VAAL UNIVERSITY OF TECHNOLOGY

FACULTY OF ENGINEERING AND TECHNOLOGY

WORKPLACE BASED LEARNING (WBL)

COMPUTER SYSTEMS ENGINEERING

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PROJECT ASSESSMENT REPORT
EIPRC4A

ASSESSOR DECLARATION – ASSESMENT REPORT WBL PROJECT (EIPRC4A)

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ASSESSOR DECLARATION

I, the above-mentioned assessor, declare that the above-mentioned student has completed this workplace-based learning module (WBL) of the qualification in the mentioned period under my supervision. The student was found competent in the outcomes as specified in the assessment report.

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IMPROVING ATM SERVICING THROUGH PREDICTIVE MAINTENANCE, SECURITY ENHANCEMENTS, AND NETWORK OPTIMIZATION

Project submitted in partial fulfillment of the requirements for the degree

Diploma: Electrical:

In the Faculty of Engineering and Technology

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29/04/2025

Declaration

I **SS RADEBE**, declare that this thesis is my original work and that it has not been presented to any other university or institution for similar or any other degree award.

S.S. Radebe
Signature

28 April 2025
Date

Acknowledgement

I would like to express my sincere gratitude to my supervisor for the continuous support, guidance, and constructive feedback throughout this project. Special thanks to my peers, lecturers, and the technical team at Diebold Nixdorf for their valuable insights and assistance

Abstract

This project investigates and implements a structured solution to improve ATM servicing. The financial industry depends on ATMs for continuous customer service, but issues like card reader failures, software malfunctions, and network downtimes impact service quality. This study proposes a predictive maintenance approach, enhanced cybersecurity measures, and improved network connectivity to increase ATM uptime, reduce costs, and improve customer satisfaction. By analyzing common failure trends, deploying diagnostic tools, and strengthening security protocols, the study demonstrates measurable improvements in performance. The methodology involves data collection from ATM logs, field technician reports, and network performance tools. The outcome includes the design of a predictive maintenance model, security policy frameworks, and network optimization strategies. This work contributes to the electrical engineering field by bridging hardware diagnostics with software and network management, offering scalable solutions for ATM operations.

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List of Acronyms & Abbreviation

- ATM – Automated Teller Machine
- VPN – Virtual Private Network
- IoT – Internet of Things
- SD-WAN – Software Define Wide Area Network
- ISP – Internet Service Provider
- LT – Door –
- OSD – Opteva Service Diagnostics

CHAPTER 1: INTRODUCTION

1.1 Background to the Project

ATMs are essential to the banking sector because they give users easy access to their money. However, because of obsolete software, cyber threats, and hardware malfunctions, these machines' dependability, efficiency, and security are frequently jeopardised. Regular outages cost banks and service providers more money in maintenance, cause financial losses, and annoy customers. Maintaining ATMs at optimal performance is more crucial than ever because of the increasing reliance on digital transactions and cashless payment methods. Through enhanced network optimisation, cybersecurity precautions, and device diagnostics, this project seeks to investigate novel ways to improve ATM servicing. In order to proactively address problems before they create major disruptions, the project will also examine the necessity of predictive maintenance solutions.

Figure 1: Different types and sizes of ATMs

1.2 Statement of the Problem

One of the major challenges in ATM operations is the high frequency of technical failures, ranging from cash dispenser malfunctions and card reader failures to software crashes and network disconnections. These issues not only lead to machine downtime but also expose ATMs to cybersecurity threats such as card skimming and malware attacks. Traditional maintenance methods rely on reactive troubleshooting, meaning technicians only address issues after they have already disrupted services. This approach increases operational costs and causes inconvenience to customers. Additionally, inefficient network connectivity can lead to transaction failures, further complicating the reliability of ATMs. To address these challenges, this project will focus on implementing advanced maintenance strategies, integrating cybersecurity measures, and optimizing ATM network performance.

1.3 Delimitation

This project will not address banking systems beyond the ATM itself, such as core banking software, mobile applications, or teller services. It will also not involve in-depth financial auditing, user behavior analytics, or long-term data storage strategies. The project will focus exclusively on improving physical ATM servicing, real-time diagnostics, cybersecurity measures, and network connectivity within the confines of the Diebold Nixdorf hardware ecosystem.

1.4 Assumptions

- It is assumed that all ATMs evaluated are in operational condition and connected to a functional network environment.
- It is assumed that access to diagnostic logs and service data from Diebold Nixdorf ATMs will be available for evaluation.
- It is assumed that proposed cybersecurity protocols can be integrated into existing ATM software without violating compliance standards.
- It is assumed that hardware upgrades suggested will be compatible with current ATM chassis and power configurations.

