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ABSTRACT

In this research, we focused on banking services and chose the Bank of Bahrain and Kuwait to establish the institutional structure. It is a bank that provides many services to customers and is distinguished by providing loans with many electronic services through its website and application, which makes it easier for the customer to complete his services quickly. Therefore, through this research, we aim to focus on increasing the bank's use of big data to improve the services of Bank of Bahrain and Kuwait, as big data provides a competitive advantage for institutions if used correctly. So, it helps banks analyze data to understand customer requirements and make decisions based on this data, which increases the efficiency and profits of the bank. To solve this problem, we will rely on the TOGAF framework to collect comprehensive information about the bank and then analyze it. In conclusion, in this research, we will address the benefits of using big data in the bank system and its importance in improving the bank's electronic business, as it will affect the long-term expansion of the bank's business in the future, gain customer confidence, understand market trends, and the ethical use of data in banking services.

Keywords: Architecture; Enterprise Architecture; Bahrain; Big Data; Bank BBK

1. INTRODUCTION

Enterprise architecture focuses on a comprehensive view of the current (As-Is) and future (to-be-implemented) state of BBK and provides a roadmap for the required transformation. For BBK, this transformation is essential to improving banking services, ensuring regulatory compliance, and enhancing customer experiences through innovative technologies such as big data and artificial intelligence. It includes multiple components, including Business Architecture (BA), Information Systems Architecture (ISA), and Technology Architecture (TA), which are used to ensure that all aspects of the bank operate consistently.

EA plays an important role at BBK in many ways, including: aligning business and IT, streamlining operations, and enabling strategic transformation. The two frameworks most relevant to the bank are TOGAF and Zachman. This is to ensure that BBK has a clear and organized view of its infrastructure, which is essential for managing the increasingly complex systems within modern banking.

Integrating big data into this architecture will enhance BBK's ability to improve customer experience, transform banking services, and support data-driven decision-making as it will enhance the components of the enterprise architecture. Data integration challenges are faced, including privacy and security concerns, cybersecurity threats, data quality, integration, and high implementation costs. The most common threats to BBK applications are phishing attacks, social engineering, denial of service (DoS/DDoS) attacks, data breaches, and inadequate endpoint security.

With these challenges of big data, there are several countermeasures to enhance security, such as multi-factor authentication, CyberArk for privileged access management, endpoint security, and threat identification. There are also some suggestions to help improve cybersecurity, such as enhanced protection against phishing, a zero-trust security model, behavioral analytics, routine penetration testing, and customer awareness programs.

2. LITERATURE REVIEW

Definition of Enterprise Architecture (EA) at BBK Bank:

Enterprise Architecture (EA) is a strategic framework used by organizations like BBK Bank to align their IT infrastructure, data management, business processes, and technology to support and advance their business objectives. EA provides a holistic view of the current (AS-IS) and future (TO-BE) state of BBK Bank and provides a roadmap for the required transformation. This transformation typically involves streamlining operations, improving efficiency, and ensuring that IT investments are closely aligned with BBK Bank's business strategy. For BBK Bank, this transformation is essential for optimizing banking services, ensuring regulatory compliance, and enhancing customer experiences through innovative technologies such as Big Data and AI.

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EA helps BBK Bank manage and design its IT systems, business processes, and data to support current needs and future growth. It includes multiple components, including Business Architecture (BA), Information Systems Architecture (ISA), and Technology Architecture (TA), which are used to ensure that all aspects of the bank operate in a consistent manner. These components are particularly important for supporting BBK Bank's expansion into digital banking and integrating advanced technologies.

Role of EA in BBK Bank:
EA plays a vital role in improving BBK Bank's organizational processes in the following ways:

1. Alignment of Business and IT: EA ensures that IT investments directly support BBK Bank's business goals. This is achieved by creating a shared understanding of business and IT priorities across the bank, enabling better decision-making. For BBK Bank, this alignment is crucial to improve operational efficiency, enhance service offerings, and ensure the ability to adapt to emerging technologies.

2. Streamlining Processes: By providing a blueprint of BBK Bank's organizational processes, capabilities, and systems, EA helps eliminate redundancies and inefficiencies. It identifies opportunities for process improvements and technology integration, ensuring that the bank's operations, such as customer service and back-office functions, are optimized. This will also ensure faster transaction processing and lower operational costs.

3. Enabling Strategic Transformation: EA is critical to BBK Bank's strategic business transformation by providing a framework that supports innovation, business capability development, and the integration of new technologies. With the rise of Big Data and AI, EA facilitates the integration of these technologies into BBK Bank's infrastructure, allowing for real-time analytics, improved customer insights, and more effective decision-making processes.

EA Framework Comparison:
Multiple EA frameworks guide the implementation of enterprise architecture at BBK Bank. The two most relevant frameworks for the bank are:

1. TOGAF (The Open Group Architecture Framework): TOGAF is a comprehensive framework that provides a structured approach to developing, managing, and maintaining enterprise architecture. For BBK Bank, TOGAF's Architecture Development Method (ADM) outlines the steps to design and implement the bank's EA, ensuring that the IT infrastructure is fully aligned with its business goals while maintaining flexibility to adapt to future changes in the banking sector.

2. Zachman Framework: The Zachman Framework is one of the earliest EA frameworks that provides a structured approach to viewing and defining an organization's architecture.

BBK Bank provides a comprehensive view of the bank's entire architecture by organizing elements like processes, data, and technology into a matrix. This approach ensures that BBK Bank has a clear, organized view of its architecture, which is essential for managing the increasingly complex systems within modern banking.

Enterprise architecture is essential for BBK Bank to bridge the gap between business strategy and technology. By providing a transformation roadmap and acting as a bridge between business goals and IT systems, EA plays a key role in improving efficiency, supporting innovation, and driving long-term business success. It enables BBK Bank to optimize its banking operations, ensure compliance with industry regulations, and meet the evolving needs of customers.

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Integration of Big Data with Enterprise Architecture at BBK Bank:

BBK Bank has a solid foundation in its existing enterprise architecture (EA), which consists of business architecture (BA), information system architecture (ISA), and technology architecture (TA). Integrating big data into this architecture will enhance BBK Bank's ability to improve customer experience, transform banking services, and support data-driven decision-making. Here's an exploration of how big data fits into these areas:

1. Business Architecture (BA)

BBK Bank's business architecture revolves around optimizing business processes to improve overall performance. By integrating big data into BA, the bank can:

• Improve customer insights: By analyzing large data sets from customer interactions, BBK can gain a deeper understanding of customer preferences and behaviors. This helps customize personalized banking services and improve customer satisfaction.

• Improved risk management: Big data can help predict potential risks and identify customer behavior patterns that may lead to fraud or other financial risks, thereby supporting better risk mitigation strategies.

• Optimize operational efficiency: Analyzing data from internal processes such as transactions or account management can reveal inefficiencies and areas for improvement in business processes.

2. Information System Architecture (ISA)

Integrating big data into BBK's information system architecture will optimize the bank's information management system. Key focus areas include:

• Data analysis and reporting: With cloud platforms such as AWS and Azure, big data tools can process large amounts of transaction data and customer data, enabling real-time reporting and business intelligence. For example, using AWS Data Lake House, structured and unstructured data from BBK Mobile, BBK Plus, and other customer-facing applications can be aggregated to generate valuable insights.

• Predictive analytics: Big data technology can process historical transaction data to predict future trends, such as customer behavior, loan defaults, or investment opportunities. This predictive capability can improve decision-making, especially in risk management and personalized financial products.

