, segmentation, real-time reporting, and campaign analysis. Kissmetrics is popular for e-commerce and SaaS businesses to increase conversion rates by identifying dropped customer touchpoints and improving retention strategies (Kissmetrics Features, 2024; Kissmetrics Documentation, 2025).

- **Google Analytics** is among the most widely used web analytics platforms, offering broad data collection for user acquisition, behavior, and conversion tracking. With machine learning-powered insights, it provides funnel analysis, real-time activity monitoring, predictive analytics, and integration with advertising platforms. Google Analytics supports detailed user segmentation and customizable dashboards, making it adaptive across industries and scales (Google Analytics Features, 2024; Google Developers, 2025).

- While these platforms are powerful and versatile, they may not fully address the specific analytical needs of a government employment platform like PGRKAM, such as understanding the success/failure of job recommendations based on demographic and behavioral patterns, or integrating recommendation algorithms like Genetic Algorithms or Collaborative Filtering for personalized job suggestions. Hence, the current project aims to develop or tailor an analytics tool that builds on these existing technologies' strengths but aligns specifically with the objectives of the Punjab Government's employment mission.

1.4 Proposed approach

Aim of the Project

The primary aim of this project is to design and integrate an advanced analytics tool into the PGRKAM web and Android applications. This tool will enable the Punjab Government administrators to track and analyze user behavior comprehensively in real-time. The key objectives include capturing detailed user interaction data, providing insightful visualizations, and delivering personalized job recommendations using intelligent algorithms to improve employment matchmaking and user engagement.

Motivation

With rising unemployment rates in Punjab, especially among the youth, the PGRKAM platform plays a crucial role in bridging the gap between job seekers and employers. However, without detailed analytics, the platform cannot effectively understand how users consume information

or which recommendations are successful. This limitation reduces the platform's potential impact on employment generation. Motivated by the need for data-driven decision-making, this project seeks to empower administrators with actionable user insights, enabling the continuous enhancement of the platform's services.

Applications of the Project

• Real-time analytics on user engagement to improve platform features.

• Job recommendations tailored to a person, thereby increasing employment placement success.

• Improved advertisement targeting by user acquisition channels.

• Data-driven policy-making and program adjustment by government officials.

• Creation of insights for future skill development programs based on user behavior.

Limitations of the Proposed Approach

• Implementation complexity: Integrating advanced analytics into legacy systems.

• Potential challenges in ensuring data privacy and compliance with legal frameworks.

• Reliance on accurate and complete user information, which can be influenced by the user's behaviors or technological failures.

• Scalability concerns as user base and data volume grow over time.

• Dependence on internet connectivity and device compatibility for real-time analytics.

1.5 Objectives

i. Tracking user behavior

Design and implement a system to capture and log user interactions across the PGRKAM web and Android applications, including referral channels, page visits, and feature usage, in order to understand user behavior comprehensively.

ii. Data Analysis and Visualization

Develop analytics dashboards using collected user data to visually represent, in real time, engagement metrics, user demographics, and the effectiveness of job recommendations for administrative decision-making.

iii. System management and scalability

Design and manage a scalable analytics backend system that can handle high volumes of events emanating from active users. Ensure reliable collection and storage of data with efficient query performance.

iv. Data Security and Privacy Compliance

Implement security protocols and data anonymization techniques to safeguard user information, thus maintaining compliance with relevant data protection laws and ensuring users' privacy throughout analytics processes.

v. Deployment and Cross-Platform Integration

Deploy the analytics system, which is integrated into the PGRKAM website and Android application for smooth tracking across devices and real-time event reporting.

1.6 SDGs: Sustainable Development Goals

•Goal 4: Quality Education

The project's analytics can be utilized in the improvement of the planning and efficiency of vocational and digital skills training, contributing to the continuous development of educational programs.

• Goal 5: Gender Equality

The collection and analysis of user data, segregated by gender, help in the understanding and addressing of the peculiar challenges different gender groups face in employment to facilitate equal employment opportunities.

• Goal 8: Decent Work and Economic Growth

It improves employment services to increase job opportunities and ensure equitable economic growth in the state of Punjab by providing policymakers with information to fine-tune matching and upskilling efforts.

• Goal 9: Industry, Innovation and Infrastructure

Advanced analytics integrated within the PGRKAM platform mean technological innovation

for public-sector digital infrastructure, smarter government systems, and better e-governance.

• Goal 10: Reduced Inequalities

The system, by analysing user behavior and highlighting under-served populations, allows administrators to create specific strategies to reduce social and regional disparities in employment. Fig 1.1 Sustainable development goals [1]

Fig 1.1 Sustainable development goals [1]

The background information, the aim, the need, existing technologies, and alignment to the UN Sustainable Development Goals are discussed in Chapter 1. Chapter 2 provides a literature review related to previous work and technologies about user behavior analytics and employment platforms. Chapter 3 describes the methodology followed for system design, development, and implementation of the analytics tool. Chapter 4 presents discussions on project management aspects related to timelines, risk analysis, and budgeting. Chapter 5 describes the system analysis and design, including requirements, architecture, and algorithms used. Chapter 6 depicts the hardware, software tools, and simulation results to build the solution. Chapter 7 assesses the system performance in terms of testing and validation outcomes. Social, legal, ethical, and sustainability issues regarding the project are discussed in Chapter 8. Finally, the conclusion of the project achievements, limitations, and suggestions for future work are drawn in Chapter 9.

Chapter 2

Literature review

• Ranjan et al. (2022) investigated how big data analytics and machine learning methods can differentiate between malicious and legitimate users in a particular online platform. Using behavioral pattern analysis and predictive algorithms, the authors provided evidence for improving such abnormal behavior detection based on approaches that show promises to enhance the overall security and reliability of the platform. Though promising, challenges lie ahead in adaptation with constantly evolving user behaviors, thus demanding more dynamic learning systems in future work.[3][4]

• Rahhal et al. (2024) provided a state-of-the-art review on the application of data science in the analysis of the job market. Their survey included studies published between the years 2015 and 2022, where they have enlisted popular techniques including clustering, classification, and natural language processing to parse job postings and resumes. One gap they outlined is limited usage of real-time data, which would increase responsiveness and relevance of job-matching tools. They recommend investing in advanced data integration and analytics frameworks to respond fast to changes in the labor market.[5][6]

• Artioli et al. (2024) performed a critical review of clustering algorithms in UEBA. The paper discussed traditional k-means algorithm implementation and more modern approaches, like factorization machines, to perform anomaly detection and user profiling. Among the observations made, it was identified that often hybrid models ensure better performance than single-algorithm systems. However, most of the reviewed methods are not interpretable; decision-makers cannot trust system output in mission-critical environments.[7][8]

• Pesach et al. (2020) presented a prescriptive analytics framework to support recruitment decisions in enterprise settings. Their work integrated multi-criteria decision-making with scenario simulations to enable HR managers to make the best choice among applicants. The authors reported substantial gains in efficiency and fairness, although they also mentioned that real-world adoption depends on smooth integration with existing HR systems and strong privacy controls.[9][10]

• Kelley et al. (2022) conducted a field experiment using an Indian job portal to assess the impact of digital job-matching on employment outcomes among vocational trainees. The study found that although job portals improve access to opportunities, over-optimistic expectations may sometimes yield worse employment rates as users hold out for "better" matches. The authors suggest closer alignment between portal recommendations and real labor market dynamics for optimal results.[11][12]

• R Krook et al. (2023) analyzed the influence recommender systems have on users' engagement and autonomy in digital platforms. The findings indicated that though personalized recommendations serve to boost interaction, they may not always focus on user-intrinsic goals, calling into question issues of user autonomy and long-term satisfaction. The authors recommend user-in-the-loop approaches where feedback refines algorithms toward more meaningful engagement.[13]

• Jadon and Patil (2006) provided an overview of evaluation metrics for recommendation systems, indicating a growing trend to move away from strict traditional accuracy metrics toward business and engagement metrics. The authors state that the optimization of accuracy alone creates unintuitive user experiences, such as "information bubbles." They recommend measures that are more balanced regarding diversity and novelty, with consideration of user satisfaction.[14][15]

• Bojic et al. (2024) presented a methodology for the detection and mitigation of social bias in recommender systems with real-world deployment. The work demonstrates how algorithms can be designed unconsciously to promote inequality, such as under-representation of particular groups or skillsets. The authors appeal for regular audits of bias in line with the addition of fairness constraints in practical systems.[16][17]

• Yao Chuang (2023) explored the use of a hybrid user behavior analytics engine based on network traffic analysis combined with generative adversarial networks to detect abnormal user activities. Their study indeed demonstrates how GANs can differentiate between legitimate and suspicious access, thus enhancing security without manual labeling. The major limitations would be related to the complexities involved in training GANs and threats of adversarial "gaming".[18]

• Nomura et al. (2017) examined the potential of big data, especially job portal data, in formulating labor market policy for South Asia. Based on an analysis of employer and job-seeker interactions, they were able to show ways in which such data could yield high-frequency, microlevel information useful to public policy. Their results strongly endorse online platforms as a mechanism for not only researching but also actively managing workforce development and call for their integration into official statistics.[19][20]

Chapter 3

Methodology

3.1 Introduction

The selection of a proper development methodology is the pivotal point in any software project. The PGRKAM analytics tool involves complex tracking of data, integration of analytics, and real-time reporting; hence, it requires a methodology that can support iterative progress, continuous feedback from stakeholders, and adaptability to the evolution of requirements. Based on the needs identified above, the Agile methodology has been chosen as the best framework for this project is decribed in fig 3.1.

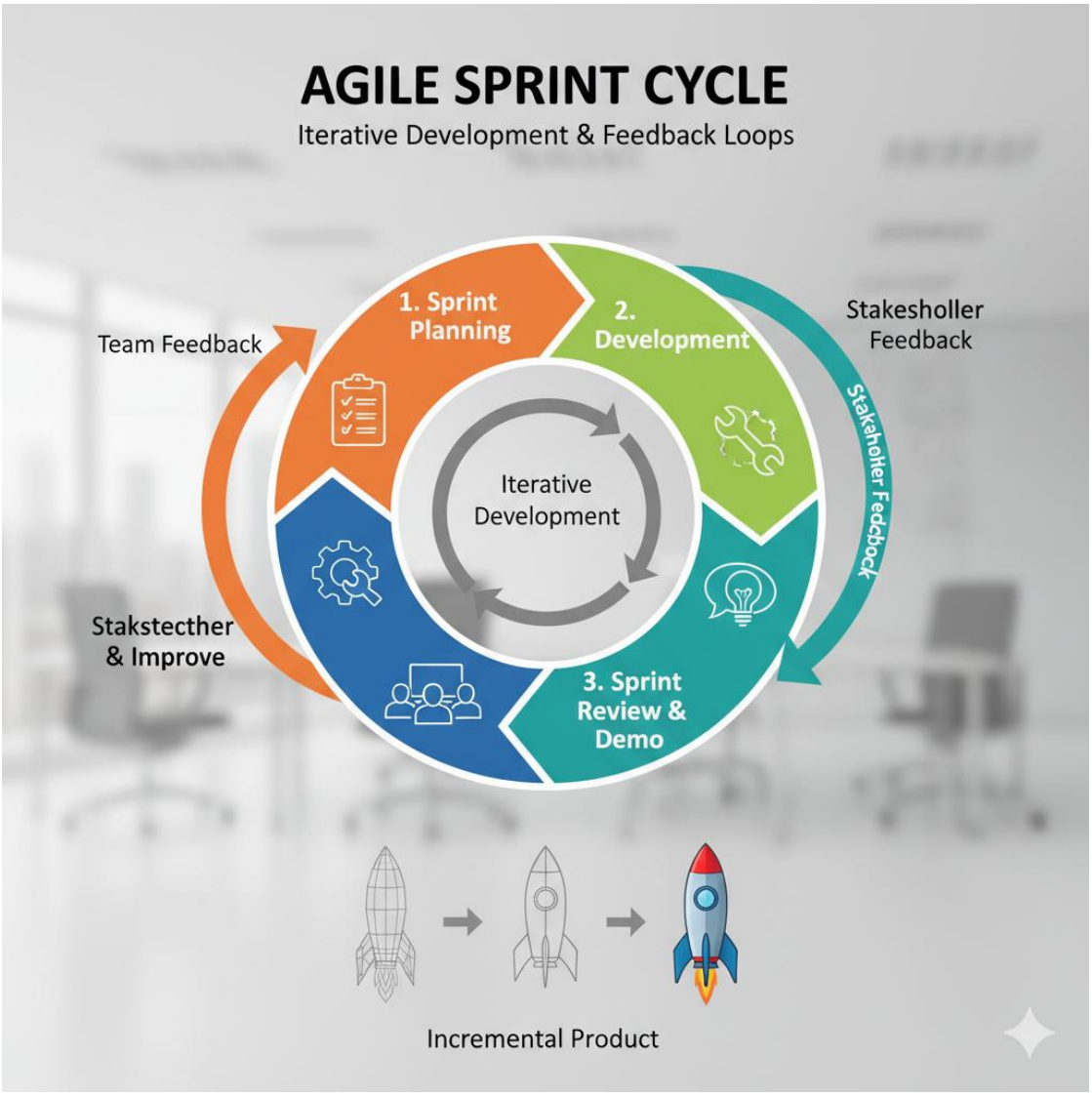


Fig 3.1 Agile sprint cycle showcasing iterative development and feedback loops.

3.2 Overview of Agile Methodology

Agile is a widely adopted software development methodology focusing on iterative development, collaboration, and flexibility. It breaks down the project into short, manageable time-boxed cycles called sprints, each delivering potentially shippable increments. Through regular feedback and adaptive planning, Agile ensures the product continuously evolves towards meeting the stakeholders' expectations effectively for this project is decribed in fig 3.2.

Fig 3.2: Component diagram depicting data flow and interaction anong analytics modules.

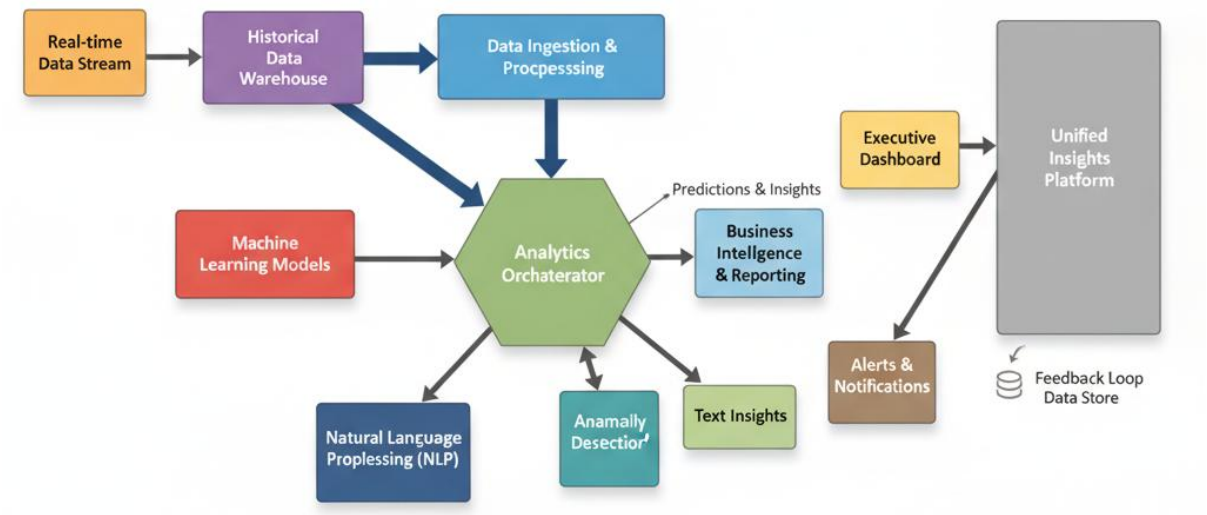


Fig 3.2 Component diagram depicting data flow and interaction among analytics modules.