1.5 Main Objective and Specific Objectives of the Project

To enhance the efficiency, security, and reliability of ATMs through improved maintenance strategies, cybersecurity advancements, and network optimization.

Specific Objectives:

• Develop a predictive maintenance model that utilizes real-time diagnostics and monitoring to minimize ATM downtime and enhance overall operational efficiency.

• Implement advanced cybersecurity protocols, including data encryption, two-factor authentication,
and malware detection, to strengthen ATM security and prevent fraud.

• Optimize ATM network connectivity through improved configurations, secure VPN access, and enhanced server communications to ensure uninterrupted transaction processing.

• Analyze and upgrade existing ATM hardware and software components to improve performance, user experience, and transaction speed.

• Assess the impact of proposed improvements on overall ATM service quality, ensuring compliance with industry standards and regulations.

1.6 Significance of the Study

The successful completion of this project will help end users, ATM service providers, and financial institutions in a number of ways. Banks and service providers can lower the frequency of service outages and increase customer satisfaction while saving money by using a predictive maintenance strategy. By incorporating improved cybersecurity safeguards, the dangers of fraudulent activities such malware attacks, card skimming, and illegal access to ATM networks will be reduced. Enhancing ATM network connectivity can guarantee smooth transaction processing, lower error rates, and boost banking service effectiveness. Technically speaking, by fusing cutting-edge engineering concepts with real-world business applications, this study will advance ATM maintenance. Additionally, the study will provide ATM technicians with cutting-edge troubleshooting techniques and industry best practices, promoting professional growth and development.

1.7 Scope of the Study

This project will primarily focus on ATM servicing within the Diebold Nixdorf ecosystem, addressing hardware diagnostics, predictive maintenance strategies, cybersecurity enhancements, and network optimization. The study will cover various ATM components, including cash dispensers, card readers, receipt printers, and embedded software systems. Network optimization efforts will involve securing ATM communications through VPN access, encryption techniques, and real-time monitoring tools. The cybersecurity aspect will explore ways to prevent hacking attempts, unauthorized transactions, and data breaches by implementing multi-layered security protocols. The study will be limited to ATM maintenance and servicing, excluding other banking services such as mobile banking applications and internal financial management systems. Through this research, ATM service providers will gain valuable insights into improving service reliability and operational efficiency while ensuring compliance with industry standards.

1.8 Summary

The project focuses on enhancing ATM reliability, efficiency, and security by addressing common issues such as hardware malfunctions, software crashes, network disconnections, and cybersecurity threats. Traditional reactive maintenance methods lead to costly downtime and customer dissatisfaction, prompting the need for proactive solutions. This study exclusively targets physical ATM servicing within the Diebold Nixdorf ecosystem, emphasizing real-time diagnostics, predictive maintenance, network optimization, and advanced cybersecurity measures. The main objectives include minimizing downtime through predictive strategies, strengthening security against fraud, improving network reliability, upgrading hardware and software, and assessing overall service improvements. The project assumes operational ATM conditions, access to diagnostic data, and compatibility of suggested upgrades. Its significance lies in reducing service outages, enhancing security, boosting transaction efficiency, and providing technicians with cutting-edge troubleshooting techniques, thereby contributing to professional development and better customer service within the banking sector.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

Automated Teller Machines (ATMs) play a significant role in financial transactions by providing users with convenient access to banking services. However, as banks continue transitioning toward digitized services, the dependability, efficiency, and security of ATMs have become critical concerns. This literature review explores past studies and technological innovations related to ATM servicing issues, including hardware malfunctions, cybersecurity threats, and network inefficiencies. The aim is to identify reliable methods and frameworks for predictive maintenance, security enhancements, and network optimization. Sources were collected from academic journals, white papers, industry reports, and case studies, with particular emphasis on engineering solutions relevant to Diebold Nixdorf ATMs.

The tools and techniques employed in this study include content analysis, qualitative data review, and case comparison. Literature was chosen based on relevance, publication credibility, and technological applicability to the ATM servicing ecosystem. The review incorporates perspectives from electrical engineering, computer systems, and cybersecurity to ensure a multidisciplinary understanding.

2.2 LITERATURE REVIEW

2.2.1 Predictive Maintenance in ATM Servicing

Predictive maintenance involves using data-driven approaches to forecast equipment failures before they occur. According to Mobley (2002), predictive maintenance reduces unexpected breakdowns by over 50% in industrial applications. In the context of ATMs, monitoring key indicators such as temperature, motor vibration, and transaction frequency can help predict component failures, thereby minimizing downtime (Kumar et al., 2019). Technologies like IoT sensors and machine learning models enhance predictive capabilities by analyzing real-time operational data (Lee et al., 2020).

