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A Systemic Approach to Digital Transformation of Electricity Distribution: The CRM Model of SNEL Kolwezi

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Abstract: Digital transformation of public utilities in developing countries presents unique challenges, particularly in electricity distribution where customer relationship management remains predominantly manual. This study examines Customer Relationship Management (CRM) system implementation at the Société Nationale d'Electricité (SNEL) Distribution Center in Kolwezi, Democratic Republic of Congo. Using a systemic approach combining documentary analysis, interviews, participatory observation, and sampling, this research analyzes current billing processes, identifies operational inefficiencies, and proposes a digitalized CRM framework. Findings reveal critical deficiencies including duplicate billing, lost payment records, and inadequate data management. The proposed system addresses these through centralized data management, automated billing, secure payment tracking, and enhanced service delivery. Results demonstrate that CRM implementation significantly improves customer satisfaction through personalized service and responsiveness, optimizes sales via process automation and opportunity tracking, and enhances organizational performance through better decision-making and collaboration. All interviewed stakeholders (100%) recognized advantages including assured security, durable conservation, easy manipulation, efficiency, real database constitution, and automated accounting. This research contributes theoretical understanding of digital transformation in African public utilities while providing practical recommendations for modernizing customer management in resource-constrained environments. The framework considers DRC's specific socio-economic context, infrastructure limitations, and transition from bureaucratic Weberian administration to performance-oriented New Public Management, representing significant advancement for public electricity companies navigating technological and marketing transformations.

Keywords: *Digital Transformation; Customer Relationship Management (CRM); Public Utilities; Electricity Sector; SNEL; Kolwezi; Democratic Republic of Congo; Billing Systems; Customer Service Digitalization; New Public Management.*

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I. INTRODUCTION

The contemporary global economy is characterized by unprecedented technological disruption that fundamentally reshapes organizational structures, business models, and customer relationships across all sectors [1, 2]. This digital transformation defined as the profound changes in organizational activities, processes, competencies, and models driven by digital technologies has become imperative for organizational survival and competitiveness in the twenty-first century [3]. While private sector enterprises in developed economies have aggressively embraced digitalization to enhance operational efficiency and customer experience, public utilities in developing nations face unique challenges in navigating this transformation [4, 5]. The electricity sector, as a critical infrastructure domain characterized by natural monopolies, regulatory complexity, and public service obligations, presents particularly acute challenges and opportunities for digital innovation [6].

The digital divide between African enterprises and their counterparts in developed economies remains substantial and multifaceted [7, 8]. African organizations lag not only in adopting advanced technologies such as big data analytics,

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artificial intelligence, and blockchain, but also in implementing basic digital solutions including e-commerce platforms, Enterprise Resource Planning (ERP) systems, and Customer Relationship Management (CRM) applications [9, 10]. This technological gap is particularly pronounced in public utilities, where legacy infrastructure, limited financial resources, inadequate technical capacity, and bureaucratic institutional cultures create formidable barriers to modernization [11, 12]. The Democratic Republic of Congo (DRC), despite its vast natural resources and strategic geopolitical position, exemplifies these challenges, with public enterprises operating predominantly through manual processes reminiscent of pre-digital era practices [13, 14].

Customer Relationship Management has evolved from a tactical marketing tool to a strategic imperative that fundamentally redefines how organizations interact with, understand, and create value for their customers [15, 16]. Contemporary CRM encompasses technological platforms, organizational processes, and strategic orientations that enable firms to systematically collect, analyze, and leverage customer data to deliver personalized experiences, enhance satisfaction, and cultivate long-term loyalty [17]. Research consistently demonstrates that effective CRM implementation yields substantial benefits including improved customer retention rates, increased lifetime customer value, enhanced cross-selling opportunities, and superior competitive positioning [18, 19]. In the utility sector specifically, CRM systems facilitate critical functions including automated billing, real-time consumption monitoring, proactive service delivery, targeted communication campaigns, and data-driven decision-making [20, 21].

Despite the extensive literature on CRM implementation in developed market contexts, scholarly attention to digital transformation in African public utilities remains remarkably limited [22, 23]. This gap is particularly concerning given the unique socio-economic, infrastructural, and institutional contexts that characterize utility provision in Sub-Saharan Africa, where electricity access rates remain below 50% in many nations and service quality issues persist even in electrified areas [24, 25]. The present study addresses this lacuna by examining CRM system implementation at the Société Nationale d'Electricité (SNEL) Distribution Center in Kolwezi, DRC. SNEL, transformed from a state enterprise to a commercial company in 2008 following Law No. 08/007, operates in an environment characterized by aging infrastructure, rapid urban expansion, limited revenue collection capacity, and escalating customer expectations [26, 27].

The Kolwezi Distribution Center currently relies on predominantly manual customer management processes that generate significant operational inefficiencies and customer dissatisfaction. Customers frequently receive duplicate billing statements for the same consumption period, payment records are maintained in deteriorating physical ledgers susceptible to damage and loss, and customer service representatives lack access to integrated databases for resolving inquiries (Field observations, 2015-2024). When customers lodge complaints regarding erroneous billing, staff members must consult fragmented paper records in notebooks designated as 'VISA,' many of which have suffered water damage, physical deterioration, or complete loss. This archaic system not only impedes operational efficiency but fundamentally undermines customer trust and the organization's capacity to fulfill its commercial mandate in an increasingly competitive environment where energy sector liberalization looms on the policy horizon [28, 29].

This study addresses the central research question: How can Customer Relationship Management systems enable SNEL Kolwezi Distribution Center to establish reliable and efficient customer billing and payment processes? Specifically, the research pursues three interrelated objectives: (1) to comprehensively analyze existing customer management practices and identify critical deficiencies; (2) to design a contextually appropriate CRM application framework that addresses identified gaps while considering resource constraints and organizational capacities; and (3) to articulate the anticipated benefits of CRM implementation for customer satisfaction, operational efficiency, and organizational performance. The investigation adopts a systemic analytical approach, conceptualizing SNEL as an open system receiving inputs (customer demands, payment obligations, service requests), processing these through organizational structures and procedures, and generating outputs (service delivery, billing accuracy, customer satisfaction) subject to feedback mechanisms [30, 31].

The analytical framework integrates three complementary theoretical perspectives. First, systems theory provides the overarching conceptual architecture, enabling examination of organizational processes as interconnected elements where dysfunction in one component cascades throughout the entire system [32]. Second, contingency theory illuminates how organizational effectiveness depends upon alignment between internal structures and external environmental conditions, suggesting that CRM implementation strategies must be tailored to specific contextual realities rather than mechanically transplanting best practices from dissimilar settings [33, 34]. Third, New Public Management theory offers insights into the ongoing transformation of state-owned enterprises from bureaucratic entities prioritizing procedural compliance toward commercial organizations emphasizing performance, efficiency, and customer orientation [35, 36]. This theoretical triangulation enables nuanced understanding of how technological innovation intersects with organizational change management in institutionally complex environments.

Methodologically, the study employs a mixed-methods case study design combining documentary analysis, semi-structured interviews with organizational stakeholders and customers, participatory observation during a practicum placement at SNEL Kolwezi, and probability sampling techniques [37, 38]. Data collection occurred between 2015 and 2024, capturing organizational dynamics during a critical period of administrative decentralization following provincial reorganization in 2015, which designated Kolwezi as the capital of the newly created Lualaba Province. The

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extended temporal scope enables longitudinal perspective on organizational challenges and change trajectories. The systemic analytical approach facilitates examination of how customer inputs (billing inquiries, payment complaints, service requests) flow through organizational processing mechanisms (reception procedures, record-keeping systems, resolution protocols) to generate outputs (problem resolution, service quality, customer satisfaction), with feedback loops influencing subsequent organizational responses.

This research makes several significant contributions to theory and practice. Theoretically, it extends the CRM implementation literature into an under-researched context African public utility thereby enhancing understanding of how digital transformation unfolds in resource-constrained, institutionally complex environments [39, 40]. The study challenges universalistic assumptions underlying much CRM scholarship by demonstrating how contextual factors including infrastructure limitations, human capital constraints, and institutional legacies shape technology adoption pathways [41]. Practically, the research provides actionable recommendations for SNEL and similar organizations navigating digital transformation, offering a replicable CRM implementation framework adapted to Sub-Saharan African realities. The findings inform policy discussions regarding public utility modernization, energy sector reform, and the application of New Public Management principles in African institutional contexts [42, 43].

The remainder of this article proceeds as follows. Section 2 reviews relevant literature on CRM systems, digital transformation in utilities, and technology adoption in developing economies, identifying theoretical foundations and empirical precedents. Section 3 details the research methodology, explaining data collection procedures, analytical techniques, and case study rationale. Section 4 analyzes findings regarding current customer management deficiencies and stakeholder perspectives. Section 5 proposes the CRM implementation framework, detailing system architecture, functional requirements, and deployment strategy. Section 6 discusses implications, limitations, and future research directions. Section 7 concludes by synthesizing key findings and articulating policy and managerial recommendations.