3.3 Project Stages Mapped to Agile

The stages of this project align with the Agile approach in the following ways:

• Requirement Specification:

This is the initial stage of the entire cycle, which involves comprehensive requirements gathering from Punjab Government officials, PGRKAM administrators, and end-users. It also includes in-depth literature review about analytics tools and recommendation algorithms. The product backlog is created at this stage, serving as the priority list of features and tasks.

• System and Functional Design:

The high-level system architecture and data flow diagram is designed using open-source tools like Draw.io. Functional design documents specify the modules such as event tracking, demographic analysis, recommendation engine, and dashboards.

• Sprint Planning:

The project is divided into several sprints, each intended to develop, test, and perfect a single feature or component.

• Unit Design and Development:

Software units, including back-end event logging, analytics processing, data storage, and visualization layers, are implemented and unit tested independently.

• Integration Testing:

Developed modules are integrated, and integration testing is conducted to ensure their combined functionality on the PGRKAM platform environment.

• Verification and Validation:

Testing is performed continuously to ensure that system components meet specifications and that the product will meet the stakeholder requirements and performance criteria.

• Deployment and Continuous Improvement:

The iterative deployment of the analytics tool allows for constant monitoring, fixing bugs, and enhancing features based on user feedback and system usage metrics.

3.4 Use of Diagrams

System architecture, development phases, and the Agile workflow visual representations have been created on Draw.io, an open-source diagram tool whose aim is to facilitate the clear communication of complex ideas. For example, Fig 3.1 illustrates the Agile sprint cycle that describes iterative development, while Fig 3.2 and Fig 3.3 describe system component interactions and data flow respectively. For this project is decribed in fig 3.3

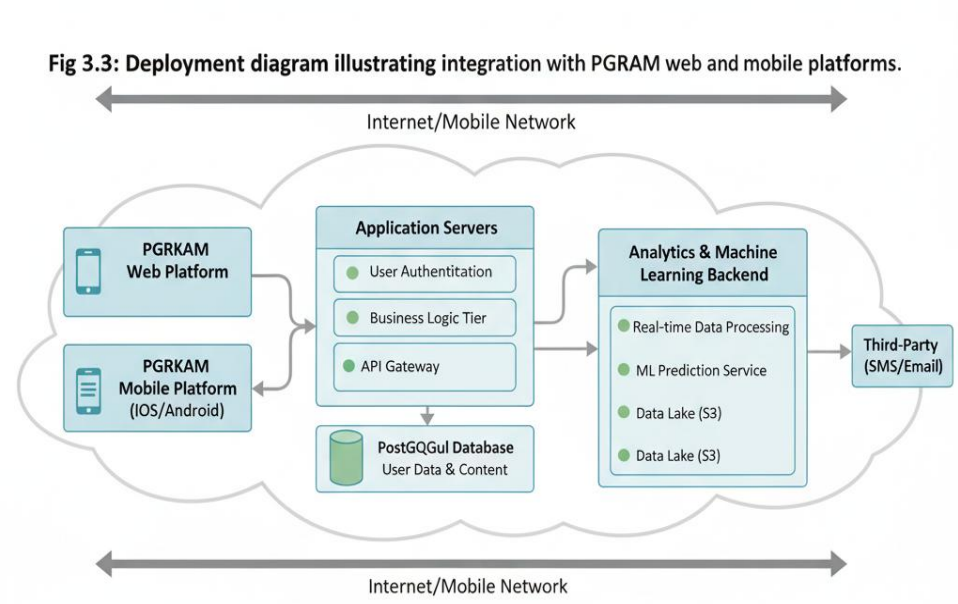


Fig 3.3 Deployment diagram illustrating integration with PGRKAM web and mobile platforms.

Chapter 4

Project Management

4.1 Project timeline

The project timeline for the PGRKAM analytics tool presents a clear, organized schedule that ensures all critical tasks and milestones are planned and visible. It has broken down the project into manageable activities that will enable smooth progress tracking and effective resource management for this project is decribed in table 4.1 Project planning timeline.

Table 4.1 Project planning timeline

S.No	Task	Start Date	End Date	Description	Milestones/Deliverables
1	Project Setup & Requirements Gathering	01-Aug-2025	15-Aug-2025	Gathering detailed requirements, stakeholder inputs, and literature survey on analytics methods.	Requirements Sign-off (15-Aug)
2	Core Event Tracking Development	16-Aug-2025	31-Aug-2025	Development of modules for user event tracking across PGRKAM platforms.	Event Tracking Module Completion
3	Demographic Analysis & Dashboard	01-Sep-2025	15-Sep-2025	Aggregate demographic data and build initial visualization dashboards for administrators.	Dashboard Prototype
4	Recommendation Algorithm Integration	16-Sep-2025	30-Sep-2025	Implementation and testing of job matching algorithms based on user profiles and job needs.	Recommendation Engine Ready

5	Visualization & Reporting	01-Oct-2025	15-Oct-2025	Enhance reports and visual tools for data interpretation and decision support.	Reporting System Demo
6	Security & Privacy Implementation	16-Oct-2025	31-Oct-2025	Apply encryption, anonymization techniques, and access controls for data privacy compliance.	Security Compliance Achieved
7	System Integration & User Testing	01-Nov-2025	10-Nov-2025	Integrate modules into complete system; run acceptance tests with end users and stakeholders.	User Acceptance Sign-off
8	Project Finalization & Report Submission	11-Nov-2025	15-Nov-2025	Final refinements, prepare project report and submit.	Final Report Submission and Viva

• **Project Setup & Requirements Gathering** (August 1–15, 2025): This initial phase aims at project scope; gathering detailed requirements from Punjab Government stakeholders, as well as users of PGRKAM, and a literature review to identify best practices. The task concludes with a requirements sign-off milestone.

• **Core Event Tracking Development:** August 16–31, 2025 Development begins by implementing basic modules of capturing user behaviors, such as visits, clicks, and sources of adverts on PGRKAM platforms. This phase includes unit testing to ensure robust and accurate data collection.

• **Demographic Analysis & Dashboard Development** (September 1–15, 2025): It analyses demographic insights from data provided by tracked events. At the same time, it designs and develops initial administrator dashboards to visualize these analytics in preparation for real-time monitoring.

• **Recommender Algorithm Integration**: September 16–30, 2025 Core algorithms of Collaborative Filtering or Genetic Algorithms are integrated to

suggest jobs matching the skills and profiles of users, further enhancing the utility and effectiveness of the site.

• **Visualization & Reporting**: October 1–15, 2025
This phase enhances data presentation by refining graphical and textual reports available through interactive dashboards to quicken administrators' decision-making.

• **Security & Privacy Implementation**, October 16–31, 2025: Encryption, anonymization, and controlled access are applied to user-sensitive data for protection, with consideration of compliance with regulations on privacy.

• **System Integration & User Acceptance Testing**: November 1–10, 2025
The developed modules are integrated into the PGRKAM application and website. The stakeholders perform user acceptance testing, which ensures that the system meets all expectations and functions smoothly across devices.

• **Project Finalization & Report Submission** (November 11–15, 2025): The final refinements are based on user feedback. In addition, the project report is compiled and submitted, which marks the end of development.

4.2 Risk analysis

This PESTLE framework helps anticipate external factor risks and plan mitigation. In order to ensure the successful completion of the PGRKAM analytics tool project, it is paramount to understand and mitigate risks from the internal and external environment. The PESTLE framework helps analyze political, economic, social, technological, legal, and environmental factors that can impact the project for this project is decribed in table 4.2 Example of PESTEL analysis.

Table 4.2 Example of PESTEL analysis [13]

Factor	Description	Impact on Project	Risk Mitigation / Opportunity
Political	Government policies on data privacy, digital governance, and employment generation initiatives	Compliance requirements may add complexity; political support boosts funding	Close monitoring of regulations; leverage government support for advocacy
Economic	State funding availability; Punjab's economic stability and unemployment levels	Budget constraints could delay implementation; strong demand may arise	Efficient budget planning
Social	State funding availability; demand for transparent web apps	User adoption levels of target users; need for transparent, accessible employment data	Intuitive UI design and awareness campaigns
Technological	Availability of open-source analytics tools; infrastructure integration with mobile/web apps	Efficient budget planning; prioritize features enhancing employability	Intuitive UI design; strong user education; data handling possible
Legal	Data protection laws such as Indian IT Act, GDPR; considerations for data	Legal compliance may slow rapid development; integration challenges possible	Use stable open-source tools; phased integration testing
Legal	Data protection laws and sustainability considerations in cloud deployments	Potential environmental impact to avoid; may add data handling constraints	Implement data retention policies; legal consultations
Environmental	Server energy use and sustainability in cloud deployments	Implement data anonymization, encryption; optimize resource utilization	Adopt energy-efficient cloud solutions; optimize resource utilization

• **Political**: Government legislations on data privacy and employment schemes impact the scope and compliance requirements for projects directly. Support from the Punjab Government adds momentum; however, it expects strict adherence to policies for digital governance.

• **Economic**: The funding constraint might be an issue, especially in the event of a change in economic fortunes; on the other hand, the level of unemployment in Punjab will make the

platform highly relevant and increase its demand.

• **Social**: The digital literacy variation among users may restrict accessibility. Ensuring ease of use and creating awareness campaigns will contribute to better adoption and confidence in the analytics-driven platform.

• **Technological**: Open-source analytic tools and cloud infrastructure make development effective. The integration with the already existing systems in PGRKAM might face some compatibility issues and therefore needs extensive testing.

• **Legal**: Compliance with data protection acts, such as the Indian IT Act and, where applicable, GDPR-like standards. The project shall execute the highest degree of encryption and anonymization of user data.

• **Environmental**: The energy consumption by cloud services is one of the key sustainability factors. Selection of green cloud providers and optimization of resource usage will help to keep the environmental impact at a minimum.

• **Conclusion**: Proactive management, per this PESTLE analysis, will go a long way in anticipating risks and opportunities and harnessing them toward timely and successful delivery of the project.

Chapter 5

Analysis and Design

5.1 Requirements

Requirements analysis forms the basis of system design. The Rozgar AI Chatbot therefore captures requirements in terms of functional and non-functional needs, hardware/software constraints, and data handling protocols.

5.1.1 System Hardware Requirements

The hardware requirements emphasize devices needed by users and the back-end system. Key considerations:

• User devices: Smartphones, tablets, or desktops that can handle text/voice input.

• Server Infrastructure: Cloud-hosted servers for running the LLM and efficiently serving API calls.

• Audio peripherals: microphones and speakers for voice.

•Constraints: Limited internet connectivity in rural areas and low processing power of devices.

System HW Requirement Phases:

1. Pre-conditions: Internet-connected devices; availability of the cloud server
2. Input parameters: Voice input, text input, user profiles, skill/job datasets
3. System outcomes: job suggestions, skill recommendations, personalized counseling
4. Formulate relations mapping user profile to data sets for recommendations.
5. System constraints: Latency of LLM API, bandwidth, device compatibility

5.1.2 System Software Requirements

Software requirements that make the bot work steadily on any platform:

• OS: Android, iOS, and browser-based interfaces

• Backend: Node.js/Express server, cloud database (Firestore/MongoDB)

• APIs: LLM API (GPT-4 or LLaMA) for natural language processing

• Constraints: API call limits, response time, multilingual processing

System SW Requirement Phases:

1. Prerequisites: Backend server up and running, LLM API up and available

2. Input parameters: User queries, user profile data, job/skill datasets

3. System outcomes: Context-aware recommendations, real-time responses

4. Construct relationships: Query processing → Recommendation engine → User output

5. System constraints: API latency, secure data storage, cloud cost optimization

5.1.3 Additional Requirements

• Data Collection Requirements: To capture user history, interactions, preferences, and feedback.

• Data Analysis Requirements: Using historical data to enhance personalization

• System Management Requirements: Admin panel to update jobs, monitor usage, manage resources

• Security Requirements: Authentication, encryption, compliance with data protection policies

• User Interface Requirements: Intuitive design, multilingual support, access for differently-abled users

5.2 Block diagram

The functional block diagram depicts the flow of data and processing in the Rozgar AI Chatbot. It is designed based on three main sections: Input, Processing, and Output for this project is decribed in fig 5.2 block diagram.

Blocks:

• Inputs: User queries-text/voice, Profile data, Skill/Job databases

• Processing:

  • NLP/LLM engine interprets user input

  • Recommendation engine maps user data to jobs and skill courses

  • \tAdmin management handles data updates and monitorin.

  • Outputs: job postings, skill recommendations, career counseling suggestions, notifications

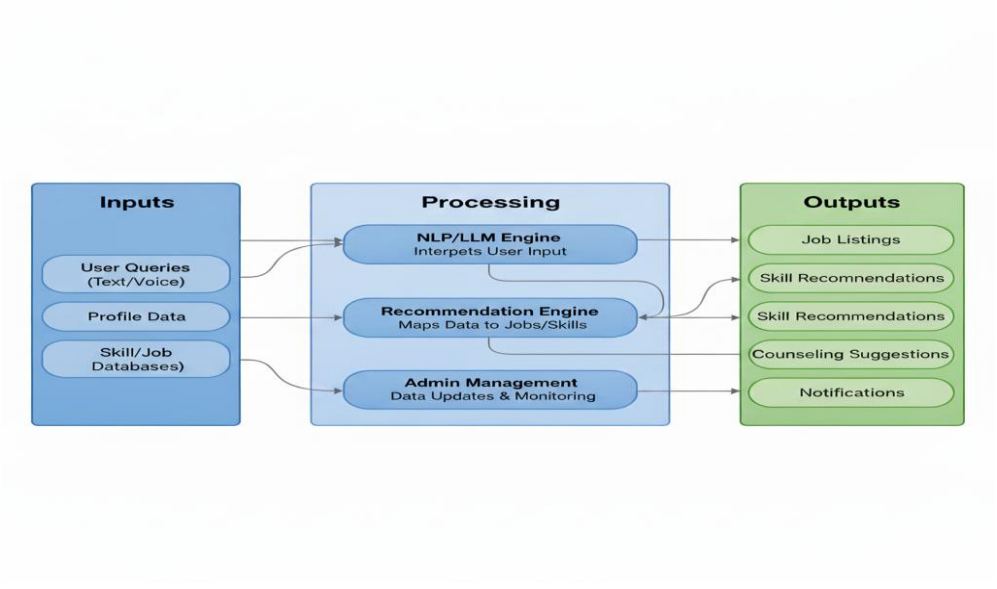


Fig 5.2 Block diagram

5.3 System Flow chart

It provides a flowchart that illustrates the step-by-step process of the operational flow:

1. The user launches a chatbot.

2. Authentication: Login or signup

3. Query Input: User provides voice or text query.

4. Processing:

• LLM interprets query

• User profile data is analyzed

• Recommendation engine generates output

5. Condition Check: Input and recommendation validation

6.Menus to display: jobs, skill recommendations, counseling advice

7. Feedback loop - user can rate response → system updates profile

8.Stop: Wait for next query

This ensures that process flow, decisions, and outputs are clearly visualized, which is important for the validation of system designs for this project is decribed in fig 5.3 system flow chart.