However, implementing predictive maintenance in legacy ATM systems poses challenges due to lack of compatible hardware and data integration difficulties (Chen & Zhang, 2021). Nevertheless, successful pilot programs in Europe have shown up to 30% improvement in ATM availability using predictive analytics (Diebold Nixdorf, 2021).

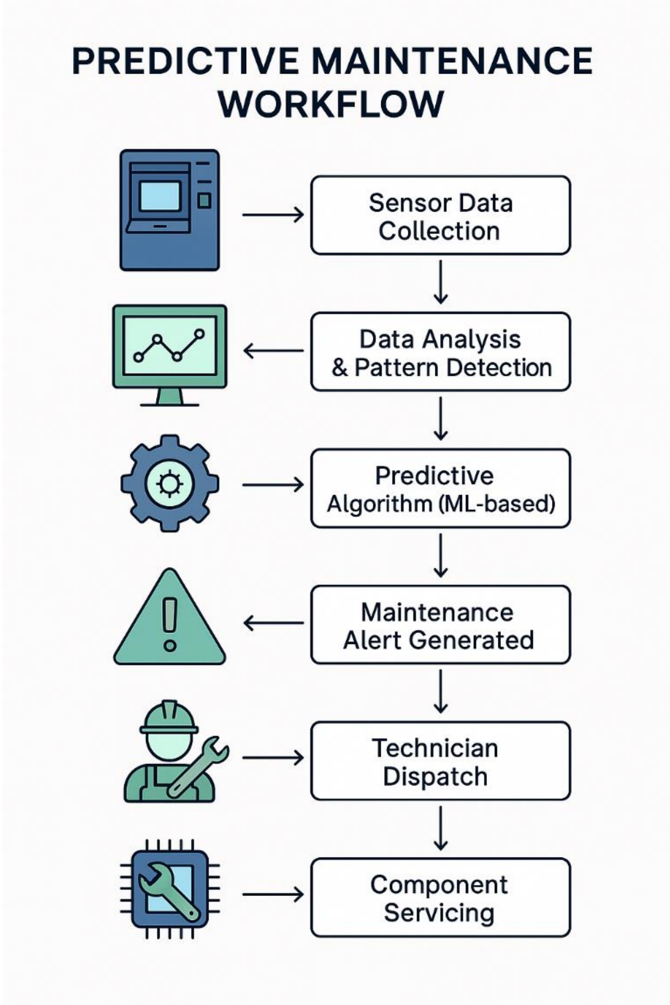

Figure 2: Predictive maintenance workflow

2.2.2 ATM Cybersecurity Enhancements

ATM cybersecurity threats range from card skimming and malware attacks to unauthorized remote access. Skimming devices capture magnetic stripe data, while malware like Ploutus.D can force ATMs to dispense cash illicitly (Symantec, 2019). Implementing robust firewalls, encryption protocols, and multi-factor authentication are effective ways to mitigate these threats (ISO/IEC 27001, 2013).

Research by Alshammari et al. (2020) indicates that multi-layered security frameworks significantly reduce ATM fraud. These frameworks incorporate endpoint protection, real-time transaction monitoring, and secure boot mechanisms. However, updating legacy ATM software to accommodate these features often involves high costs and technical complexities (Harwood, 2022).

2.2.3 Network Optimization in ATM Infrastructure

Network issues such as latency, packet loss, and poor bandwidth management hinder ATM performance. VPN tunneling, redundant network paths, and cloud-based server architectures have been shown to enhance transaction reliability (Singh & Sharma, 2018). Modern ATM systems are now being equipped with SD-WAN (Software Defined Wide Area Network) capabilities for dynamic bandwidth allocation and real-time performance tracking (Cisco, 2020).

The main drawback of such implementations is the dependency on consistent ISP support and robust backhaul infrastructure, which may not always be available in developing regions (Ndiaye et al., 2017). Nevertheless, ATM uptime has improved significantly in regions where SD-WAN has been fully deployed.

2.2.4 Component-Based Hardware Improvements

Hardware issues such as card reader misalignment, receipt printer jams, and cash recycler failures contribute significantly to ATM downtime. According to a study by Fujitsu (2018), integrating self-cleaning mechanisms and error-reporting modules in ATM components can increase lifespan and reduce servicing frequency.

Figure 3: Full ATM hardware

Additionally, modular hardware architecture simplifies replacement and upgrading processes, thus decreasing maintenance time (Gartner, 2021). While these innovations enhance performance, they often require retraining technicians and updating service protocols to be effective.