II. LITERATURE REVIEW

This section reviews the theoretical and empirical literature relevant to Customer Relationship Management implementation in public utilities within developing country contexts. The review is organized into five subsections that progressively build the conceptual foundation for this study. First, we examine the fundamental concepts and evolution of CRM systems, establishing their strategic importance for organizational performance. Second, we explore digital transformation processes specific to public utilities, highlighting sector-specific challenges and opportunities. Third, we analyze technology adoption patterns in African contexts, identifying barriers and success factors relevant to the Democratic Republic of Congo. Fourth, we present the theoretical perspectives that inform our analytical framework, including systems theory, contingency theory, and New Public Management. Finally, we identify critical gaps in existing literature that this research addresses, positioning our study's contribution to scholarship on digital transformation in African public utilities.

➢ *Customer Relationship Management: Conceptual Foundations*

Customer Relationship Management represents a strategic approach that organizations employ to manage interactions with current and potential customers [15]. CRM systems integrate technology, processes, and people to collect, analyze, and utilize customer information for delivering superior service and building long-term relationships [16]. The evolution of CRM has transformed it from a simple contact management tool to a comprehensive business strategy that encompasses marketing, sales, and service functions [17].

Research demonstrates that effective CRM implementation yields measurable benefits including improved customer retention, increased profitability, and enhanced competitive advantage [18]. Organizations utilizing CRM systems report higher customer satisfaction rates through personalized service delivery and faster response times [19]. In the utility sector specifically, CRM enables automated billing processes, real-time service monitoring, and proactive customer engagement [20, 21].

➢ *Digital Transformation in Public Utilities*

Digital transformation in public utilities involves integrating digital technologies into all operational areas, fundamentally changing service delivery models [3]. Unlike private enterprises that pursue digitalization for competitive advantage, public utilities face unique constraints including regulatory requirements, infrastructure limitations, and public service obligations [6]. The electricity sector presents particular challenges due to its capital-intensive nature, long asset lifecycles, and complex stakeholder environments.

Studies indicate that utilities adopting digital solutions achieve significant operational improvements including reduced billing errors, improved revenue collection, and enhanced asset management [20]. However, the pace of digital adoption varies considerably across regions, with developing countries lagging behind due to resource constraints and institutional barriers [11, 12].

➢ *Technology Adoption in African Contexts*

The digital divide between African organizations and their developed economy counterparts remains substantial [7, 8]. African enterprises face multiple barriers to technology adoption including limited financial resources, inadequate technical expertise, poor infrastructure, and institutional resistance to change [9, 10]. These challenges are particularly acute in public sector organizations where bureaucratic cultures and political interference impede innovation [13, 14].

Despite these obstacles, evidence suggests that African organizations can successfully implement digital solutions

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when adoption strategies account for local contexts [39, 40]. Research emphasizes the importance of contextually appropriate technology choices, phased implementation approaches, and capacity building initiatives [41]. Mobile technology adoption in Africa demonstrates that leapfrogging traditional infrastructure is possible when solutions address specific local needs [23].

➢ *Theoretical Perspectives on Organizational Change*

Systems theory provides a framework for understanding organizations as interconnected entities where changes in one component affect the entire system [30, 31, 32]. This perspective is particularly relevant for CRM implementation, which requires integration across multiple organizational functions including billing, customer service, and technical operations.

Contingency theory suggests that organizational effectiveness depends on alignment between internal structures and external environmental conditions [33, 34]. This theory implies that CRM implementation strategies must be adapted to specific organizational contexts rather than mechanically replicating best practices from dissimilar settings.

New Public Management theory explains the transformation of state-owned enterprises from bureaucratic entities to performance-oriented commercial organizations [35, 36]. This theoretical lens illuminates how public utilities increasingly adopt private sector management practices, including customer-centric approaches and efficiency-driven operations.

➢ *Research Gaps*

Despite extensive CRM literature, scholarly attention to digital transformation in African public utilities remains limited [22, 23]. Most existing research focuses on developed market contexts, leaving questions about implementation strategies, success factors, and contextual adaptations in resource-constrained environments inadequately addressed [39, 40, 41]. This study addresses this gap by examining CRM implementation in a Sub-Saharan African electricity utility, contributing empirical evidence from an under-researched context.

III. METHODOLOGY

This section presents the proposed Customer Relationship Management system architecture for SNEL Kolwezi Distribution Center. The architecture is designed to address the identified operational deficiencies while considering the specific technological, financial, and human resource constraints of the DRC context. We first outline the overall system framework, then detail the core functional modules, describe the data management structure, explain the user interface design, and finally discuss the technical infrastructure requirements necessary for successful implementation.

➢ *Overall System Framework*

The proposed CRM system follows a three-tier architecture consisting of the presentation layer, application logic layer, and data storage layer [1]. This modular design ensures scalability, maintainability, and flexibility for future enhancements. The presentation layer provides user interfaces for different stakeholder groups including customer service representatives, billing clerks, technical staff, and management. The application logic layer processes business rules, manages workflows, and coordinates system functions. The data storage layer maintains centralized databases containing customer information, billing records, payment histories, and service requests.

The system operates as an integrated platform that replaces fragmented manual processes with automated workflows. Customer data flows seamlessly between modules, eliminating duplicate entries and ensuring information consistency across all organizational functions [16, 17]. Real-time data synchronization enables immediate access to updated information, supporting faster decision-making and improved customer service delivery.

➢ *Core Functional Modules*

- *Customer Information Management Module*

This module serves as the central repository for all customer-related data including identification details, contact information, service addresses, meter numbers, and account histories. It replaces the deteriorating VISA notebooks currently used at SNEL Kolwezi. The module enables customer service representatives to quickly retrieve comprehensive customer profiles, eliminating the time-consuming manual search through fragmented paper records [15, 20]. Features include customer registration, profile updates, account status tracking, and historical consumption patterns.

- *Billing and Invoicing Module*

The billing module automates electricity consumption calculation and invoice generation based on meter readings. It eliminates duplicate billing errors by implementing validation checks that prevent multiple invoices for the same consumption period [21]. The system generates standardized bills with clear consumption details, tariff breakdowns, and payment instructions. Automated billing cycles ensure timely invoice distribution and reduce administrative workload. The module also supports multiple tariff structures to accommodate different customer categories including residential, commercial, and industrial users.

- *Payment Management Module*

This module tracks all customer payments, recording transaction dates, amounts, payment methods, and receipts. It addresses the critical problem of lost payment records by maintaining secure digital archives accessible across the organization [18, 19]. Features include payment posting, receipt generation, payment plan management, and arrears tracking. Integration with the billing module ensures automatic account balance updates and prevents service disconnections for customers with current payments. The

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system generates alerts for overdue accounts and facilitates targeted revenue collection efforts.

- *Service Request and Complaint Management Module*

This module streamlines the handling of customer inquiries, service requests, and complaints. It replaces ad-hoc complaint resolution processes with structured workflows that ensure timely responses and proper escalation [20]. Each request receives a unique tracking number, enabling customers and staff to monitor resolution progress. The system categorizes requests by type, priority, and assigned personnel, facilitating workload distribution and performance monitoring. Automated notifications alert relevant staff when action is required, preventing delays and improving service quality.

- *Reporting and Analytics Module*

The reporting module provides management with comprehensive analytical tools for monitoring organizational performance and supporting strategic decision-making [3, 6]. Standard reports include revenue summaries, collection rates, customer satisfaction metrics, billing accuracy indicators, and service delivery statistics. Customizable dashboards enable managers to track key performance indicators in real-time. The module supports data export in multiple formats for further analysis and regulatory reporting requirements.

➢ *Data Management Structure*

The system employs a relational database management system that ensures data integrity, security, and accessibility [31, 32]. Core database tables include customers, meters, readings, bills, payments, service requests, and users. Relationships between tables maintain referential integrity, preventing orphaned records and ensuring data consistency. The database implements role-based access controls, restricting sensitive information to authorized personnel only [16].

Data backup procedures occur automatically at scheduled intervals, with redundant storage ensuring business continuity in case of hardware failures. Archive mechanisms maintain historical records while optimizing system performance by moving inactive data to separate storage. Data validation rules prevent entry of incomplete or incorrect information, improving overall data quality and system reliability.

➢ *User Interface Design*

The system features intuitive interfaces designed for users with varying levels of computer literacy, recognizing the capacity constraints in the DRC context [9, 10, 41]. Navigation follows familiar patterns with clearly labeled menus, buttons, and forms. Critical functions are accessible within three clicks from the main dashboard. Color coding distinguishes different account statuses and alert priorities. The interface supports both French and local languages to accommodate the multilingual workforce.

