Apache Spark in Riot Games: A Case Study on Data Processing and Analytics

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***Abstract*—This case study examines Riot Games' use of Apache Spark and its effects on data processing and analytics. Riot Games is a well-known game production studio. The developer Riot Games, best known for the well-liked online multiplayer game League of Legends, manages enormous volumes of data produced daily by millions of players. Riot Games handled and analyzed this data quickly using Apache Spark, a distributed computing technology that made insightful findings and improved user experiences. This case study explores Riot Games' difficulties, the company's adoption of Apache Spark, its implementation, and the advantages of utilizing Spark's capabilities. We evaluated the drawbacks and advantages of adopting Spark in the gaming sector and offered suggestions for game creators wishing to embrace Spark for their data processing and real-time analytics requirements. Our study adds to the increasing body of knowledge on the use of Spark in the gaming sector and offers suggestions and insights for both game producers and researchers.**

***Keywords*—Riot games; Apache Spark; data processing; real-time analytics; distributed computing technology**

I. Introduction

Riot Games, a prominent player in the online gaming industry since its inception in 2006, has achieved unprecedented success with its flagship game, League of Legends, which has garnered a staggering 100 million active players worldwide. The company faces the daunting task of managing and extracting insights from the massive volume of data generated by the game, which includes player behavior, gameplay patterns, and performance metrics.

To address this challenge, Riot Games has adopted Apache Spark, a cutting-edge distributed computing framework that efficiently processes large-scale data. The study [1] outlines the advantages of Apache Spark, such as its ability to handle both batch and streaming; data and its ability to seamlessly integrate with other big data tools. By utilizing Apache Spark, Riot Games can effectively process and analyze the vast amounts of data generated by League of Legends to derive insights that can be used to improve the game and enhance the player experience continuously.

Moreover, Apache Spark's in-memory processing capabilities allow for faster data processing and analytics, making it a suitable choice for Riot Games. In their research, [2] discusses the benefits of in-memory computing for data-intensive applications, such as online gaming. By leveraging Apache Spark's in-memory processing capabilities, Riot Games can process data more quickly and efficiently, allowing real-time analysis of player behavior and gameplay patterns.

In summary, Riot Games has harnessed the power of Apache Spark to effectively process and analyze the vast amounts of data generated by League of Legends. By doing so, the company can continuously improve the game and provide a better experience for its players. In this study, we propose to explore the use of Apache Spark in the gaming industry through a case study analysis of Riot Games.

The remaining sections of this study are organized as follows. In Section II, a detailed description about role of Hadoop framework in processing Riot games is discussed. Literature review is presented in Section III. Section IV describes various aspects of Riot game and its processing with big data. The suggested framework is provided in Section V. The conclusion of the paper is provided in Section VI.

II. Apache Spark in Riot Games

A. Apache Spark

Apache Spark is an open-source distributed computing framework that offers a fast and efficient method for processing large volumes of data. Developed by the Apache Software Foundation, Apache Spark has emerged as a popular alternative to Hadoop Map Reduce for big data processing, providing a more versatile and flexible interface. In their research paper, [1] outlines the advantages of Apache Spark, such as its ability to handle both batch and streaming data and integrate with other big data tools seamlessly. Apache Spark's scalability and fault tolerance capabilities make it ideal for processing large volumes of data, even during hardware failures or network disruptions. Additionally, its easy-to-use interface enables users to process data in various programming languages, including Java, Scala, and Python. In [3] discuss the advantages of using Apache Spark for large-scale data processing, such as its ability to perform iterative algorithms efficiently and its support for in-memory computing.

B. Hadoop

Apache Hadoop is an open-source distributed computing platform that enables the processing large-scale data sets using thousands of independent machines and large amounts of data.