• Improve customer service: By integrating data from various applications (such as BBK Mobile and CrediMax), big data can be used to track customer interactions and service performance. This helps provide proactive solutions, personalized recommendations, and enhanced support (such as using ITM – Interactive Teller Machines for complex transactions) through real-time interactions.

3. Technology Architecture (TA)

Big data will leverage BBK's existing technology infrastructure to build a scalable, secure, and efficient system. Key technology integrations include:

• Data security: Security measures such as HSM (Hardware Security Module), PAM (Privileged Access Management) ensure that the massive amounts of sensitive data processed by big data technologies are protected. These measures help maintain the confidentiality and integrity of customer data and financial transactions.

By integrating big data into BBK Bank's enterprise architecture, the bank can take operational efficiency, superior customer service, and informed decision-making to new levels. The ability to leverage predictive analytics and data-driven insights can not only improve existing services but also develop innovative products and services that meet the evolving needs of customers. Through this integration, BBK will strengthen its position as a future-oriented, data-driven financial institution that continuously adapts to market demands and provides added value to customers.

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Challenges in Big Data Integration at BBK Bank:

Data Privacy and Security Concerns: Significant privacy concerns arise from managing extensive amounts of sensitive financial and personal customer information. To comply with regulations like GDPR (General Data Protection Regulation) and Bahrain's Personal Data Protection Law (PDPL), it is essential to implement strong security measures, including encryption, access control, and frequent audits. Inadequate data protection may result in harm to reputation, legal repercussions, and a loss of customer trust.

Data quality and integration: big data sources often include structured and unstructured data from various systems, such as BBK Mobile, BBK Plus, and external financial platforms. Ensuring data consistency, accuracy, and relevance across these systems can be challenging, especially for legacy systems that may not integrate seamlessly with modern big data tools.

High implementation costs: Deploying big data solutions requires significant financial investments in technology, infrastructure, and qualified personnel. Updating existing IT systems and implementing advanced tools such as data lakes, predictive analytics platforms, and AI-driven solutions can put a strain on resources.

Cybersecurity threats: big data integration exposes banks to advanced cybersecurity risks, such as data breaches, ransomware attacks, and unauthorized access. To mitigate these risks, it is necessary to implement layered security measures, such as privileged access management (PAM) and intrusion detection systems. Addressing these challenges is critical for BBK Bank to fully realize the benefits of big data integration. By proactively planning for these obstacles, the bank can ensure a smooth transition and maximize the value of its enterprise architecture transformation.

Cybersecurity Threats for BBK Bank Applications:

As BBK Bank incorporates advanced technologies such as big data, artificial intelligence, and cloud computing into its enterprise architecture, it is increasingly vulnerable to sophisticated cybersecurity threats. The financial sector is a prime target for cybercriminals, and banks must address these threats to protect their assets, data, and reputation. Here are the main cybersecurity threats that BBK Bank may face:

1. Phishing Assaults Fraudulent websites or emails imitate BBK services, such as BBK Mobile and BBK Plus, in an attempt to capture customer credentials, resulting in compromised accounts and harm to reputation.

2. Social Engineering Deceptive strategies aim at both customers and employees of BBK Plus and CrediMax, seeking to obtain sensitive data such as passwords or PINs, potentially leading to fraudulent activities.

3. Attacks of Denial of Service (DoS/DDoS) Disrupting service availability and resulting in downtime and a decline in customer trust occurs when public-facing applications like BBK Mobile and BBK Online are flooded.

4. Data Breaches Exposing sensitive information by taking advantage of weaknesses in systems such as HR and RAF results in legal challenges and violations of compliance.

5. Insufficient Endpoint Security Compromised mobile devices utilizing BBK Mobile or BBK Plus face the threat of unauthorized access to accounts and potential financial losses.

Security Features and Countermeasures:

1. Authentication with Multiple Factors (MFA) Implements additional layers of login security for BBK Online and BBK Mobile.

2. CyberArk for Privileged Access Management. Secures administrative access to safeguard essential systems.

3. HSM Encryption Provides secure safeguarding of customer and transaction information.

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4. Endpoint Security (FortiClient VPN) Stops susceptible devices from connecting to internal systems.

5. Threat Identification (Zscaler, SolarWinds) Detects and prevents phishing, malware, and various other online threats.

Suggestions for Improved Cybersecurity:

1. Enhanced Protection Against Phishing: Utilize AI technologies to enhance phishing detection and improve customer education.

2. Security Model Based on Zero Trust: Implement rigorous verification processes for access to cloud services and third-party platforms.

3. Behavioral Analytics: Keep an eye on atypical behavior to identify accounts that may have been compromised.

4. Routine Penetration Testing: Detect and remediate vulnerabilities across all systems.

5. Programs for Customer Awareness: Inform users about safe online behaviors and methods to prevent fraud.

Governance and Compliance in (EA) at BBK Bank :

Governance and compliance are essential to ensure BBK Bank's Enterprise Architecture (EA) aligns with regulations and internal standards. As a financial institution, BBK Bank must meet numerous regulations while maintaining effective EA. Here's the impact of governance and compliance on the bank's EA:

1. Compliance with Laws and Regulations: BBK Bank must follow international standards like CBB, FATF, and GDPR. Compliance helps prevent risks like fraud and data breaches. The EA should ensure that all systems and data practices adhere to these laws.
2. Data Protection and Security: With big data and AI, protecting customer data is critical. The bank must ensure governance policies are in place to manage customer data in line with regulations like GDPR, protecting it from vulnerabilities.
3. IT Governance: BBK's IT resources should support business strategy and comply with legal requirements. Governance committees should oversee IT projects, ensuring they meet business objectives while minimizing risk.
4. Risk Management and Internal Controls: The bank's EA should include processes to assess and mitigate risks related to technology and data management, preventing fraud and unauthorized access.
5. Audit and Compliance Monitoring: Regular audits and automated tools help track compliance, identity issues early, and ensure transparency. This reduces human error and ensures ongoing compliance.
6. Alignment with Corporate Governance: BBK's EA should align with corporate governance, promoting transparency, accountability, and integrity across the bank to meet regulatory standards.
7. Adapting to New Technologies: As technologies like cloud computing and blockchain evolve, the EA should adapt without compromising security or compliance, ensuring the bank stays competitive.

Governance and compliance are vital for BBK Bank's EA, ensuring systems meet legal requirements, protect customer data, and align with business goals. A solid governance framework enables the bank to adapt to regulations, integrate new technologies, and manage vendors effectively for long-term success.

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3. METHOD

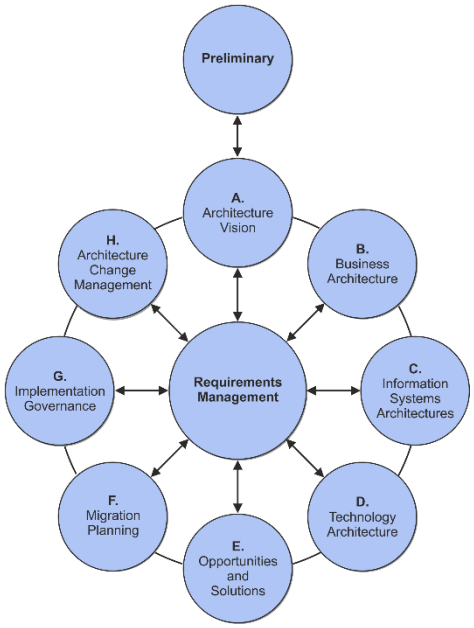

Figure 1: TOGAF Framework

We will follow a TOGAF framework to build the enterprise architecture as shown in Figure 1. First, we defined the vision of building the enterprise architecture. Second, we contacted the Bank of Bahrain and Kuwait and got their permission to interview them to determine the current status of the bank's AS-IS on 30th October to collect information (business, Information Systems, Technology) which are the stages B, C, and D. Then, we will analyse this information to find the most appropriate solution to our problem to move to TO-BE. Also, we will use SOA to see the importance of using big data in the enterprise infrastructure.