Forms incorporate dropdown menus, radio buttons, and checkboxes to minimize typing and reduce data entry errors. Mandatory fields are clearly marked, and validation messages provide immediate feedback on input errors. Search functions enable quick customer lookup using multiple criteria including account numbers, names, addresses, or meter identifiers. Context-sensitive help provides guidance for complex tasks without requiring external documentation.

➢ *Technical Infrastructure Requirements*

Successful system deployment requires adequate technical infrastructure including servers, networking equipment, workstations, and power backup systems [11, 12]. The server configuration should provide sufficient processing power and storage capacity to handle current customer volumes with room for growth. Network connectivity between SNEL offices enables real-time data access across locations, though the system can operate in offline mode during connectivity disruptions with automatic synchronization when connections are restored.

Workstations at customer service points, billing offices, and management locations require standard specifications capable of running the application smoothly. Uninterruptible Power Supply (UPS) units protect against data loss during frequent power interruptions common in the DRC context [13, 14]. The system supports both desktop and web-based deployment options, with web-based access providing flexibility for remote work and mobile field operations.

IV. ANALYSIS OF THE EXISTING CUSTOMER RELATIONSHIP AT THE KOLWEZI DISTRIBUTION CENTER

The functional analysis methodology was systematically applied to the Kolwezi Distribution Center to construct a reliable information model. This approach focused on examining existing information supports primarily the documents exchanged between the service center and its clients to meticulously gather and analyze data related to the current customer relationship and billing processes.

➢ *Operational Document Review and System Evaluation*

The existing information system is fundamentally a paper-based operation, documented through a series of key official registers and forms that govern client lifecycle management.

- *Key Operational Documents*

The analysis identified four primary documents crucial to transactional integrity and data storage:

✓ Registration Notebooks: Used for initial client subscription, capturing essential static data such as the client's surname, registration date, address, and the applicable tariffs and amounts.
✓ Invoice: The official accounting document confirming the service provided and the debt owed. It includes critical identifiers like the date of issue, Meter Number, and the final Amount.
✓ Duplicate Invoice: A copy used primarily by the teller to process and track partial payments or deposits (*acomptes*).

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✓ Breakdown of Daily Receipts (*Éclatement des recettes journalières*): A financial reconciliation tool that summarizes aggregate daily collections, detailing figures for Energy consumption, VAT, Tariffs, and the final Daily Total collected.

- *System Strengths and Critical Weaknesses*

While the reliance on structured, certified documents provides a measure of organizational control, the inherent characteristics of the manual system present serious operational risks, as summarized below in table 1:

Table 1 System Strengths and Critical Weaknesses

Critical Weaknesses (Pain Points)	Organizational Strengths
Data Integrity and Security: High risk of information loss due to paper storage, coupled with non-secure data susceptible to permanent falsifiability.	Good Organization: The service benefits from a clear, established structure where each actor possesses a well-defined role.
Operational Efficiency: Significant loss of time and cumbersomeness in accounting due to manual transcription and processing.	Effective Communication: Established protocols ensure smooth information exchange between different internal services.
Retrieval and Conservation: Difficulty in quickly retrieving archived client information and doubtful long-term conservation due to illegibility and physical deterioration.	

➢ *Analysis of the Existing Workforce Profile*

A questionnaire was administered to the agents to establish the demographic context of the workforce responsible for managing customer relations. The data provides valuable insight into the human capital operating the existing system.

- *Agent Profile Data*

The demographic structure of the Kolwezi Center's workforce is synthesized in the following table:

Table 2 Agent Profile Data

Category	Modality	Freq	(%)
Gender	Male	63	63%
	Female	37	37%
Age Group	Over 50 years	52	52%
	41 – 49 years	21	21%
	36 – 40 years	13	13%
	30-35 years	7	7%
	20 – 29 years	7	7%
Marital Status	Married	61	61%
	Widower(s)	25	25%
	Single	9	9%
	Divorced	5	5%
Education Level	Secondary	42	42%
	University	32	32%
	Primary	26	26%
Household Size	5 to 10 persons	44	44%
	11 to 15 persons	30	30%
	Less than 5 persons	26	26%
	More than 15 persons	4	4%

Source: Designed by the Authors, Based on Field Data.

- *Graphical Representation of the Kolwezi Center Agent Profile*

From the data presented in Table 2, the demographic structure of the Kolwezi Center's workforce can be visually examined. The following figures provide a detailed graphical representation of the agent profile.

This pie chart illustrates the distribution of men and women within the surveyed workforce, revealing a strong male majority, as shown in figure 1.

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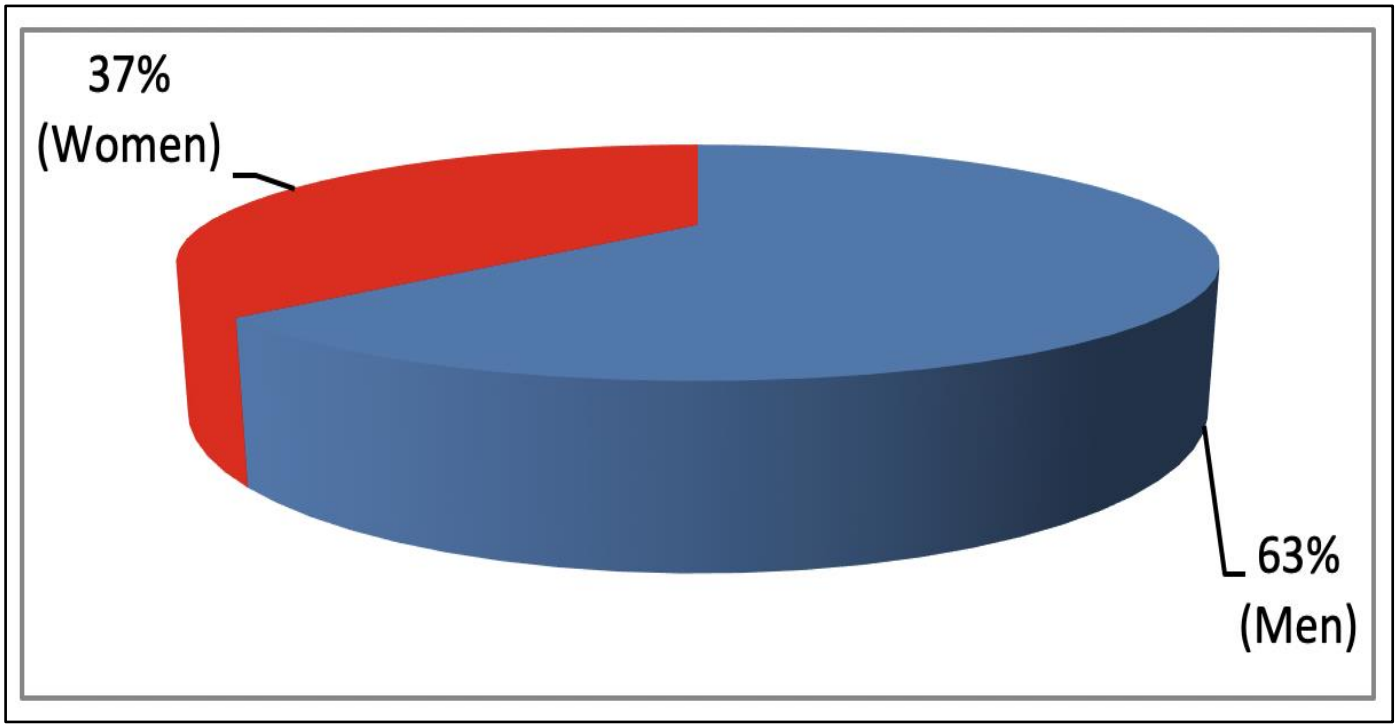

Fig 1 Gender Distribution of Kolwezi Center Agents

The workforce is predominantly male (63%), a situation primarily attributed to the historically technical and industrial character of the SNEL company.

This bar chart categorizes the workforce by age group, highlighting the concentration of older agents.