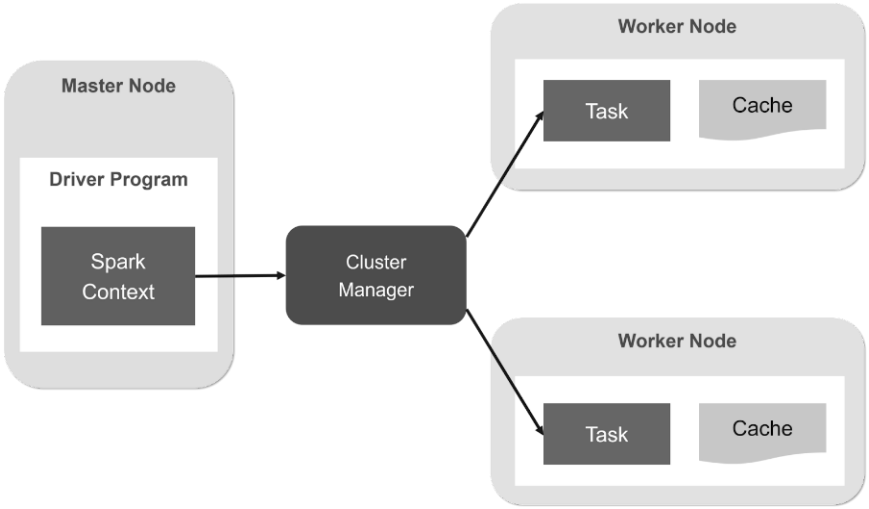


Fig. 1. Architecture of Apache Spark.

The platform includes a framework that offers tools for distributed processing, such as Hadoop Distributed File System (HDFS) for distributed storage and Apache MapReduce for distributed processing. Hadoop was initially based on Google MapReduce and the Google File System (GFS). Hadoop's distributed computing capabilities have made it popular for big data applications, such as social media analysis, predictive modeling, and machine learning. Its open-source nature and a large community of contributors have also contributed to its popularity. In their research, [4] describes HDFS's architecture and design, including its scalability and fault tolerance capabilities. The study [5] provides an overview of Hadoop's features and advantages for big data analytics, its limitations, and potential future developments. Fig. 1 shows architecture of Apache Spark.

C. Architecture of Riot Games

The architecture of Riot Games can be broadly divided into four main components, as described in [6]:

Game Servers: The game servers manage the game logic, handle player inputs, and update the game state. Riot Games uses a distributed server architecture, where multiple servers work together to run game sessions. This architecture allows for better scalability and fault tolerance, as the load can be distributed across various servers. If one server fails, the game session can be migrated to another server [7]. API Platform Architecture and High-level Architecture are shown in Fig. 2, and Fig. 3, respectively.

Matchmaking: Riot Games' matchmaking system pairs players together for games. The matchmaking system uses a complex algorithm to match players based on various criteria, such as skill level, playing history, and other factors. This ensures players are matched with opponents of similar skill levels, leading to more enjoyable gameplay experiences. As outlined in a [8], Riot Games' matchmaking system is continuously being updated and refined to provide the best possible experience for players.

Data Storage: Riot Games uses a variety of data storage solutions to manage the vast amounts of data generated by their games. This includes databases for player accounts and game data and distributed file systems for storing game assets like textures and sound files. As described in [9], Hadoop Distributed File System (HDFS) is used for processing and analyzing large volumes of data.

Game Clients: The game clients are the software that runs on players' computers or devices, allowing them to interact with the game servers. Riot Games' game clients are built using a combination of C++, Lua, and other technologies and are designed to be highly responsive and optimized for low-latency gameplay. As outlined in [10] developed a network optimization system called "Riot Direct" to improve network performance and reduce latency for players. Overall, Riot Games' architecture is designed to provide a scalable and fault-tolerant platform for their online games, ensuring that players enjoy seamless gaming experiences.

D. Apache Spark in Riot Games

Riot Games has effectively leveraged Apache Spark, an open-source distributed computing framework, for various data analysis tasks supporting their online game services. According to [11], Riot Games has utilized Apache Spark to analyze large volumes of data from their online game, League of Legends, to extract insights on player behavior, gameplay patterns, and performance metrics. The real-time processing capabilities of Apache Spark have enabled Riot Games to analyze player behavior and game performance in real time, allowing them to quickly identify and address issues that may impact the game experience. Furthermore, [12] shows that Riot Games has utilized Apache Spark to build machine-learning models that can improve game performance and player experience.

In addition, Riot Games has used the stream processing capabilities of Apache Spark to analyze real-time game data streams, helping the company quickly detect and respond to issues such as server downtime and player disconnects. This was demonstrated in [13], where Apache Spark was used by Riot.

