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Optimizing Data Capture and Storage for Research Data Management: A Study on Cloud Computing Solutions in Academic Institutions

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Abstract. The increasing volume of research data generated by academic institutions necessitates effective data management strategies to ensure data accessibility, security, and long-term preservation. This study explores the optimization of data capture and storage for research data management, focusing on cloud computing solutions within academic settings. A systematic literature review was conducted, examining studies from the past five years sourced from reputable databases such as IEEE, Springer, and Elsevier. Thematic analysis was employed to identify key trends, challenges, and best practices related to data management, cloud technologies, and storage optimization. The results of a bibliometric analysis indicated a significant upward trend in publications addressing Data Management, Cloud Computing, and Research Data Storage between 2009 and 2023, with a notable peak in 2023. Findings revealed that while cloud computing platforms offer significant advantages—such as scalability, cost-efficiency, and enhanced collaboration—challenges related to data standardization, security, and interoperability persist. Furthermore, the study highlights the growing importance of automated data capture techniques and metadata tagging in managing large datasets. Despite the transformative potential of cloud-based solutions, optimization efforts remain necessary to fully realize their benefits for research purposes. This research underscores the need for future empirical studies to test cloud solutions in real-world academic contexts and develop standardized, secure, and efficient practices for research data management. Optimizing cloud computing solutions is crucial for enabling academic institutions to meet the demands of the evolving digital research environment.

Keywords: Data Management, Cloud Computing, Research Data Storage.

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1. Introduction

The management of research data is becoming increasingly complex as academic institutions generate large volumes of data across various disciplines. Effective data management ensures that data is collected, organized, stored, and made accessible in a secure and efficient manner [1]. Among the most promising solutions for handling such data challenges is cloud computing, which offers scalable and cost-efficient infrastructures for storing and managing research data [2]. Research data storage is a critical component of this process, enabling academic institutions to securely store vast amounts of data while maintaining accessibility for further analysis and sharing [3]. Cloud computing platforms, by offering robust storage solutions, provide flexibility and enhanced collaboration opportunities in research environments [4]. However, as the demand for larger data storage increases, the optimization of data capture and storage systems in academic institutions remains an ongoing challenge [5].

Previous studies have explored various aspects of data management and cloud computing in academic institutions. Universities are increasingly adopting cloud-based storage solutions to support research activities and enable easy access to data across multiple platforms [6]. Cloud computing also enhances data security and facilitates collaboration between researchers from different institutions [7]. In addition, efficient data management practices are needed to ensure that research data is properly stored and easily retrievable for future use [8].

Several studies have examined cloud-based solutions in the context of higher education, emphasizing the importance of scalable storage systems in accommodating the growing volume of research data [9]. Cloud computing platforms offer better disaster recovery options compared to traditional on-premise storage systems [10]. As cloud storage technology continues to evolve, it provides more opportunities to optimize research data management [11]. Techniques such as automated data capture and metadata tagging are also being explored to simplify the management of large datasets [12]. However, despite these advancements, several challenges remain in optimizing cloud computing for research purposes. Many studies have primarily focused on the technical aspects of cloud storage without addressing the specific needs of research data capture and storage in academic institutions [13]. Although some studies provide insights into the integration of cloud solutions, they often lack comprehensive strategies for long-term research data preservation.

Additionally, although cloud solutions provide cost-effective storage, they often lack standardization and interoperability, which can be a barrier to their widespread adoption in academia [14]. Moreover, research on data optimization techniques that balance cost, efficiency, and security is still limited, particularly within academic research institutions. This paper aims to address these gaps by focusing on the optimization of data capture and storage practices for research management, with an emphasis on cloud computing solutions in academic settings.

The objective of this research is to explore the ways in which cloud computing solutions can be optimized for managing research data in academic institutions. Specifically, the research aims to evaluate various cloud platforms and data storage strategies to identify best practices for optimizing data capture, accessibility, and security in research contexts. The research will employ a mixed-methods approach, combining qualitative interviews with academic staff and quantitative analysis of cloud computing performance metrics to assess storage solutions. The study will also analyze the challenges faced by institutions in adopting cloud technologies and propose strategies to overcome these challenges. Ultimately, the

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research seeks to provide actionable recommendations for improving research data management in academic settings through the effective use of cloud computing solutions.

