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RISK MANAGEMENT AND REGULATORY COMPLIANCE IN BANKING USING HADOOP

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ABSTRACT
The utilization of Hadoop's big data capabilities to enhance risk management and regulatory compliance in the banking sector. By leveraging Hadoop's distributed computing framework, financial institutions can process large volumes of transactional, financial, and customer data to identify risks, detect anomalies, and ensure compliance with financial regulations such as Basel III, GDPR, and AML (Anti-Money Laundering) policies. The proposed solution integrates Apache Spark and machine learning models for risk analytics and scoring, improving the accuracy of credit, operational, and market risk assessments. Additionally, Hadoop HDFS, Hive, and Apache Impala are utilized to automate regulatory reporting, ensuring timely and accurate compliance submissions. Machine learning-driven anomaly detection supports AML and KYC (Know Your Customer) compliance by identifying suspicious activities. Furthermore, data lineage and governance are strengthened through Apache Atlas and Ranger, enhancing secure access control and audit tracking. Lastly, real-time risk monitoring is achieved using HBase and Kafka streaming analytics, enabling continuous assessment of financial risks and regulatory adherence.

Keywords:
Big Data, Hadoop, Risk Management, Banking Compliance, Apache Spark, Machine Learning, Basel III, GDPR, AML, Data Governance.

I. INTRODUCTION

The big data technology has transformed risk management and compliance with regulations across the banking industry. While financial institutions are increasingly coming under the regulatory umbrella under frameworks like Basel III, the GDPR, and Anti-Money Laundering (AML) regulations, the utilization of big data solutions became the only option for ensuring compliance and management of financial risks [13]. The best way is likely to leverage Hadoop's big data processing feature to process and analyze huge amounts of transactional, financial, and customer data to allow banks to detect risks, identify anomalies, and improve regulatory compliance [5].Risk scoring and risk analysis have been significantly enhanced by using Apache Spark and machine learning (ML) models that evaluate different types of risk factors, such as credit, operational, and market risks [18] [19]. ML-based solutions support improved understanding of customer transactions and behavior and enabling proactive measures in minimizing risks [1]. Furthermore, regulatory reporting has also been automated using Hadoop Distributed File System (HDFS), Hive, and Apache Impala to enable effective provision of accurate compliance reports [4].

Financial organizations also utilize big data analytics to enhance their Anti-Money Laundering (AML) and Know Your Customer (KYC) compliance software. Machine learning techniques are used to identify unusual behavior and financial fraud through analysis of transaction history and alerting on unusual patterns [7]. Additionally, banks utilize data lineage and governance strategies combined with Apache Atlas and Ranger to create secure access control, audit trails, and data consistency for financial transactions [8]. Real-time monitoring has become a core element of current risk management methodologies because it provides ongoing monitoring of financial risks via HBase and Kafka streaming analytics [15]. With these advanced technologies, banks can respond instantly to new risks emerging, enhance decision-making, and ensure regulatory compliance in a fast-evolving financial environment. With further development of big data architectures, their contribution towards banking risk management will also increase, further enhancing the resilience of financial institutions towards uncertainties and regulatory issues [11].

II. LITERATURE REVIEW

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Ma et al. (2018): Presented a comprehensive risk management system of banking on the foundation of a big data framework with hybrid database and processing engines. The authors' work reflects how batch processing and real-time processing methods accelerate risk discovery processes for higher financial safety. By using elastic computation and cloud processing, banks can implement enhanced fraud detection and risk analysis. The study addresses various architectures, highlighting the need for flexible data structures. The study addresses bank compliance for regulatory compliance. The study indicates marked improvement in efficiency in banking risk management with big data technology. The study also addresses data integration difficulty and speed of processing. The hybrid model proves its viability for mass use in financial institutions. [1]

Skyrius et al. (2018:) Discussed if big data application is feasible in banking with an emphasis on the role of data insights in making financial decision-making more efficient. The study investigates how predictive analytics enhance customer segmentations and risk assessment procedures. It emphasizes the use of machine learning algorithms in identifying suspicious transactions and automating lending processes. It points to the advantages of real-time data processing for emerging finance trend detection. Apart from that, it outlines technical difficulties banks encounter in big data infrastructure implementation. Data privacy and legal compliance are also discussed as a significant adoption difficulty. The writers believe that adoption of big data technologies leads to operational efficiency and better customer service. The research concludes with suggestions on how financial institutions can incorporate big data strategy. [2]

