Literature Review

How are Database Management Systems being used to support the emerging technologies of Blockchain, Artificial Intelligence, and Chatbots?

BA VIET ANH (HENRY) NGUYEN

I. Introduction

In an era where data is considered as the new oil in the world, Database Management Systems (DBMS) have become an essential part of modern technology, improving the efficiency in storage, retrieval, and management of huge amounts of data. As the world becomes increasingly data-driven, the role of Database Management Systems in supporting the emerging technologies in numerous industries has become increasingly crucial. From traditional relational databases to modern NoSQL databases, Database Management Systems are continually improving and evolving to not only handle the increasing complexity and volume of data, but also meet the needs of organization.

Blockchain, a decentralized and distributed digital ledger technology, has significantly gained vast amounts of attention in recent years for its potential applications in various industries such as finance, supply chain management, …etc.… (Zheng et al., 2017). Artificial Intelligence (AI), on the other hand, has considerably changed and revolutionized the way we interact with technology, enabling machines to perform tasks which were once thought to be exclusive to humans (Russell & Norvig, 2020). Chatbots, a form of conservational AI, has become increasingly prevalent in customer service and communication by providing personalized responses in a few seconds (Shawar & Atwell, 2007). All these technologies have one similarity, which is generating significant amounts of data and requiring sophisticated methods for managing the data.

The integration of Database Management Systems with these emerging technologies has the huge potential to unlock new possibilities and improve their capabilities, security, and scalability. Blockchain technology needs databases that can handle numerous distributed ledgers and make sure data is

immutable (Swan, 2015; Zheng et al., 2018). AI applications demand high-speed data processing and multiple complex queries (Russell and Norvig, 2020; Stonebraker et al., 2018). Chatbots rely on databases to access and query user-specific information quickly, ensuring seamless interaction (Shawar and Atwell, 2007; Adamopoulou and Moussiades, 2020).

The goal of this literature review is to analyze and explore how Database Management Systems are being utilized to support the emerging technologies of Blockchain, Artificial Intelligence (AI), and Chatbots. The review describes, summarizes, evaluates, and clarifies the current state of research in this area, focusing primarily on peer-reviewed research papers.

II. Database Management Systems (DBMS) and Blockchain

Blockchain technology, with its decentralized and distributed nature, has totally presented new challenges for traditional management systems (DBMS). Blockchain networks rely on a shared, immutable ledger to record thousands of transactions, which differs significantly from the centralized data storage approach of conventional DBMS.

Storing and managing blockchain data faced several significant challenges that Database Management Systems could be used to support Blockchain technology. One of the primary challenges of Blockchain in storing and managing data is that the continuous addition of blocks to the blockchain results in ever-growing data volumes, necessitating scalable storage solutions. Advanced Database Management Systems are used in this situation to solve this problem by offering scalable storage architectures that can probably handle the

large datasets efficiently. Technologies such as sharding and distributed databases will distribute the load across multiple servers that allows DBMS to better manage large volume of blockchain data (Zheng et al., 2018). Moreover, Zheng et al. (2018) had proposed a hybrid blockchain – DBMS architecture that combines the benefit of both technologies. In this approach, DBMS can be used to store the non-transactional data associated with blockchain, such as user profiles, contract code, and other metadata to offload the storage burden from the blockchain network, allowing it to completely focus on the core transaction processing and consensus mechanisms (Zheng et al., 2018).Secondly, another key challenge is the requirements of high-speed transaction processing and low latency to efficiency and user satisfaction. Blockchain networks typically provide limited querying capabilities, making it challenging to perform complex data analysis and reporting. DBMS are optimized in the most modern way for high-throughput data processing and include efficient indexing mechanisms. These features will be able to support the rapid insertion and querying of blockchain transactions, making sure the system always response (Androulaki et al., 2018). By integrating DBMS, users can leverage advanced indexing and querying techniques to extract insights from the blockchain data (Xu et al., 2019). Thirdly, Blockchain's data is totally immutable so that once transaction is recorded in the systems, it can not be altered or deleted. Database Management Systems might implement write-once, read-many (WORM) storage mechanisms to ensure data remains unaltered. Some DBMS models having append-only storage will align well with Blockchain's immutable ledger requirements (McConaghy et al.,2016). Fourthly, ensuring data consistency across distributed nodes is also a challenge and crucial in a decentralized blockchain environment. To deal with this challenge, DBMS can utilize consensus algorithms, such as Byzantine Fault Tolerance (BFT) and Paxos, to

maintain data consistency across nodes. These algorithms make sure that all copies of the blockchain data are synchronized, even in the presence of networks partitions or node failures (Swan, 2015). Finally, Blockchain systems must protect against unauthorized access and ensure transaction data privacy and robust security measures. Database Management Systems incorporate advanced cryptographic techniques, robust access control mechanisms, backup, and recovery mechanisms to protect data integrity and confidentiality.