4. CASE STUDY

BBK is one of the approved banks in Bahrain, with 17 branches, specializing in retail banking, corporate banking, international banking, bonds, and investment. It aims to lead and provide high-quality services through the use of technology such as effective online banking platforms, award-winning applications, modern digital branches, and financial centers in residential and commercial complexes. The bank has two applications: BBK Plus, which is used to help open new accounts with the bank, and BBK Mobile, which is used for regular transactions. The bank uses a comprehensive website for all banking services and customer inquiries that individuals and businesses need.

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Architecture Mode:

A. BA Archi model:

Figure 2: BA

B. ISA Archi model:

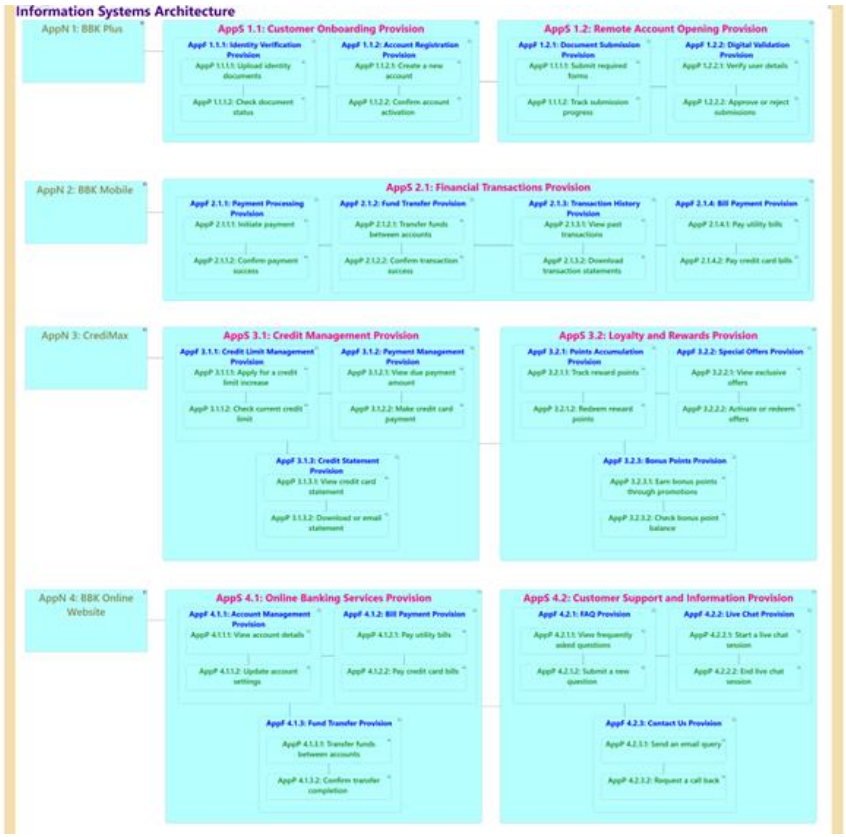

Figure 3: ISA

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C. TA Archi model:

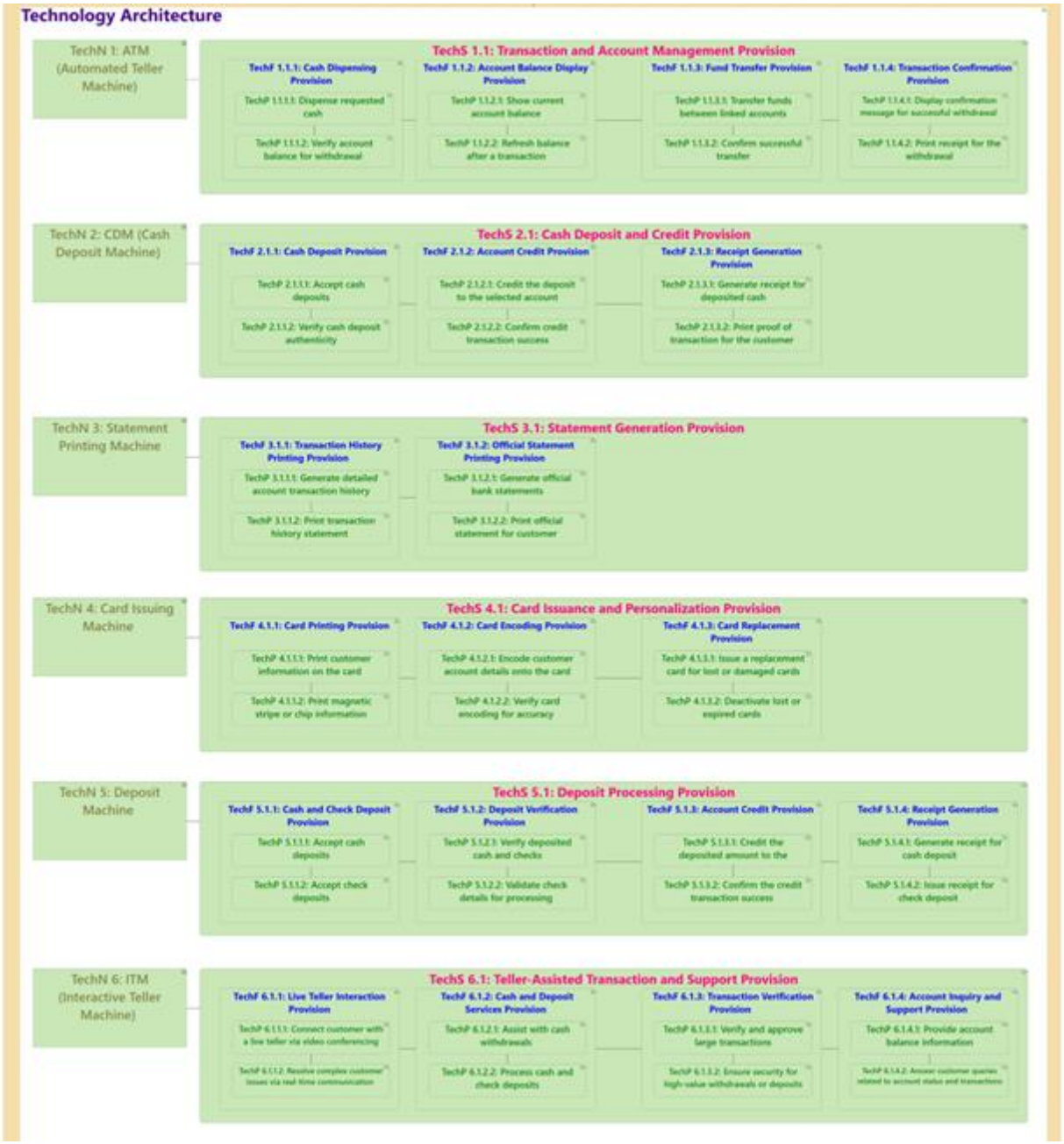

Figure 4: TA

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D. Full Architecture Model:

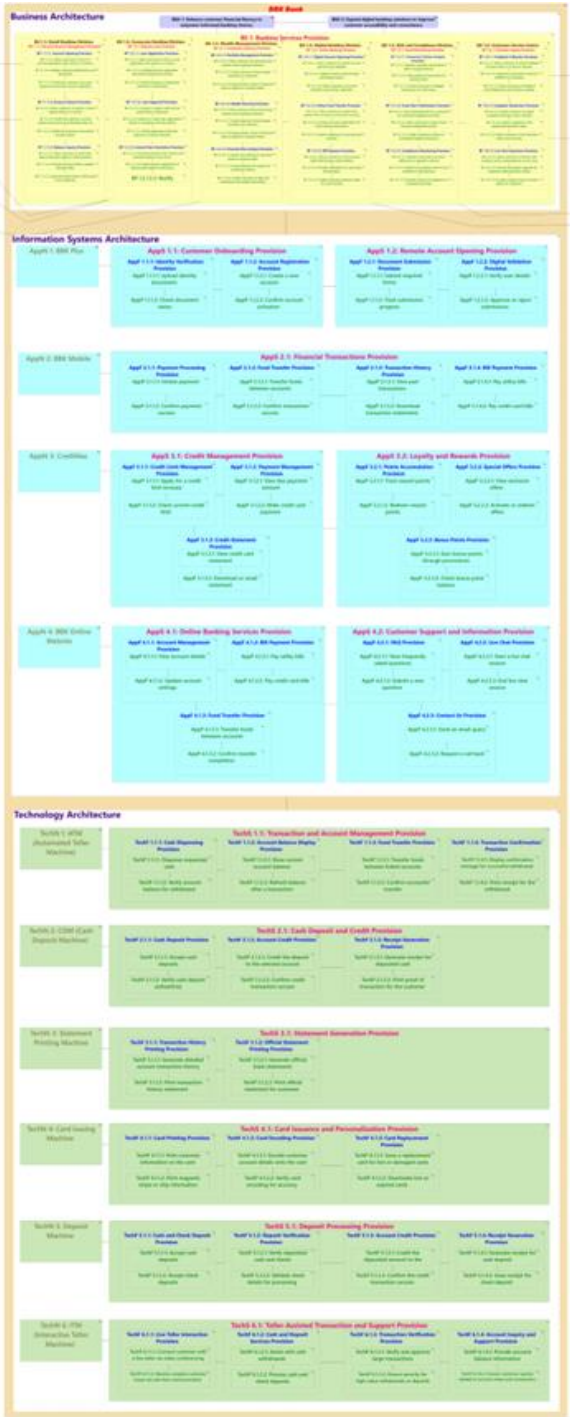

Figure 5: Full Architecture

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SOA:

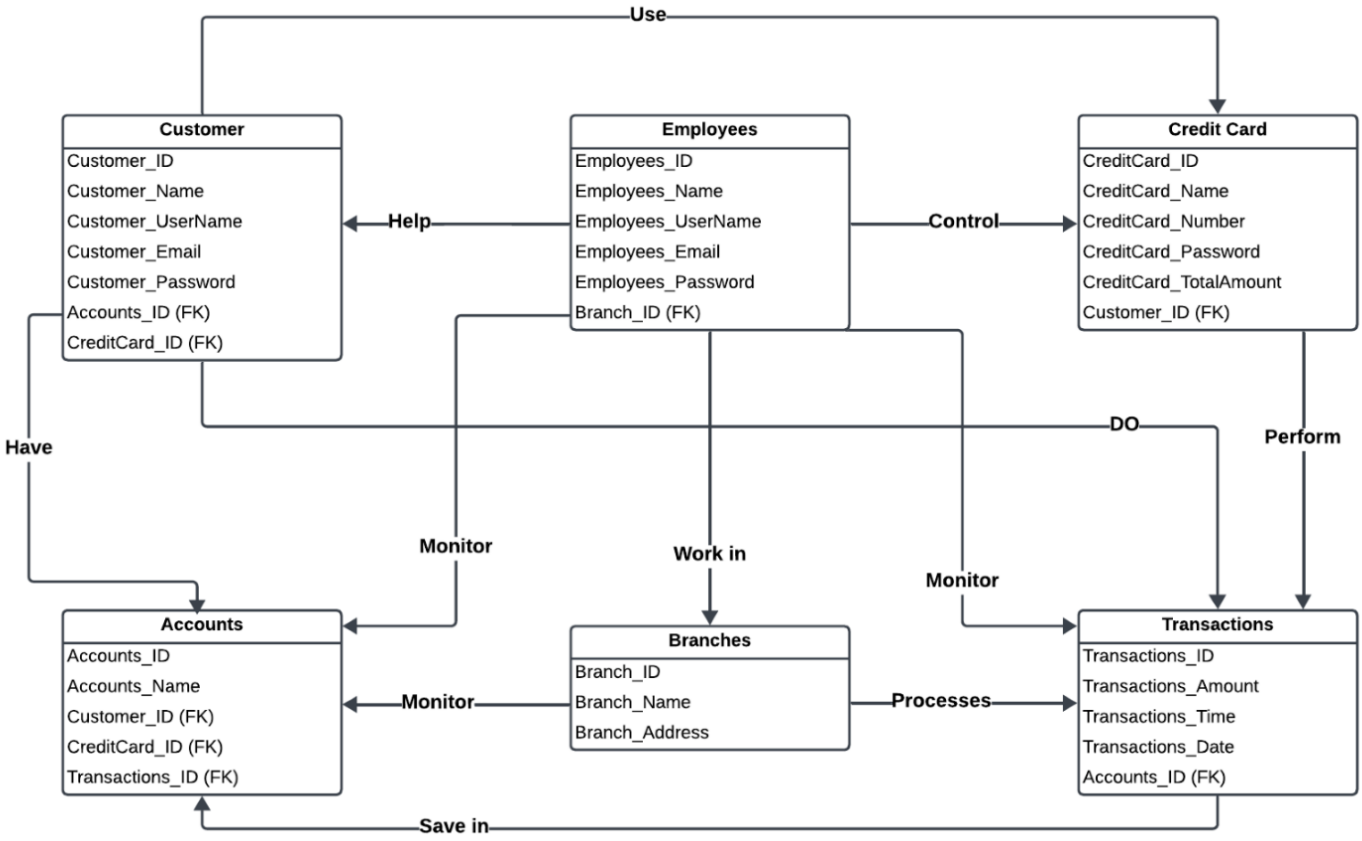

Figure 6: SOA

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Architecture model with SOA:

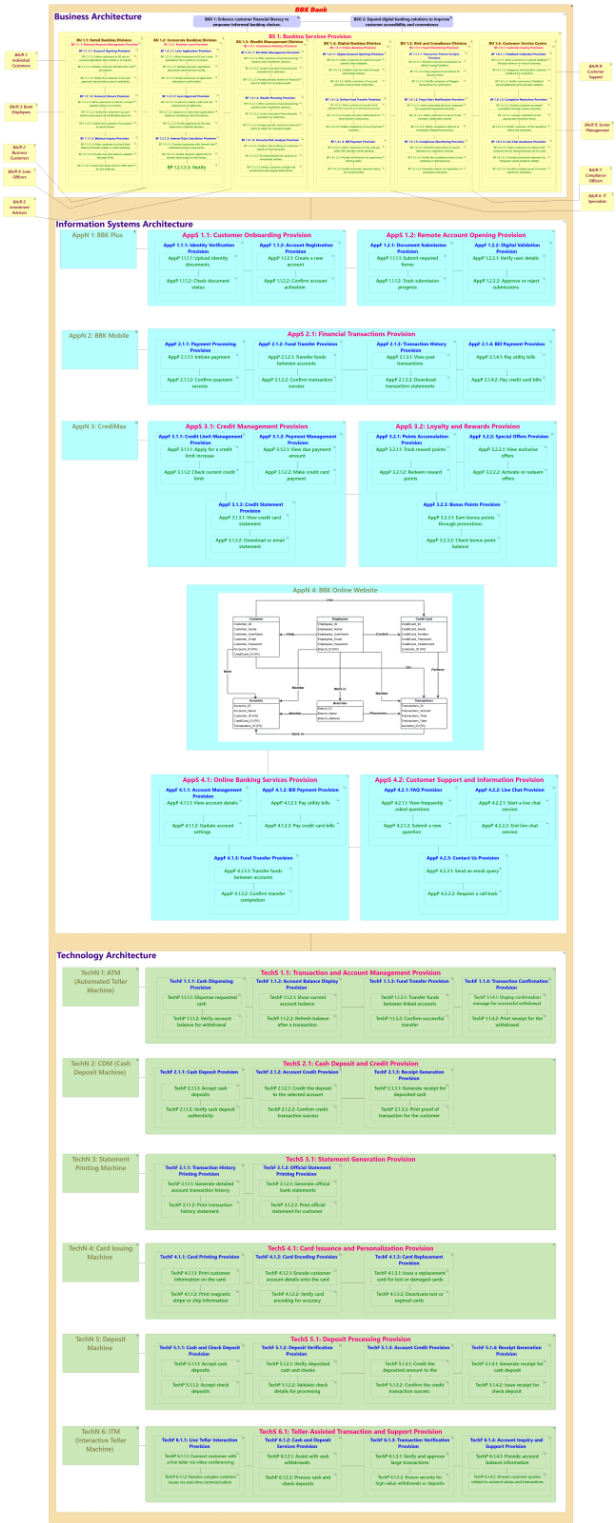

Figure 7: Full Architecture with SOA

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Table

Business Architecture (BA) Tabular:

Business Layer Architecture Tabular	
Business Strategy (BSO):	**BSO 1:** Enhance customer financial literacy to empower informed banking choices. **BSO 2:** Expand digital banking solutions to improve customer accessibility and convenience.
Business Actors/Role (BA/R):	**BA/R 1:** Individual Customers **BA/R 2:** Business Customers **BA/R 3:** Bank Employees **BA/R 4:** Loan Officers **BA/R 5:** Investment Advisors **BA/R 6:** IT Specialists **BA/R 7:** Compliance Officers **BA/R 8:** Customer Support Representatives **BA/R 9:** Senior Management
Business Service (BS):	**BS 1:** Banking Services Provision
Business units (BU):	**BU 1.1:** Retail Banking Division **BU 1.2:** Corporate Banking Division **BU 1.3:** Wealth Management Division **BU 1.4:** Digital Banking Division **BU 1.5:** Risk and Compliance Division **BU 1.6:** Customer Service Centre
Business Service (BS) for each Business units (BU):	BU 1.1: Retail Banking Division **BS 1.1.1**: Personal Account Management Provision BU 1.2: Corporate Banking Division **BS 1.2.1**: Business Loan Provision BU 1.3: Wealth Management Division **BS 1.3.1**: Investment Advisory Provision BU 1.4: Digital Banking Division **BS 1.4.1**: Online Banking Provision BU 1.5: Risk and Compliance Division

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	BS 1.5.1: Fraud Monitoring Provision BU 1.6: Customer Service Centre **BS 1.6.1**: Customer Inquiry Provision
Business Functions (BF) for each Business Service (BS):	Personal Account Management Provision (BS 1.1.1) BF 1.1.1.1: Account Opening Provision BF 1.1.1.2: Account Closure Provision BF 1.1.1.3: Balance Inquiry Provision Business Loan Provision (BS 1.2.1) BF 1.2.1.1: Loan Application Provision BF 1.2.1.2: Loan Approval Provision BF 1.2.1.3: Interest Rate Calculation Provision Investment Advisory Provision (BS 1.3.1) BF 1.3.1.1: Portfolio Management Provision BF 1.3.1.2: Wealth Planning Provision BF 1.3.1.3: Financial Risk Analysis Provision Online Banking Provision (BS 1.4.1) BF 1.4.1.1: Digital Account Opening Provision BF 1.4.1.2: Online Fund Transfer Provision BF 1.4.1.3: Bill Payment Provision Fraud Monitoring Provision (BS 1.5.1) BF 1.5.1.1: Transaction Pattern Analysis Provision BF 1.5.1.2: Fraud Alert Notification Provision BF 1.5.1.3: Compliance Monitoring Provision Customer Inquiry Provision (BS 1.6.1) BF 1.6.1.1: Feedback Collection Provision BF 1.6.1.2: Complaint Resolution Provision BF 1.6.1.3: Live Chat Assistance Provision
Business Processes (BP) for each Business Functions (BF) :	**1. Personal Account Management Provision (BU 1.1: Retail Banking Division)** • **BF 1.1.1.1: Account Opening Provision** BP 1.1.1.1.1: Allow customers to fill out an account application form online or in-branch. BP 1.1.1.1.2: Validate customer identification and documents. BP 1.1.1.1.3: Notify the customer of account approval and provide account credentials. • **BF 1.1.1.2: Account Closure Provision** BP 1.1.1.2.1: Allow customers to submit a closure request online or in-branch. BP 1.1.1.2.2: Verify the customer's account balance and ensure all outstanding dues are cleared. BP 1.1.1.2.3: Notify the customer of successful account closure. • **BF 1.1.1.3: Balance Inquiry Provision**

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	BP 1.1.1.3.1: Allow customers to check their balance through mobile or online banking. BP 1.1.1.3.2: Provide real-time balance updates through ATMs. BP 1.1.1.3.3: Send automated email or SMS alerts for low balances. **2. Business Loan Provision (BU 1.2: Corporate Banking Division)** • **BF 1.2.1.1: Loan Application Provision** BP 1.2.1.1.1: Allow businesses to fill out a loan application form online or in-branch. BP 1.2.1.1.2: Validate business registration documents and financial records. BP 1.2.1.1.3: Notify businesses of application submission confirmation. • **BF 1.2.1.2: Loan Approval Provision** BP 1.2.1.2.1: Conduct in-depth credit and risk assessments of applicants. BP 1.2.1.2.2: Approve or reject loan applications based on compliance and risk policies. BP 1.2.1.2.3: Notify applicants of the loan approval or rejection decision. • **BF 1.2.1.3: Interest Rate Calculation Provision** BP 1.2.1.3.1: Provide businesses with interest rate estimates based on loan terms. BP 1.2.1.3.2: Enable dynamic adjustment of interest rates based on risk factors. BP 1.2.1.3.3: Notify applicants of the finalized interest rate as part of loan terms. **3. Investment Advisory Provision (BU 1.3: Wealth Management Division)** • **BF 1.3.1.1: Portfolio Management Provision** BP 1.3.1.1.1: Enable customers to create and customize investment portfolios. BP 1.3.1.1.2: Allow investment advisors to monitor and rebalance portfolios.