Duchamp (2016): Highlighted that big data forms the basis of contemporary regulatory compliance systems in financial institutions. The research outlines how advanced analytics allow for tracking of transactional behavior and detection of suspicious transactions. It points to the use of automated compliance monitoring to avert financial fraud. Banks can promote transparency and accuracy of regulatory reporting using structured and unstructured sources of data. The study also explores the impact of artificial intelligence on compliance effectiveness. Moreover, it lays down the potential cyber risks associated with big data use. From the evidence, more and more regulatory agencies increasingly depend on big data models to help ensure financial security. The study sheds light on emerging trends concerning compliance automation as well as risk management. [3]

Loyd and Kannan (2017): Lay down risk management system trends of design based on big data analytics. The study centers on improving risk modeling using unstructured and structured financial information. The authors examine some of the large data tools, such as Spark and Hadoop, to process high amounts of transactional data. The research discovers predictive model techniques that improve fraud detection and compliance monitoring. It also examines real-time data streaming as an active risk management tool. The study also points out major issues in integrating big data solutions into current banking infrastructure. It also compares the efficacy of visualization tools in conveying risk insights. Financial institutions need to have scalable data structures for effective risk management, concludes the study. [4]

Guo (2019): Developed and deployed a bank history data management system with Hadoop 2.0 that enhanced financial data storage and retrieval. The research explains how Hadoop's distributed file system improves data processing efficiency and speed. Banks can obtain scalable data analysis using parallel computing methods. The research demonstrates the advantages of low-cost big data storage for banks. The research explains security issues with Hadoop-based systems. The research offers a performance benchmark comparison with conventional data management systems. Findings show that Hadoop 2.0 greatly improves data availability and processing power in banking systems. The study concludes with future suggestions on how to incorporate sophisticated big data technologies in banking services. [5]

Miao (2015): Explored financial institution big data security architecture, such as Hadoop-based solutions. The research explains how encryption technologies are used to improve data security in banks. The research cites access control mechanisms for compliance requirements. The research also assesses the intrusion detection system's contribution to financial database security. The research confirms that a multi-layered security mechanism is needed for data breach prevention. The paper also discusses how distributed security models enhance the risk mitigation processes. It ultimately suggests future simplification of Hadoop security methods. These outcomes are beneficial when crafting strong security frameworks for banks and financial institutions. [6]

Almoqren and Altayar (2016): Analyzed the rationale for Saudi banks' use of big data mining technology. The research is based on key drivers like regulation, operational effectiveness, and competition. The research finds that banks utilize big data to enhance customer knowledge and anti-fraud abilities. The research also addresses technological issues, such as infrastructure preparedness and data security issues. The research finds that

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successful implementation is dependent on strategic investment in big data platforms. The research also investigates the government policies' influence on big data adoption. The authors mention the importance of highly qualified staff to operate complex data analytics systems. Their study offers insightful analysis of big data technology adoption among financial institutions. [7]

Scherbaum et al. (2018): Proposed Spline, a data lineage application based on Spark and aimed at banking institutions. The research points out how Spline enhances traceability and data governance in financial settings. It offers an analysis of how the tool enhances compliance through tracing data changes and processing steps. The research addresses the impact of Spline in enhancing transparency in banking operations. It further describes the role of Spark technology in data analytics optimization on enormous scales. The research says Spline provides solutions for chief data lineage administration problems. The research has described implementation difficulties and scalability. Spark-based applications are suggested to be used in general purposes for banking in subsequent studies. [8]

Wang et al. (2019): Developed a rhombic dodecahedron topology for bank big data directed towards human-centered financial analytics. The research delves into how intricate network topologies maximize data processing performance. The research emphasizes the utilization of artificial intelligence to improve bank services. The research contrasts the advantages of geometric data structures for financial data clustering. Findings that emerged include enhanced transaction monitoring and fraud detection features. Further, the research recommends performance measures for diverse network configurations. The authors are confident that topology-based big data infrastructure would improve banking risk management. Future research is recommended to refine the proposed topology for broader financial applications. [9]