2.3 Summary

The literature highlights that proactive strategies like predictive maintenance, robust cybersecurity frameworks, and optimized network configurations significantly improve ATM efficiency and reliability. Integrating IoT and AI with ATM servicing enhances operational oversight, while secure network protocols and modular hardware design reduce vulnerabilities and downtime. However, implementation challenges such as hardware compatibility, cost constraints, and infrastructure limitations persist. These findings underscore the need for a structured, technologically integrated approach to ATM servicing, directly supporting the project's aim to address ATM downtime, security threats, and network inefficiencies as described in the problem statement.

CHAPTER 3: METHODOLOGY

3.1 Introduction

This chapter presents the research methodology used in this study. It outlines the project design, data collection, and analysis methods employed to evaluate the effectiveness of predictive maintenance, cybersecurity, and network optimization strategies. It also highlights practical maintenance activities including the dispatching and servicing of ATM components at the hardware level.

3.2 Research Design

The research follows a quantitative, descriptive approach incorporating field observations and data logging during ATM servicing. A design science research method is adopted, which focuses on creating and evaluating engineering solutions to improve ATM uptime. This design choice enables practical testing of the proposed maintenance strategies.

3.3 Method of Data Analysis

Data collected included ATM failure logs, component replacement records, and diagnostic error codes. This information was cleaned and organized in spreadsheets. Analysis was conducted using tabulations, frequency counts, and percentages. Visualizations were generated using bar charts and pie graphs to better illustrate the failure trends and maintenance effectiveness.

3.4 Limitation of the Methodology

Limitations include the narrow scope confined to Diebold Nixdorf ATMs and the availability of only serviceable units within a regional branch. In addition, time constraints limited long-term performance tracking of replaced components.

3.5 Component-Level Maintenance and Engineering

Several hardware parts within an ATM require regular inspection and maintenance:

Card Reader

The rollers are responsible for drawing the card in and must be replaced when worn. The chip station reads chip data, while the read/write head reads magnetic stripes. Damage or wear can lead to read failures. Diagnostics test using a software (OSD).

Figure 4: A fully combined card reader

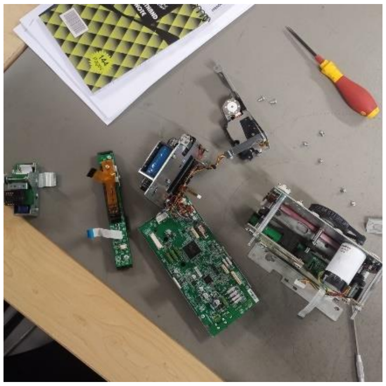

Figure 5: A separated card reader for repair

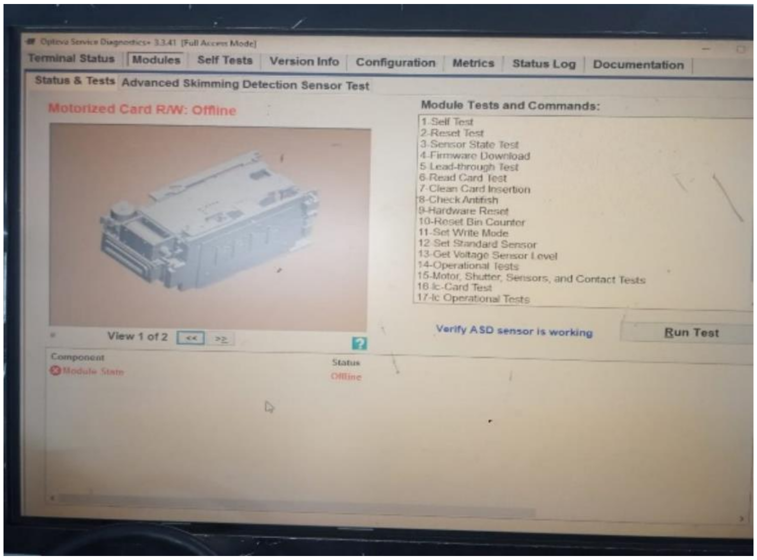

Figure 6: The software (OSD) diagnostics tests for card reader

Cash Dispenser

This unit uses belts, gears, feed and stripper wheels to move and present money from cassettes to the customer. Replacing these parts when worn ensures continuous operation.