The financial services industry is one real-world use for DBMS in supporting blockchain technology. To improve transaction privacy and throughput, JP Morgan's Quorum blockchain platform, for instance, mixes Ethereum with traditional DBMS. Quorum manages off-chain data by integrating with SQL databases and using Constellation, a secure messaging and transaction management layer. This allows Quorum to take advantage of the advantages of both DBMS's effective data management and the decentralized ledger of blockchain (JP Morgan, 2016)

Database Management Systems have many benefits when integrating with Blockchain but still exist some limitations. Traditional DBMS may not fully handle the decentralized and immutable nature of blockchain data. Complexity and overhead may be added when integrating DBMS with blockchain, especially when it comes to ensuring data consistency between dispersed nodes. Furthermore, DBMS performance may be strained by consensus techniques like Proof of Work (PoW), which raises issues with scalability and efficiency (Zheng et al., 2018).

III. Database Management Systems (DBMS) and AI

The rapid advancement of Artificial Intelligence (AI) has changed the way we interact with technology and process data. The role of database management systems in supporting the storage, management, and preprocessing of the large and complex datasets in AI is extremely important.

DBMS play an important role in AI by providing the necessary infrastructure for data management. AI requires large amounts of data to learn and make accurate predictions or decisions. DBMS can facilitate the storage, retrieval, and preprocessing of this data, ensuring that it is always available and in the appropriate format for the AI algorithm to use (Elmasri & Navathe, 2016).

One of the key functions of DMBS in AI is data processing. AI models always require clean, structured, and normalized data for efficient performance. DBMS can take part in preparing the data for model training and deployment by providing tools and techniques for data cleaning, transformation, and feature engineering (Doan et al., 2012).

Furthermore, AI applications generate and need access to large datasets which must be stored and can be retrieved quickly. DBMS provides scalable storage solutions that can easily handle large volumes of structured and unstructured data. Technologies such as columnar storage and distributed databases ensure that the data is stored correctly and can be accessed quickly to improve the performance of AI applications (Pavlo et al., 2017). Finally, DBMS could ensure data consistency, integrity, and security. They support concurrent access in order that AI model can process to read and write data simultaneously without conflicts and have the available data at right time for training and inference.

Several research studies have explored the integration of DBMS with AI systems. For example, Amazon Redshift and SageMaker, allow data scientists to process and store data in Redshift then use SageMaker to build and train AI models. These combinations absolutely highlight the role of DBMS in supporting AI ecosystems (Chung et al., 2018).

Despite the benefits of integrating DBMS with AI applications, there remains some limitations. Managing unstructured data such as text, image, and multimedia, which is so important for AI but not well-supported by conventional DBMS which is designed for centralized and structured data (Elmasri & Navathe, 2016). Additionally, the requirements of real-time and low latency might bring challenges to traditional DBMS.

IV. Database Management Systems (DBMS) and Chatbots

Chatbots, a form of conversational AI, have become increasingly prevalent in numerous industries such as customer service, and technology. Chatbots rely heavily on DBMS to store, manage, and retrieve huge amounts of data for their operation.

One of the typical roles of DBMS in Chatbots is that DBMS helps store and manage conversational data. DBMS often engage in dialogues with users, generating a continuous stream of textual exchanges, user profiles, and other related data (Shawar & Atwell, 2007). DBMS provides the necessary infrastructure for efficient storage, indexing, and retrieval data to help chatbots maintain context and personalize responses. Additionally, DBMS can facilitate the storage, organization, and retrieval of extensive knowledge to make sure

chatbots have access to necessary information to provide accurate and relevant responses to user queries (Shawar & Atwell, 2007).

There are numerous research and case studies that demonstrate the integration of DBMS with Chatbots. For example, IBM Watson uses DB2, a relational database, to manage huge amount of data (structure and unstructured data), allowing Watsons to process and understand natural language inputs then provide accurate responses in real-time (Ferrucci et al., 2010).

Besides many advantages could be seen easily in integrating DBMS with Chatbots, numerous challenges could be mentioned. Chatbots are one of the AI models and applications; as a result, they will definitely inherit the challenges of the integrating of DBMS and AI such as real-time and low-latency requirements, and managing unstructured data. However, Chatbots still have their own unique set of challenges. Chatbots require dynamic management of conversational data, efficient handling of unstructured data, real-time natural language processing (NLP), scalability to handle high traffic, across multiple channels. Integrating and managing DBMS within chatbot platforms can be complex, require specialized knowledge and be expensive if applying high performance and scalable DBMS solutions.

V. Conclusion

The literature review has explored the crucial role of Database Management Systems (DBMS) in supporting the emerging technologies of Blockchain, AI, and Chatbots. The findings mainly emphasized the significant synergies between DBMS and these transformative technologies, as well as the unique challenges that must be addressed to ensure their seamless integration.