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BP 1.3.1.1.3: Provide customers with detailed performance reports.

- **BF 1.3.1.2: Wealth Planning Provision**

  BP 1.3.1.2.1: Offer customers financial planning sessions with investment advisors.

  BP 1.3.1.2.2: Create long-term financial goals and plans for customers.

  BP 1.3.1.2.3: Provide periodic reviews of financial plans to adjust for changing needs.

- **BF 1.3.1.3: Financial Risk Analysis Provision**

  BP 1.3.1.3.1: Conduct risk profiling of customers based on financial goals.

  BP 1.3.1.3.2: Provide detailed risk analysis for investment options.

  BP 1.3.1.3.3: Notify customers of high-risk investments and suggest alternatives.

4. Online Banking Provision (BU 1.4: Digital Banking Division)

- **BF 1.4.1.1: Digital Account Opening Provision**

  BP 1.4.1.1.1: Allow customers to submit account opening forms digitally.

  BP 1.4.1.1.2: Validate customer data through automated systems.

  BP 1.4.1.1.3: Notify customers of account activation and provide credentials.

- **BF 1.4.1.2: Online Fund Transfer Provision**

  BP 1.4.1.2.1: Allow customers to transfer funds between their accounts or to third-party accounts.

  BP 1.4.1.2.2: Provide real-time notifications for fund transfer transactions.

  BP 1.4.1.2.3: Enable scheduling of recurring fund transfers.

- **BF 1.4.1.3: Bill Payment Provision**

  BP 1.4.1.3.1: Allow customers to view and pay utility bills through online banking.

  BP 1.4.1.3.2: Provide notifications for upcoming bill due dates.

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BP 1.4.1.3.3: Enable automatic payment setup for recurring bills.

5. Fraud Monitoring Provision (BU 1.5: Risk and Compliance Division)

- **BF 1.5.1.1: Transaction Pattern Analysis Provision**

  BP 1.5.1.1.1: Monitor customer transactions to detect unusual patterns.

  BP 1.5.1.1.2: Flag suspicious transactions for manual review.

  BP 1.5.1.1.3: Notify customers of flagged transactions for verification.

- **BF 1.5.1.2: Fraud Alert Notification Provision**

  BP 1.5.1.2.1: Send automated alerts to customers for suspected fraudulent activities.

  BP 1.5.1.2.2: Allow customers to report fraud through a dedicated channel.

  BP 1.5.1.2.3: Notify compliance officers to investigate flagged transactions.

- **BF 1.5.1.3: Compliance Monitoring Provision**

  BP 1.5.1.3.1: Monitor transactions to ensure adherence to regulatory policies.

  BP 1.5.1.3.2: Notify the compliance team of any violations or discrepancies.

  BP 1.5.1.3.3: Generate reports for regulators on compliance activities.

6.Customer Inquiry Provision (BU 1.6: Customer Service Centre)

- **BF 1.6.1.1: Feedback Collection Provision**

  BP 1.6.1.1.1: Allow customers to submit feedback through online or in-branch channels.

  BP 1.6.1.1.2: Categorize and prioritize customer feedback for resolution.

  BP 1.6.1.1.3: Notify customers of feedback acknowledgment and resolution updates.

- **BF 1.6.1.2: Complaint Resolution Provision**

  BP 1.6.1.2.1: Enable customers to submit complaints through various

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Journal of Computer Networks, Architecture and High Performance Computing
Volume xx, Number xx, month Year
https://doi.org/10.47709/cnapc.vxix.xxxx

Submitted : xxxxx
Accepted : xxxxx
Published : xxxxx

	channels. BP 1.6.1.2.2: Assign complaints to the appropriate resolution team. BP 1.6.1.2.3: Notify customers of the resolution status and outcomes. • **BF 1.6.1.3: Live Chat Assistance Provision** BP 1.6.1.3.1: Allow customers to interact with customer service representatives via live chat. BP 1.6.1.3.2: Provide automated responses for frequently asked questions (FAQs). BP 1.6.1.3.3: Escalate complex issues to human agents for resolution.

Information System Architecture (ISA) Tabular:

Information Systems Architecture Layer Architecture Tabular	
Application Name (AppN):	**AppN 1:** BBK Plus **AppN 2:** BBK Mobile **AppN 3:** CrediMax **AppN 4:** BBK Online Website
Application Service (AppS) for each Application Name (AppN):	AppN 1: BBK Plus **AppS 1.1**: Customer Onboarding Provision **AppS 1.2**: Remote Account Opening Provision AppN 2: BBK Mobile **AppS 2.1**: Financial Transactions Provision AppN 3: CrediMax **AppS 3.1**: Credit Management Provision **AppS 3.2**: Loyalty and Rewards Provision AppN 4: BBK Online Website **AppS 4.1**: Online Banking Services Provision **AppS 4.2**: Customer Support and Information Provision

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Journal of Computer Networks, Architecture and High Performance Computing
Volume xx, Number xx, month Year
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Submitted : xxxxx
Accepted : xxxxx
Published : xxxxx

Application Functions (AppF) for each Application Service (AppS):	Customer Onboarding Provision (AppS 1.1) AppF 1.1.1: Identity Verification Provision AppF 1.1.2: Account Registration Provision Remote Account Opening Provision (AppS 1.2) AppF 1.2.1: Document Submission Provision AppF 1.2.2: Digital Validation Provision Financial Transactions Provision (AppS 2.1) AppF 2.1.1: Payment Processing Provision AppF 2.1.2: Fund Transfer Provision AppF 2.1.3: Transaction History Provision AppF 2.1.4: Bill Payment Provision Credit Management Provision (AppS 3.1) AppF 3.1.1: Credit Limit Management Provision AppF 3.1.2: Payment Management Provision AppF 3.1.3: Credit Statement Provision Loyalty and Rewards Provision (AppS 3.2) AppF 3.1.1: Points Accumulation Provision AppF 3.1.2: Special Offers Provision AppF 3.1.3: Bonus Points Provision Online Banking Services Provision (AppS 4.1) AppF 4.1.1: Account Management Provision AppF 4.1.2: Bill Payment Provision AppF 4.1.3: Fund Transfer Provision Customer Support and Information Provision (AppS 4.2) AppF 4.2.1: FAQ Provision AppF 4.2.2: Live Chat Provision AppF 4.2.3: Contact Us Provision

Application Process (AppP) for each Application Functions (AppF):	**1. BBK Plus**
	
	(AppS 1.1: Customer Onboarding Provision)
	
	• **AppF 1.1.1: Identity Verification Provision**
	  ○ AppP 1.1.1.1: Upload identity documents
	  ○ AppP 1.1.1.2: Check document status
	• **AppF 1.1.2: Account Registration Provision**
	  ○ AppP 1.1.2.1: Create a new account
	  ○ AppP 1.1.2.2: Confirm account activation
	
	(AppS 1.2: Remote Account Opening Provision)

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Journal of Computer Networks, Architecture and High Performance Computing
Volume xx, Number xx, month Year
https://doi.org/10.47709/cnapc.vxix.xxxx