2. Method

This study adopts a qualitative research approach to explore the optimization of data capture and storage for research data management through cloud computing solutions in academic institutions. Data collection involves a comprehensive literature review focusing on studies from the past five years, sourced from databases like Google Scholar, Scopus, and Web of Science. Relevant articles, conference papers, and industry reports from reputable publishers such as IEEE, Springer, and Elsevier are selected based on keywords like data management, cloud computing, and research data storage. Additionally, case studies of academic institutions that have implemented cloud solutions are reviewed to provide practical insights.

For data analysis, thematic analysis is used to identify patterns, challenges, and benefits of cloud computing for research data management. The analysis focuses on three main areas: data capture techniques and automation, cloud technologies in academic settings, and challenges faced in adopting cloud solutions. This study, limited to a literature review without experimental testing, aims to provide a foundation for future empirical research. While focusing on academic institutions, the findings may also offer insights for other sectors requiring large-scale data management with cloud technologies.

3. Results and Discussion

Bibliometric analysis was conducted to understand the trend of publications related to topics of *Data Management*, *Cloud Computing*, and *Research Data Storage* over the period from 2009 to 2023. See Figure 1 for the distribution of documents per year based on the Scopus database search.

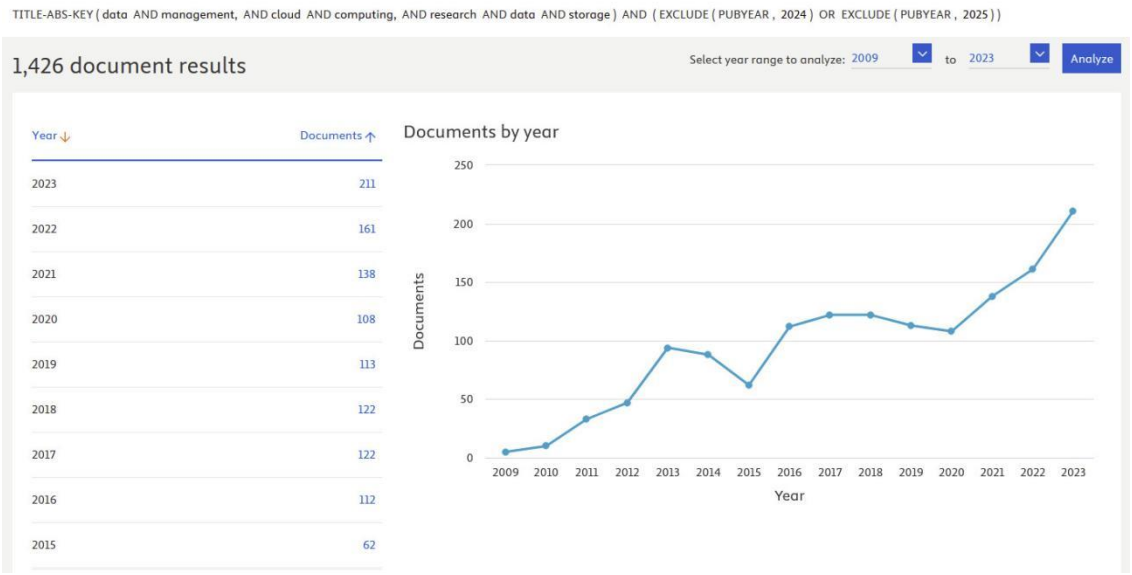

Figure 1. Publication of Research Data Management (2009-2023).

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As depicted in Figure 1, the number of publications addressing topics of Data Management, Cloud Computing, and Research Data Storage has shown a significant upward trend from 2009 to 2023. In 2009, there were almost no publications, but a gradual increase began in 2010 with a slight rise to approximately 10 documents. This growth continued steadily, reaching around 50 documents by 2012. A sharp rise was observed between 2012 and 2013, where the number of publications nearly doubled, indicating growing interest in these research areas. From 2013 to 2016, the trend stabilized at around 90 to 110 publications per year, although a minor dip occurred in 2015, where only 62 documents were recorded.