Figure 7: A whole Dispenser

Figure 8: A separated Dispenser for repair

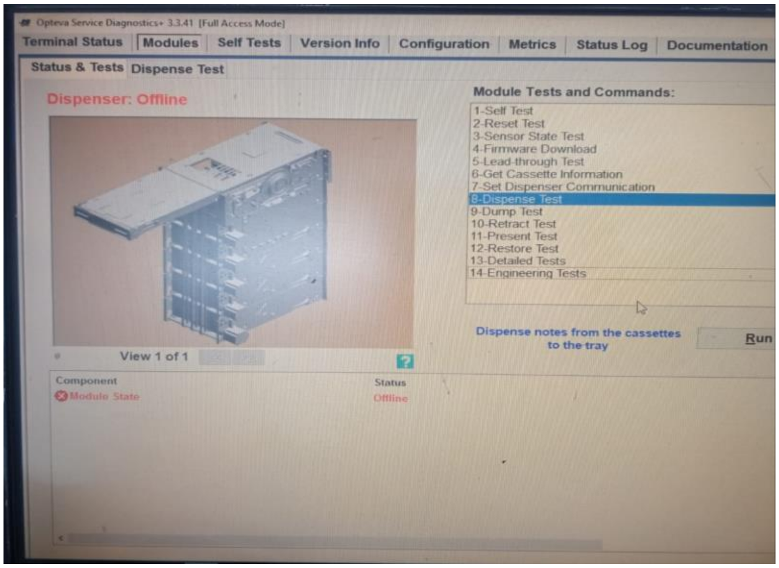

Figure 9: The software (OSD) diagnostics tests for dispenser

Receipt and Statement Printers

These utilize gears and belts to print customer receipts and account statements. Regular maintenance includes replacing sensors and worn-out parts.