Submitted : xxxxx
Accepted : xxxxx
Published : xxxxx

	• **AppF 1.2.1: Document Submission Provision**
	  ○ AppP 1.1.1.1: Submit required forms
	  ○ AppP 1.1.1.2: Track submission progress
	• **AppF 1.2.2: Digital Validation Provision**
	  ○ AppP 1.2.2.1: Verify user details
	  ○ AppP 1.2.2.2: Approve or reject submissions
	2. BBK Mobile
	(AppS 2.1: Financial Transactions Provision)
	• **AppF 2.1.1: Payment Processing Provision**
	  ○ AppP 2.1.1.1: Initiate payment
	  ○ AppP 2.1.1.2: Confirm payment success
	• **AppF 2.1.2: Fund Transfer Provision**
	  ○ AppP 2.1.2.1: Transfer funds between accounts
	  ○ AppP 2.1.2.2: Confirm transaction success
	• **AppF 2.1.3: Transaction History Provision**
	  ○ AppP 2.1.3.1: View past transactions
	  ○ AppP 2.1.3.2: Download transaction statements
	• **AppF 2.1.4: Bill Payment Provision**
	  ○ AppP 2.1.4.1: Pay utility bills
	  ○ AppP 2.1.4.2: Pay credit card bills
	3. CrediMax
	(AppS 3.1: Credit Management Provision)
	• **AppF 3.1.1: Credit Limit Management Provision**
	  ○ AppP 3.1.1.1: Apply for a credit limit increase
	  ○ AppP 3.1.1.2: Check current credit limit
	• **AppF 3.1.2: Payment Management Provision**
	  ○ AppP 3.1.2.1: View due payment amount

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Journal of Computer Networks, Architecture and High Performance Computing
Volume xx, Number xx, month Year
https://doi.org/10.47709/cnapc.vxix.xxxx

Submitted : xxxxx
Accepted : xxxxx
Published : xxxxx

	○ AppP 3.1.2.2: Make credit card payment • **AppF 3.1.3: Credit Statement Provision** ○ AppP 3.1.3.1: View credit card statement ○ AppP 3.1.3.2: Download or email statement **(AppS 3.2: Loyalty and Rewards Provision)** • **AppF 3.2.1: Points Accumulation Provision** ○ AppP 3.2.1.1: Track reward points ○ AppP 3.2.1.2: Redeem reward points • **AppF 3.2.2: Special Offers Provision** ○ AppP 3.2.2.1: View exclusive offers ○ AppP 3.2.2.2: Activate or redeem offers • **AppF 3.2.3: Bonus Points Provision** ○ AppP 3.2.3.1: Earn bonus points through promotions ○ AppP 3.2.3.2: Check bonus point balance **4. BBK Online Website** **(AppS 4.1: Online Banking Services Provision)** • **AppF 4.1.1: Account Management Provision** ○ AppP 4.1.1.1: View account details ○ AppP 4.1.1.2: Update account settings • **AppF 4.1.2: Bill Payment Provision** ○ AppP 4.1.2.1: Pay utility bills ○ AppP 4.1.2.2: Pay credit card bills • **AppF 4.1.3: Fund Transfer Provision** ○ AppP 4.1.3.1: Transfer funds between accounts ○ AppP 4.1.3.2: Confirm transfer completion **(AppS 4.2: Customer Support and Information Provision)** • **AppF 4.2.1: FAQ Provision**

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Journal of Computer Networks, Architecture and High Performance Computing
Volume xx, Number xx, month Year
https://doi.org/10.47709/cnapc.vxix.xxxx

Submitted : xxxxx
Accepted : xxxxx
Published : xxxxx

	○ AppP 4.2.1.1: View frequently asked questions ○ AppP 4.2.1.2: Submit a new question • **AppF 4.2.2: Live Chat Provision** ○ AppP 4.2.2.1: Start a live chat session ○ AppP 4.2.2.2: End live chat session • **AppF 4.2.3: Contact Us Provision** ○ AppP 4.2.3.1: Send an email query ○ AppP 4.2.3.2: Request a call back

Technology Architecture (TA) Tabular:

Technology Architecture Layer Architecture Tabular	
Technology Name (TechN):	**TechN 1:** ATM (Automated Teller Machine) **TechN 2:** CDM (Cash Deposit Machine) **TechN 3:** Statement Printing Machine **TechN 4:** Card Issuing Machine **TechN 5:** Deposit Machine **TechN 6:** ITM (Interactive Teller Machine)
Technology Service (TechS) for each Technology Name (TechN):	TechN 1: ATM **TechS 1.1**: Transaction and Account Management Provision TechN 2: CDM **TechS 2.1**: Cash Deposit and Credit Provision TechN 3: Statement Printing Machine **TechS 3.1**: Statement Generation Provision TechN 4: Card Issuing Machine **TechS 4.1**: Card Issuance and Personalization Provision TechN 5: Deposit Machine **TechS 5.1**: Deposit Processing Provision TechN 6: ITM **TechS 6.1**: Teller-Assisted Transaction and Support Provision

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Journal of Computer Networks, Architecture and High Performance Computing
Volume xx, Number xx, month Year
https://doi.org/10.47709/cnapc.vxix.xxxx

Submitted : xxxxx
Accepted : xxxxx
Published : xxxxx

Technology Functions (TechF) for each Technology Service (TechS):	Transaction and Account Management Provision (TechS 1.1) TechF 1.1.1: Cash Dispensing Provision TechF 1.1.2: Account Balance Display Provision TechF 1.1.3: Fund Transfer Provision TechF 1.1.4: Transaction Confirmation Provision Cash Deposit and Credit Provision (TechS 2.1) TechF 2.1.1: Cash Deposit Provision TechF 2.1.2: Account Credit Provision TechF 2.1.3: Receipt Generation Provision Statement Generation Provision (TechS 3.1) TechF 3.1.1: Transaction History Printing Provision TechF 3.1.2: Official Statement Printing Provision Card Issuance and Personalization Provision (TechS 4.1) TechF 4.1.1: Card Printing Provision TechF 4.1.2: Card Encoding Provision TechF 4.1.3: Card Replacement Provision Deposit Processing Provision (TechS 5.1) TechF 5.1.1: Cash and Check Deposit Provision TechF 5.1.2: Deposit Verification Provision TechF 5.1.3: Account Credit Provision TechF 5.1.4: Receipt Generation Provision Teller-Assisted Transaction and Support Provision (TechS 6.1) TechF 6.1.1: Live Teller Interaction Provision TechF 6.1.2: Cash and Deposit Services Provision TechF 6.1.3: Transaction Verification Provision TechF 6.1.4: Account Inquiry and Support Provision

Technology Process (TechP) for each Technology Functions (TechF):	**1. ATM**
	
	(TechS 1.1: Transaction and Account Management Provision)
	
	• **TechF 1.1.1: Cash Dispensing Provision**
	  ○ TechP 1.1.1.1: Dispense requested cash
	  ○ TechP 1.1.1.2: Verify account balance for withdrawal
	• **TechF 1.1.2: Account Balance Display Provision**
	  ○ TechP 1.1.2.1: Show current account balance
	  ○ TechP 1.1.2.2: Refresh balance after a transaction
	• **TechF 1.1.3: Fund Transfer Provision**
	  ○ TechP 1.1.3.1: Transfer funds between linked accounts

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Journal of Computer Networks, Architecture and High Performance Computing
Volume xx, Number xx, month Year
https://doi.org/10.47709/cnapc.vxix.xxxx

