International Journal of
INTELLIGENT SYSTEMS AND APPLICATIONS IN ENGINEERING
ISSN:2147-6799 www.ijisae.org Original Research Paper

Intelligent Cloud Platform for Enhancing Operational Efficiency in College Management System

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Submitted: 21/11/2024 **Revised:** 28/11/2024 **Accepted:** 05/12/2024 **Published:** 19/12/2024

Abstract: As more and more educational institutions opt for cloud solutions, they encounter major issues regarding the management of a huge amount of data. The paper discusses the idea behind smart cloud systems aimed at improving the processes of data gathering, scanning, and algorithms of reports related to the governance of colleges. With the use of these tools, administrators are able to make better decisions in a shorter period of time, thus enhancing the overall productivity of the organization and its resource allocation. One of such highlights is the recent development in the area of data aggregation and its benefits in process, risk control and compliance with accreditation requirements. A review of the papers cited in this article reveals the necessity for such cloud based solutions as the educational institutions of today need to meet the requirements of the 21st century, which is characterized by the omnipresence of data.

Keywords: *Cloud Computing, Educational Technology, Data Aggregation, Risk Mitigation, Reporting Algorithms, Intelligent Cloud Platforms, College Management Systems, Data Analytics, Operational Efficiency*

1. Introduction

In the present world, institutions (Colleges) are overwhelmed with information. This new information comes from student records to activities in online courses as new technologies evolve [1]. However, this information could be incredibly helpful for making better decisions, but traditional college management systems are struggling to keep up with the increasing amount of information [2]. Badly integrated data, poor constructs, and insufficient reporting systems leave them lost in the mass of data while not taking advantage of the vast data at their disposal [3].

This is where the cloud comes into play. Cloud computing allows for remotely controlled processing and storage, enabling colleges to overcome limitations imposed by traditional systems [4]. However, simply migrating data to the cloud is insufficient. To enhance college management effectively, specialized cloud solutions that include advanced data gathering and effective reporting algorithms are required [5].

This paper proposes exactly that. We introduce an intelligent cloud platform that is suitable for college management systems. In this sense, this platform is more than just a vault; it enables institutions to integrate various systems and provides valuable output for decision-making within the institution [1].

2. Literature Survey

The trend of embracing cloud solutions in education, and more specifically within college institutions' management systems has initiated the research on Smart cloud platforms. This survey is concerned with the state-of-the-art in data collection and risk mitigation or reporting algorithms and their implementation in a college institution to improve its general processes as well as save some resources [1], [6].

The adoption of cloud computing is increasing in education rapidly particularly within the college management systems, that urged to research into the intelligent

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cloud platforms. Now this survey holds the information about the recent advancements in data aggregation and reporting algorithms, exploring their potential to enhance efficiency and diminish the risks in educational institutions which mitigate the lot work to college management systems [7], [8].

2.1. Related Work

1) **Cloud Computing in Education:** Zhang Mingjing's (2023) work focus on the pivotal role of smart campus cloud platforms in educational management. The research spotlights on significance of big data, Internet of Things (IOT), and artificial intelligence in optimizing the utilization of resource and enhancing software deployment within colleges. Mingjing found the challenges related to the data security and the drawbacks of old traditional resource management systems, supporting for a more integrated approach to data collection, handling and sharing within educational atmosphere [1], [9].
2) **Intelligent Campus Platforms:** Xie Chaoman (2022) examines the construction of smart campus cloud service platforms based on big data systems [10]. This analysis contrasts traditional service platforms with modern big data layout, illustrating how improved data aggregation capabilities lead to enhanced operational efficiencies in educational institutions. The researches tells that big data frameworks not just the enhanced resource management but also encourages problem solving through various documenting tools [10].
3) **Cloud Adoption Guidelines:** A crucial study by [11] explored the factors like network infrastructure, software projects and administrative frameworks were very crucial factors for effective cloud integration in Turkish universities. The study helped in providing guidelines for the institutions considering of all the aspects of user requirements [11].
4) **Intelligent Management Systems:** A study on the implementation of intelligent campus student information management system proves that using cloud technology in web-based applications for handling the data permits them for accessing the data and enables critical thinking which also reduces the operational risk that evolve during data processing [8], [12].
5) **Laboratory Management Systems:** A correlated study extends its focus on advancement of the cloud based laboratory information management system [13] which defines a framework for accessing the tools and methods which may be extended for larger college systems by cloud computing, which provides all the tools and maintains data privacy and security [13].