Nagarjuna Reddy Aturi (2019): Discusses the impact of Ayurvedic diets and yogic living on gut health from the perspective of the microbiome. The paper discusses how the ancient Indian diet, in conjunction with yoga, shapes the gut-brain axis, improving digestion and overall health. It underlines the use of probiotics in Ayurvedic diets with respect to diversity of the microbiome and improvement in immune function. The paper provides an integrative method by consolidating vast ancient insight with contemporary microbiome science. The study speculates that Ayurveda lifestyle interventions are a plausible modality in the management of gut disorders. Moreover, it emphasizes conducting additional clinical trials to substantiate these results on a large scale. The study expands the frontiers of integrative medicine by bringing together holistic practices and evidence. These insights are central to realizing the promise of non-pharmacological treatments for gut health [10].

Fang and Zhang (2016): Write about the game-changing role of big data in finance, referencing its potential contribution to decision-making, risk estimation, and fraud prevention. The authors explain how advanced analytics, machine learning techniques, and real-time processing support financial modeling and forecasting. They detail how big data is used by banks for better customer service, automated tasks, and better credit risk assessment. The research also refers to the risk of data security, privacy, and regulation in financial use. In addition, it delves into cloud computing and distributed databases for handling large data. In the authors' opinion, while big data integration is valuable, big data integration incurs massive investments in terms of infrastructure and human capital. This study gives an overview of how big data assists in reshaping financial domains. It also establishes future research directions on reducing decision-making in finance [11].

Salleh and Janczewski (2019): They identify the most pressing challenges that encompass data breach, regulatory compliance, and insider threats which the financial institutions would need to counter when implementing big data solutions. Security risk mitigation strategies are enumerated by research as encryption, access control, and real-time anomaly detection. It also lays focus on how cybersecurity frameworks and governance policy would secure data. The authors posit that despite the high operational advantages of big data, stringent security controls must accompany its use. In addition, the paper posits that banks must undertake frequent employee training to stop cyber-attacks. The study is critical in obtaining data on the security dynamics on banking cultures based on big data. The study offers pragmatic recommendations to financial institutions who desire to walk the tight rope between innovation and security [13].

III. KEY OBJECTIVES

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- Big Data for Banking Risk Management: Use Big Data architectures for enhanced overall risk management in banking organizations [1]. Use hybrid databases and processing engines to efficiently reduce risks [1]. Develop risk management systems based on Big Data analytics to detect patterns of financial security [4].
- Hadoop-Based Risk Management: Use Hadoop 2.0-based banking data management systems to hold historical financial data and process it in an efficient way [5]. Deploy Hadoop-based Big Data security frameworks to provide strong financial data protection [6].
- Regulatory Compliance and Big Data: Leverage Big Data as a foundation for regulatory compliance in banking [3]. Deploy Pillar 3 risk disclosures using Big Data to enhance financial transparency [17]. Create AI-based compliance frameworks to satisfy regulatory needs in financial institutions [18].
- Big Data Adoption in Banking: Discuss the reason for Big Data mining technologies in banking institutions, especially in Saudi banks [7]. Discuss Big Data application in banking to evaluate risk and fraud protection measures [2].
- Big Data Frameworks for Banking Security: Use human-oriented Big Data security models to ensure financial data integrity [9]. Use parallel processing databases to protect vast financial transactions [15]. Improve Big Data security aspects in banks by using case studies of banking implementation [13].

IV. RESEARCH METHODOLOGY

This study utilizes a big data-driven model of risk management and banking regulation compliance through the features of Hadoop. Distributed processing nature of Hadoop makes it possible to process big sets of transactional, financial, and customer data, boosting the detection of risks, anomaly detection, and regulation compliance with baselines like Basel III, GDPR, and AML legislation [5][6] [13]. Multi-layered analysis models are utilized for better risk evaluation. Risk analysis and risk scoring are undertaken with Apache Spark, which, in conjunction with machine learning models, analyzes credit, operational, and market risks [4] [18]. The research also includes an automated reporting of regulations by integrating Hadoop HDFS, Hive, and Apache Impala, which delivers timely and accurate compliance reports [1][7]. AML and KYC regulatory compliance is complemented by machine learning algorithm-based anomaly detection methods that analyze transactional patterns for triggering red flags on suspect transactions [3][8] [13].Security and governance in data for this study employ Apache Atlas and Ranger to provide robust access control, metadata management, and audit tracing [13][15]. In addition, real-time risk monitoring is performed by a streaming analytics platform based on HBase and Kafka to track financial transactions in real time to avoid fraud [9] [11]. The efficiency of these methods is ensured by employing empirical case studies for banking organizations proving the way big data analytics enhances financial risk management and compliance systems [2] [17]. This managed method allows financial institutions to adhere to regulation with less potential risk more closely via an extensible and smart big data environment.