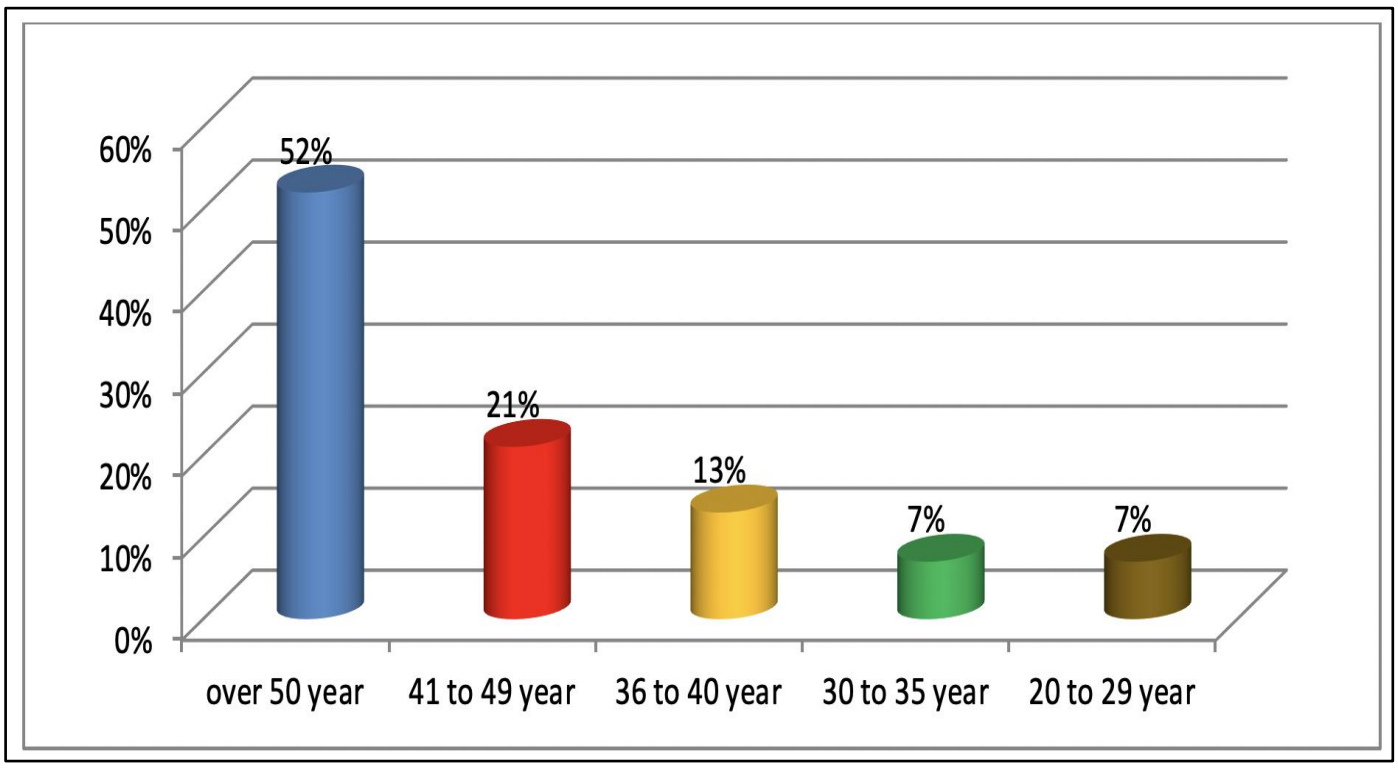

Fig 2 Age Group Distribution of Kolwezi Center Agents

Observation: The most significant group are agents aged 50 years and older (52%), indicating a considerably aging workforce. This demographic trend must be considered for succession planning and technology transition training.

This bar chart details the marital status of the surveyed agents.

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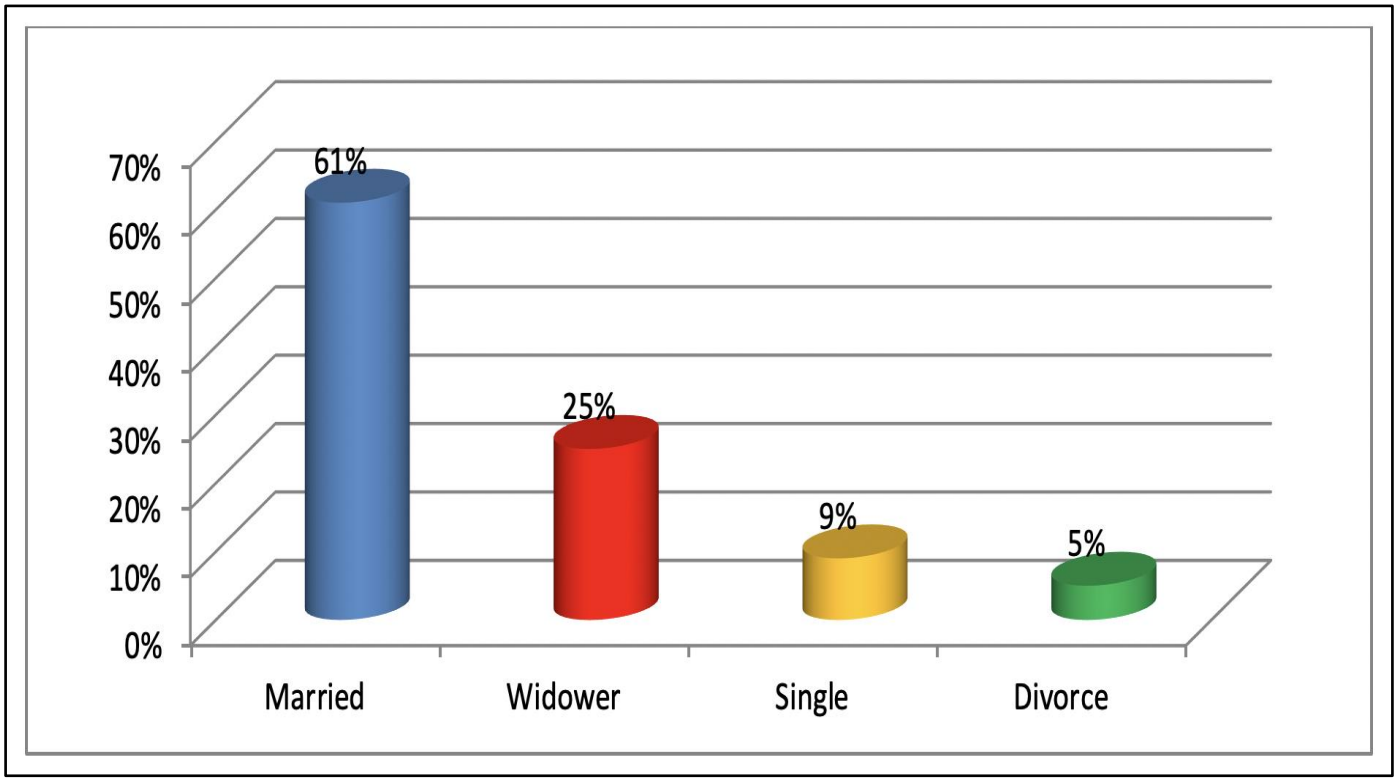

Fig 3 Marital Status Distribution of Kolwezi Center Agents

Observation: The majority of the agents (61%) are married.

This bar chart presents the highest level of education attained by the workforce.

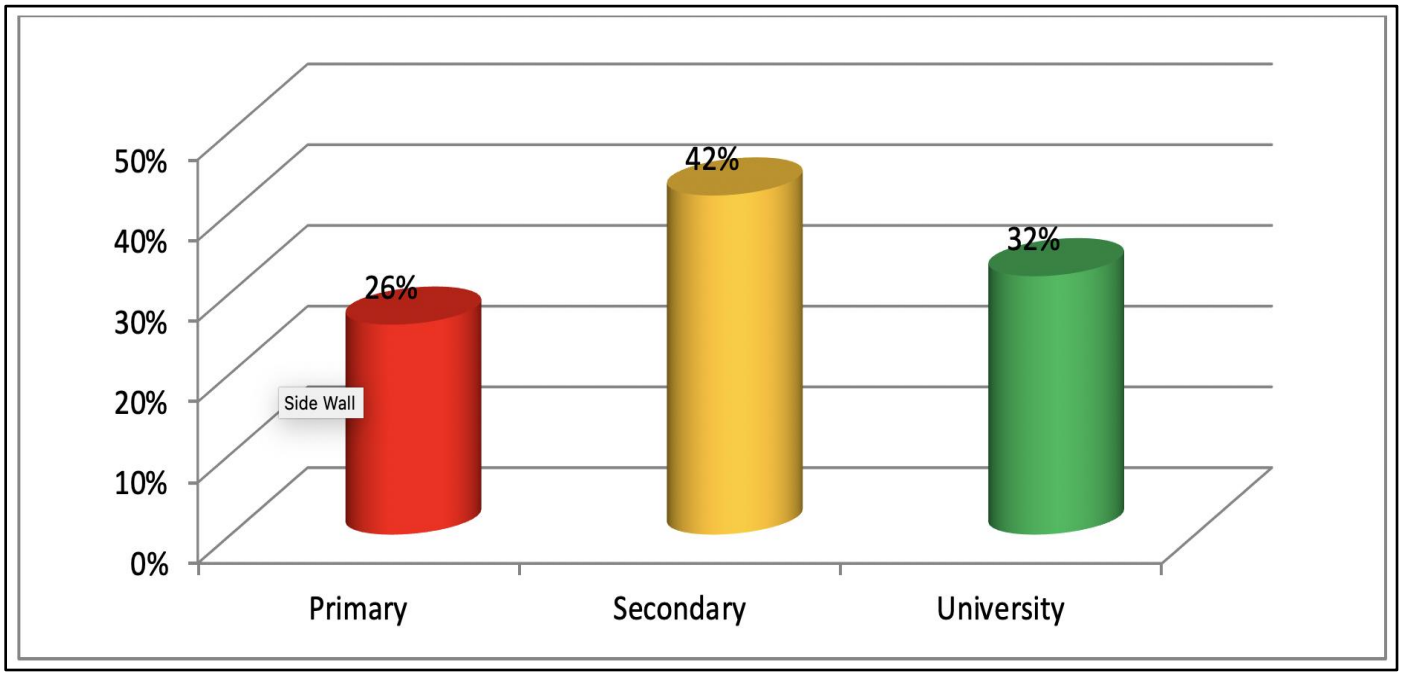

Fig 4 Education Level of Kolwezi Center Agents

Observation: The highest proportion of agents have reached the secondary level (42%), followed closely by those with a university education (32%). This mixed educational background necessitates a user-friendly design for any new digital system.