Table I. Summary of Selected Research on Cloud Computing in Education

Authors	Year	Title	Objective/Purpose	Methodology	Key Findings	Research Gap
Zhang Mingjing	2023	Smart Campus Cloud Platforms	To explore the role of big data, IoT, and AI in optimizing educational resource management.	Analysis of challenges in traditional systems and the potential of smart campus cloud solutions.	Enhanced resource utilization, better software deployment, and addressing data security challenges.	Addressing evolving data security challenges and advancing traditional frameworks.
Xie Chaoman	2022	Intelligent Campus Platforms	To examine big data-based service platforms for enhanced operational efficiencies in educational institutions.	Comparison of traditional and big data-based service platforms.	Improved data aggregation capabilities and problem-solving tools.	Developing scalable solutions for diverse institution types.
Hakan Aydin	2021	Cloud Adoption Guidelines	To identify factors critical for successful cloud integration in educational institutions.	Study of Turkish universities considering network infrastructure, administrative frameworks, and user requirements.	Guidelines for effective cloud adoption tailored to user needs.	Adapting guidelines for varied institutional requirements.
Yun Zhou & Lanbao Hou	2023	Intelligent Management Systems	To assess the impact of cloud-based web applications for data	Implementation of cloud technologies in web-based student information systems.	Improved data access, enhanced critical thinking, and reduced operational risk.	Overcoming challenges in user adoption and scaling the systems for larger setups.

			handling and decision-making in institutions.			
Renen Xie	2019	Laboratory Management Systems	To develop a framework for cloud-based laboratory information management systems.	Implementation of cloud tools focusing on privacy and data security.	Efficient tools for laboratory management and maintaining data privacy.	Extending methodologies to larger educational ecosystems while maintaining security and privacy.

The report concludes that the platforms developed provide various advanced tools and benefits which reduces the risks and also enhance efficiency of the platform. However, the evolving challenges need new techniques and methodologies for facing and them.

2.2. Problem Statement Identification

For dealing with various problems that affect efficiency and performance, colleges and various educational institutions focus on the need for integrated systems that can handle data and provide analytical reporting. It also provides key reasons for the advancement of the platforms like this to handle institutions [14].

Advancement of the regular process, which includes people adapting for a totally different methods and technologies face lot of challenges, both from owners and users. But handling and understanding the development is needed to face the problems faced by the colleges currently [1].

Traditional practices lead to inaccurate and delayed results, which can affect the institutional performance in handling challenges. The administrator require an advanced, developed fast platform for managing student data, analyzing their performance, and suggesting solutions [7].

Regarding the order of tasks, it becomes much simpler when a cloud solution is implemented on a company's dashboard, eliminating the hassle of collating and customizing data from multiple platforms. The aim of this research is to investigate barriers to sharing information, such as user involvement, fear of overload, heavy reporting requirements, and resistance to change. Addressing these fears is crucial for engaging stakeholders in adopting modern frameworks within educational institutions [15]. However, the work at hand must be transformed into schemes that build trust among educational institutions through modern frameworks [8].

3. Proposed System

This paper proposes the advanced data aggregation and reporting algorithms through dataflow pipeline in cloud computing instead of using pandas in cloud for processing.

3.1. Architecture

In this paper we are using GCP as our Cloud Infrastructure. First, use Google CloudSQL for MySQL to store and access Student Information. To process this stored large batch of data/information, we use apache-beam and then Google Cloud Dataflow will take action and manages the processing and security of the data.

To utilize the cloud computing processing effectively, here we use PCollection and PTransform to work with parallel computing. The PCollection will represent a distributed dataset in the pipeline which was read from the CloudSQL and PTransform will perform the operations like count, sum, mean, mode, median, min, max and group-by which are related to the Aggregation.

To ensure the security and privacy of data, we use encrypt tion of data both at rest and in transit, and also provided access to limited people using IAM policies in cloud computing.