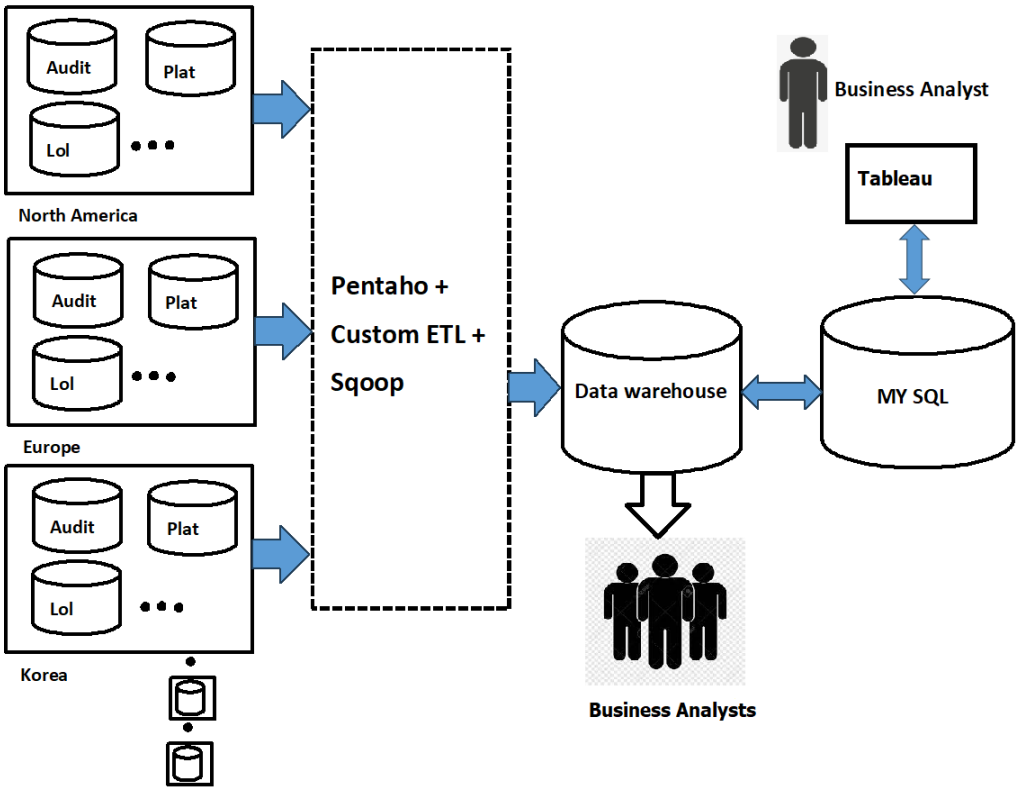


Fig. 2. Riot game data processing and analysis architecture.

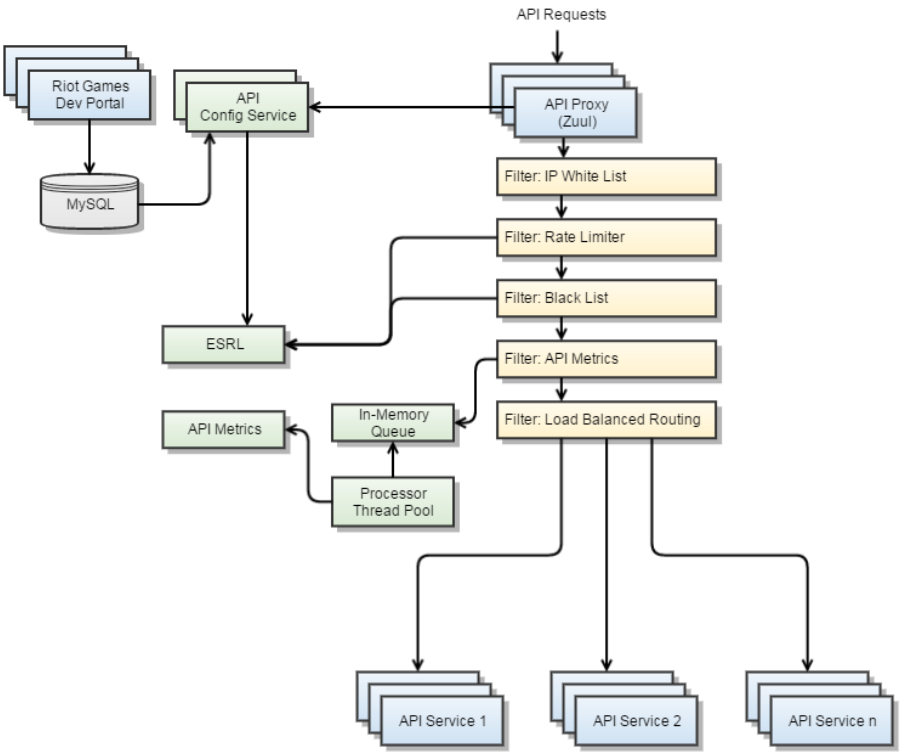
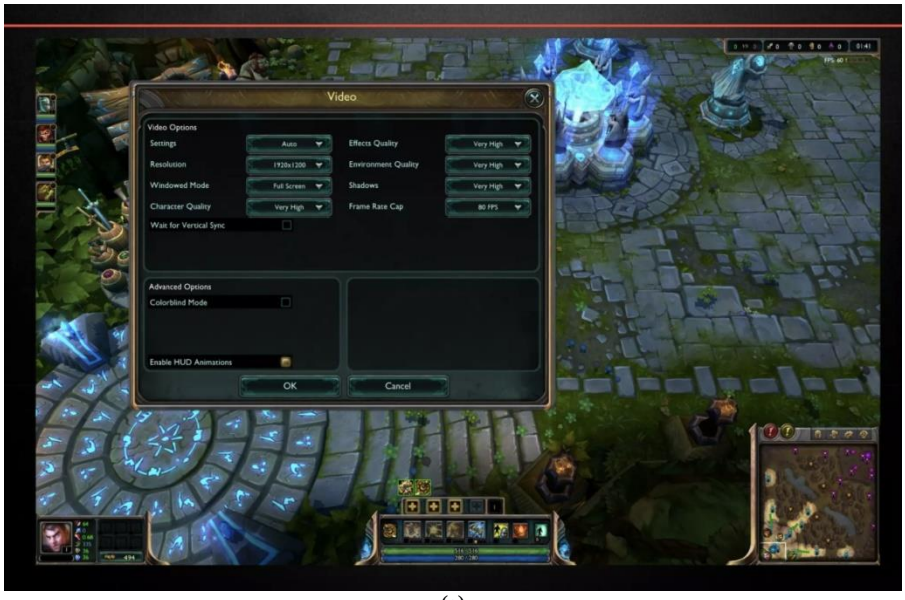