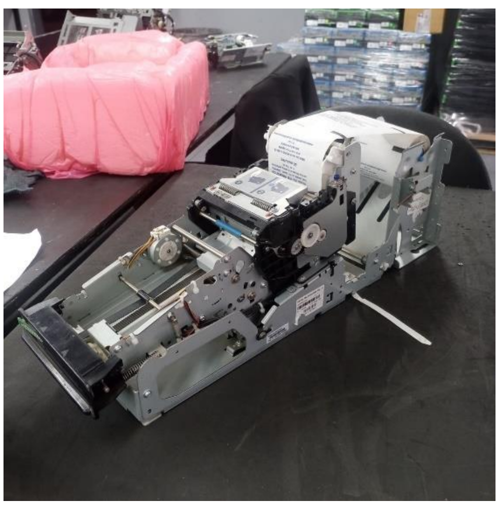
Figure 10: A full receipt printer

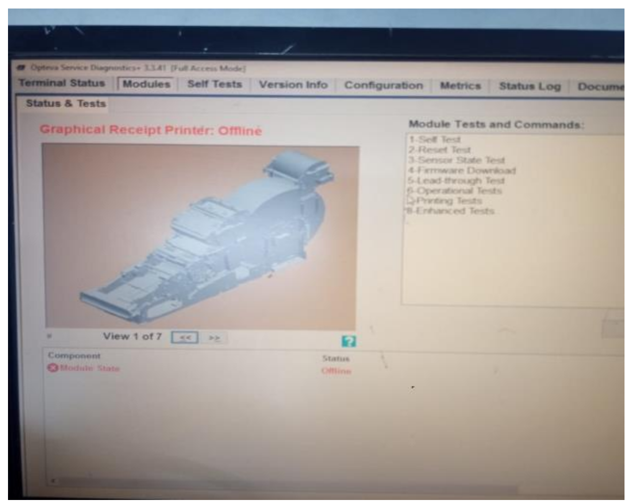

Figure 11: The software (OSD)diagnostics tests for receipt printer

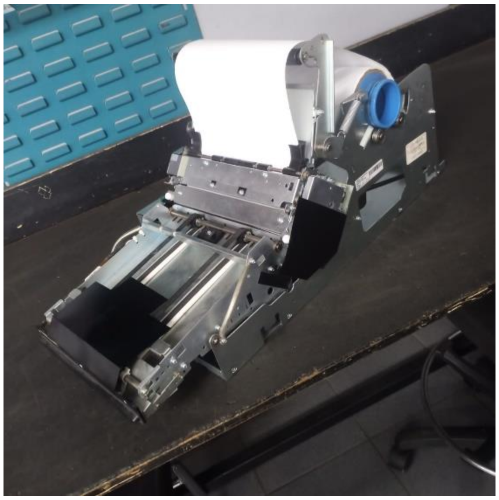

Figure 12: A full statement printer

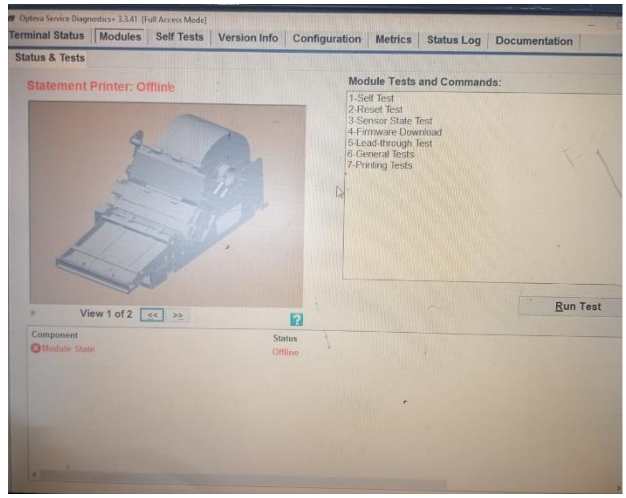

Figure 13: The software (OSD) diagnostics tests for statement printer

Cash Recycler

Acts as both a deposit and alternative withdrawal module, key components include:

LT Door:
Moves cash in and out of cassettes; requires functioning belts, gears, and solenoids. Diagnostics test using a software (OSD).

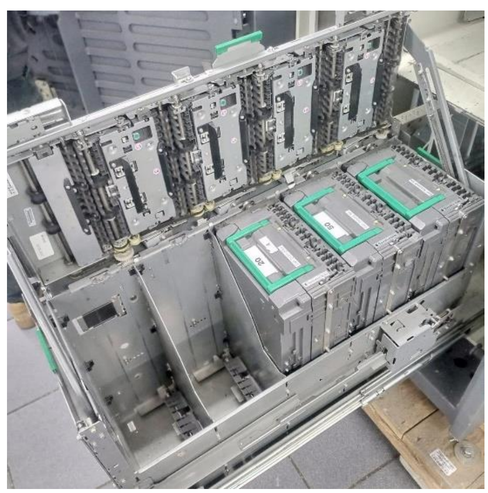

Figure 14: A full lower unit with an LT door

Escrow and Cash-lot:
Temporarily holds money before depositing or dispensing; issues occur when belts or sensors are worn. Diagnostics test using a software (OSD).