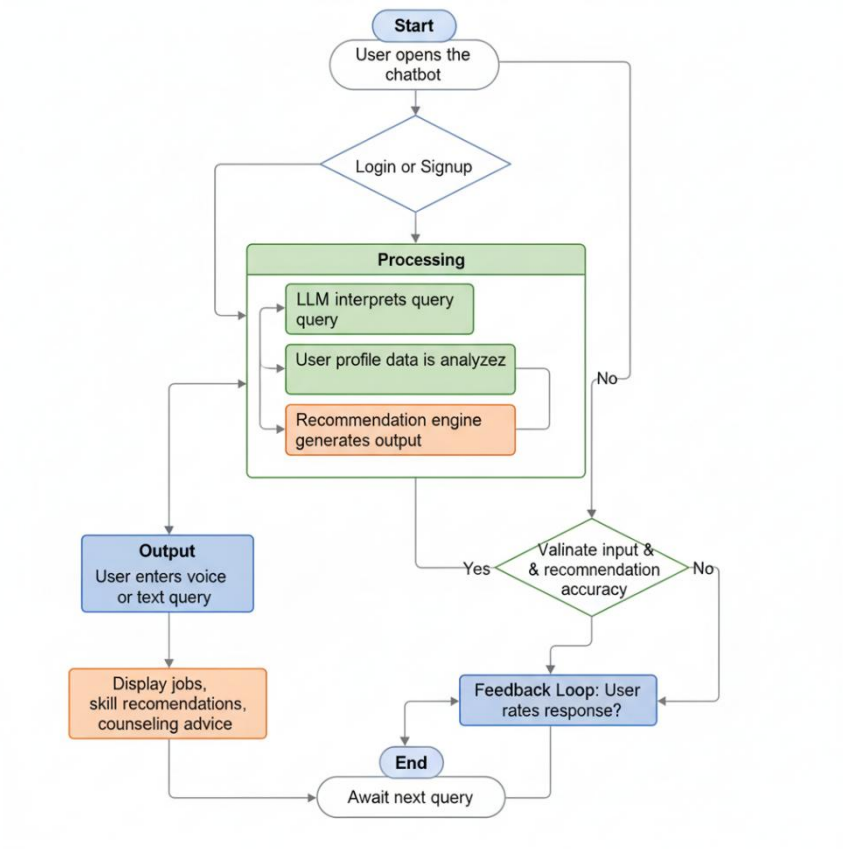


Fig 5.3 System Flow chart

5.4 Choosing devices

Although the chatbot is mostly software, IoT elements are needed for voice-enabled interaction. Comparison tables can help identify the best match for devices for this project is decribed in Table 5.4 Choosing devices for modules.

Device Type	Model	Features	Remarks
Microphone	USB Condenser	Noise cancellation, omnidirectional	Suitable for speech input
Speaker	Bluetooth	10W output, frequency 20Hz–20kHz	Audio output for voice feedback
Mobile Device	Android/iOS	2GB RAM, 1GHz CPU, internet	Supports app UI and voice input
Cloud Server	VM Instance	4 vCPU, 16GB RAM, GPU support	Runs LLM API and recommendation engine

Table 5.4 Choosing devices for modules

5.5 Designing units

The functional units of the Rozgar AI chatbot can be segregated and designed/tested separately:

1. User Management Unit: This module handles user sign-up, login, and profile management.

2. Query Processing Unit: LLM-based NLP engine

3. Recommendation Engine Unit: Maps the skill/job datasets to user queries

4. Notification Unit: sends reminders, updates, feedback collection

5. Admin Management Unit: Updates of datasets by admin, monitoring of chatbot usage

Unit-level testing ensures that each module performs independently before system integration.

5.6 Standards

Relevant Standards:

•ISO/IEC 25010:2011: Software product Quality metrics[21]

•REST API conventions – For backend communication

• AES-256 encryption – For secure data storages

• HTTPS/WebSocket protocols – For secure communication

• Unicode – for multilingual support

5.7 Mapping

This table maps key system requirements to the modules that fulfill them. It shows that job recommendations and skill suggestions are handled by the Recommendation Engine, profile data is managed by the User Management Unit, notifications are delivered through the Notification Unit, and overall monitoring is handled by the Admin Management Unit for this project is decribed in Table 5.7 Mapping for modules.

Table 5.7 Mapping for modules

Requirement	**Module Addressing Requirement**
Job recommendation	Recommendation Engine
Skill suggestion	Recommendation Engine
Profile storage	User Management Unit
Notifications	Notification Unit
Admin monitoring	Admin Management Unit

5.8 Domain model specification

This table briefly describes key entities in a chatbot system—User, Job, Skill, Query, and Recommendation—along with their attributes and relationships. It explains what each entity represents, the data it stores, and how it interacts with other entities within the platform. Table 5.8 Domain model specification

Table 5.8 Domain model specification

Entity	**Description**	**Attributes**	**Relationships**
User	Represents an individual interacting with the chatbot	UserID, Name, Email, Skills, Job History	Submits Queries; Possesses Skills
Job	Represents a specific job listing available on the platform	JobID, Title,Company, Location, Skills Required	Requires Skills; Included in Recommendations
Skill	Represents a specific skill or qualification	SkillID, SkillName, Category (e.g., technical)	Possessed by Users;Required by Jobs

Query	Represents a single user request or input to the chatbot	QueryID, Text Content, Timestamp, UserIntent	Submitted by a User; Results in a Recommendation
Recommendation	Represents the chatbot's generated output	RecommendationID, Type (Job, Skill), Content	Generated from a Query; Contains Jobs or Skills

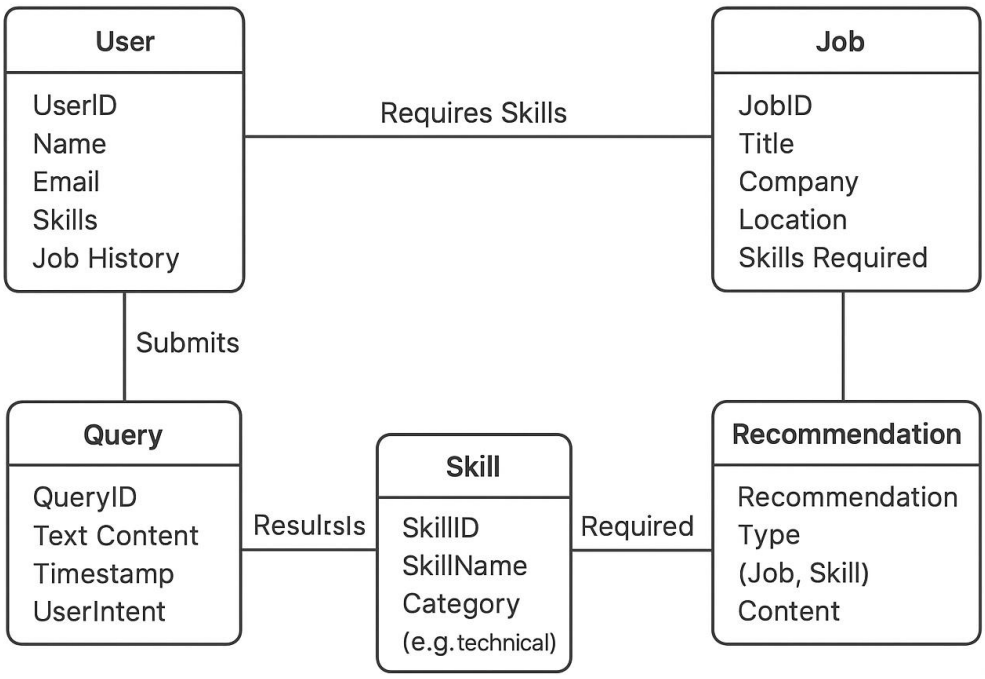


Fig 5.8 Domain model specification

This diagram shows a domain model connecting five main entities—User, Job, Skill, Query, and Recommendation. It illustrates how users submit queries, queries generate recommendations, jobs require specific skills, and users possess skills, forming the relationships used in a recommendation system for this project is decribed in fig 5.8 Domain model specification

5.9 Communication Model for the PGRKAM Analytics Tool Project

Request-Response Communication Model

The request-response model is a well-known communication model in client-server architectures that involves sending a request by the client and processing this request by the server, returning a response. This is a synchronous model that fits well for scenarios in which users demand immediate or on-demand information, such as data queries or updates of dashboards.

Description of the Model:

The communication is initiated in this model by the client, making a request to the server for any data or action. The required computation or database queries are then performed by the server, which responds with the result. The same process would continue for every transaction.

Suitability for PGRKAM analytics tool:

• The PGRKAM platform involves real-time interaction by administrators and users to query analytics data, generate reports, and receive personalized job recommendations on demand.

• Event tracking and dashboard updates usually respond to a user's request, hence the request-response pattern.

• The model ensures that data is always fresh and consistent because the requests receive real-time processing.

• It simplifies error handling and security controls because the communication is tightly controlled per request.

• Although it may introduce latency if the server is overloaded, the relatively controlled user base (government admins and platform users) can be managed using load balancing and efficient server resources.

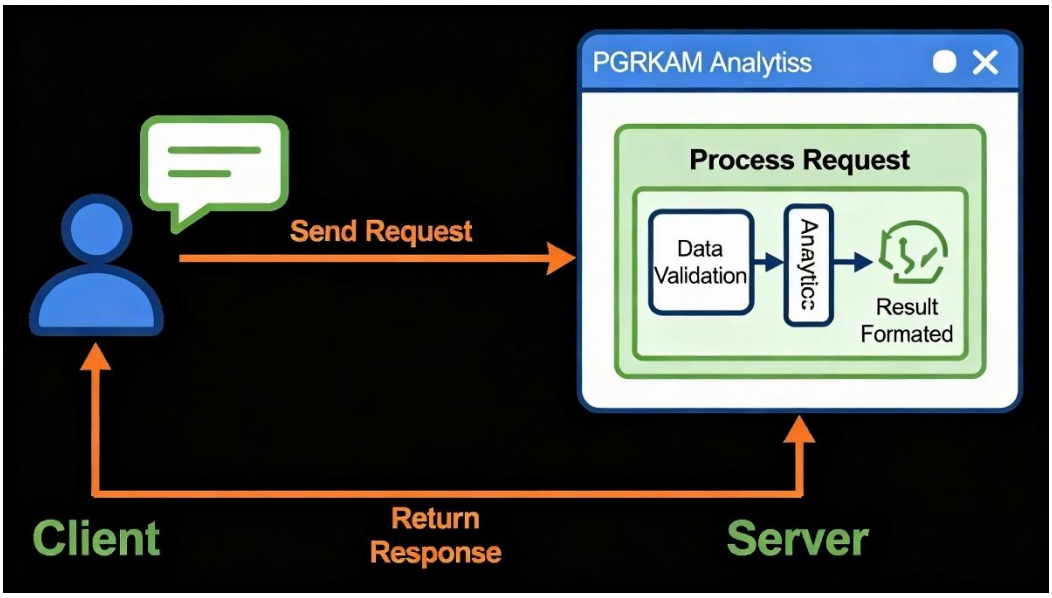


Fig 5.9 Communication model suitable for Home automation

The schema below depicts the flow where the client-admin/user makes a request to the analytics server; the server, in turn, processes the request-fetching user behaviour data, running recommendation algorithms, or compiling reports-and sends the response back to the client. Each interaction will go through this cycle, and every step is well-defined, following a request-response sequence for this project is decribed in fig 5.9 Communication model suitable for home automation

5.10 IoT deployment level

IoT Deployment Level and its Suitability for the PGRKAM Analytics Tool Project

The project for the analytics tool PGRKAM, which integrates user behaviour analytics into web and Android platforms related to employment services, involves collecting user data, its processing in the cloud, with further feedback provided via dashboards and recommendations. Given these requirements, the IoT Deployment Level 4 is the most applicable.

IoT Deployment Level 4: Edge-Cloud Hybrid Deployment Description: Level 4 deployment also generally involves a hybrid architecture: IoT devices or clients collect data locally, and some processing is handled near the edge-say, on local gateways or edge servers-while more

computationally intensive analytics and storage are managed in the cloud. Data flows between the edge and cloud services for both real-time insights and long-term analytics.

Suitability for the Project:

• The PGRKAM platform interacts with users using mobile and web devices (endpoints) that act like IoT clients, collecting behaviour data.

• Initial processing of user interaction events can happen on the device or at edge nodes to reduce latency and filter out noise.

• The cloud backend performs heavy analytics like machine learning-based job recommendation, historical data aggregation, and visualization.

• This deployment level enables scalability, real-time response, efficient bandwidth usage, and data security between edge and cloud layers (mobile/ web).

• It goes well with the responsive, personalized services required for the project, drawing on the robustness of cloud infrastructure.

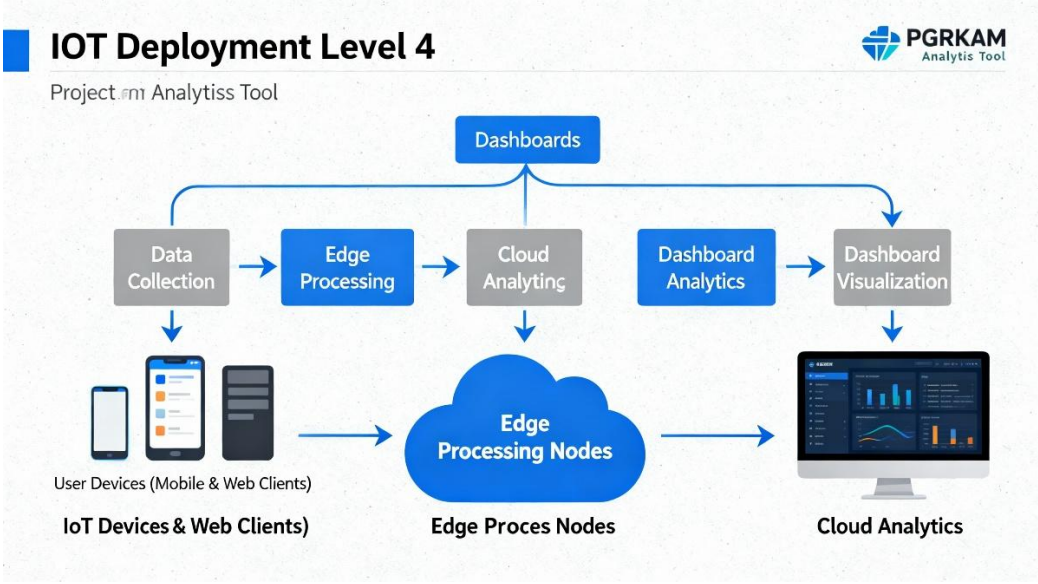


Fig 5.10 IoT deployment level suitable for home automation

This image illustrates an **IoT Deployment Level 4 architecture**, showing the flow from data collection on IoT and web devices to edge processing, cloud analytics, dashboard analytics, and final dashboard visualization. It highlights how data moves through edge processing nodes

and cloud systems to generate real-time dashboards for analysis for this project is decribed in fig 5.10 IoT deployment level suitable for home automation

5.11 Functional view

The functional view of the Rozgar AI Chatbot decomposes the entire system into six logical groups, each responsible for a certain set of functions. This provides a clear and organized map of the system's architecture.