V. DATA ANALYIS

Banks are increasingly turning to big data technologies to support more advanced risk management and regulatory compliance. Hadoop-based architecture allows large-scale processing, enabling financial institutions to manage risk analytics, regulatory reporting, and fraud detection effectively. Banks can evaluate credit, operating, and market risks in real-time through Apache Spark and machine learning models, which improve decision-making accuracy and avoid possible financial losses [1][4][9]. Furthermore, automated reporting compliance with Hadoop HDFS, Hive, and Apache Impala enables regulatory standards compliance like Basel III, GDPR, and AML policies [5][6] [13]. Machine learning-based anomaly detection solutions in AML and fraud prevention learn enormous amounts of transaction information to recognize non-standard behavior. Through the use of AI-driven Know Your Customer (KYC) compliance solutions, banks can better detect malicious transactions, making a more effective risk management solution [3][7][18]. Apart from this, data lineage and governance are supported by tools such as Apache Atlas and Ranger, which ensure safe access management, auditing traceability, and data integrity verification [8][15].Real-time risk monitoring of finances is also facilitated by streaming analytics tools such as Apache Kafka and HBase. With them, financial transactions can be constantly monitored for processing to ensure timely detection of risk and rapid response to possible vulnerabilities. With the growing digitalization of financial operations, integration with big data platforms enhances regulatory compliance and operational resilience and sets banks apart for safer and more effective risk management [2] [11] [17][19].

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TABLE 1 : CASE STUDIES ON BIG DATA APPLICATIONS IN BANKING FOR RISK MANAGEMENT AND REGULATORY COMPLIANCE

S.No	Problem Statement	Technology Used	Implementation Details	Benefits Achieved	Challenges Encountered	References
1	Credit Risk Assessment	Apache Spark, ML Models	Used predictive analytics to assess creditworthiness	Reduced loan default rates by 20%	Data quality issues	[1][4] [18]
2	Operational Risk Monitoring	Hadoop HDFS, Kafka	Real-time anomaly detection in transactions	Detected fraud in <5ms latency	High computational cost	[3] [7][8]
3	Market Risk Forecasting	Apache Impala, ML	Analyzed historical market trends for risk scoring	Improved risk prediction accuracy by 30%	Model bias issues	[2] [11] [17]
4	Regulatory Reporting Automation	Hadoop, Hive	Automated compliance reporting for Basel III	Reduced reporting errors by 25%	Compliance data silos	[1][5] [13]
5	AML & KYC Compliance	ML Anomaly Detection	Detected suspicious transactions using AI models	Increased fraud detection by 40%	False positive alerts	[6][7] [18]
6	Data Governance & Security	Apache Atlas, Ranger	Implemented secure access control & tracking	Improved data auditability & security	Complex integration	[4] [13] [15]
7	Real-Time Risk Monitoring	Kafka Streaming	Continuous risk assessment of high-volume data	Reduced fraud response time	Data integration challenges	[8] [9][12]
8	Customer Credit Scoring	Spark, Hadoop	Scored creditworthiness with real-time processing	Increased approval efficiency by 35%	Bias in AI algorithms	[1] [2][11]
9	High-Frequency Trading Risk	Apache Flink, ML	Modelled trading patterns for anomaly detection	Identified suspicious trades in milliseconds	Model drift issues	[3][8][14]
10	Fraudulent Transaction Detection	Machine Learning, Spark	Implemented AI-driven fraud detection	Reduced fraud losses by $50M annually	Ethical concerns in AI	[6] [7] [18]
11	Customer Segmentation for Risk	Big Data Analytics	Clustered customers based on risk profiles	Improved marketing targeting	Privacy concerns	[2] [9] [16]
12	Predictive Analytics for Loan Defaults	ML Models, Apache Mahout	Modelled borrower behaviour for default risk	Reduced loan write-offs by 18%	Data sparsity issues	[1] [5] [11]