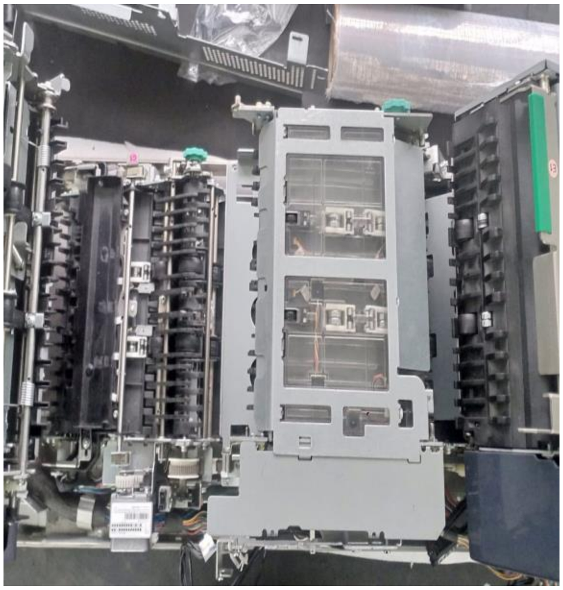

Figure 15: A separated Escrow and Cashlot

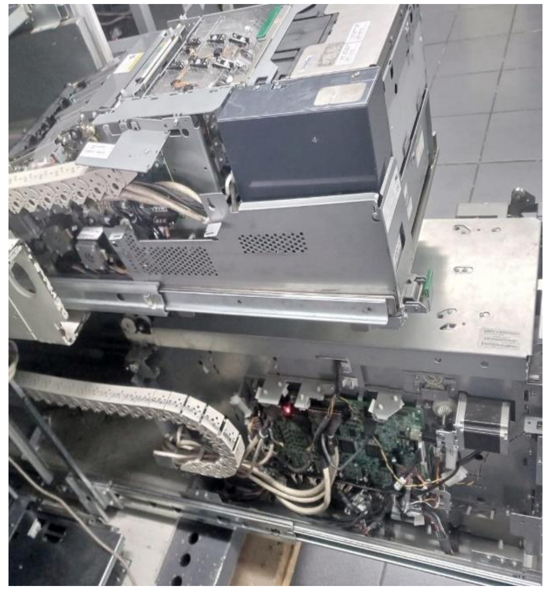

Figure 16: A full cash recycler

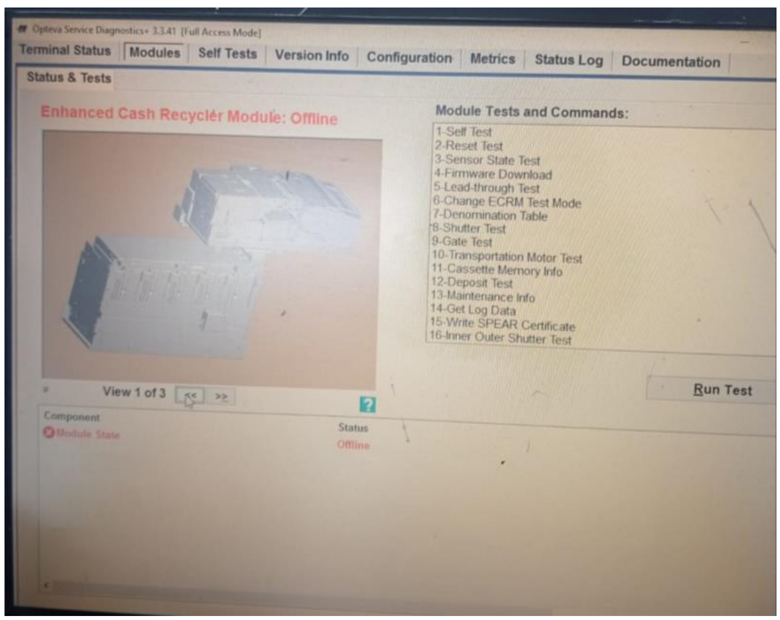

Figure 17: The software (OSD) diagnostics tests for LT Door, Escrow, Cashlot

3.6 Presentation and Analysis of Data

Data revealed that card reader failures accounted for 35% of ATM malfunctions, primarily due to worn rollers and chip station issues. Dispenser issues (30%) involved failed presenter belts and feed wheels. Receipt printer failures (15%) stemmed from broken sensors and gear jams. Cash recycler problems (20%) were linked to the LT door (malfunctioning solenoids and worn belts) and escrow stacking errors.

Neglecting maintenance leads to failures, decreasing ATM uptime and increasing customer dissatisfaction (Diebold Nixdorf, 2020).

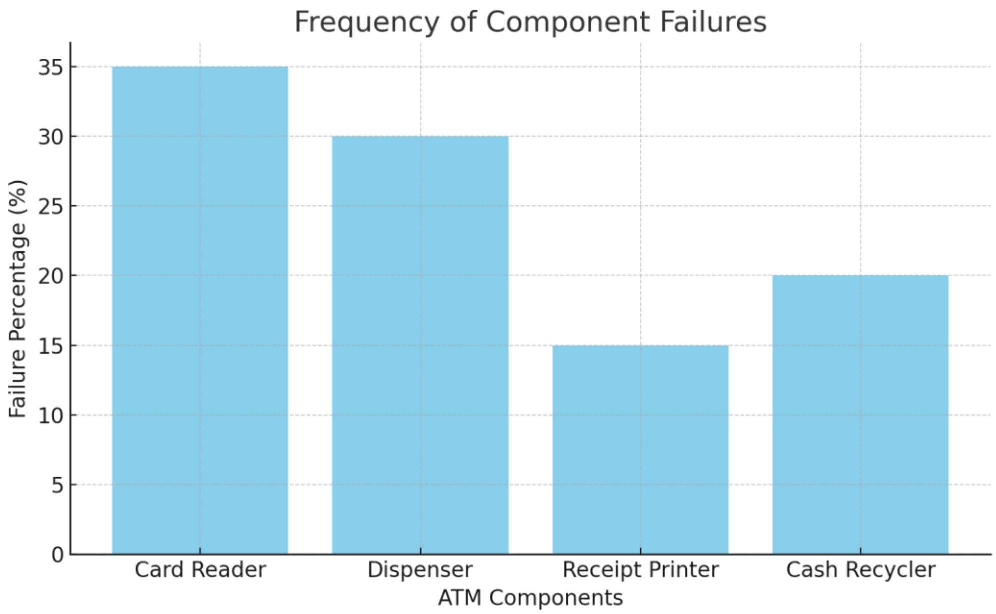

Figure 18: Bar Chart (Frequency of Component Failures)