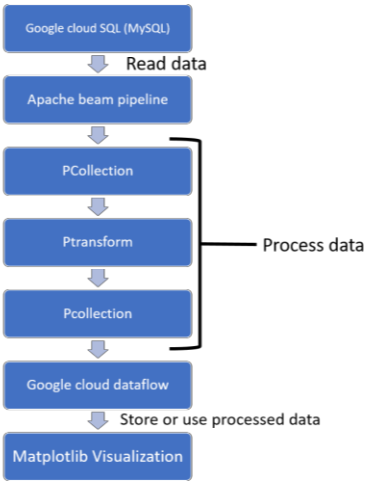

Fig 1: Dataflow Diagram

3.2. Dataset

Columns in the Database: This database stores the information like id, first name, last name, email, gender, part time job, absence days, extracurricular activities,

weekly self study hours, career aspiration, math score, history score, physics score, chemistry score, biology score, english score, geography score

This sample data is used to test our assumptions on aggregating and reporting algorithms. By using this sample data we can efficiently find that the difference between using pandas and apache-beam in cloud computing.

3.3. Algorithms

To demonstrate the difference between pandas and apache-beam, we use Aggregation and Reporting Algorithms.

Aggregation: It involves collecting, summarizing, and presenting data in a well-defined format where further decisions will be taken. In this paper we implemented the Aggregation techniques like Counting, Mean.

Counting: To create a pie chart in reporting algorithm we used counting aggregation method on career aspiration

Here is the example to perform counting method in python using apache-beam, where students is the PCollection of students data in the database.

$$average\_career\_aspiration = (\ students$$
$$| 'ExtractCareerAspiration' \gg beam.Map(lambda\ student: student['career\_aspiration'])$$
$$| 'CountCareerAspirations' \gg beam.combiners.Count.PerElement()$$
$$)$$

Mean: To create a histogram on students percentage we used mean aggregation method on scores on different subjects.

Reporting: It involves in using the data from Aggregation and creating/visualizing the graphs from the data. These reporting algorithms will be used to visualize the data and creates story from it.

4. Results

Here, as part of testing we had created reports that visualize the percentage of students and career aspiration of students.

A colorful pie chart (fig 2) showed us the dream jobs of the students. We found that ”Software Engineer was the most popular career choice, with many students also aspiring to become Business Owner and Unknown.” This gives us a sense of their motivations and future goals.

A histogram (fig 3) was generated to visualize the overall performance of students in their tests.

Table II. Summary of Beam and Pandas Calculation Times and Memory Usage

Run	Beam Calculation Time (Sec)	Beam Memory Usage (MB)	Pandas Calculation Time (Sec)	Pandas Memory Usage (MB)
1	1.2709941864013672	202.53125	1.5752382278442383	383 253.26171875
2	1.2081716060638428	428 202.75390625	1.5660371780395508	508 253.4765625
3	0.8524208068847656	202.9140625	1.5461232662200928	928 253.4140625
4	0.841616153717041	202.84765625	1.5441522598266602	602 253.44140625
5	1.2117323875427246	202.71875	1.4607224464416504	504 253.30859375
...	...	...	..	...
30	0.9194591045379639	202.80078125	1.4137272834777832	250.171875