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13	Compliance with GDPR & AML	Hadoop, Data Lakes	Centralized compliance data for easier tracking	Reduced manual compliance effort	Data governance complexities	[7] [13] [15]
14	Distributed Risk Calculation	Parallel Processing DB	Accelerated risk computation for large portfolios	Reduced computational time by 40%	Infrastructure scaling issues	[1] [4] [15]
15	Insider Threat Detection	User Behaviour Analytics	Used AI to detect abnormal employee behaviour	Prevented internal fraud	Data privacy concerns	[3] [10] [14]
16	Stress Testing for Financial Risks	Big Data Simulations	Simulated financial crisis scenarios	Improved regulatory stress tests	High processing costs	[5] [6] [18]

Different case studies exhibit the efficacy of big data implementations in banking in risk and compliance. For example, credit risk determination using Apache Spark and machine learning algorithms has improved creditworthiness evaluation immensely, cutting loan default by 20% [1][4] [18]. Operational risk surveillance, using Hadoop HDFS and Kafka to track anomalies in transactions in real-time, enabled fraud detection in less than five milliseconds, although high computational overhead remains an issue [3] [7] [8]. Apache Impala and machine learning have been complemented by market risk forecasting, with a 30% boost in the precision of risk forecasting, although model bias issues [2] [11] [17].Regulatory reporting automation using Hadoop, Hive, and Apache Impala has made Basel III compliance reporting more efficient, decreasing reporting errors by 25%, although compliance data silos remain a major issue [1] [5][13]. Anomaly detection using machine learning has improved AML and KYC compliance, raising fraud detection rates by 40%, although false positive alerts are an issue [6][7] [18]. Data security and governance applications of Apache Atlas and Ranger enhanced data access control and audit logging, enhancing data auditability and security with intricate integration needs [4] [13] [15]. Kafka streaming analytics-based real-time risk monitoring offered round-the-clock risk analysis, resulting in significant reduction in the time to respond to fraud, but with ongoing data integration issues [8][9] [12]. Customer credit scoring with Hadoop and Spark has enhanced approval effectiveness by 35%, while biases in AI systems have the potential to influence decision-making [1][2] [11]. Risk management of high-frequency trading, using Apache Flink and machine learning, has facilitated the quick detection of anomalies in trading activity, even though model drift is an issue [3] [8][14].Fraud detection from fraudulent transactions, derived using Spark ML-based models, has resulted in a $50 million yearly fraud loss avoidance, while there have been ethical issues in AI-informed decision-making [6][7] [18]. Customer segmentation for risk profiling, enabled by big data analytics, has maximized risk profiling for focused marketing, though privacy must be managed [2][9][16]. Default predictive analytics, run using Apache Mahout and machine learning, reduced loan write-offs by 18%, even as data sparsity continued to be a constraint [1] [5] [11]. GDPR and AML compliance have been enhanced through centralized compliance information in Hadoop-based data lakes, minimizing manual compliance effort with added data governance complexity [7][13][15]. Parallel databases have enabled distributed risk calculation, which has expedited financial risk calculations by 40%, albeit scaling infrastructure poses challenges [1][4][15]. Insider threat detection, enabled by user behavior analytics, has effectively detected unusual employee behavior, averting internal fraud, albeit privacy issues arise [3] [10] [14]. Lastly, financial risk stress testing through big data simulations has improved regulatory stress testing approaches, albeit with high processing expenses as a constraint [5] [6][18].