This bar chart classifies agents based on the size of their household.

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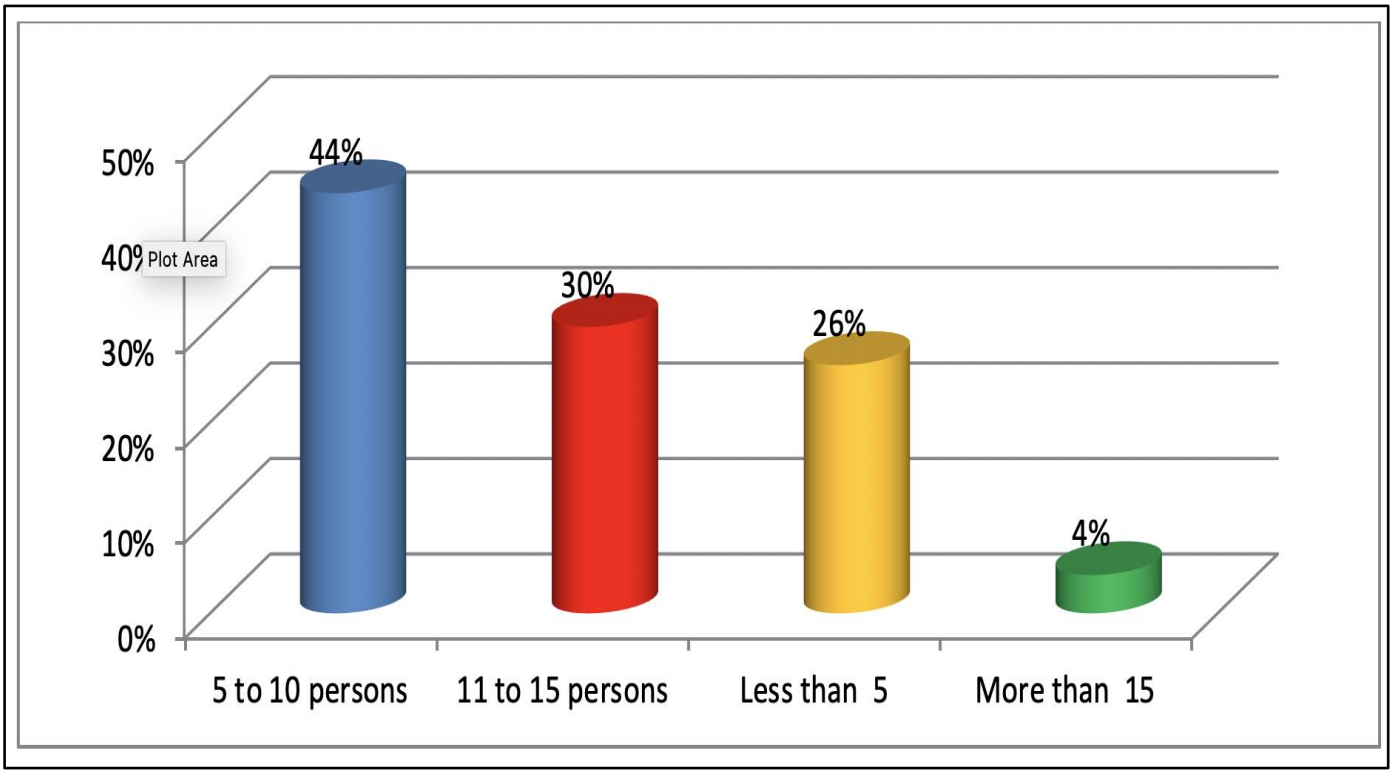

Fig 5 Household Size Distribution of Kolwezi Center Agents

The most common household size falls within the 5 to 10 persons range (44%).

➢ *Agent Perceptions: Critical Need for Digitalization*

The survey results confirm the severity of the operational deficiencies and validate the need for a digital solution.

- *Confirmation of Document Usage*

The agents unanimously confirmed (100%) the compulsory use of the four primary documents (Registration Notebook, Invoice, Duplicate Invoice, and Breakdown of Daily Receipts) in the billing process.

The unanimous recognition of the manual system's limitations and the concrete benefits of digitalization provide robust empirical justification for the development and implementation of a new information system.

➢ *Business Process Analysis: Client Payment Scenario*

The analysis of the business process highlights the sequential, manual steps involved in a client payment transaction:

- Client presents invoice at the collection point.
- Teller records the payment details (client name, amount, date) in the paper "visa" register.
- Teller uses a duplicate invoice for any partial payment transaction.
- Teller transfers the physical invoice to the cashier.
- Cashier registers and validates the payment, returning a coupon to the client.

V. SYSTEM MODELING AND DESIGN

The preceding analysis established the functional deficiencies of the paper-based system and affirmed the organizational necessity for digitalization. Section 5 transitions from problem identification to solution engineering by defining the architecture and components of the proposed IT system. This stage, guided by a rigorous software engineering approach, will translate the documented needs namely, security, efficiency, and automated accounting into concrete technical specifications and models. The overall objective is to design a robust, user-friendly application capable of replacing manual processes and serving as the centralized source of truth for customer relationship and billing data.

➢ *Objectives of the Proposed System*

Based on the critical weaknesses identified in Section 5, the proposed Customer Relationship Management and Billing Application must achieve the following core objectives:

- Enhance Data Security and Integrity: Replace vulnerable paper records with a secured, non-falsifiable digital database, ensuring the long-term conservation and integrity of all client and transactional data.
- Maximize Operational Efficiency: Eliminate manual transcription and transfer steps (currently present in the payment scenario) to significantly reduce processing time and minimize accounting cumbersomeness.
- Automate Core Functions: Provide automated tools for client registration, invoice generation, payment tracking, and financial reconciliation, thereby centralizing management and reducing human error.

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- Improve Data Retrieval: Implement powerful query and reporting capabilities to allow for the immediate retrieval of client and payment history, overcoming the difficulty of locating physical archives.
- Provide a User-Friendly Interface: Given the mixed educational profile of the workforce (Figure 5.4), the system must be intuitive and easy to manipulate to ensure rapid adoption and optimal utilization by all agents.

➢ *Conceptual Data Model (CDM)*

The Conceptual Data Model (CDM) provides an abstract, high-level map of the data structure required for the new system, defining the main entities (the real-world objects the system needs to track) and the relationships between them. This model is language- and technology-independent, ensuring the database design supports all functional requirements identified.

- *Entity Definition*

The analysis of the existing documents and processes leads to the definition of the following core entities for the relational database:

Table 3 Entity Definition

Entity Name	Description	Key Attributes	Other Key Attributes
ABONNE (Client)	Represents the individual or organization receiving the service.	ID_Abonne (Primary Key)	Nom, PostNom, Prenom, Adresse, Telephone, Date_Abonnement
POINT_ABONNEMENT (P.A.)	Represents the physical service point or meter location.	ID_PA (Primary Key)	Compteur_Numero (Meter No.), Date_Installation, Localisation
TARIF	Defines the pricing structure for different consumption levels or types of clients.	ID_Tarif (Primary Key)	Designation (e.g., Residential, Industrial), Prix_Unitaire
CONSOMMATION	Records the meter readings and calculated usage for a specific period.	ID_Consommation (Primary Key)	Index_Initial, Index_Final, Date_Releve (Reading Date), Quantite_Consommee
FACTURE (Invoice)	The core accounting document recording the debt owed by the client.	ID_Facture (Primary Key)	Date_Emission, Date_Echeance, Montant_HTVA, Montant_TVA, Montant_Total, Statut (e.g., Paid, Pending)
PAIEMENT (Payment)	Records all cash receipts and payments made against an invoice.	ID_Paiement (Primary Key)	Date_Paiement, Montant_Paye, Type_Paiement (e.g., Full, Acompte)
AGENT	Represents the system users (tellers, cashiers, administrators).	ID_Agent (Primary Key)	Nom, Fonction, Identifiant_Connexion

- *Conceptual Relationships*

The relationships established between these entities reflect the business rules of the Kolwezi Distribution Center:

✓ ABONNE $\stackrel {1, n} {\longleftarrow} $ Est_Proprietaire $\stackrel {1, 1} {\longrightarrow} $ POINT_ABONNEMENT (P.A.): One Client can own one or more Subscription Points (P.A.s), but each P.A. belongs to only one Client.