Submitted : xxxxx
Accepted : xxxxx
Published : xxxxx

	○ TechP 1.1.3.2: Confirm successful transfer • **TechF 1.1.4: Transaction Confirmation Provision** ○ TechP 1.1.4.1: Display confirmation message for successful withdrawal ○ TechP 1.1.4.2: Print receipt for the withdrawal **2. CDM** **(TechS 2.1: Cash Deposit and Credit Provision)** • **TechF 2.1.1: Cash Deposit Provision** ○ TechP 2.1.1.1: Accept cash deposits ○ TechP 2.1.1.2: Verify cash deposit authenticity • **TechF 2.1.2: Account Credit Provision** ○ TechP 2.1.2.1: Credit the deposit to the selected account ○ TechP 2.1.2.2: Confirm credit transaction success • **TechF 2.1.3: Receipt Generation Provision** ○ TechP 2.1.3.1: Generate receipt for deposited cash ○ TechP 2.1.3.2: Print proof of transaction for the customer **3. Statement Printing Machine** **(TechS 3.1: Statement Generation Provision)** • **TechF 3.1.1: Transaction History Printing Provision** ○ TechP 3.1.1.1: Generate detailed account transaction history ○ TechP 3.1.1.2: Print transaction history statement • **TechF 3.1.2: Official Statement Printing Provision** ○ TechP 3.1.2.1: Generate official bank statements ○ TechP 3.1.2.2: Print official statement for customer **4. Card Issuing Machine** **(TechS 4.1: Card Issuance and Personalization Provision)** • **TechF 4.1.1: Card Printing Provision** ○ TechP 4.1.1.1: Print customer information on the card

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Journal of Computer Networks, Architecture and High Performance Computing
Volume xx, Number xx, month Year
https://doi.org/10.47709/cnapc.vxix.xxxx

Submitted : xxxxx
Accepted : xxxxx
Published : xxxxx

	○ TechP 4.1.1.2: Print magnetic stripe or chip information • **TechF 4.1.2: Card Encoding Provision** ○ TechP 4.1.2.1: Encode customer account details onto the card ○ TechP 4.1.2.2: Verify card encoding for accuracy • **TechF 4.1.3: Card Replacement Provision** ○ TechP 4.1.3.1: Issue a replacement card for lost or damaged cards ○ TechP 4.1.3.2: Deactivate lost or expired cards **5. Deposit Machine** **(TechS 5.1: Deposit Processing Provision)** • **TechF 5.1.1: Cash and Check Deposit Provision** ○ TechP 5.1.1.1: Accept cash deposits ○ TechP 5.1.1.2: Accept check deposits • **TechF 5.1.2: Deposit Verification Provision** ○ TechP 5.1.2.1: Verify deposited cash and checks ○ TechP 5.1.2.2: Validate check details for processing • **TechF 5.1.3: Account Credit Provision** ○ TechP 5.1.3.1: Credit the deposited amount to the customer's account ○ TechP 5.1.3.2: Confirm the credit transaction success • **TechF 5.1.4: Receipt Generation Provision** ○ TechP 5.1.4.1: Generate receipt for cash deposit ○ TechP 5.1.4.2: Issue receipt for check deposit **6. Deposit Machine** **(TechS 6.1: Teller-Assisted Transaction and Support Provision)** • **TechF 6.1.1: Live Teller Interaction Provision** ○ TechP 6.1.1.1: Connect customer with a live teller via video conferencing

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Journal of Computer Networks, Architecture and High Performance Computing
Volume xx, Number xx, month Year
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Submitted : xxxxx
Accepted : xxxxx
Published : xxxxx

	○ TechP 6.1.1.2: Resolve complex customer issues via real-time communication • **TechF 6.1.2: Cash and Deposit Services Provision** ○ TechP 6.1.2.1: Assist with cash withdrawals ○ TechP 6.1.2.2: Process cash and check deposits • **TechF 6.1.3: Transaction Verification Provision** ○ TechP 6.1.3.1: Verify and approve large transactions ○ TechP 6.1.3.2: Ensure security for high-value withdrawals or deposits • **TechF 6.1.4: Account Inquiry and Support Provision** ○ TechP 6.1.4.1: Provide account balance information ○ TechP 6.1.4.2: Answer customer queries related to account status and transactions

5. RESULT

1. Enterprise Architecture (EA) Models: The developed EA models successfully illustrate the architecture of BBK Bank in three main areas:

• Business Architecture (BA): Highlighted the structure, objectives, and services of the bank, along with the roles of key actors.
• Information Systems Architecture (ISA): Identified and organized critical applications, such as BBK Mobile and BBK Plus, used in the bank's operations.
• Technology Architecture (TA): Outlined the bank's technological components, including ATMs, ITMs, and secure systems.

2. Unified Enterprise Architecture: A comprehensive EA model was created, integrating BA, ISA, and TA to provide a holistic view of BBK Bank's operations.

3. SOA Integration: A Service-Oriented Architecture (SOA) was incorporated to address Big Data challenges, particularly within ISA, The SOA model streamlined data processing, enhanced the system's efficiency, and resolved issues related to the bank's website and Big Data analysis.

4. Impact on Efficiency: The implemented architecture improved BBK Bank's operational efficiency, supported data-driven decision-making, and laid a foundation for future service enhancements.

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DISCUSSIONS

EA Models

The figures illustrate BBK Bank's Enterprise Architecture (EA) in detail. Figure 1 shows the Business Architecture (BA), highlighting the bank's structure with 2 business objectives, 1 core business service (Banking Services Provision), 9 business roles or actors, each matching a business unit. Each business unit has its own business service and performs 3 functions, each supported by 3 processes. Figure 3 presents the Information System Architecture (ISA), which includes 4 applications. Figure 4 illustrates the Technology Architecture (TA), comprising 6 applications, each linked to 1 application service. Figure 5 combines these elements into a unified EA view for BBK Bank, showing the complete architecture. Lastly, Figure 6 shows the updated EA after introducing the Service-Oriented Architecture (SOA) model to address issues with big data in the 4th application. This change made the system faster, more efficient, and solved the big data problem on the BBK Bank website.

SOA

Service-oriented architecture increases business agility and reduces risk. Service-oriented architecture helps in many aspects of the bank. It is useful for managing customer information and helps in expanding the business. We have created a service-oriented architecture using UML notations to define the benefits of big data in the bank system. We have found that big data is most useful in customer bank accounts, where each customer's account contains financial details such as balance, loans or investments, transactions (transfers), payments, cards, and many other services. Therefore, we will implement the service-oriented architecture in the ISA section to illustrate the impact of big data on the bank's infrastructure that leads to providing new services that customers need after analyzing and understanding this data.

6. CONCLUSION

In conclusion, we used the TOGAF framework to analyze the bank through business, information systems, and information technology. The framework helped us build a new infrastructure for the bank, which led to our success in achieving our vision of reducing the risk of big data on the bank's business.

In addition, we used service-oriented architecture, which develops the bank's services and helps it expand its services in the future. It also helps develop the electronic infrastructure by improving large and complex systems that require the integration of applications that depend on big data.

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We would like to express our sincere gratitude to BBK Bank for their invaluable support and assistance in the completion of this project. The insights and information provided by the bank have played a crucial role in shaping our research and contributing to the successful development of the Enterprise Architecture (EA) integration for Big Data within the bank's operations.We would also like to extend our thanks to the staff at BBK Bank for their time and effort in providing the necessary resources and guidance throughout the course of this project. Their willingness to share their expertise has been instrumental in achieving the objectives of our research. This project would not have been possible without the cooperation and dedication of BBK Bank, and we truly appreciate their contribution to the success of this endeavor

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