The period between 2017 and 2020 saw consistent publication outputs, with around 108 to 122 documents annually, suggesting a steady academic focus during these years. A noticeable escalation occurred in 2021 with 138 publications, followed by a substantial increase in 2022 with 161 documents. The most significant surge happened in 2023, where the number of related publications peaked at 211 documents, marking the highest record within the observed period. This data clearly indicates an accelerating momentum and heightened scholarly attention towards the strategic roles of data management, cloud-based solutions, and efficient research data storage infrastructures.

In the bibliometric analysis section, various data from Scopus related to research on the topics of Data Management, Cloud Computing, and Research Data Storage are presented. To support the understanding of data classification and management strategies, a visual representation is provided (see Figure 2).

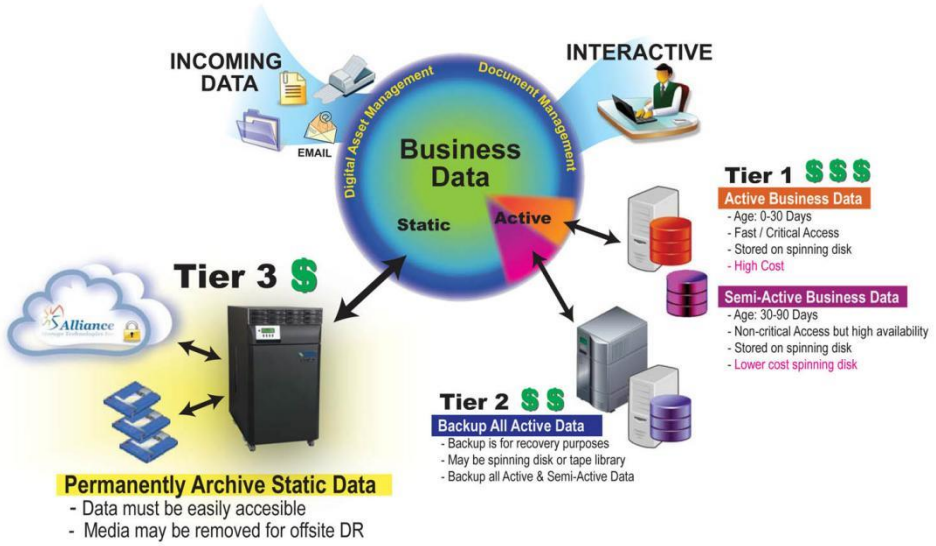

Figure 2. Storage Optimization.

Figure 2 illustrates a tiered data storage model designed to efficiently manage business data by categorizing it into different tiers based on usage patterns and cost considerations [15]. Incoming data, such as emails and documents, flow into the central repository of Business Data, which is divided into Static and Active data.

Active data is further categorized into Tier 1 and Tier 2. Tier 1 ($$$) encompasses Active Business Data, which is typically 0–30 days old, requires fast or critical access, is stored on

high-performance spinning disks, and incurs high costs. Semi-Active Business Data, aged 30–90 days, also resides in Tier 1 but requires non-critical access with high availability and is stored on lower-cost spinning disks. Tier 2 ($$) is responsible for backing up all active data, serving recovery purposes. Storage in this tier can involve either spinning disks or tape libraries, encompassing backups for both active and semi-active business data. Meanwhile, Tier 3 ($) addresses the need to permanently archive static data. This data must be easily accessible for business or regulatory needs, and the media may be removed for offsite disaster recovery purposes. The figure shows the use of cloud storage solutions and physical tape libraries for this tier, emphasizing cost efficiency and long-term retention.

This layered approach provides a structured and cost-effective framework for managing the lifecycle of business data, ensuring fast access to recent data while securely archiving older, less frequently accessed information.

4. Conclusion

This study explores the optimization of data capture and storage for research data management, with a focus on cloud computing solutions in academic institutions. The bibliometric analysis indicates a steady increase in scholarly attention towards data management, cloud computing, and research data storage from 2009 to 2023, highlighting their growing importance. While cloud computing offers benefits like scalability, cost-efficiency, and collaboration, challenges in data standardization, security, and interoperability hinder its full adoption. The research, combining a systematic literature review and thematic analysis, identifies key patterns and gaps, emphasizing the need for further optimization in data capture techniques, automation, and standardized storage. Future research should test cloud-based solutions in academic settings to address current limitations and enhance cloud computing's role in managing the complexity of research data.

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