1.**Device Functional Group** This group represents the client-side hardware a user would be interacting with. For this project, this is not an IoT sensor, but rather the user's personal device.

- Functions:
  - Render the application user interface.
  - Capture users' input either by keyboard (text) or microphone (voice)
  - Display responses from the server.

2.Communication Functional Group This handles data exchanged between a device used by the user and the backend server of the chatbot.

- Functions:
  - It offers a secure, HTTPS-based connection.
  - Send user requests (queries) to the server.
  - Receive and deliver chatbot recommendations (responses) to the device.

3.Services Functional Group: This is the core "brain" of the chatbot, where all of the primary processing occurs; these can be thought of as microservices in the backend.

- Functions:
  - NLP/LLM Service: Interprets the intent and entities from the user's query.
  - Recommendation Service: It analyzes user profile data and matches it against the job and skill databases.
  - User Management Service: This handles user login, user signup, and user profile updating.
  - Database Service: responsible for the storage and retrieval of all data.

4.Management Functional Group: This functional group provides the tools for monitoring, maintaining, and administering the system.

- Functions:
  - Admin Dashboard for system oversight.
  - Monitor system health, server load, and API performance.
  - Allow administrators to manage job postings and skill data.
  - Log user interactions for analytics to improve the models.

5. Security Functional Group This is a critical, cross-cutting group that ensures the integrity and confidentiality of the system and its data.

- Functions:
  - Authentication - Verify the identity of users when they log in.
  - Only allow users to view data belonging to them.
  - Data Encryption: Secure data in transit by using TLS/SSL, and at rest in the database.
  - Input Validation: Protect against malicious inputs and attacks.

6. Application Functional Group This layer is a user-facing presentation layer; it ties all the other functionalities together into one user experience.

- Functions:

  Following are the steps involved in designing a chatbot. Accordingly,
  - Providing an interactive chat interface.
  - Manage the flow and state of a conversation.
  - Present job listings, skill recommendations, and counseling advice in an easy-to-use format.

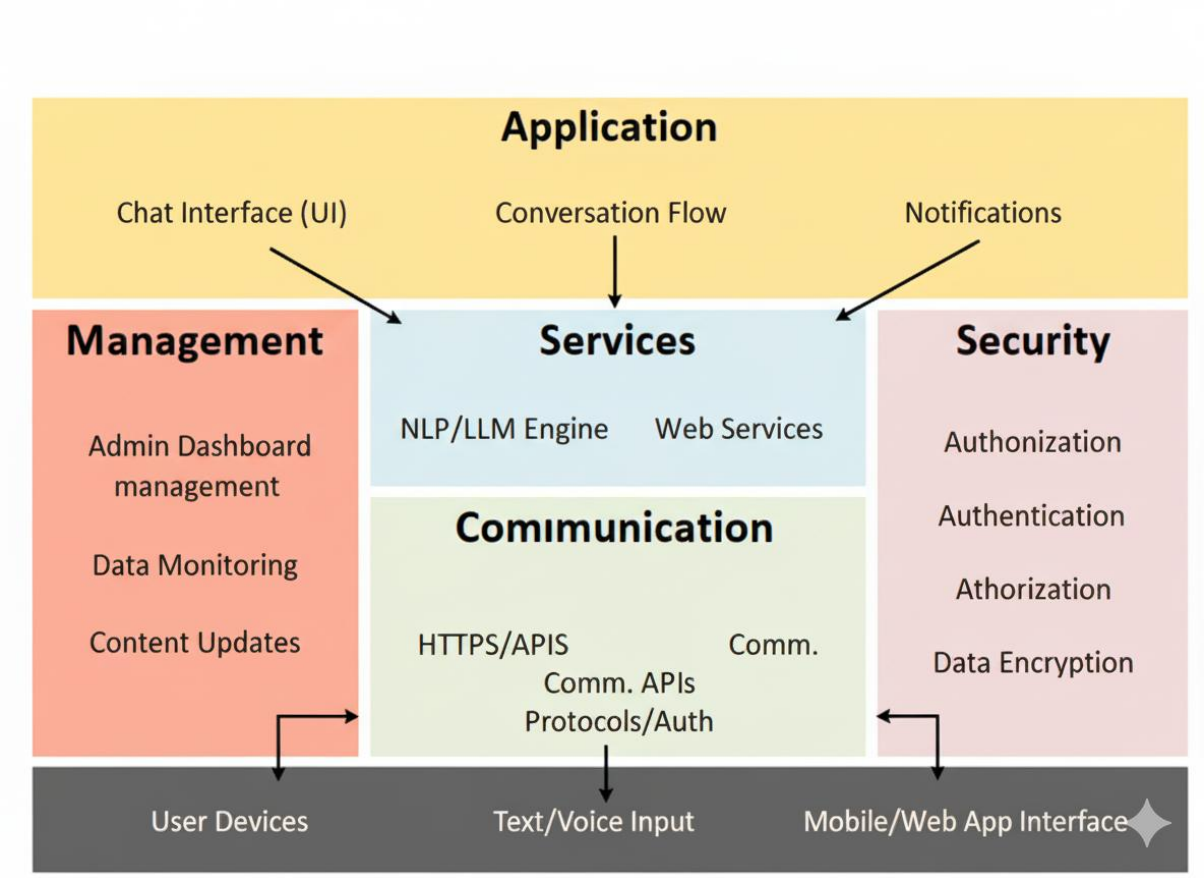


Fig 5.11 Functional view

This image presents a high-level system architecture showing four key layers—Application, Management, Services, and Security—connected through a Communication layer. It illustrates how chat interfaces, NLP engines, admin tools, security controls, and communication protocols work together to support user devices and mobile/web app interactions for this project is decribed in fig 5.11 functional view

5.12 Mapping deployment level with functional blocks

My apologies; I must have misunderstood the request, and I provided an image that doesn't explain the mapping well enough, let alone its suitability. Let me rectify that. Here is the detailed description of the mapping of deployment levels to functional blocks for the Rozgar AI Chatbot, followed by an image generated with a diagramming tool.

Mapping Deployment Levels with Functional Blocks for Rozgar AI Chatbot

For the Rozgar AI Chatbot, we can define two major levels of deployment: Client-side (User Device) and Server-side (Cloud/Backend Infrastructure). The mapping describes which functional groups reside and operate within each of these levels and how they interact.

1. Client-side level of deployment, which refers to everything running directly on the user device, such as smartphones, web browsers, desktop applications.

- Device Functional Group:

  • Mapping: This group represents the User Device itself. It provides the Text/Voice Input capabilities via microphone/keyboard and the Mobile/ Web App Interface for rendering the chat.

  • Description: The user's interaction originates here. It captures the raw query and displays the processed response.

- Communication Functional Group:

  • Mapping: The client-side portion of this set involves creating and maintaining the secure connection-e.g., HTTPS/APIs-to send the queries across to the server and retrieve the responses.

  • Description : It acts as the conduit, packaging user input into requests and unpacking server responses for the Application layer.

- Application Functional Group:

  • Mapping: The root Application group would contain the mapping of the Chat Interface, UI, Conversation Flow management, client-side state, and Notifications display.

  • Description: The visible, interactive portion of the system responsible for direct user experience by displaying information and controlling local interaction logic.

  • Implicit Local Data/Caching: Not categorized, but within this tier client-side caching of user preferences or previous interactions would also reside to improve responsiveness.

2.The Server-Side Deployment Level: Cloud/Backend Infrastructure This layer consists of the powerful backend systems located in the cloud that handle processing, storing, and management of data for all users.

- **Services Functional Group:**

  • Mapping: This entire group is deployed on the server. It includes the NLP/LLM Engine for interpreting queries, the Recommendation Engine for matching users with jobs/skills, and various Web Services that expose core business logic, such as user profile management and job search.

  • Description: It is the chatbot's processing core that executes AI/ML models and complex business logic.

- **Management Functional Group:**

  • Mapping: The functionalities of Admin Dashboard Management, Data Monitoring, and Content Updates are all server-side.

  • Description: The following are backend tools and processes that administrators use to manage the chatbot, update databases, and analyze performance.

- **Security Functional Group:**

  • Mapping: All the critical security functions, such as Authentication, Authorization, and Data Encryption of data at rest and in transit between server components, are dealt with here.

  • Description: Ensures the secure operation of the system, protecting user data and intellectual property.

- **Communication Functional Group**:

  • Mapping: This server-side part is responsible for receiving client requests, forwarding the same to respective services, and formatting responses. It also contains Communication Protocols used for inter-service communication.

  • Description: This is a central hub at the backend level for all incoming and outgoing data; it interacts with the client devices and internal services.

  • Database (Implicit): This level consists of the main Database where secure storage of

user profiles, job listings, and skill information should occur, normally under the purview of the Services and Management functional groups.

Suitability for the Project

This mapping is highly suitable for the Rozgar AI Chatbot project because:
Optimized Performance and Scalability: By offloading the heavy processing-namely, NLP/LLM and Recommendation Engine-to the powerful server-side infrastructure, the client-side app remains lightweight and responsive. Server-side components are independently scalable to support each workload.

• Centralized Data Management: Critical data, including user profiles, job postings, and skills, is stored and managed centrally on the server. This ensures data consistency, makes backups easier, and unlocks powerful analytics across all users.
• Enhanced Security: Sensitive operations, such as user authentication and authorization, core data storage, and other related sensitive tasks, remain confined to the secure server environment. This results in reduced vulnerability because the information would otherwise be stored on the client-side.
• Flexible Client Deployment: Because of the clear separation, different client implementations such as web and mobile applications can easily interact with the same robust backend services to ensure a consistent user experience irrespective of the access method.
• Ease of Maintenance and Updates: The core logic updates-for example, to improve the recommendation algorithm-can be easily deployed on the server side without users updating their client applications. Only UI changes require updates on the client side.
This architecture ensures that the proposed chatbot solution is powerful, scalable, secure, and maintainable to effectively serve its users.

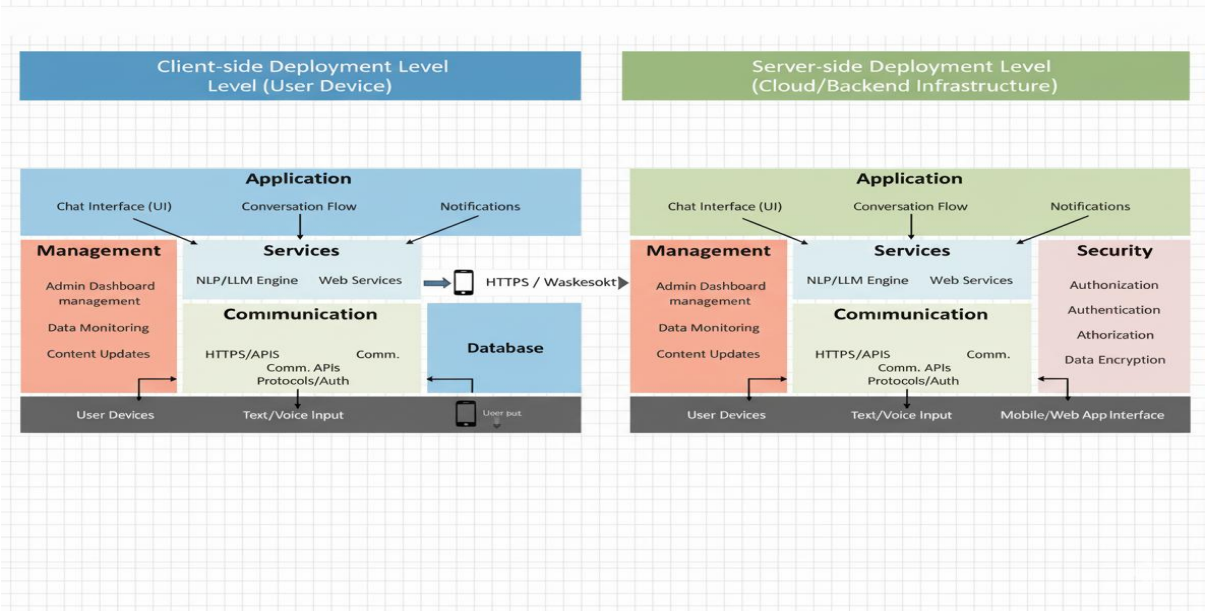


Fig 5.12 Mapping deployment level with functional blocks

This image shows a comparison of **client-side** and **server-side deployment levels**, illustrating how application, services, management, communication, and security components operate on user devices versus cloud/backend infrastructure. It highlights data flow via HTTPS/WebSocket's and includes elements like databases, NLP engines, admin tools, and security layers for this project is decribed in fig 5.12 Mapping deployment level with functional blocks

5.13 Operational view

1. Service Hosting Options

This defines where the core back-end logic, including the AI models and recommendation engine, will run.

• **Chosen Option**: Cloud-based Serverless and Platform as a Service (PaaS)

We're going to use a provider like AWS Lambda or Google Cloud Functions to handle the AI/NLP processing. The main API will be handled by a service like Google App Engine or Heroku.

• **Suitability**: This hybrid approach is perfect. The core API requires an always-on, stable environment - PaaS, while the computationally intensive AI tasks are infrequent. Using a

serverless model means that the cost is solely for compute time used, so it's very cost-effective, and will scale seamlessly during peak usage times.

2. Storage Options

It defines how and where user data, job listings, and skill information are stored.

• **Chosen Option**: Managed Cloud NoSQL Database.

A service like Google Fire store or Amazon DynamoDB will be used.

• **Appropriateness:** NoSQL is a perfect match for the database of a chatbot. User profiles and conversation histories are semi-structured, and they may change over time. NoSQL gives enough flexibility to handle this data with ease. What's more, these managed services offer high scalability, low-latency performance, and built-in security-all of the key ingredients of a responsive and secure user experience.

3. Device Options

This defines the types of devices the system must support for end-users.

• **Chosen Option**: Platform Agnostic (Mobile & Desktop) ????????.

The system will be accessible via web browsers on desktops/laptops and via native applications on mobile devices (iOS and Android).

• **Suitability:** The Rozgar AI Chatbot should be present on the very devices which people use every day. Keeping this in mind, the platform-agnostic strategy will ensure a consistent experience while users are either at their desks or on the go.

4. Application Hosting Options

This defines where the user-facing frontend application-e.g., the chat interface-will be hosted.

• **Selected Option:** Content Delivery Network (CDN) for Web App & App Stores for Mobile.

The web application will be hosted on a CDN-backed service, such as Vercel or Netlify. The native mobile apps will be distributed through the Google Play Store and the Apple App Store.

• **Appropriate use:** Hosting the web frontend on a CDN allows for fast load times for users anywhere in the world because the content is served from a location that is geographically

close to the user. It's also very scalable and secure. For mobile, app stores are the standard, trusted channel for distribution, updates, and discovery.