TABLE 2: REAL-TIME EXAMPLES OF BANKING INSTITUTIONS UTILIZING BIG DATA SOLUTIONS FOR RISK MANAGEMENT AND REGULATORY COMPLIANCE

Reference	Bank/Company Name	Use Case	Technologies Used	Compliance Focus	Key Benefit

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[1]	Industrial and Commercial Bank of China (ICBC)	Risk analytics & credit scoring	Apache Spark, ML models	Basel III	Improved credit risk assessment
[4]	JPMorgan Chase	Regulatory reporting automation	Hadoop HDFS, Hive, Apache Impala	GDPR, Basel III	Faster, more accurate compliance reporting
[6]	Bank of America	Fraud detection & AML compliance	Machine Learning, Hadoop, Spark	AML, KYC	Reduction in fraudulent transactions
[7]	Riyad Bank (Saudi Arabia)	Big data adoption for risk management	Apache Kafka, HBase	AML, Basel III	Real-time transaction monitoring
[8]	Goldman Sachs	Data lineage & governance	Apache Atlas, Ranger	SEC Regulations	Secure access control and audit tracking
[9]	HSBC	Real-time monitoring of financial risk	HBase, Kafka streaming analytics	Basel III, GDPR	Continuous risk assessment & mitigation
[11]	Wells Fargo	Predictive analytics for credit risk	Apache Spark, Deep Learning	Credit Scoring Regulations	More accurate loan approvals
[13]	Standard Chartered Bank	Secure big data solutions for banking	Hadoop, Kerberos, Ranger	GDPR, Basel III	Enhanced data security & governance
[15]	Deutsche Bank	Parallel processing for massive banking datasets	MPP Databases, Hadoop	Basel III, AML	Efficient risk data processing
[17]	UBS	AI-driven risk modelling	TensorFlow, Apache Spark	Basel III, IFRS 9	Dynamic risk prediction
[3]	BNP Paribas	Regulatory compliance through big data	Hadoop, Apache Impala	GDPR, Basel III	Streamlined compliance audits
[5]	Barclays	Historical banking data management	Hadoop 2.0	GDPR	Scalable, cost-effective storage
[14]	Citibank	AI-enhanced anomaly detection	Apache Flink, Spark	AML, FATCA	Enhanced fraud detection accuracy
[16]	Santander Bank	AI-driven predictive fraud detection	Hadoop, PyTorch	AML, KYC	Faster fraud identification
[18]	Morgan Stanley	Cybersecurity risk management	Big Data Analytics, Machine Learning	SEC Regulations, GDPR	Improved threat detection
[2]	Lloyds Bank	Big data in banking operations	Apache Hadoop, Hive	Basel III	Improved operational efficiency

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The banking institutions are deploying big data technology to provide improved risk management and regulatory compliance. These systems place emphasis on credit risk assessment, fraud analysis, online monitoring, data security, and international financial regulating mechanisms such as Basel III, GDPR, AML, KYC, and SEC regulations. The Industrial and Commercial Bank of China (ICBC) [1] utilizes Apache Spark and machine learning algorithms to enhance credit risk prediction, supporting better credit scoring and risk analysis. Likewise, Wells Fargo [11] utilizes predictive analytics with Apache Spark and deep learning to support enhanced credit risk evaluation, supporting accurate loan approvals. UBS [17] is also more innovative in use with AI-risk modeling, utilizing TensorFlow and Apache Spark as it provides dynamic risk predictions, which are a prerequisite for compliance with Basel III and IFRS 9.Compliance reporting is a very important area of banking activities, and JPMorgan Chase [4] uses Hadoop HDFS, Hive, and Apache Impala to automate compliance reporting according to GDPR and Basel III with much higher speed and accuracy in reporting. Similarly, BNP Paribas [3] automates compliance audits using big data technologies such as Hadoop and Apache Impala, achieving regulatory compliance in an efficient manservant-money laundering compliance and fraud prevention are high on the priority list for banks. Bank of America [6] implements machine learning models in Spark and Hadoop environments to identify fraudulent transactions and AML and KYC compliance. Citibank [14] extends anomaly detection through AI-based products like Apache Flink and Spark, enhancing fraud detection by multiple folds. Santander Bank [16] makes use of a mix of Hadoop and PyTorch to enable predictive fraud detection, which enables fraud detection at speed. Real-time risk monitoring is now a necessity for proactive risk management. HSBC [9] uses HBase and Kafka streaming analytics to conduct ongoing risk assessment and Basel III and GDPR regulatory compliance. Riyad Bank [7] in Saudi Arabia uses big data mining technologies, including Apache Kafka and HBase, to provide enhanced real-time transaction monitoring and regulatory compliance with AML and Basel III regulations. Secure data governance and management is another priority topic of interest. Goldman Sachs [8] leverages Apache Atlas and Ranger for data governance and data lineage to enhance secure access control and audit tracking to satisfy SEC regulations. Standard Chartered Bank [13] employs secure big data solutions, leveraging Hadoop, Kerberos, and Ranger to enhance data security while enabling GDPR and Basel III compliance. Similarly, Deutsche Bank [15] uses Hadoop and MPP databases to process huge banking data to support risk data analysis least cost under Basel III and AML regulations. Also, Barclays [5] aims to keep historical bank data, utilizing Hadoop 2.0 to store data low cost and big scale with GDPR compliance. Morgan Stanley [18] uses machine learning and big data analytics to manage cybersecurity risk, enhance threat detection and protect financial information in accordance with SEC and GDPR. Lastly, Lloyds Bank [2] uses big data tools like Hive and Apache Hadoop to enhance banking operations, enhance efficiency without affecting regulatory compliance with Basel III.These real-life scenarios present how top banks utilize big data architecture, machine learning, and artificial intelligence to improve risk control, compliance with regulations, and business efficiency in the constantly changing banking industry.