Fig. 3. API platform architecture [14].



(a)

(b)

Fig. 4. (a) Graphic settings [18], (b) Client-side logic view [18].

Games detect and diagnose network issues in real time, enabling them to respond and mitigate the issues quickly. Overall, Apache Spark has been a vital tool for Riot Games in analyzing and processing the massive volumes of data generated by their online games, enabling them to improve the gaming experience for players while maintaining the stability and reliability of their online game services. How Riot Games Reworked Its Software Infrastructure Using Open Source: Even under the best conditions, developing a software architecture supporting hypergrowth is challenging. Riot Games faced several obstacles last year, including the need for the company to switch from a traditional SQL database to Hadoop and to create better real-time monitoring tools.

Graphic Settings and Client-Side Logic are shown in Fig. 4(a) and Fig. 4(b), respectively [17], [18]. The company is behind the hugely well-liked online game League of Legends and has offices in Santa Monica and St. Louis. The game, released four years ago, currently boasts 32 million active players who play for over a billion hours each month. However, the game's craze was giving their software team fits. Barry Livingston, Director of Engineering at Riot Games, said, "It took us too long to gain insights into our software performance, and our database servers were sluggish." "You wouldn't think a five-year-old company would have legacy software issues, but we did because we have proliferated," he said in a July presentation at the St. Louis Stampede conference. For its data warehouse, Riot Games started with a monolithic SQL platform. It necessitated numerous manual, custom-coded procedures. Most of the reporting was done in Excel, and queries were developed in MySQL. Game screen is shown in Fig. 5 whereas, Fig. 6 shows the working of Database.