✓ P.A. $\stackrel {1, 1} {\longleftarrow} $ Est_Consomme $\stackrel {1, n} {\longrightarrow} $ CONSOMMATION: Each P.A. generates multiple Consumption records over time.

✓ CONSOMMATION $\stackrel {1, 1} {\longleftarrow} $ Est_Regi_Par $\stackrel {1, 1} {\longrightarrow} $ TARIF: Every Consumption record is linked to a specific Tariff structure for calculation.

✓ CONSOMMATION $\stackrel {1, 1} {\longleftarrow} $ Est_Base_De $\stackrel {1, 1} {\longrightarrow} $ FACTURE: Each Consumption record results in the creation of exactly one Invoice.

✓ FACTURE $\stackrel {1, 1} {\longleftarrow} $ Est_Cible $\stackrel {0, n} {\longrightarrow} $ PAIEMENT: One Invoice can be the target of zero or many Payment records (to handle partial payments/deposits).

✓ PAIEMENT $\stackrel {1, 1} {\longleftarrow} $ Est_Effectue_Par $\stackrel {1, 1} {\longrightarrow} $ AGENT: Every Payment must be recorded by a single Agent (Teller/Cashier).

- *Graphical Representation (ERD/UML)*

The Entity-Relationship Diagram (ERD) visually confirms the CDM, ensuring the relational structure is sound.

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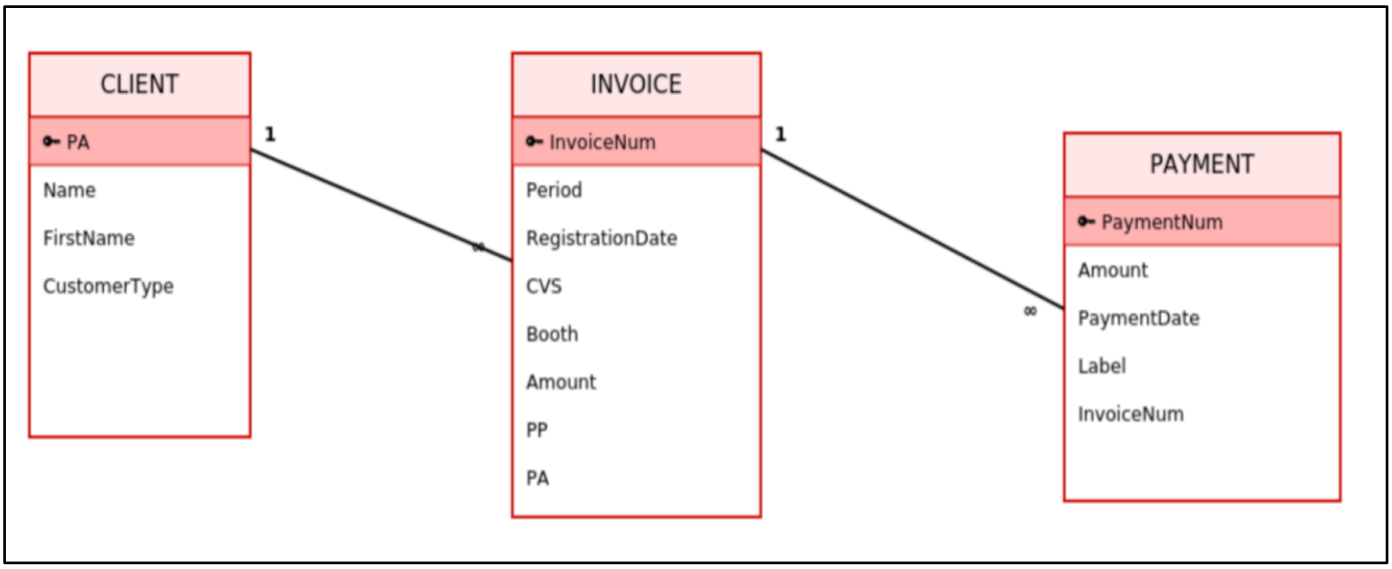

Fig 6 Entity-Relationship Diagram (ERD)

Figure 6 demonstrates the core relational structure, specifically the one-to-many relationship (1, ∞) between Client and Invoice, and Invoice and Payment. This structure is foundational for ensuring data integrity: every payment is traceable to a specific invoice, and every invoice is linked to a single client. This directly supports the automation of accounting reconciliation and the efficient retrieval of payment history (Objective 1, 3, and 4).

➢ *Functional Modeling (Use Case Diagram)*

Functional modeling identifies the scope of the system by defining the main actors and the services (use cases) they require from the application.

- *Actors and Use Cases*

The actors of the system are defined based on the roles identified in the business process analysis (Section 5.4):

✓ Guichetier (Teller): Responsible for registering new invoices/consumption readings.
✓ Caissier (Cashier): Responsible for receiving and processing payments.
✓ Client (Customer): Interacts with the system through the agents (indirectly).

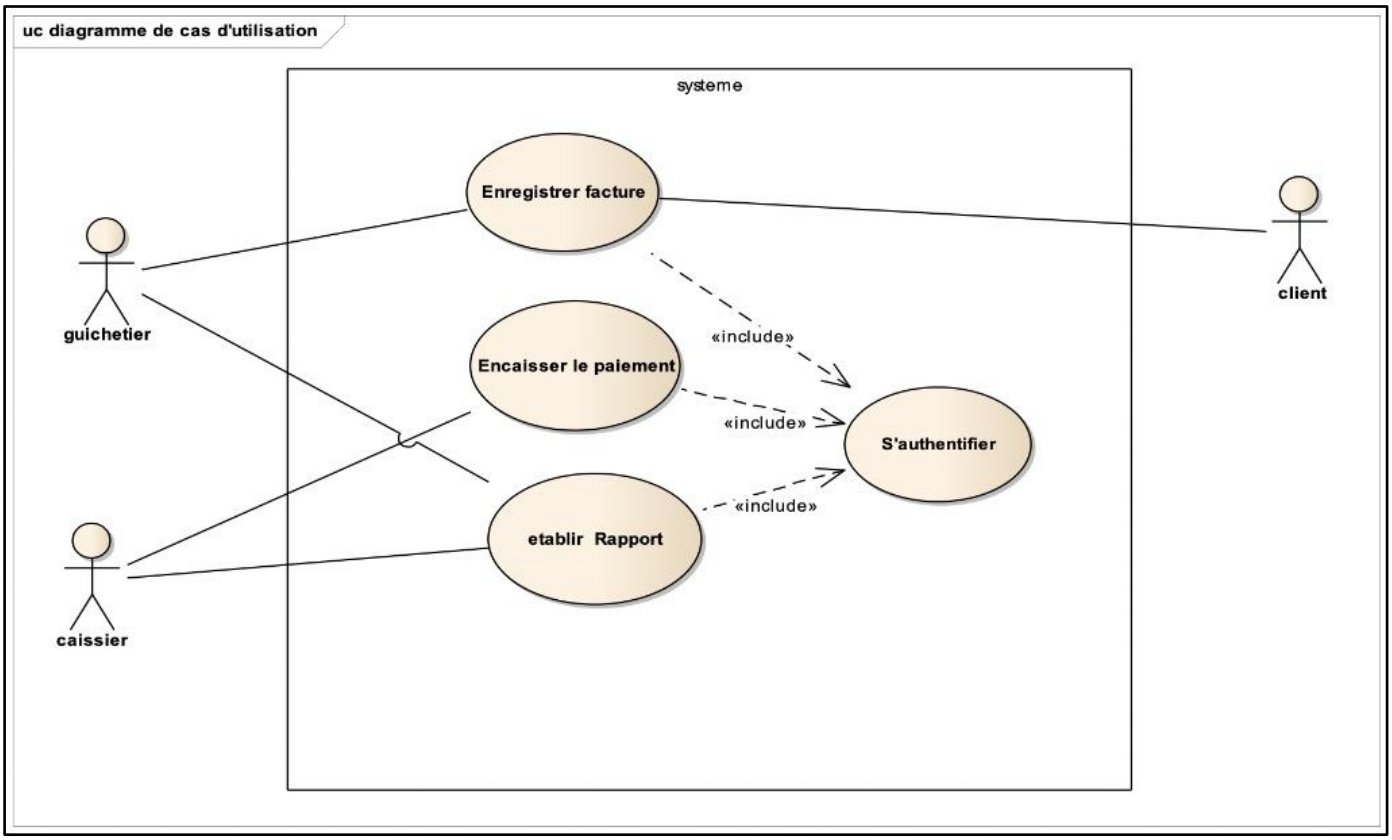

Fig 7 Use Case Diagram

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Figure 7 clearly delineates the system boundaries. The core functionalities are Enregistrer facture (Register Invoice), Encaisser le paiement (Process Payment), and Etablir Rapport (Establish Report). The critical inclusion of S'authentifier (Authenticate) as an $\ll$include$\gg$ relationship for all major use cases ensures that data security and user traceability are non-negotiable prerequisites for all system operations. This directly addresses the security and non-falsifiability requirement (Objective 1).

