Delta Lake as Offline feature store for Hopsworks

GIOVANNI MANFREDI
gioman@kth.se

20th February 2024

1 Thesis title

Delta Lake as Offline feature store for Hopsworks

2 Background

Hopsworks is an open-source feature store for machine learning that manages both large volumes of historical feature data (for model training) and the latest feature values (for model inference) [1, 2]. Hopsworks offline store is built on Apache Hudi [3], one of three open-source table formats (the others are Delta Lake and Apache Iceberg), known colloquially as lakehouse formats [4].

The lakehouse formats are the lowest cost way to manage historical feature data in the cloud on object storage, and they each have their own strong points. One of the problems (and strengths) of Apache Hudi is that each row requires a primary key. This helps Hudi prevent duplicate data being written to a table, but it also makes writing to a feature group much slower, as a check has to be made if the row already exists before it is added to the cluster.

Delta Lake [5], in contrast, does not support primary key constraints, but it enables much faster writes than Hudi, in general. For many use cases, being able to write a 1 GB dataset to a feature group in 10 seconds is more important than the write taking 10 minutes, but ensuring duplicates were removed. Delta Lake is now an open-source format, controlled by the Open Cloud Native Foundation, and in contrast to Hudi, it has a native Python client, built on a Rust client, called Delta-RS. The ability for Python clients to write directly to the Lakehouse (Feature Store), will improve performance such that the Feature Store could become like a “Dropbox for DataFrames” - an easy to use network drive for storing incrementally updated feature groups in Python-based feature pipelines.

3 Research question

This is a systems research project, where I will develop an extension to Hopsworks adding support for Delta Lake as an offline store. I will need to add support for both writing and reading to Delta Lake from Python clients, and I will experimentally evaluate the performance of the offline feature store in Delta Lake compared to the current solution that uses Apache Hudi.

4 Hypothesis

This project works on the hypothesis that an offline feature store in Delta Lake makes a higher performance platform for Python clients than an Apache Hudi-based platform.

5 Research method

1. Literature research of what is needed for the implementation and the new feature store. Understand metrics for benchmarking
2. Implementation phase.
3. Evaluation of performance of system built.

6 Background of the student

My academic journey has provided me with a robust foundation in Distributed Systems, Machine Learning, and Machine Learning Operations (MLOps), all of which are integral to my thesis project on ”Delta Lake as Offline Feature Store.” Notably, my coursework across Politecnico di Milano, including ”Databases 2,” ”Distributed Systems,” ”Computing Infrastructures,” and ”Machine Learning,” and KTH with ”Data Intensive Computing” and ”Scalable Machine Learning and Deep Learning”, has provided me with a comprehensive understanding of the principles and practical applications crucial for this research.

The ”Databases 2” course equipped me with knowledge of database architectures and transactions, preparing me to handle the intricacies of implementing Delta Lake as a feature store. ”Distributed Systems” and ”Computing Infrastructures” courses imparted an understanding of the design and development of modern distributed systems and data center architectures, which are fundamental in exploring Delta Lake in a distributed environment.

The ”Data Intensive Computing” course at KTH expanded my skills in handling massive data sets using distributed file systems and execution engines like Spark, directly applicable to the performance analysis of Delta Lake. Additionally, the ”Data Mining” and ”Scalable Machine Learning and Deep Learning” courses provided me with hands-on experience in deploying scalable machine learning algorithms, which is pivotal in assessing Delta Lake’s efficacy as a feature store.

Finally, ”Software Engineering 2” reinforced my ability to apply engineering methods and processes essential for managing the complexity of integrating Delta Lake into an MLOps pipeline. My collective experiences from these courses make this thesis not only appropriate but an exciting opportunity to consolidate and apply my academic learning to a real-world challenge.

7 Supervisor at the company/external organization

Jim Dowling is the CEO and founder of HopsWorks, and also Course Coordinator of “Scalable Machine Learning and Deep Learning” course at KTH and he is the one that first introduced me to this master thesis opportunity in HopsWorks. I already had a series of emails with him (jim@hopswork.ai) after accepting the offer, where we discussed the topics of the project in detail, and where we explored together which professors at KTH would be best suited for this master thesis project. The supervisor within the company will be **Davit Bzhalava** (davit@hopswork.ai), Head of Data Science in HopsWorks. He will be the reference within the company for this project, but also Jim Dowling will be involved in the project.

8 Suggested examiner at KTH

Vladimir Vlassov (vladv@kth.se), professor at KTH, after being presented the project and having a brief discussion with Jim Dowling, he accepted to be the examiner for this project.

9 Suggested supervisor at KTH

The suggested examiner of this project also indicated **Sina Sheikholeslami** (sinash@kth.se) and **Fabian Schmidt** (fschm@kth.se) as supervisors for this project.

10 Resources

During the Master thesis period, I will work on a daily basis in HopsWorks headquarters. This will allow me both access to the current implementation of the Offline feature store in Apache Hudi, and gain new knowledge and expertise from HopsWorks employees.

11 Eligibility

I am currently on track to have completed all my courses before the beginning of Period 3 2023-2024. This means that all requirements (related to the courses cited before and Research Methodologies and Scientific Writing) will be met before the start of the project.

12 Study Planning

This is the list of courses I am currently attending and that I will complete by the end of this period, and so before the beginning of Period 3, where my thesis project will start.

- Data Mining
- Scalable Machine Learning and Deep Learning
- Research Methodologies and Scientific Writing

References

[1] "Hopsworks - Batch and Real-time ML Platform," https://www.hopsworks.ai/, 2024.

[2] A. Moré and E. Gebremeskel, "HopsWorks : A project-based access control model for Hadoop," Ph.D. dissertation, KTH, School of Information and Communication Technology (ICT) / KTH, School of Information and Communication Technology (ICT) and KTH, School of Information and Communication Technology (ICT), 2015.

[3] N. Gebretsadkan Kidane, "Hudi on hops : Incremental processing and fast data ingestion for hops," Master's thesis, KTH, School of Electrical Engineering and Computer Science (EECS) / KTH, School of Electrical Engineering and Computer Science (EECS), 2019.

[4] M. Armbrust, A. Ghodsi, R. Xin, and M. Zaharia, "Lakehouse: A new generation of open platforms that unify data warehousing and advanced analytics," in *Proceedings of CIDR*, vol. 8, 2021.

[5] M. Armbrust, T. Das, L. Sun, B. Yavuz, S. Zhu, M. Murthy, J. Torres, H. Van Hovell, A. Ionescu, A. Łuszczak, M. Świtakowski, M. Szafrański, X. Li, T. Ueshin, M. Mokhtar, P. Boncz, A. Ghodsi, S. Paranjpye, P. Senster, R. Xin, and M. Zaharia, "Delta lake: High-performance ACID table storage over cloud object stores," *Proceedings of the VLDB Endowment*, vol. 13, no. 12, pp. 3411–3424, Aug. 2020. doi: 10.14778/3415478.3415560