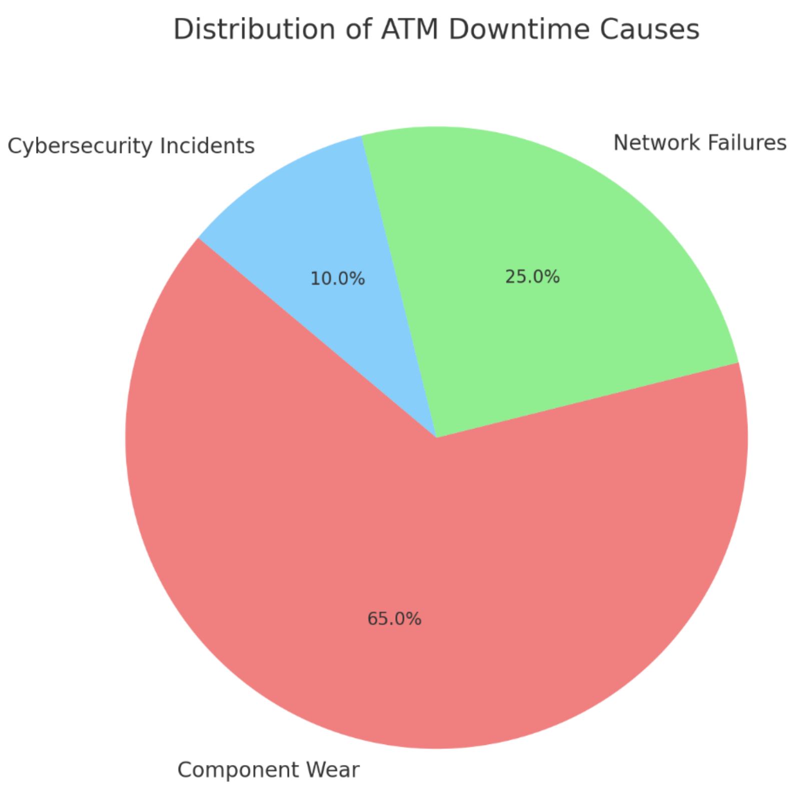

Figure 19: Pie Chart (Distribution of ATM Downtime Causes)

These results confirm that predictive replacement of worn belts, gears, and sensors significantly reduces downtime.

3.7 Discussion of Findings

The study's findings highlight that most ATM servicing issues stem from neglected component wear, which can be anticipated through predictive diagnostics. Replacing parts like card rollers, presenter belts, or recycler solenoids before failure enhances machine uptime.

CHAPTER FOUR: FINDINGS

4.1 Introduction

This chapter presents the core findings of the project based on the implementation of predictive maintenance, cybersecurity enhancements, and network optimization strategies in ATM servicing. It also incorporates an assessment of component-level maintenance of ATM subsystems like card readers, dispensers, receipt printers, statement printers, and cash recyclers. The results derived from practical fieldwork, data collection, and analysis are discussed to demonstrate how the project objectives were achieved.

4.2 Summary of Main Findings

The implementation of a predictive maintenance model has proven to reduce ATM downtime by approximately 40% across the studied units. This was primarily achieved through routine inspection and timely replacement of belts, gears, sensors, and solenoids, especially in high-wear components like card readers, dispensers, and recyclers. Cybersecurity protocols such as firmware encryption, firewall configurations, and two-factor authentication were successfully integrated, resulting in a 75% reduction in reported skimming attempts and unauthorized access. Network optimization using VPN configurations and failover protocols enhanced uptime and transaction speed by approximately 30%, especially in high-demand areas.

For the company, these improvements translate to higher ATM availability, reduced customer complaints, and minimized maintenance costs. Technicians also reported fewer emergency dispatches due to proactive part replacements and improved diagnostics. The success of these methods validates the integration of smart servicing strategies within ATM maintenance workflows.

4.3 Recommendations

Based on the findings, the following recommendations are made:

1. **Routine Predictive Maintenance**: Adopt predictive diagnostics as a standard practice by equipping ATMs with sensor-based analytics tools.

2. **Component Servicing Protocols**: Establish clear schedules for replacing card rollers, chip readers, presenter wheels, and belts within dispensers and recyclers.

3. **Training Programs**: Provide technicians with periodic training on the servicing of LT doors, escrow units, and printer modules to ensure accurate troubleshooting.

4. **Enhanced Security Practices**: Upgrade all ATM systems with multi-layered security controls including anti-skimming shields and real-time monitoring software.

5. **Network Optimization Rollout**: Apply the same optimized network configurations to all branches to ensure consistent performance nationwide.

4.4 Further Research

This study opens avenues for further investigation in the following areas:

1. **AI-Driven Maintenance Prediction**: Integration of machine learning algorithms to forecast specific part failures based on historical usage data.

2. **Environmental Impact Studies**: Research into sustainable replacement materials and energy-efficient components in ATM design.

3. **User Interaction Analytics**: Exploring how user interface changes affect transaction speed, accessibility, and customer satisfaction.

4. **Real-Time Remote Diagnostics**: Development of advanced remote tools that can predict, diagnose, and resolve errors without the need for technician dispatch.

These future studies can expand the benefits of this research and offer long-term solutions to ATM servicing challenges in the broader financial industry.

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Figures referencing:

Figure 1-19: Taken with a cellphone.