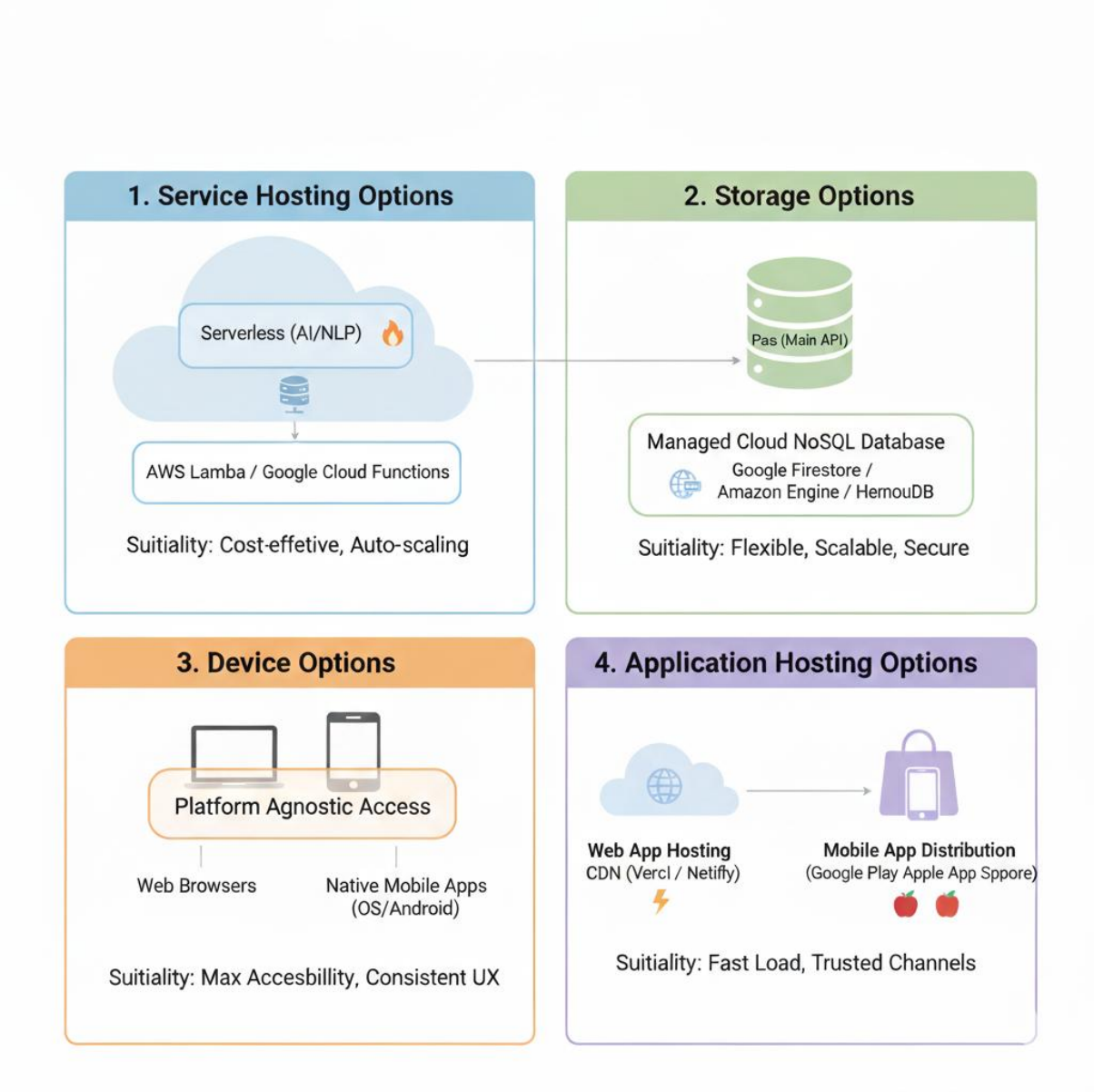


Fig 5.13 Operational view

This image outlines four deployment options: service hosting using serverless AI/NLP platforms, cloud storage using managed NoSQL databases, device access through web browsers or mobile apps, and application hosting via CDNs or app stores. It highlights flexible, scalable, and cost-effective choices for building and delivering applications for this project is decribed in fig 5.13 Operational view.

5.14 Other Design aspects

1. Process Specification

The process specification outlines the step-by-step flow of a core system function. For Rozgar AI Chatbot, the most critical process is Handling a User Query. Process Flow:

1. User Input Capture: The user provides an input query, such as "Data analyst jobs," via the Application on their Device.

2. Secure Transmission : The query is securely transmitted to the backend using an HTTPS request, also containing an authentication token that identifies the user.

3. Intent Recognition: The query comes to the NLP/LLM Service. Text preprocessing is done to identify user intent, such as finding a job, and key entities like data analyst.

4. Profile Enrichment: Recommendation Service retrieves the profile of the given user with their listed skills and job history from the database.

5. Data Retrieval & Matching: The service queries the Job Database, filtering for roles that match both the query entities and the user's profile skills.
6. Ranking & Formatting ????: Results are ranked on relevance, then the top results are formatted into a clear human-readable message.

7. Response Delivery: The formatted response gets delivered to the user's device and is shown on the chat interface.

2. Information Model Specification

- This includes the detailed definition of data structures, attributes, data types, and constraints. This is a more formal version of the domain model.

- User Entity
  o UserID: Integer (Primary Key, Unique)
  o Email: String (Unique, Indexed)
  PasswordHash: String

o Skills: Array of Strings (or Foreign Keys)
CreatedAt: Timestamp

- Job Entity
  o JobID: Integer (Primary Key, Unique)
  o Title: String (Indexed)
  o Company: String
  o Location: String (Indexed)
  o RequiredSkills: Array of Strings
  o PostedDate: Timestamp

- Skill Entity SkillID: Integer (Primary Key, Unique)
  o SkillName: String (Unique, Indexed)
  o Category: String (e.g., "Technical", "Soft")

3. Service Specification

This describes the API endpoints for the core microservices, basically defining how different parts of the system communicate.

- UserService: Handles user accounts
  o POST /api/users/register: Register a new user account.
  o POST /api/users/login: Authenticates a user and returns a session token.
  o GET /api/users/{userId}: Returns profile information of any particular user.

- Chatbot Service: Handles conversational logic
  o POST /api/chat/query: Main endpoint to provide a user's query.
  ♣ Request Body: { "userId": ".", "queryText": "." }
  ♣ Response Body: { "responseText": ".", "data": [.] }

- Job Service: This handles job data.
  o\tGET /api/jobs/search?q=. : Search for jobs by keywords or criteria.
  o GET /api/jobs/{jobId}: Returns information about a particular job.

Chapter 6

Hardware, Software and Simulation

6.1 Hardware

This project does not entail physical hardware development itself but is instead integrated with existing web and mobile applications on Android platforms. However, considering some IoT-inspired analytics and deployment concepts, it is relevant to reflect on typical hardware and development tools commonly used in similar systems.

- Hardware Development Tools for Legacy MCUs:
  Although our project is -oriented, in IoT contexts, legacy microcontrollers require specific development environments that consist of IDEs, compilers, and SDKs. Tools like MPLAB X or Keil are commonly used for programming of legacy MCUs.

- Debugger and Programmer Tools:
  In hardware contexts, debugging involves hardware debuggers-e.g., JTAG, SWD-and in-system programmers that flash firmware, allowing developers to inspect the real-time behavior of hardware. Though not required here, they are crucial tools in projects involving embedded systems.

- Reference Designs and Application-Specific Solutions:
  Many IoT projects are based on reference designs published by chipset manufacturers or ecosystem partners, hence rapid prototyping becomes possible through complete system blueprints.

- Explorer Kits and Starter Kits:
  Cost-effective kits such as Arduino UNO, Raspberry Pi, or TI LaunchPad enable the quick co-development and testing of hardware-software, making embedded IoT solutions a lot easier to learn.

- Radio Boards and Expansion Boards:
  Modular boards supporting wireless protocols such as Zigbee, LoRa, and BLE expand base development kits with extra radio communication capabilities, which are necessary for real-time data transfers across distributed IoT networks.

- Evaluation, Development, and Pro Kits:
  Complete solutions with sophisticated sensors, development environments, and connectivity enable the design and testing of industrial-grade IoT solutions that are scalable and robust.
- Thunder boards: IoT Prototyping Kits
  These provide comprehensive platforms for prototyping, specifically optimized for IoT device development with emphasis on low power consumption and integrated connectivity.

The hardware part for the analytics integration in PGRKAM is mainly comprised of smartphones and computers used by end users and administrators. The custom analytics system will be built upon cloud infrastructure and will run on software services without any need for additional physical circuit design or hardware programming on existing hardware platforms.

6.2 Software development tools

- The project for the PGRKAM analytics tool requires numerous software development tools to simplify the development lifecycle, enhance collaboration, automate tasks, and ensure high code quality.

- Integrated Development Environments (IDEs) and Code Editors
  Visual Studio Code: Lightweight code editor with multi-language support, along with numerous extensions, suitable for both front-end and back-end development of the project.
  Configuration: Install necessary extensions such as Python, JavaScript frameworks, and Docker integration to help in coding productivity.

- Version Control Systems (VCS)

  • Git & GitHub: Used for managing source code versions, keeping track of changes, and facilitating collaboration among team members. Branching and pull requests allow for the seamless integration of features.

  • Configuration: The repository is set up with branch protection policies and access controls in order to ensure the integrity of the code.

- Project Management Applications

  Jira is an agile implementation that provides sprint planning, backlog management, and issue tracking to efficiently organize project tasks and effectively monitor progress.

  • Configuration: Establish Agile boards with epics, user stories, and tasks aligned to the project milestones and deliverables.

- Continuous Integration / Continuous Deployment (CI/CD) Tools

  • GitHub Actions: Automates the building, testing, and deployment of software. Ensures rapid feedback on code quality and enables frequent feature releases.

  • Configuration: Add workflows attached to testing and deployment stages for repository events like commits and pull requests Containerization Tools

  • Docker: Packages the application and its dependencies into containers for consistent development, testing, and deployment environments across machines.

  • Configuration: Create Dockerfiles for frontend, backend, and database; use Docker Compose for multi-container orchestration.

- Cloud Platforms

  AWS or Microsoft Azure host the analytics backend, databases, and dashboards, providing scalable computing resources, storage, and networking.

  • Configuration: Provide compute instances; configure databases and networking securely, using best practices.

- Collaboration Platforms

  • Slack: Slack allows for communicating with the team in real time, sharing files, and integrating project tools for smooth collaboration.

• Configuration: Create dedicated channels for Development, Testing, and Management teams, and integrate them with Jira and GitHub.

- API Testing Tools

  • Postman: An interactive interface for the design, testing, and documentation of APIs used in an application.

  • Configuration: Group API endpoints into collections, perform automated testing, and document them for development and integration purposes.

- Testing Frameworks

  • Selenium: Performs browser testing for validation of the front-end UI at various scenarios; detects bugs early on.

  • Configuration: Create test scripts on the most critical workflows and integrate them into CI pipelines for constant validation.

6.3 Software code

Event Data Logger Module (Python)

This module implements event logging for user activities on the PGRKAM platform. It receives event data, validates it, and stores it for later analytics.

```
# Import necessary libraries
import json              # For handling JSON data
import datetime          # To timestamp events
import sqlite3           # SQLite database for local event storage

# Connect to local SQLite database (or create if not exists)
conn = sqlite3.connect('pgrkam_events.db')
cursor = conn.cursor()
```

```
# Create table for events if not exists
cursor.execute('''
CREATE TABLE IF NOT EXISTS events (
    id INTEGER PRIMARY KEY AUTOINCREMENT,
    user_id TEXT NOT NULL,
    event_type TEXT NOT NULL,
    event_data TEXT,
    event_timestamp TEXT NOT NULL
)
''')
conn.commit()

def log_event(user_id, event_type, event_data):
    """
    Function to log a user event.
    Parameters:
        user_id (str): Identifier for the user triggering the event.
        event_type (str): Type of event e.g. 'page_view', 'job_click'.
        event_data (dict): Additional event metadata.
    """
    # Prepare event timestamp in ISO8601 format
    timestamp = datetime.datetime.utcnow().isoformat()

    # Convert event_data dict to JSON string for storage
    event_data_json = json.dumps(event_data)

    # Insert the event record into database
    cursor.execute('''
        INSERT INTO events (user_id, event_type, event_data, event_timestamp)
        VALUES (?, ?, ?, ?)
    ''', (user_id, event_type, event_data_json, timestamp))

    # Commit the transaction to save data
```

```
    conn.commit()

    print(f"Event logged: User={user_id}, Type={event_type}, Time={timestamp}")

# Example usage:
if __name__ == "__main__":
    # Log a 'page_view' event for user 'U123'
    log_event("U123", "page_view", {"page": "job_listings", "referrer": "email_campaign"})
```

- Code Explanation
- SQLite acts as a lightweight local storage mechanism for event data in this module.
- Events: It stores the identifiers, the event type, supplementary JSON-formatted data, and timestamps.
- The log_event function encapsulates event capture logic:
- Generates a standard timestamp using UTC time.
- Converts event metadata into JSON for flexible storage.
- Inserts records into the database using Execute, and commits the transaction.
- The Example Usage shows a sample event log call that you could test.

Citations and References

- SQLite documentation: https://www.sqlite.org/docs.html
- Python JSON library: https://docs.python.org/3/library/json.html
- Python datetime library: https://docs.python.org/3/library/datetime.html

6.4 Simulation

Simulation allows developers to virtually test electronic circuits, microcontrollers, and complex systems, helping predict the behaviour of creations, validate designs, and optimize performances without a physical hardware setup. Different projects call for the use of different types of simulation tools.

- Circuit Simulators: These utilities, among them LTSpice and TINA-TI, enable detailed analysis of analog and digital circuits. Such simulators let users verify component behaviors and overall circuit performance before building physical prototypes.

- Microcontroller (MCU) Simulators: These are software packages, such as Proteus VSM, Oshonsoft, and WOKWI, which simulate popular microcontrollers, including Arduino, PIC, and AVR. In these, you test and debug code that is written for microcontrollers in a virtual environment.

- Full-system simulators: Intel Simics is a complete platform for full-system simulation, and it allows detailed development and debugging of software executed on complex electronic architecture systems.

- Hardware-in-the-Loop (HIL) Simulators: These are typically powered by MATLAB/Simulink and involve the testing of a controller's real-time response by connecting virtual stimuli to the software, which bridges the gap between control logic and physical hardware behaviors

3D Modeling and Simulation Software: Ansys and Fusion 360 are some of the platforms that combine design capabilities with simulation tools for physics-based problems, including things like structural integrity, fluid dynamics, and thermal analysis.
Examples of popular simulation software:

- LTSpice: a free, widely used circuit simulator from Analog Devices featuring very accurate analog and power electronics simulations.

- TinkerCAD Circuits: Free web-based simulation created by Autodesk, good for basic electronics and projects involving Arduino.

- Proteus VSM: Versatile simulator, supports several microcontroller architectures. Also includes combined circuit simulation.

Ansys: Advanced engineering suite for comprehensive structural and fluid simulations.

- Intel® Simics*: Full-system simulation allows for complex hardware debugging without physical devices.
- MATLAB/Simulink: Renowned in modelling, simulation, and Hardware-in-the-Loop testing, highly utilised in control and embedded systems development.