➢ *Structural Modeling (UML Diagrams)*

Structural modeling details the architecture and organization of the system's components, promoting modularity and maintainability.

- *Package Diagram*

The Package Diagram organizes the system elements into logical groupings (packages) based on their function, adhering to the Model-View-Controller (MVC) principle.

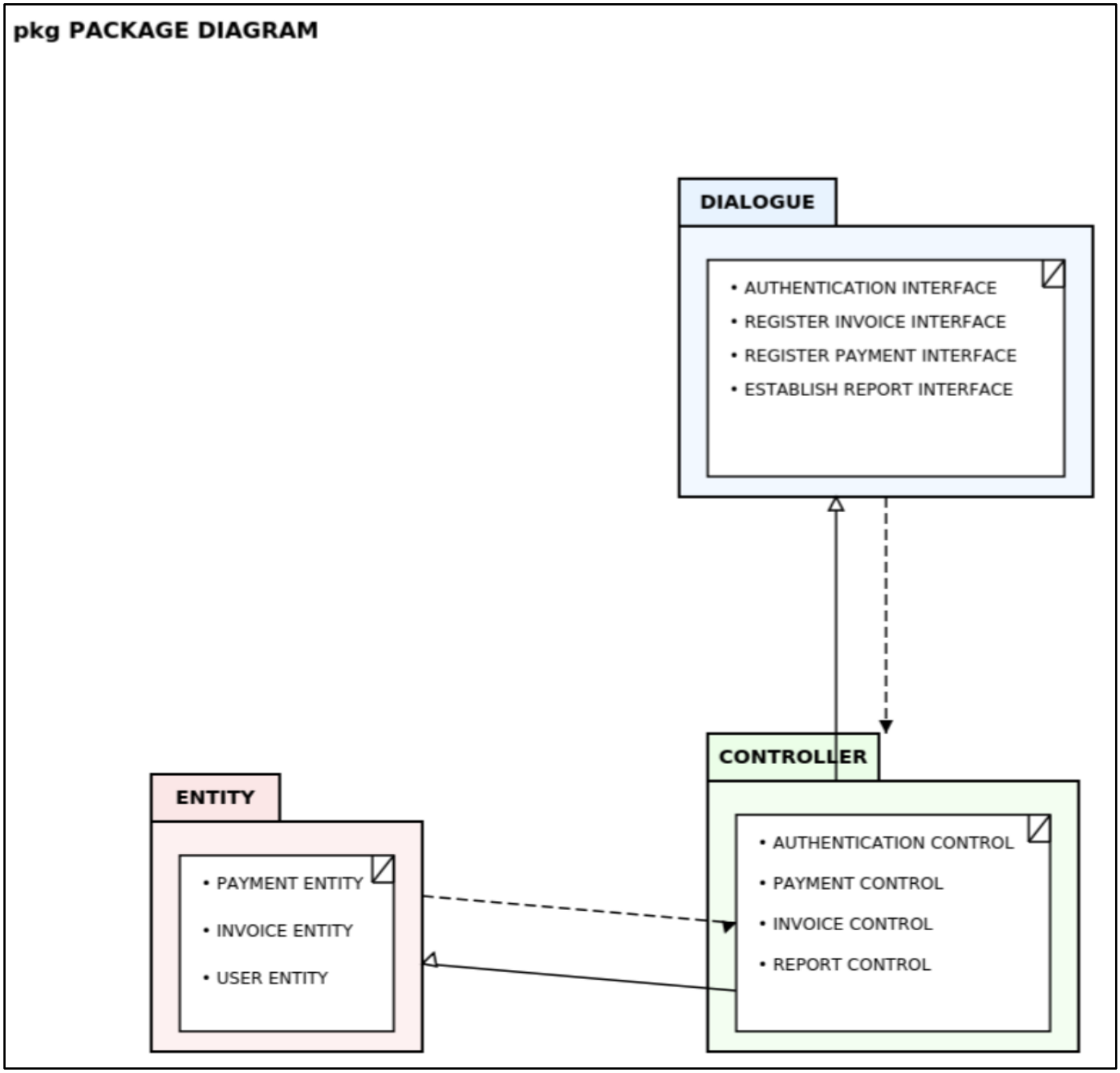

Fig 8 Package Diagram

As seen in Figure 8, the system architecture is structured into three packages: DIALOGUE (Interfaces/Views), CONTROLLER (Business Logic/Control), and ENTITY (Data Model/Database). The Controller acts as the central hub, managing the flow between the user interface and the persistent data store (Entities). This layered approach ensures high system cohesion and low coupling, making the application robust and easy to modify, supporting maintainability and future scalability.

- *Component Diagram*

The Component Diagram shows the physical structure of the code components and their dependencies.

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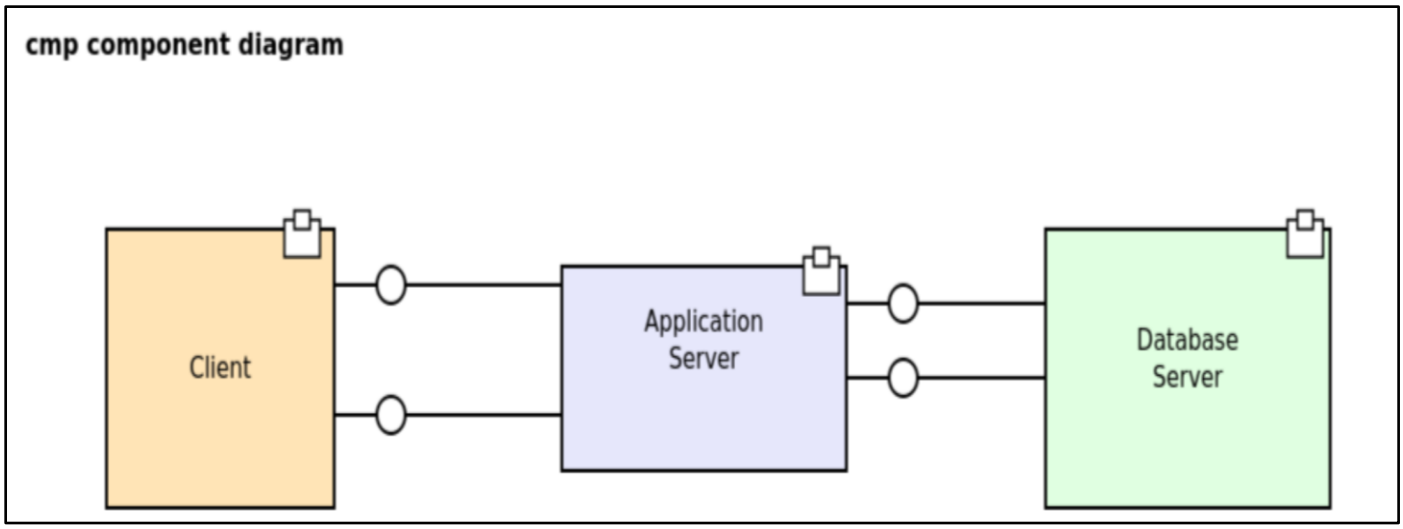

Fig 9 Component Diagram

Figure 9 illustrates a three-tier logical component architecture: Client (handling the user interface), Application Server (processing business logic and transactions), and Database Server (managing the persistent data store). The clear separation of concerns, represented by the provided and required interfaces (circles and sockets), confirms a robust architecture capable of supporting multiple concurrent user sessions, which is vital for the Kolwezi Center's efficiency goals (Objective 2).

➢ *Dynamic Modeling (Sequence Diagrams)*

Dynamic modeling illustrates how the system components interact over time to execute the core business processes defined in the Use Case Diagram.

- *Register Invoice Sequence Diagram*

This diagram maps the process of capturing consumption data and generating an invoice.