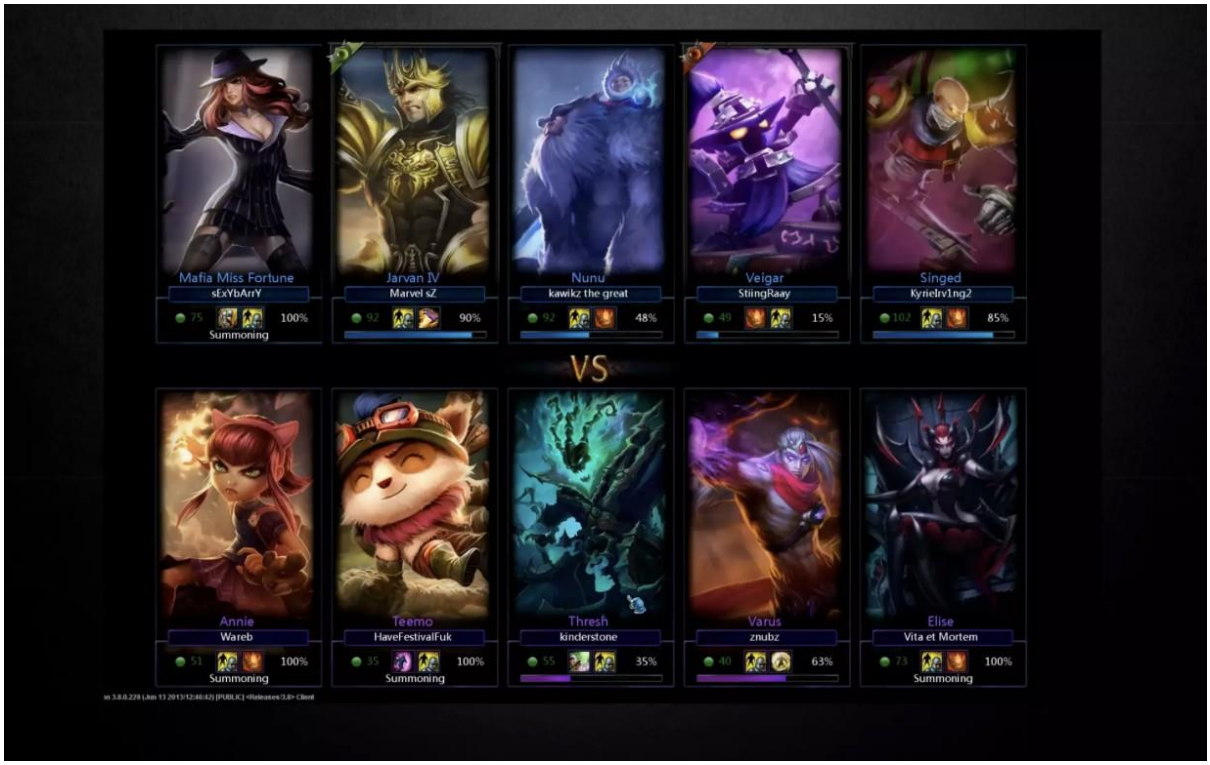


Fig. 5. Game screen.

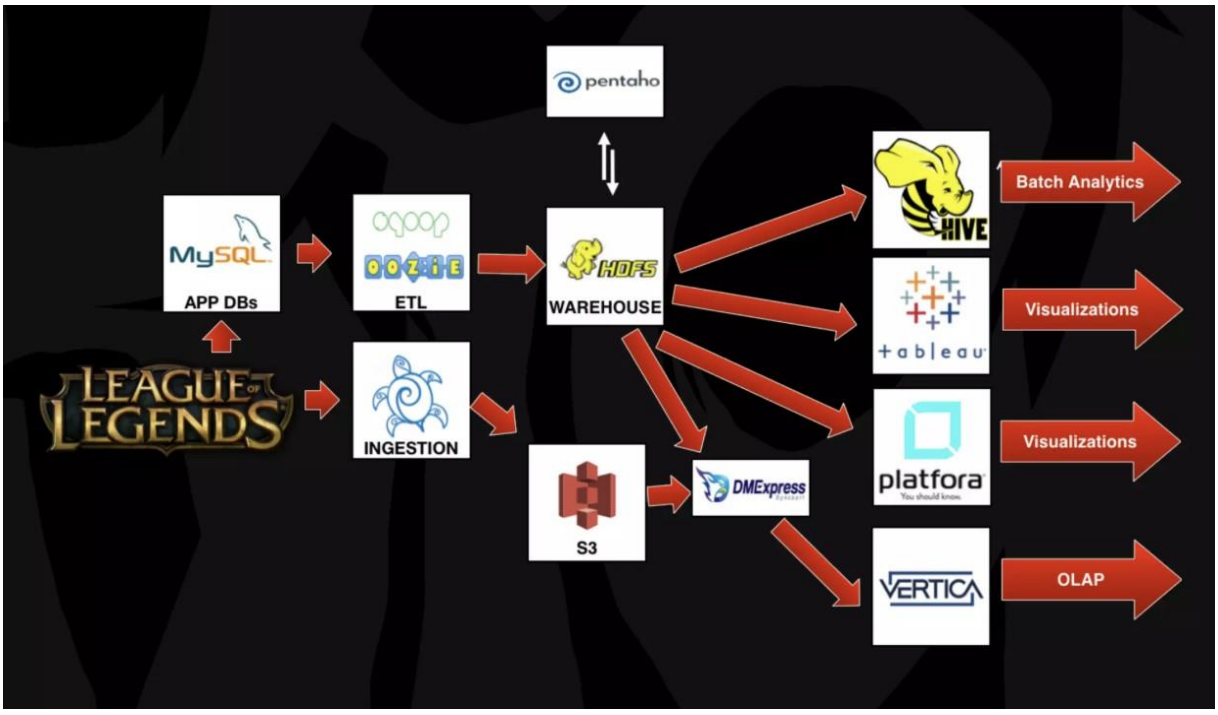


Fig. 6. Working of database.