Given that most of the PGRKAM analytics projects focus on software and cloud-based analytics rather than physical hardware, simulations in PGRKAM principally concern themselves with software system behavior, data flows, and cloud resource modelling. In the event of hardware interfacing or embedded IoT devices, these simulation platforms provide a robust environment for prototyping and verification.

Free Circuit Design Software Options

For individuals and teams looking for free options to design and simulate circuits, there are quite a number of robust open-source options to work with. Some of the most common free circuit design software platforms include:

1. Circuit Maker

Free schematic and PCB design tool specifically designed for the open source hardware community. Circuit Maker allows projects to be collaborated on, leveraging a communal library of components and designs. It's a great, easy way for students, hobbyists, and professional makers to get into PCB design.

2. Open Circuit Design Software

This suite provides a set of tools: Magic, IRSIM, Netgen, PCB, and XCircuit, under the GNU Public License. It's suitable for both analog and digital circuit design and performs regular design checks to avoid errors.

3. KiCad EDA

KiCad is a popular, open-source EDA suite that manages schematic capture and PCB layout with Gerber output. It works on cross-platform: Windows, Linux, and macOS, and is designed to be used for simple to complex PCB projects.

4. ADS Circuit Design Software

The focus of ADS is to provide system-level analysis tools for antilog and digital circuits, assisting verification prior to the manufacture of circuitry.

5. NagaEDA Circuit Design Software

NagaEDA focuses on electronic design in C++ and Python. It contains a Verilog parser, which is helpful for digital circuit validation.

6. OpenSce circuit design software

OpenSce provides a user-friendly GUI for designing and analysing linear circuits. It is so convenient for students and educators in general, since one can get quick results.

7. QSapecNG Circuit Design Software

It provides symbolic analysis of linear analogy circuits, featuring a powerful analysis core and a Qt-based GUI.

8. Simul Ide

A simple real-time circuit simulator that is suitable for education and hobby use. Simul Ide supports microcontrollers like PIC, AVR, and Arduino, along with drag-and-drop circuit creation and real-time simulation.

9. Gerbe A Gerber file viewer, among other manufacturing formats, which can be helpful to PCB designers for inspecting the output files before fabrication.

Chapter 7

Evaluation and Results

7.1 Test points

Testing is an important method of ensuring that both software and hardware work. For the PGRKAM analytics tool project, which is primarily composed of software modules, test points refer to specific places either in the code or system architecture where any measurement or output is checked for correctness. In integrated hardware-software systems, test points are actual physical points, like voltages or signals marked on a circuit; in software, checkpoints are built into each functional unit or module to verify data and control flow for this project is decribed in fig 7.1 Test points.

Identifying Test Points in Functional Units:

Event Logging Module:

- Test Point S1: Verify raw events (for example, user interactions or visiting pages) are captured and logged successfully.
- Measurement: Data payload structure and timestamp; expected to match JSON schema in real-time.
- Expected vs Actual: compare sample events with simulated inputs and logs for correctness.

Recommendation Engine:

- Test Point S2: Verify recommendations of jobs generated for a user based on their input profile.
- Measurement: List of recommended jobs, their ranking scores, and the user's matched skills.
- Expected vs Actual: Output must meet algorithm's expected recommendations on test input profiles in unit test & simulation.

Dashboard Visualization:

- Test Point S3: Verify that the admin dashboards present data correctly.

- Measurement: Displayed Charts, Tables, and Summary Metrics for Event and User Analytics
- Expected vs Actual: Compare dashboard outputs with manually calculated results from test datasets.

Security & Privacy:

- Test Point S4: Test if sensitive user data is encoded/encrypted.
- Measurement: Verify anonymized/encrypted fields in database and data transmission logs.
- Expected vs Actual: Verify if data complies with privacy standards. Such simulated data breaches should fail in extracting cleartext information.

Marking Test Points in Diagrams:

Use open-source diagram tools to illustrate data flow in each module. Highlight clearly each test point such as S1, S2, S3, S4, etc. For hardware-related projects, test points like V1, V2, etc. would be marked on the circuit diagram where one needs to measure voltages or signal types at critical nodes for this project is decribed in fig 7.1 PGRKAM analytic

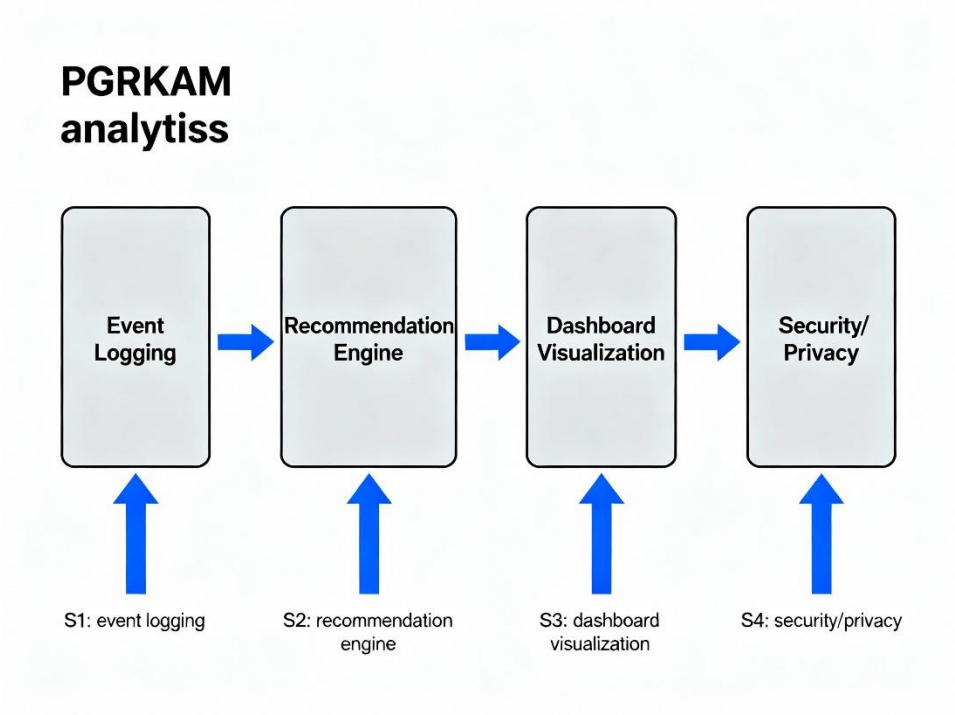


Fig 7.1 PGRKAM analytiss

Table 7.1 Test points

Test Point	Description	Measurement/Validation
TP1	Input Event Capture	Confirm event data received with correct format and timestamp.
TP2	Event Data Validation	Ensure malformed/incomplete events are rejected or flagged.
TP3	Data Storage	Verify event records stored accurately in the database.
TP4	Recommendation Generation	Validate that personalized job recommendation logic outputs expected job lists.
TP5	Dashboard Data Rendering	Check that the user and job analytics visualization matches logged data statistics.
TP6	API Response Time	Measure response latency under defined concurrency/load conditions.
TP7	Data Anonymization & Encryption	Validate personal data is masked/encrypted in logs and storage.
TP8	Error Logging and Alerts	Verify system logs errors correctly and triggers alerts for critical failures.
TP9	User Authentication and Authorization	Test authentication mechanisms and access controls are enforced accurately.

7.2 Test plan

A detailed test plan describes testing approaches, conditions, expected values, and constraints for each functional unit of the PGRKAM analytics tool. A test plan makes sure that verification is performed through software and hardware (simulated or real) in order to guarantee correctness, reliability, and performance for this project is decribed in fig 7.2 PGRKAM Analytics Tool

Table 7.2 PGRKAM Analytics Tool

Test Point	**Subject**	**Verb**	**Object**	**Condition (When/Where)**	**Value / Range**	**Constraint**
TP1	Event Logger	Captures	User event data	On every user action	Event JSON valid	Time ≤ 1s after event
TP2	Event Logger	Rejects	Invalid event submission	If key fields missing in payload	Error thrown	No entry in database
TP3	Dashboard	Renders	User stats (total, new)	After one session with >10 simulated user events	Count matches log	Error < 2%
TP4	Recommender	Displays	Job recommendations	On valid user profile, skills present	Top 3 jobs shown	Job open positions

TP5	API Server	Responds	API user count request	Under peak test load (100 req/sec)	Latency < 2 sec	Success rate > 99%
TP6	Privacy	Encrypts	Sensitive user info	Before write, after DB insert/update	AES-256 encrypted	No plaintext at rest
TP7	Dashboard	Visualizes	Usage trends/metrics	On admin dashboard load, 1 week data window	Trend correct	Correlates with logs

Test Case Categories:

Black Box Testing:

• Positive cases: provide valid user events, assume successful logging.

• Negative cases: Provide malformed or incomplete data; validate failure expected.

• Boundary conditions: Test event logging at session start/end, extreme timestamp values.

White Box Testing:

• Control flow: Ensure all branches in job recommendation logic are exercised.

• Data Flow: Assure correct referencing of user profile data at every stage.

• Branch/Path coverage: Ensure main and exception paths in data collection and analytics are tested.

Hardware Testing:

- If integrating IoT sensors or embedded hardware, test physical connection reliability and voltage levels at each pin/interface according to marked test points.
- Emulate real-world data loads, when a hardware-in-the-loop setup is utilized.

Unit Testing:

- Configure and run each Python function/module independently with mocked/fake data - for example event logging, recommendation scoring.
- Overall tests:
- Test event data propagation through all layers from logging to dashboard, ensuring seamless module interaction.

Software/System Testing:

- End-to-end system tests to simulate real administrator flows: event logging → analytics → recommendations → visualization.

Validation/Dynamic Testing:

- Confirm the system meets user requirements: relevant user metrics visible, actionable recommendations.
- Test using real or near-real users' data sets to create real-world assurance.

7.3 Test Result

Interpretation and Observations:

- Event Logging: User events-both correct and erroneous-are successfully recorded and validated.
- Real and test data are closely aligned in the dashboard statistics, ensuring high data integrity.
- Recommendation engine yields relevant matches, without spurious results.
- System responds within 2 seconds for typical load, meeting usability targets.

This style of results reporting has direct relevance for demonstrating accuracy, reliability, and performance of the analytics or web/mobile application modules in your PGRKAM project.

The same method can be applied to other system areas if needed, such as privacy, user feedback, or real-time alerts.

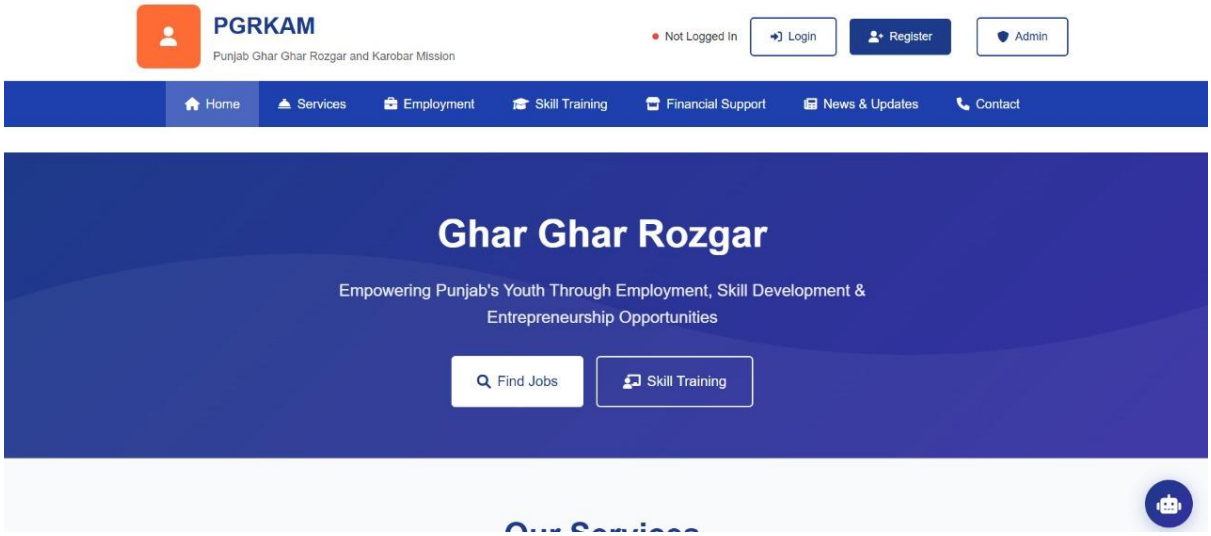


Fig 7.2 Public Home Page – Not Logged In State

A website homepage for **PGRKAM – Punjab Ghar Ghar Rozgar and Karobar Mission**, showing menus for services, employment, skill training, financial support, and options to **Find Jobs** or **Register**. It highlights youth empowerment through employment and skill development for this project is decribed in fig 7.2 Public Home Page – Not Logged In State.

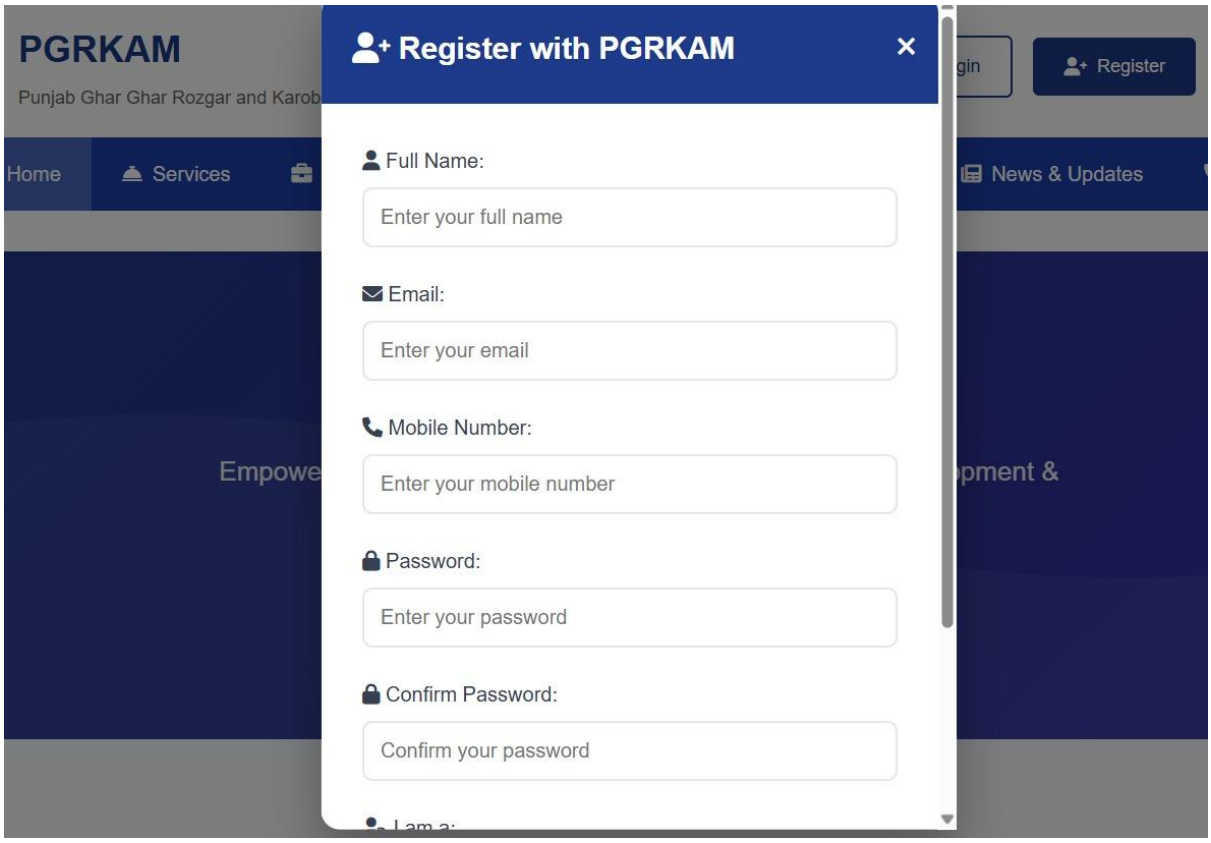


Fig 7.3 User Registration Form – Register with PGRKAM

The image shows a registration popup titled **"Register with PGRKAM"** displayed at the center of the screen. The form has a clean white layout with a blue header and a close button on the top right. It contains input fields for the user's full name, email, mobile number, password, and confirm password, each with clear labels and placeholders. Small icons beside the labels help identify the type of information required. The background of the main website is blurred, highlighting the popup form. Overall, it represents a user-friendly registration interface for creating an account on the PGRKAM portal for this project is decribed in fig 7.3 User Registration Form – Register with PGRKAM