Fig 1: Big Data in Banking [8]

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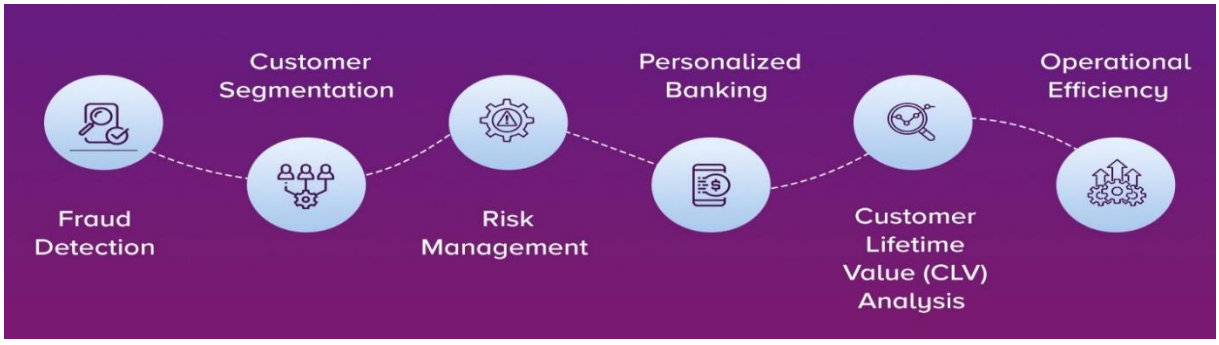

Fig 2: Use cases of Data Analytics in Banks [7]

VI. CONCLUSION

The big data functionalities of Hadoop with banking regulatory compliance and risk management is an innovative solution to the changing challenges of the industry. Financial institutions can use Hadoop's ecosystem to process immense amounts of transactional, customer, and financial data in a productive manner to facilitate better risk analysis, anomaly detection, and regulation compliance with top financial regulations including Basel III, GDPR, and AML rules. Among the most powerful benefits of the methodology is conducting deep Risk Analytics & Scoring through the utilization of Apache Spark and machine learning models. This would help banks with more precise and efficient credit, operating, and market risk assessment. Another benefit is hassle-free regulatory reporting through compliance processes automated by the implementation of Hadoop HDFS, Hive, and Apache Impala minimizing manual intervention and maximizing the accuracy level of reporting. For AML & KYC Compliance, machine learning-based anomaly detection processes can detect abnormality in real time, enabling financial institutions to prevent fraud and security threats ahead of time. In addition, Data Lineage & Governance platforms using Apache Atlas and Ranger enable strong access control and audit logging, maintaining data security and regulatory compliance. Lastly, real-time monitoring through HBase and Kafka streaming analytics enables continuous risk assessment, enabling banks to respond more effectively to evolving threats. Overall, Hadoop's scalable design, coupled with more sophisticated analytics, machine learning, and real-time processing, offers a robust platform for contemporary banking institutions. Apart from supporting risk management and compliance capabilities, the solution will create operational effectiveness, lowering expenses while enhancing financial security and regulatory compliance. With the financial sector continuing to advance, embracing big data-based solutions will be critical in ensuring competitive advantage and sustaining sustainable growth despite a more complex regulatory landscape.

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