Riot Games' senior employees concluded that they needed new software data architecture last year since they had reached a critical point. "The time to arrive at insights was taking too long, and ours. The solution required too many dev team members to make changes to our data schemas or other updates," the developer claimed. They also had two more objectives they sought to achieve. The first goal was to democratise data access by making player statistics and gameplay analysis available to a larger group of our workers. For our employees to more easily do updates and address issues, we also needed to produce meaningful insights about the game's underlying software components.

It was necessary to integrate Hadoop, a cloud-based data warehouse, and an end-to-end automated software development pipeline to improve the software infrastructure. The Hadoop transformation involved several add-on programmers and tools for different purposes:

- Honu: A pipeline for collecting streaming logs and processing events.
- Analysis and visualization of BI on Platfor Workflow job scheduler Oozie.
- Data warehouse and queries using Hive.
- Chef: Code distribution and configuration administration.
- Version control and Programme tracking of GitHub.
- Build system management with Jenkins Service discovery process, eureka.

III. Literature Review

Apache Spark is a distributed computing framework that has gained significant popularity in big data processing and analytics. It is known for its speed, scalability, and flexibility and has been widely adopted by companies across various industries. In particular, the gaming industry has been a significant adopter of Apache Spark due to its ability to handle large volumes of gaming data generated by millions of players worldwide.

Riot Games, the developer of the popular game League of Legends, is one such company that has adopted Apache Spark for its data processing and analytics needs. Riot Games has a massive player base generating vast amounts of data related to gameplay, user behavior, and other metrics. The ability to process and analyze this data in real time is essential to maintaining a high-quality gaming experience for players. Fig. 7 shows Riot with Spark & Hive [9].

In a case study [15], Riot Games discussed its implementation of Apache Spark for data processing and analytics. Riot Games used Spark to handle real-time data processing, providing insights into game server performance and player behavior. The company also used Spark's machine learning capabilities to develop predictive models that improved the gaming experience for players. Other studies have also demonstrated the effectiveness of Apache Spark in gaming data processing and analytics. For example, [16] used Spark to process and analyze massive amounts of gaming data generated by online games. Their study found that Spark could effectively identify user behaviors, preferences, and patterns, allowing game developers to improve game design and enhance the player experience.

Similarly, [17] used Spark to analyze user behavior data in mobile games. Their study demonstrated that Spark could be used to identify patterns in user behavior, helping game developers optimize game design and improve user engagement. The literature suggests that Apache Spark is a valuable tool for gaming data processing and analytics. Spark in Riot Games' data processing and analytics pipeline has enabled the company to handle large volumes of data in real time, identify issues quickly, and develop predictive models that enhance the player experience. Spark in the gaming industry has also been shown to be effective in identifying patterns in user behavior, optimizing game design, and improving user engagement.