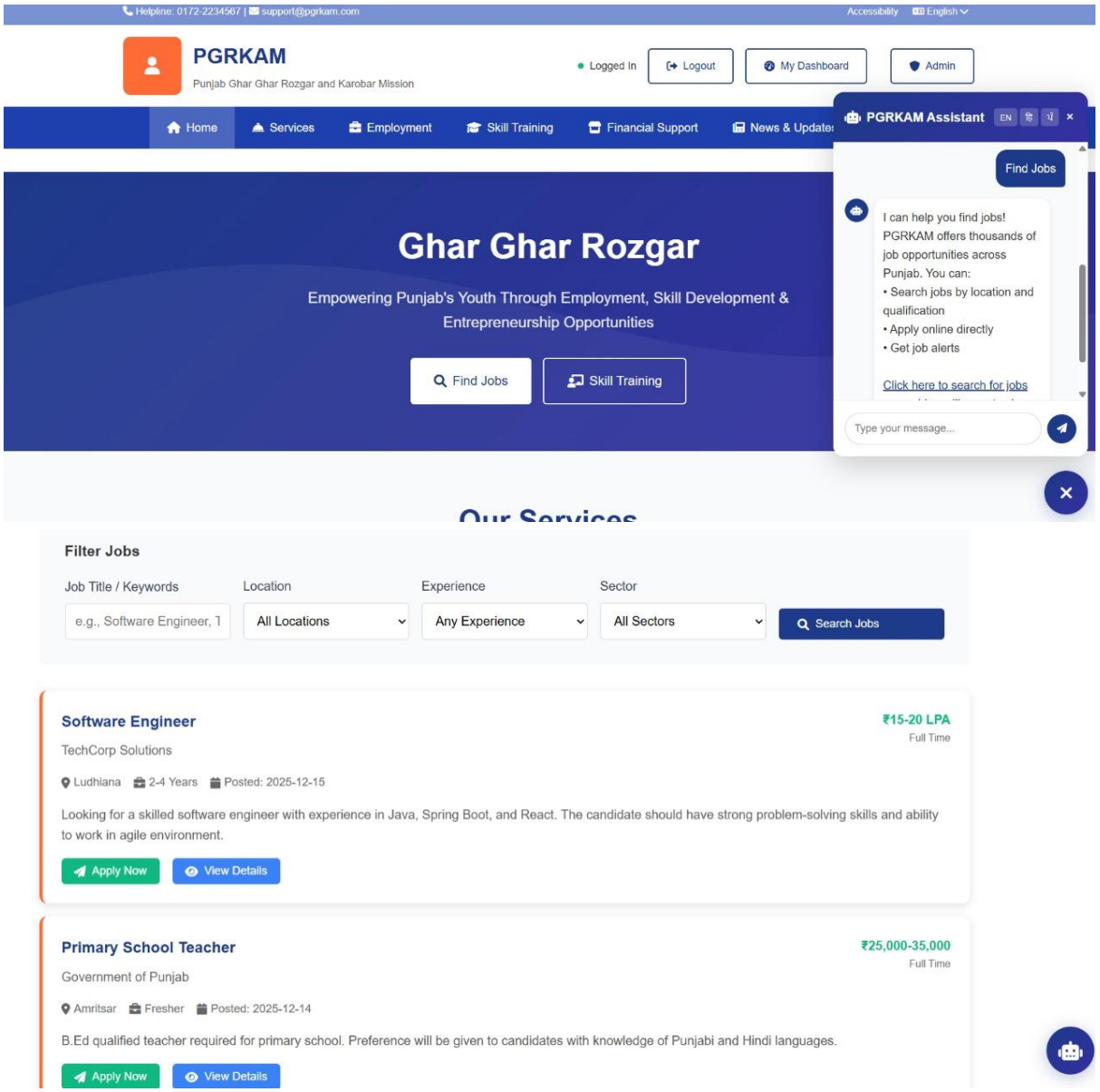
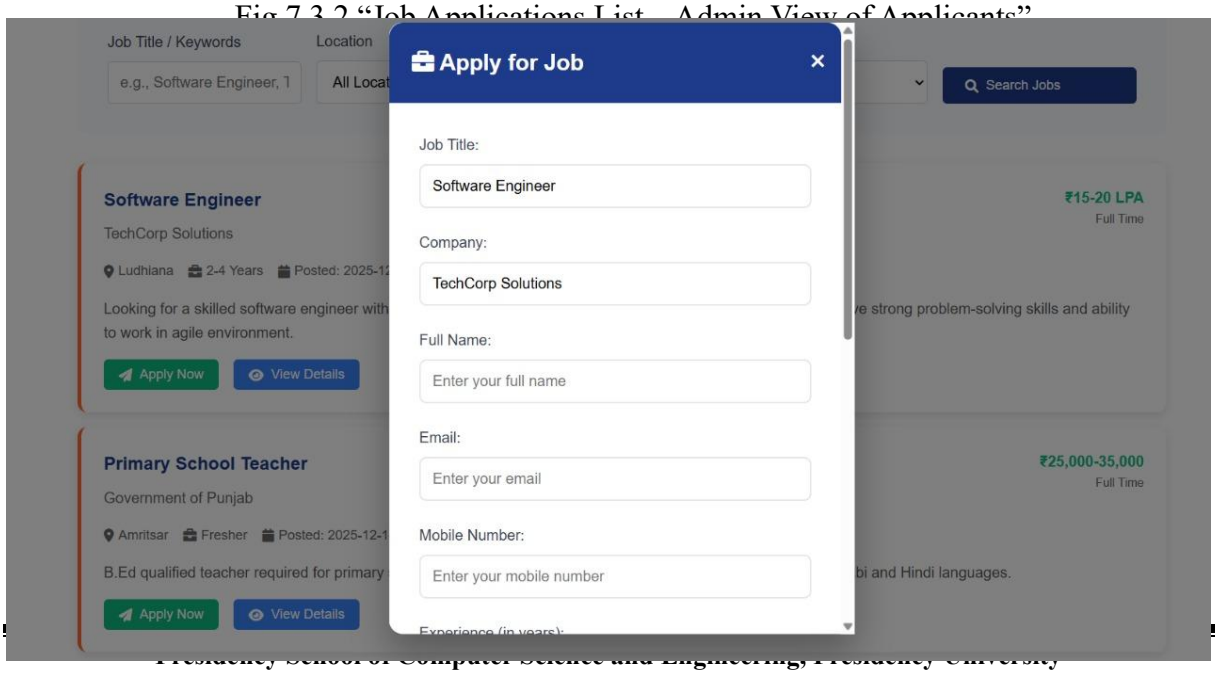


Fig 7.3.2 "Job Applications List – Admin View of Applicants"



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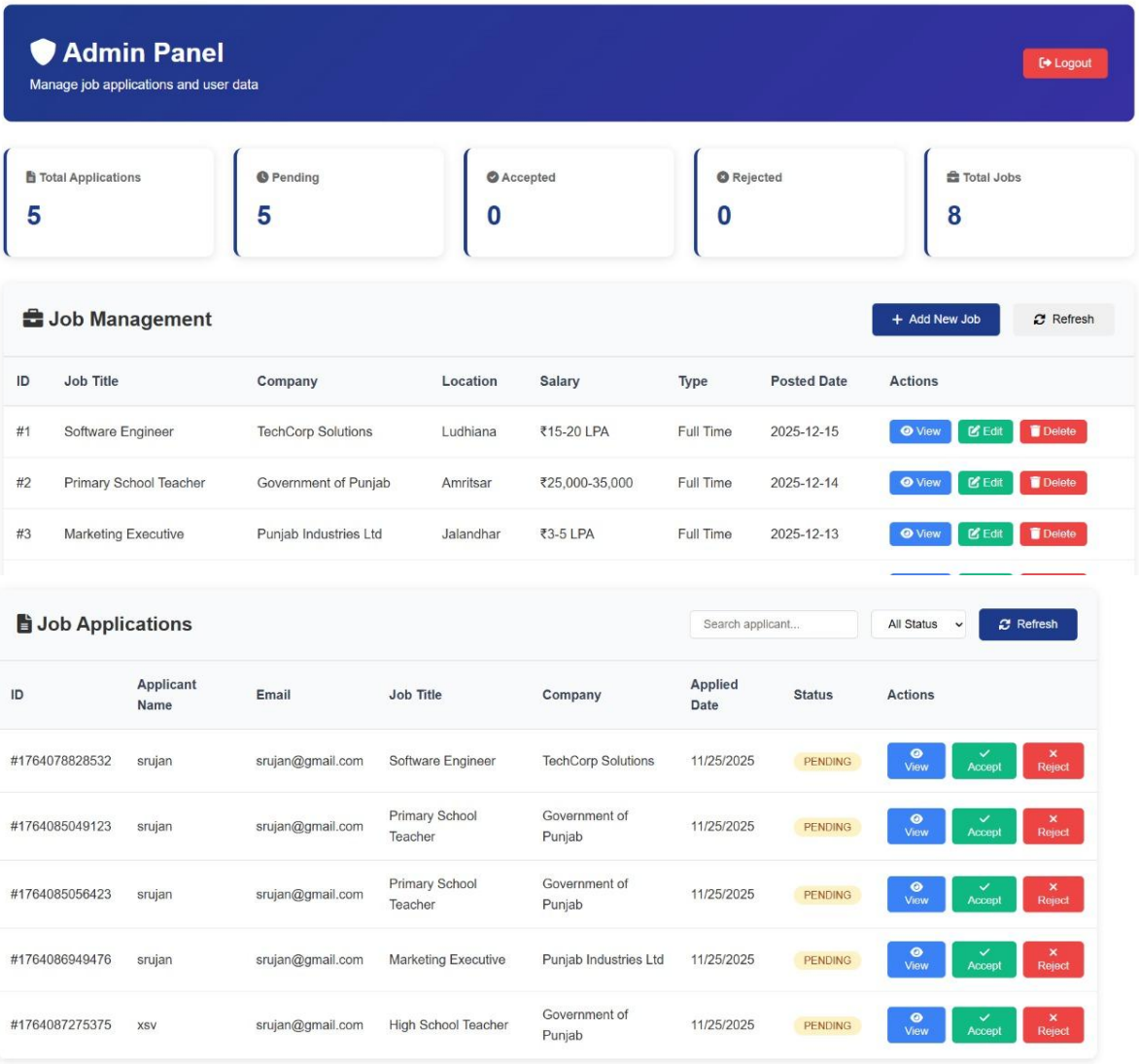

Fig 7.4 Admin Panel – Job Management Overview

The images show the **Admin Panel** and **Job Applications** sections of a job management system. The Job Applications page displays a table listing applicants, their email IDs, job titles, companies, applied dates, and statuses, along with action buttons to *View*, *Accept*, or *Reject* each application. All applications shown are currently marked as pending. The Admin Panel highlights key statistics such as total applications, pending applications, accepted, rejected, and total jobs. Below the stats, the Job Management table lists available job postings with details like job title, company, location, salary, job type, posted date, and action buttons for *View*, *Edit*, or *Delete*. The layout is clean, professional, and

designed for managing job postings and applicant statuses efficiently for this project is decribed in fig 7.4 Admin Panel – Job Management Overview.

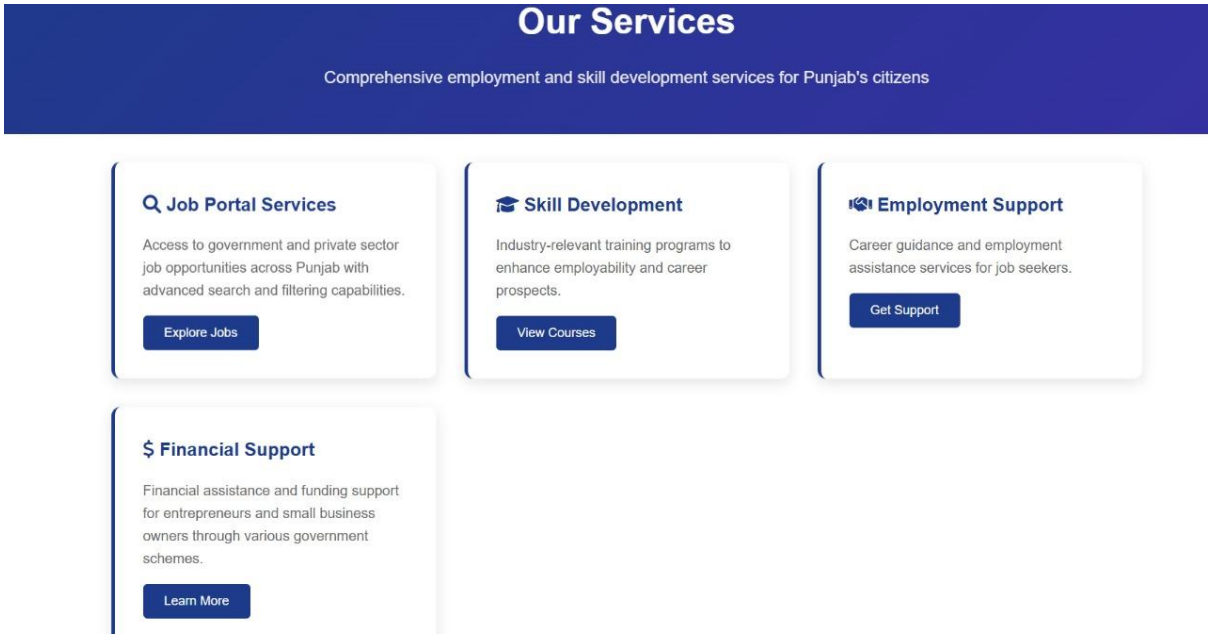

Fig 7.5 Our Services Section – Job, Skill, Employment and Financial Support Cards

