

Distributed, Concurrent, and Independent Access to Encrypted Cloud Databases

Luca Fanetti, Michele Colajanni, and Mirco Marchetti

Abstract—Placing critical data in the hands of a cloud provider should come with the guarantee of security and availability for data at rest, in motion, and in use. Several alternatives exist for storage services, while data confidentiality solutions for the database as a service paradigm are still immature. We propose a novel architecture that integrates cloud database services with data confidentiality and the possibility of executing concurrent operations on encrypted data. This is the first solution supporting geographically distributed clients to connect directly to an encrypted cloud database, and to execute concurrent and independent operations including those modifying the database structure. The proposed architecture has the further advantage of eliminating intermediate proxies that limit the elasticity, availability, and scalability properties that are critical in cloud-based solutions. The efficacy of the proposed architecture is evaluated through theoretical analyses and extensive experimental results based on a prototype implementation subject to the TPC-C standard benchmark for different numbers of clients and network latencies.

Index Terms—Cloud, security, confidentiality, SecureDBaaS, database

1 INTRODUCTION

In a cloud context, where critical information is placed in infrastructures of untrusted third parties, ensuring data confidentiality is of paramount importance [1], [2]. This requirement imposes clear data management choices: original plain data must be accessible only by trusted parties that do not include cloud providers, intermediaries, and, inherent in any untrusted context, data must be encrypted. Satisfying these goals has different levels of complexity depending on the type of cloud service. There are several solutions ensuring confidentiality for the storage as a service paradigms (e.g., [3], [4], [5]), while guaranteeing confidentiality in the database as a service (DBaaS) paradigm [6] is still an open research area. In this context, we propose SecureDBaaS as the first solution that allows cloud tenants to take full advantage of DBaaS qualities, such as availability, reliability, and elastic scalability, without exposing unencrypted data to the cloud provider.

The architecture design was motivated by a threefold goal: to allow multiple, independent, and geographically distributed clients to execute concurrent operations on encrypted data, including SQL statements that modify the database structure; to preserve data confidentiality and consistency at the client and cloud level; to eliminate any intermediate server between the cloud client and the cloud provider. The possibility of combining availability, elasticity, and scalability of a typical cloud DBaaS with data confidentiality is demonstrated through a prototype of

SecureDBaaS that supports the execution of concurrent and independent operations to the remote encrypted database from many geographically distributed clients as in any unencrypted DBaaS setup. To achieve these goals, SecureDBaaS integrates existing cryptographic schemes, isolation mechanisms, and novel strategies for management of encrypted metadata on the untrusted cloud database. This paper contains a theoretical discussion about solutions for data consistency issues due to concurrent and independent client accesses to encrypted data. In this context, we cannot apply fully homomorphic encryption schemes [7] because of their excessive computational complexity.

The SecureDBaaS architecture is tailored to cloud platforms and does not introduce any intermediary proxy or broker server between the client and the cloud provider. Eliminating any trusted intermediate server allows SecureDBaaS to achieve the same availability, reliability, and elasticity levels of a cloud DBaaS. Other proposals (e.g., [8], [9], [10], [11]) based on intermediate server(s) were considered impracticable for a cloud-based solution because any proxy represents a single point of failure and a system bottleneck that limits the main benefits (e.g., scalability, availability, and elasticity) of a database service deployed on a cloud platform. Unlike SecureDBaaS, architectures relying on a trusted intermediate proxy do not support the most typical cloud scenario where geographically dispersed clients can concurrently issue read/write operations and data structure modifications to a cloud database.

A large set of experiments based on real cloud platforms demonstrate that SecureDBaaS is immediately applicable to any DBaaS because it requires no modifications to the cloud database services. Other studies where the proposed architecture is subject to the TPC-C standard benchmark for different numbers of clients and network latencies show that the performance of concurrent read and write operations not modifying the SecureDBaaS database

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Lee, Reinhard Klette, Ching-Hsien Hsu**

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Cloud Computing Nick Antonopoulos, Lee Gillam, 2017-06-02 This practically focused reference presents a comprehensive overview of the state of the art in Cloud Computing and examines the potential for future Cloud and Cloud related technologies to address specific industrial and research challenges This new edition explores both established and emergent principles techniques protocols and algorithms involved with the design development and management of Cloud based systems The text reviews a range of applications and methods for linking Clouds undertaking data management and scientific data analysis and addressing requirements both of data analysis and of management of large scale and complex systems This new edition also extends into the emergent next generation of mobile telecommunications relating network function virtualization and mobile edge Cloud Computing as supports Smart Grids and Smart Cities As with the first edition emphasis is placed on the four quality of service cornerstones of efficiency scalability robustness and security [DRHA2014 Proceedings / Full Papers](#)

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Computer-Aided Architectural Design: The Next City - New Technologies and the Future of the Built Environment Gabriela Celani, David Moreno Sperling, Juarez Moara Santos Franco, 2015-06-15 This book constitutes the refereed proceedings of the 16th International Conference on Computer Aided Architectural Design Futures CAAD Futures 2015 held in S o Paulo Brazil in July 2015 The 33 revised full papers presented were carefully reviewed and selected from 200 submissions The papers are organized in topical sections on modeling analyzing and simulating the city sustainability and performance of the built space automated and parametric design building information modelling BIM fabrication and materiality shape studies

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skills and more skills that administer and manage information Bill Gates was recently quoted How you gather manage and use information will determine whether you win or lose Cloud Computing impacts will be broad and pervasive applying to public and private institutions alike Internet of Vehicles. Technologies and Services for Smart Cities Sheng-Lung Peng,Guan-Ling Lee,Reinhard Klette,Ching-Hsien Hsu,2017-11-20 This book constitutes the proceedings of the 4th International Conference on Internet of Vehicles IOV 2017 held in Kanazawa Japan in November 2017 The 19 papers presented in this volume were carefully reviewed and selected from 40 submissions They deal with advances in the state of the art and practice of the IoV architectures protocols services and applications as well as identifying emerging research topics and define the future directions of Internet of Vehicles *Human-Computer Interaction. User Interface Design, Development and Multimodality* Masaaki Kurosu,2017-06-28 The two volume set LNCS 10271 and 10272 constitutes the refereed proceedings of the 19th International Conference on Human Computer Interaction HCII 2017 held in Vancouver BC Canada in July 2017 The total of 1228 papers presented at the 15 colocated HCII 2017 conferences was carefully reviewed and selected from 4340 submissions The papers address the latest research and development efforts and highlight the human aspects of design and use of computing systems They cover the entire field of Human Computer Interaction addressing major advances in knowledge and effective use of computers in a variety of application areas The papers included in this volume cover the following topics HCI theory and education HCI innovation and technology acceptance interaction design and evaluation methods user interface development methods tools and architectures multimodal interaction and emotions in HCI

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