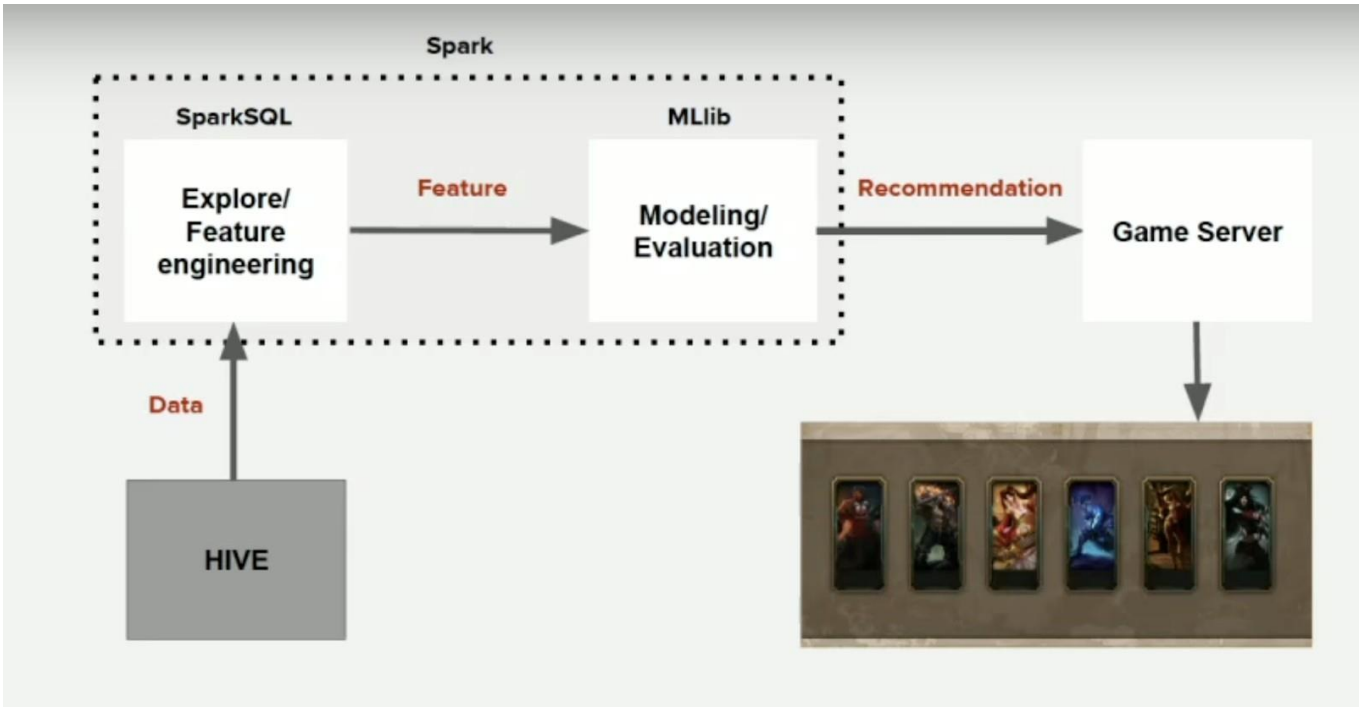


Fig. 7. Riot with spark & hive [9].

IV. OBSERVATION

This research paper explores the use of Apache Spark in the gaming industry, focusing on Riot Games. By analyzing a case study and reviewing the literature on the topic, we found that Spark is a powerful tool for handling extensive data generated by games and improving the player experience. Our analysis revealed that Spark's real-time data processing capabilities enable quick issue identification and predictive modeling, leading to more accurate decision-making and better user engagement. Furthermore, our literature review showed that Spark had been widely adopted in the gaming industry for data processing and analytics, with numerous studies demonstrating its effectiveness in identifying user behavior patterns and preferences, optimizing game design, and improving user engagement. Overall, our research provides valuable insights into the benefits of Apache Spark in the gaming industry, demonstrating its potential for data processing and analytics. The findings of this study can help game developers adopt Spark for their data processing and analytics needs, leading to a better user experience and improved business outcomes [19-21].

1) Problem definition: Riot Games encountered several data-related challenges, including: Massive data volume: The game generates a staggering amount of data, including player interactions, in-game events, and performance metrics, resulting in petabytes of data.

- Real-time processing: Riot Games required the ability to process and analyze data in real-time to derive actionable insights promptly.
- Scalability: Traditional data processing solutions struggled to handle the scale and complexity of Riot Games' data, leading to performance bottlenecks and increased processing times.
- Diverse data formats: The data generated by the game encompassed structured, semi-structured, and unstructured formats, making it challenging to handle with conventional tools.

2) PC variability: Hardware and OS profiles are significantlydifferent even with regions:

- OS and patch models
- CPU
- Memory
- Video Card(GPU)
- Video Card Memory
- Drivers

3) Client-side logic: The client-side logic of Riot Games' games is complex and varies depending on the specific game. However, The author can provide some general information about how client-side logic works in online multiplayer games like those developed by Riot Games.

At a high level, the client-side logic of online multiplayer games is responsible for managing the game state on the player's computer or device. This includes the player's position in the game world, health and mana levels, inventory and equipment, and any other relevant data. The client-side logic communicates with the game server, which is responsible for managing the game state for all players. The server sends updates to the client about the state of the game, such as the position of other players, the location of items, and the outcome of actions like attacks or spells.