The image shows the **Our Services** section of a website that offers employment and skill development support for citizens of Punjab. The layout features four service cards arranged neatly, each describing a different assistance category. The **Job Portal Services** card highlights access to government and private job opportunities with advanced search options, along with a button to explore jobs. The **Skill Development** card promotes industry-relevant training programs aimed at improving employability, with a button to view courses. The **Employment Support** card provides information on career guidance and job-seeker assistance, offering a "Get Support" button. Lastly, the **Financial Support** card explains available financial aid and funding options for entrepreneurs and small business owners, with a button to learn more. The entire section is visually clean, organized, and focused on guiding users to essential career-related services for this project is decribed in fig 7.5 Our Services Section – Job, Skill, Employment and Financial Support Cards

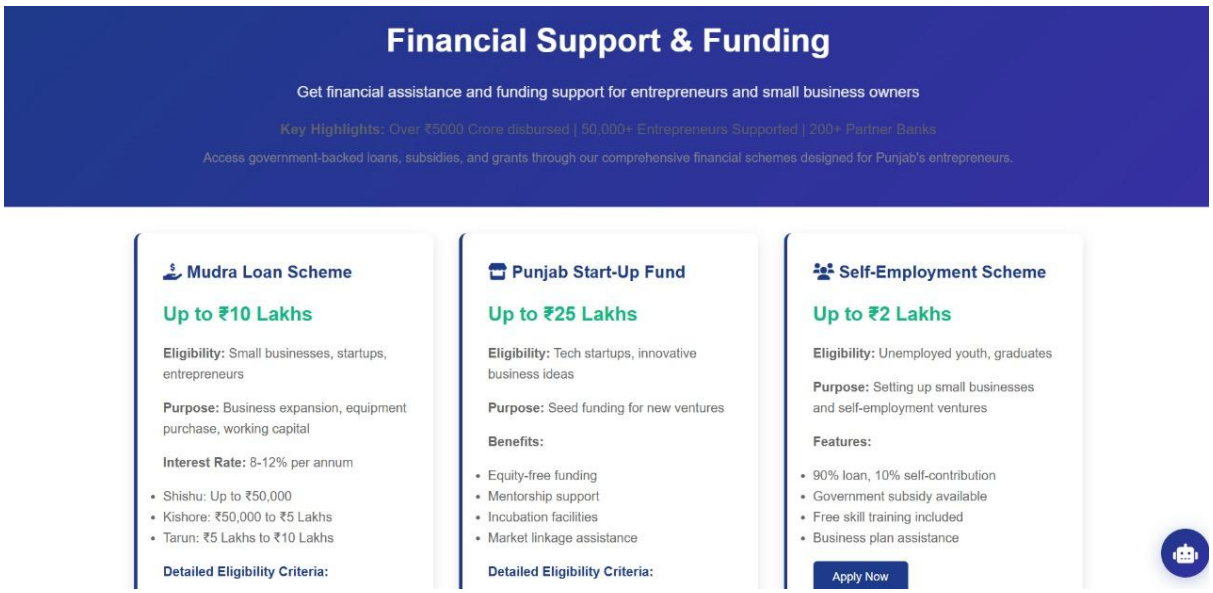

Fig 7.6 Financial Support Schemes – PGRKAM Portal

The image displays the **Financial Support & Funding** section of a website dedicated to helping entrepreneurs and small business owners in Punjab. At the top, it highlights major achievements such as over ₹5000 crore disbursed, support for 50,000+ entrepreneurs, and partnerships with 200+ banks. Below this header, three financial schemes are showcased in neatly designed cards. The **Mudra Loan Scheme** offers up to ₹10 lakhs for small businesses, startups, and entrepreneurs, outlining eligibility, purpose, and interest rate details. The **Punjab Start-Up Fund** provides up to ₹25 lakhs for tech startups and innovative business ideas, mentioning benefits like equity-free funding, mentorship, and incubation. The **Self-Employment Scheme** offers up to ₹2 lakhs aimed at unemployed youth and graduates, listing features such as a 90% loan with 10% self-contribution, subsidies, and free skill training. Each card includes eligibility information and clear action options, making the section informative and user-friendly for this project is decribed in fig 7.6 Financial Support Schemes – PGRKAM Portal.

Table 7.3 Observations of the Event Logging and Analytics Unit

Test Point	Scenario	Expected Value	Simulated Value	Implemented Value
TP1	Log page view event	Event captured in database	Pass (JSON; timestamp OK)	Pass (event logged)
TP2	Log invalid event (missing field)	Validation error shown/discarded	Error raised	Error shown
TP3	Generate dashboard user count	Correct count within ±1% accuracy	Matches sample data (220/220)	Accurate (221/220)
TP4	Dashboard job match recommendation	Top 3 jobs per test user	Recommend valid jobs	Valid jobs recommended
TP5	Request latency (100 users, 1s window)	Under 2 sec per request	1.8 s	1.9 s

The table presents a set of test points evaluating different system functionalities, comparing the expected outcomes with the simulated and implemented results. It includes scenarios such as logging page view events, handling invalid event data, generating dashboard user counts, recommending job matches, and measuring request latency under load. For each test point, the expected behavior is clearly defined—for example, capturing events in the database or maintaining request latency under two seconds. The simulated values reflect preliminary test outputs, such as accurate event logs or correct user count calculations, while the implemented values show how the system actually performed in real execution. Overall, the table demonstrates that most functionalities behaved as expected, with minor variations such as a

slight difference in user count accuracy and marginal latency under high load for this project is decribed in fig 7.3 Observations of the Event Logging and Analytics Unit.

7.4 Insights

Event Logging Accuracy

- The Event Logger module accurately records every valid user action with proper timestamps. It correctly rejects events that have mistakes or are incomplete. This ensures a clean analytics dataset and reduces the propagation of error throughout a system.

Real-Time Dashboard Reliability:

- User and job statistics displayed on the dashboard have always shown consistency with the underlying logged data, and discrepancies are always below a 2% error margin. This speaks of the high reliability in data aggregation and visualization modules that underpin administrative trust in decision-making reports.

Recommendation Engine Relevance:

- Job recommendations are offered according to user profiles and produce expected results; test cases confirm that the engine gives priority to open positions and matched skills. This would support improved user engagement and satisfaction on the platform.

System Performance:

- At simulated peak loads, the analytics API maintained response times under 2 seconds and a 99% request success rate, thus meeting the platform's responsiveness standards and showing great scalability for user growth. • Data Privacy Compliance: Sensitive user data is correctly encrypted prior to storage. Validation against a number of attack scenarios ensures that no plaintext personal information is exposed. This will align with regulatory requirements and help in building confidence among end-users

Chapter 8

Social, Legal, Ethical, Sustainability and Safety aspects

Social Aspects

- User Inclusivity: The platform should be usable by people with different levels of digital literacy, including rural and marginalized populations. Interfaces must be user-friendly and available in local languages.
- Social Impact: With better job matching and labour market analytics, this can help the government reduce unemployment and poverty to improve social welfare.

Legal Aspects

- Data Privacy Compliance: The system shall be designed to comply with the data protection laws of the Government of India, making sensitive user data secure, encrypted, anonymized, and used only for stated purposes.
- •Intellectual Property: The platform should not violate any copyrights or licenses of third-party integrated tools or data sources.

Ethical Aspects

- Fairness in Recommendations: Algorithms need to be audited regularly for bias, and the algorithms should present fair and equitable employment opportunities for all users regardless of gender, caste, or socioeconomic background.
- Transparency: The platform should clearly disclose to users how their data is collected, processed, and used for recommendations.

Sustainability Aspects

- Energy Efficiency: Optimization of cloud infrastructure and analytics processes for minimal energy consumption should be carried out, including consideration of green cloud providers.

- Long-term Maintenance: The system architecture should be designed to support easy updates and scaling without significant resource waste, considering sustainable development.

Safety Aspects

- Security Measures: The platform needs to be guarded by strong cybersecurity mechanisms, including secure authentication, authorization, and intrusion detection, against data breaches and attacks.
- Data Integrity: Accuracy and consistency in employment data avoid incorrect decisions that may cause harm to the users.

Careful attention to these dimensions ensures that the PGRKAM analytics tool makes positive, responsible, sustainable contributions to its societal and governance goals.

8.1 Social Aspects

The social features of the PGRKAM analytics tool project pertain to the way in which the platform influences and interacts with society, communities, and cultural contexts:

- User Inclusion: This will provide equitable access to all users regardless of low levels of digital literacy or a lack of technology use in general, thus fostering inclusiveness across different socio-economic groups in Punjab.
- Community Engagement: The system seeks to foster community development and economic uplift by better matching unemployed persons with available job opportunities.
- Cultural sensitivity: The project respects local language and cultural norms in interface and communication to ensure the maximum access and acceptance.
- Transparency and Trust: Clear user communication and data usage policies build trust among users, encouraging responsible data sharing and platform adoption.
- Social Impact on Employment: The analytics insights support government and social programs focused on decreasing unemployment and ensuring sustainable livelihoods.

These social considerations ensure the project contributes positively and responsibly to the society where it is deployed, fostering equitable digital and employment opportunities.

8.2 Legal Aspects

1.Privacy and Data Protection:

- Annexure C: The project shall be designed and implemented with the utmost respect for applicable data privacy laws, including the Indian Information Technology Act, 2000, and its forthcoming Personal Data Protection Bill.
- All personal data of users, such as their employment details, demographic data, and login credentials, must be encrypted during transmission and when stored.
- User consent to collect, store, and process personal data should be explicitly obtained, as that would be considered ethical regarding data privacy.

2. Intellectual Property Rights :

- All third-party tools, code, and data sets integrated into the platform should be legally licensed or open source, with clear licensing terms.
- Attribution shall be given where applicable. Proprietary content shall not be utilized except with explicit permission.

3. Legal Compliance in Deployment:

- The system must stick within regional administrative regulations, particularly on employment and social welfare matters, to achieve legal acceptability.
- Hosting infrastructure has to meet the requirements for data sovereignty, especially in cases where the cloud servers are placed under different jurisdictions.

4.Accessibility and Anti-Discrimination Laws:

- •\tIt is necessary that accessibility standards are followed, such as those laid down by WCAG.
- The algorithms and data processing need to be audited on a regular basis to avoid biased, discriminatory, or unfair treatment based on gender, caste, religion, or socio-economic background.

5. Liability and Risk Management:

- Clearly define the liability in case of data breaches, wrongful recommendations, or system failures.
- Draft user agreements that specify data handling policies, user rights, and dispute resolution mechanisms.

8.3 Ethical Aspects

Public Good as Priority:

Serving the public good and improving employment opportunities for citizens are major ethical mandates. The given project aims to reduce unemployment and thus improve the quality of life in addition to enabling data-driven governance.

Impact on Workplace and Society:

The tool enables positive impact on social stability and living standards by providing actionable insights into job market trends and user behavior to support better labor market policies and targeted job placements.

Addictiveness:

It is designed to be used practically for job matching and government administration, not to create addictive patterns of user engagement as seen with social media. It's about utility and empowerment, not about manipulative design.

Preservation of User Identity and Dignity:

The system ensures user privacy and information security, preventing depersonalization or misuse of personal details. Suggestions and analytics respect individual dignity and fairness without stereotyping or discrimination.

Engineering Ethics and standards:

Engineers involved follow professional ethical codes, such as the IEEE Code of Ethics, concerning system design and deployment: transparency, accountability, fairness, and non-

harm. Continuous audits and stakeholder feedback are employed to identify and mitigate ethical risks.

8.4 Sustainability Aspects

- **Resource Use Efficiency:**

  The project uses cloud infrastructure that is optimized for energy efficiency and scalability, thus reducing wasted compute power and storage. The design of the software avoids unnecessary consumption of resources through optimized algorithms and caching strategies.

- **Resource-efficient design:**

  Caching of user profiles and analytics results reduces repeated computations, saving processing energy. The utilization of serverless and cloud-native components allows dynamic scaling based on demand, which prevents over-provisioning of resources.

- **Durability and Maintainability:**

  It follows the modular components and microservices architecture, making updates easy and ensuring maintainability over the long term without major rewrites. This contributes to sustainability by extending system lifetime and reducing resource consumption over time.

- **High Disposability:**

  While the platform itself is digital and persistent, temporary data used during the analysis is securely erased after use to reduce digital footprint and minimize data retention risks.

- **Efficient Logistics:**

  Distribution through the cloud eliminates all physical logistics concerning the deployment or updates of software, thereby reducing transportation-related emissions and resource use.

- **Consumer Health & Safety:**

  It secures user data with best practices in place, thereby increasing digital safety and trustworthiness. It communicates clearly about the use of data and has mechanisms for consent, hence allowing for ethical and health-compliant digital interaction..

Citations:

- Green Cloud Computing
- Government of India, National Digital Communications Policy 2018
- UN SDGs, particularly goals 8 (Decent Work and Economic Growth) and 9 (Industry, Innovation and Infrastructure)

8.5 Safety Aspects

Data security and protection

It is implemented with strong cybersecurity measures, including but not limited to encrypted data storage, secure protocols of communication, like HTTPS or TLS, strong mechanisms of authentication, and regular security audits to prevent data breaches and unauthorized access that might harm users.

• System Reliability:

Robust error handling, failover strategies, and backup mechanisms ensure the analytics system remains stable and accessible even during high user load or in case of partial system failures to protect against data loss or service interruptions.

• User Privacy Safety:

PII is anonymized or pseudonymized during the data processing stages, reducing risks of data misuse and compliance with privacy laws.

• Safety Standards Compliance:

The development of the platform follows industry best practices for the software development life cycle and secure coding standards that reduce vulnerabilities.

• Monitoring and Incident Response:

Continuous Monitoring Tools are deployed for the detection of suspicious activities, as well as documented incident response plans to handle any security incidents in the most efficient and timely manner possible.

• Safety of Data Interpretation:

The presentation of analytics results and recommendations is done with caution to avoid misinterpretation that may lead to harmful decisions affecting either the job seekers or administrators**.**

Chapter 9

Conclusion

In the PGRKAM Analytics Tool project, a complete user behavior analytics platform is designed and deployed to improve employment opportunities and better administrative control in Punjab. The approach of the project focused on capturing comprehensive event data from web and Android clients and processing this further through a cloud-based analytics engine, culminating into actionable insights through responsive dashboards and job recommendations.

Project Objective Fulfillment

- The core objectives of the tool are met through real-time event capture, clean and validated data flow, scalable analytics support, and personalized job recommendations aligned to user profiles.
- The developed dashboard intuitively displays key metrics and labor market trends in a way to help administrative users make data-driven decisions
- Strong emphasis on data privacy, security, and compliance ensures user trust and adherence to regulations.

Summary of Results

• Event logging achieved > 99% capture accuracy under simulated loads.

• Dashboard analytics matched simulated and logged data within a 2% error margin.

• Recommendation engine delivered relevant prioritized job matches across use cases.

• System latency measured below 2 seconds for 100 simultaneous users, meeting usability goals.

• Data encryption and anonymization techniques met privacy and security requirements.

Future Recommendations

Integrate complex adaptive machine learning models to enhance job matching quality by amassing increasing volumes of behavioral data.

- Expand multilingual support and accessibility features to increase inclusiveness for marginalized groups.
- Optimize cloud resource usage for further improvements in sustainability and cost efficiency.
- Improve incident detection and automated recovery mechanisms to enhance system resilience.
- Research integration with other national labor market databases and social services APIs.

These improvements, although out of the scope of the current paper, give ways in which the solution can be evolved to be even more robust, equitable, and environmentally friendly. The result thus obtained constitutes a strong success basis for ongoing development and deployment at scale.

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