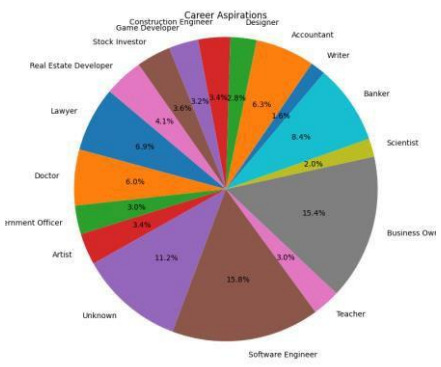

Fig 2: Pie Chart Generated by apache-beam

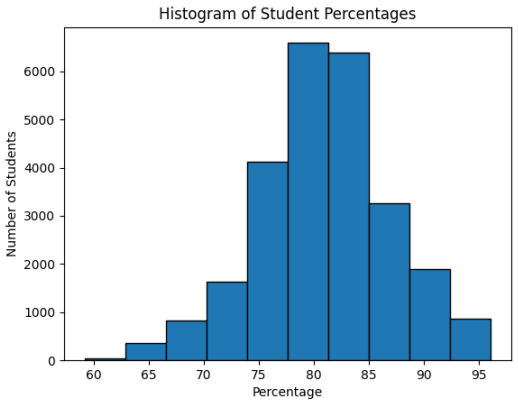

Fig 3: Histogram Generated by apache-beam

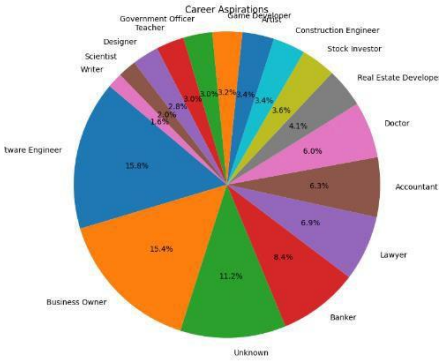

Fig 4: Pie Chart Generated by pandas

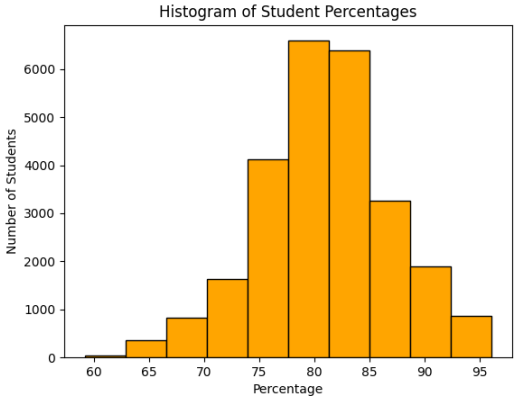

Fig 5: Histogram Generated by pandas

5. Comparision

The following data points were recorded during multiple runs of the script (TABLE I): Total Runs: 30

Analysis

5.1 Calculation Time:Beam

• *Minimum Time:* 0.4963960647583008 seconds

• *Maximum Time:* 1.2879023551940918 seconds

• *Average Time:*

$$\text{Average} = \frac{Sum\ of\ all\ Beam\ \ Times}{30}$$

$$\approx \frac{29.509}{30}$$

$$\approx 0.9836 \text{ seconds}$$

Pandas

• *Minimum Time:* 1.318202018737793 seconds

• *Maximum Time:* 1.6215662956237793 seconds

• *Average Time:*

$$\text{Average} = \frac{Sum\ of\ all\ Beam\ \ Times}{30}$$

$$\approx \frac{45.059}{30}$$

$$\approx 1.50197 \text{ seconds}$$

5.2 Memory Usage:

Beam

• *Minimum Memory:* 202.53125 MB

• *Maximum Memory:* 203.1875 MB

• *Average Memory:*

$$\text{Average} = \frac{Sum\ of\ all\ Beam\ \ \ Memories}{30}$$

$$\approx \frac{6077.6875}{30}$$

$$\approx 202.58958 \text{ MB}$$

Pandas

• *Minimum Memory:* 250.171875 MB

• *Maximum Memory:* 253.97265625 MB

• *Average Memory:*

$$\text{Average} = \frac{Sum\ of\ all\ \ Beam\ Memories}{30}$$

$$\approx \frac{7594.84375}{30}$$

$$\approx 252.99479 \text{ MB}$$

6. Conclusion

Our analysis reveals that Apache Beam offers a significant performance advantage over Pandas in terms of processing speed. On average, Beam operations were completed in approximately 0.98 seconds, while Pandas operations took around 1.50 seconds. This indicates that Beam is considerably faster for the tasks examined.

In terms of memory usage, both frameworks exhibited relatively stable resource consumption. Beam consistently used an average of around 202 MB of memory, while Pandas utilized slightly more, averaging approximately 253 MB. This suggests that while Pandas requires slightly more memory, both frameworks are generally efficient in their resource utilization.

7. Future Work

This paper proposes only the Aggregation and Reporting algorithms and to extend this we can use the machine learning models to predict student performance, and identify potential dropout risks from courses. Implement Real-Time Analytic capabilities to enhance the efficiency of models in the prediction.

Design and implement user-interface to enhance the experience of users. Focus on encryption and decryption to protect the data from various threats.

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