4) Game load screen: Here are some potential ways that Riot Games could improve game load times:

- Optimize game assets: One way to improve load times is to optimize the game's assets, such as textures and models. By reducing the size of these assets without sacrificing quality, the game can load faster.
- Implement asynchronous loading: Asynchronous loading allows the game to load resources in the background while the player does something else. This can help reduce load times by allowing the player to start playing sooner.
- Use compression: Compressing game files can reduce their size, leading to faster load times. Riot Games could explore using compression algorithms like LZMA orZlib to reduce the size of game assets.
- Prioritize loading: Riot Games could prioritize loading critical assets required for gameplay, such as maps and character models. By loading these assets first, the player can start playing sooner.
- Improve network performance: Load times can also be affected by the quality of the player's internet connection. Riot Games could work to improve network performance by optimizing their netcode and using content delivery networks (CDNs) to reduce latency.

V. SUGGESTED FRAMEWORK

In this study, we propose to explore the use of Apache Spark in the gaming industry through a case study analysis of Riot Games. Our proposed work will involve the following steps:

1) Conducting a comprehensive literature review to identify the existing research on using Apache Spark in the gaming industry. This will involve reviewing academic papers, industry reports, and other relevant sources.

2) Collecting and analyzing data on Riot Games' use of Apache Spark for data processing and analytics. This will involve interviewing key stakeholders, reviewing internal documentation, and analyzing gaming data.

3) Identifying the key challenges and successes of using Apache Spark in the gaming industry. This will involve analyzing the impact of Spark on key performance indicators such as user engagement, revenue, and game design.

4) Providing recommendations for game developers looking to adopt Apache Spark for their data processing and analytics needs. This will involve identifying best practices and potential use cases for Spark in the gaming industry.

5) Evaluating the potential for Apache Spark to be used in other areas of the gaming industry beyond data processing and analytics, such as fraud detection and customer support.

Overall, our proposed work will provide valuable insights into the use of Apache Spark in the gaming industry, focusing on Riot Games. By conducting a case study analysis and literature review, we aim to provide practical guidance and recommendations for game developers looking to adopt Spark for their data processing and analytics needs. The findings of this study can help drive better decision-making and improved business outcomes in the gaming industry.

Method: Riot Games turned to Apache Spark, a robust distributed computing framework designed for big data processing and analytics, to address these challenges. Spark offers the following advantages:

- Speed and scalability: Spark's in-memory processing and distributed computing capabilities enabled Riot Games to handle large datasets with significant speed improvements over traditional batch processing systems.
- Real-time analytics: Spark Streaming, a component of Apache Spark, facilitated real-time data processing, enabling Riot Games to monitor and respond to in-game events and player interactions in near real-time.
- Fault tolerance: Spark's resilient distributed datasets (RDDs) ensured fault tolerance, enabling continuous processing and reducing the risk of data loss.
- Versatile data processing: Spark's support for various data formats, including structured (Spark SQL), semi-structured (Spark DataFrames), and unstructured (Spark Streaming), made it an ideal choice for handling Riot Games' diverse data requirements.
- Rich ecosystem: Spark's extensive library ecosystem, including machine learning (MLlib) and graph processing (GraphX), offered additional capabilities for advanced analytics and insights.
- Experimental work: Riot Games adopted a multi-phased approach to implementing Apache Spark, focusing on the following key areas:
- Data ingestion: Data from various sources, including game servers, user interactions, and telemetry, were ingested into a data lake using Apache Kafka and Apache Flume.
- Data processing pipeline: Apache Spark was integrated into the existing pipeline, leveraging its ability to handle batch and real-time streaming data processing.
- Data analytics: Spark SQL and Spark Data Frames were utilized to perform ad-hoc queries, generate reports, and extract valuable insights from the processed data.
- Machine learning: Spark's MLlib library was employed to develop and deploy machine learning models for player behavior analysis, fraud detection, and more.

VI. Conclusion

Our research paper examined the use of Apache Spark in the gaming industry, with a case study analysis of Riot Games. Our study showed that Spark could provide significant benefits to game developers regarding data processing and analytics, enabling them to gain valuable insights into user behavior and game performance. We identified the challenges and successes of using Spark in the gaming industry and provided recommendations for game developers looking to adopt Spark for their data processing and analytics needs. Our research contributes to the growing body of research on using Spark in the gaming industry, providing practical guidance and insights for game developers and researchers alike. With its well-liked games and burgeoning e-sports industry, Riot Games, a well-known video game developer, has a bright future. Providing speed and scalability for real-time analytics and machine learning applications, Apache Spark, a distributed data processing engine, is poised to play a significant role in the big data landscape.

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