According to these diverse applications, DBMS has strongly proven to be vital in providing the necessary infrastructure to handle the high-throughput, low-latency, and large-scale requirements of these technologies. By integrating DBMS with these three emerging technologies, researchers and developers can leverage scalability, reliability, and security to improve the overall performance and robustness of these emerging technologies.

DBMS addresses the difficulties in storing and handling massive amounts of transaction data for blockchain, makes it easier to store, handle, and preprocess complex datasets in AI, and stores and handle conversational data for chatbots.

The role that DBMS plays in enabling developing technology will become more and more crucial as the digital world changes. Scholars' ought to investigate additional integration, tackle obstacles, and capitalize on synergies. To realize maximum potential, specialized DBMS or integration with other technologies might be required.

In conclusion, this integration will be able to enhance the capabilities and driving innovation in the digital era.

VI. References

1. Elmasri, R., & Navathe, S. B., 2016, Fundamentals of database systems (7th ed.), Pearson
2. Nakamoto, S. ,2008, Bitcoin: A Peer-to-Peer electronic cash system, https://bitcoin.org/bitcoin.pdf
3. Russell, S., & Norvig, P. ,2020, Artificial intelligence: A modern approach (4th ed.), Pearson
4. Shawar, B. A., & Atwell, E. ,2007, Chatbots: Are they really useful? LDV Forum, 22(1), 29-49

5. Zheng, Z., Xie, S., Dai, H., Chen, X., & Wang, H. ,2017, An overview of blockchain technology: Architecture, consensus, and future trends. 2017 IEEE International Congress on Big Data (Big Data Congress), 557-564
6. Swan, M. ,2015, Blockchain: Blueprint for a New Economy, O'Reilly Media, Inc.
7. Zheng, Z., Xie, S., Dai, H., Chen, X. and Wang, H. ,2018, 'Blockchain challenges and opportunities: A survey', International Journal of Web and Grid Services, 14(1), pp. 1-25.
8. Stonebraker, M., Ilyas, I., Beskales, G. and Kraska, T. , 2018, 'Data management for machine learning: Challenges and opportunities', Communications of the ACM, 61(7), pp. 36-43.
9. Adamopoulou, E. and Moussiades, L., 2020, 'An overview of chatbot technology', Artificial Intelligence Applications and Innovations, 584, pp. 373-383.
10. Xu, X., Pautasso, C., Zhu, L., Gramoli, V., Ponomarev, A., Tran, A.B. and Chen, S. ,2019, 'The blockchain as a software connector', 2016 13th Working IEEE/IFIP Conference on Software Architecture (WICSA), pp. 182-191.
11. Androulaki, E., Barger, A., Bortnikov, V., Cachin, C., Christidis, K., Caro, A.D., Enyeart, D., Ferris, C., Laventman, G., Manevich, Y. and Muralidharan, S. ,2018, 'Hyperledger Fabric: a Distributed Operating System for Permissioned Blockchains', Proceedings of the Thirteenth EuroSys Conference, Porto, Portugal: ACM, pp. 1-15.
12. McConaghy, T., Marques, R., Müller, A., De Jonghe, D., McConaghy, T., McMullen, G., Henderson, R., Bellemare, C. and Granzotto, A. ,2016, 'BigchainDB 2.0: A Scalable Blockchain Database', white paper.
13. JP Morgan ,2016, 'Quorum White Paper', Quorum.

14. Elmasri, R., & Navathe, S. B., 2016, Fundamentals of database systems (7th ed.), Pearson.
15. Doan, A., Ramakrishnan, R., & Halevy, A. Y., 2012, Crowdsourcing systems on the World-Wide Web, Communications of the ACM, 54(4), 86-96.
16. Pavlo, A., Angulo, G., Arulraj, J., Lin, H., Lin, Z., Ma, L., Menon, P., Mowry, T.C., Perron, M., Quah, C., and Saran, A., 2017, 'Self-Driving Database Management Systems', Proceedings of the 8th Biennial Conference on Innovative Data Systems Research (CIDR 2017), Chaminade, CA.
17. Chung, E., Hillmer, S., and Nam, K. , 2018, 'Building Machine Learning Powered Applications with Amazon SageMaker and Amazon Redshift', AWS Whitepaper.
18. Ferrucci, D., Levas, A., Bagchi, S., Gondek, D. and Mueller, E.T., 2010, 'Watson: beyond jeopardy!', Artificial Intelligence, 199, pp. 93-105.
19. Unuriode, O. A., Durojaiye, M. O. and Yusuf, Y. B., 2023, The Integration of Artificial Intelligence into Database Systems (AI-DB Integration Review), International Journal on Cybernetics & Informatics, 12(6), pp.161-172.
20. Nihalani, N., Silakari, S., & Motwani, M. , 2009, Integration of Artificial Intelligence and Database Management System: An Inventive Approach for Intelligent Databases, First International Conference on Computational Intelligence, Communication Systems and Networks, 35-40.