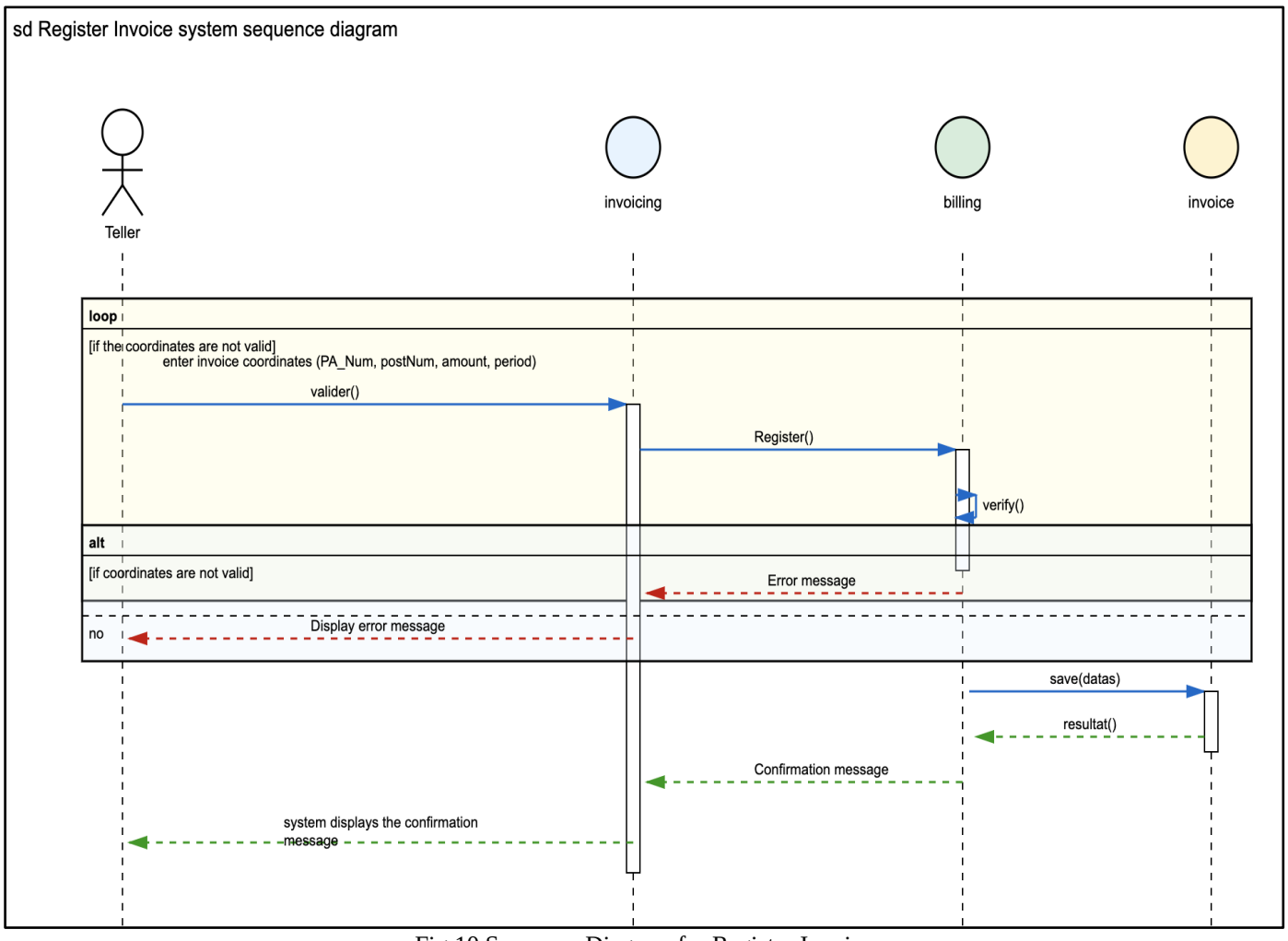

Fig 10 Sequence Diagram for Register Invoice

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Figure 10 details the Teller's interaction to register a new invoice. The process emphasizes validation: coordinates are entered, validated by the invoicing object, and the billing object performs a second verify () step before the invoice object saves the data. The use of a Loop (loop: [if the coordinates are not valid]) is crucial for user experience, requiring the Teller to correct invalid data immediately, preventing the persistent data integrity issues of the old paper system (Objective 1, 5).

- *Register Payment Sequence Diagram*

This diagram maps the process of a Cashier receiving and recording a client payment against an invoice.

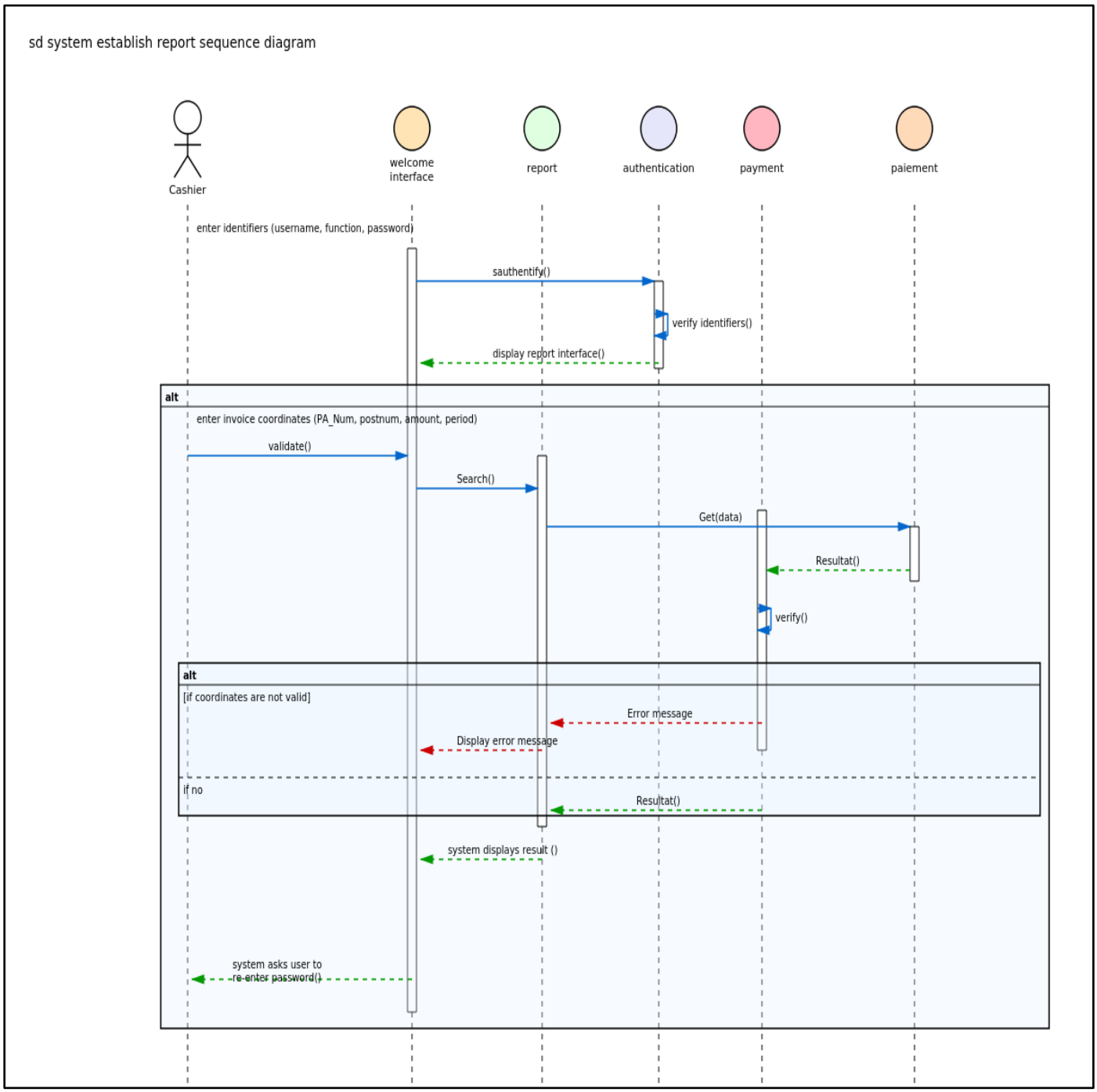

Fig 11 Sequence Diagram for Register Payment

The payment sequence in Figure 11 is executed by the Cashier. Similar to the invoice process, it emphasizes security and validation through the Payment Control object's verifyCoordinates () operation. The Alt block (alt: [If coordinates are not valid]) ensures that only valid transaction data proceeds to the Payment Entity for registration. This rigorous, automated validation eliminates the error-prone, manual transcription steps of the old system (Objective 2).

➢ *Deployment Architecture*

The Deployment Diagram maps the physical distribution of the system components across the network infrastructure.

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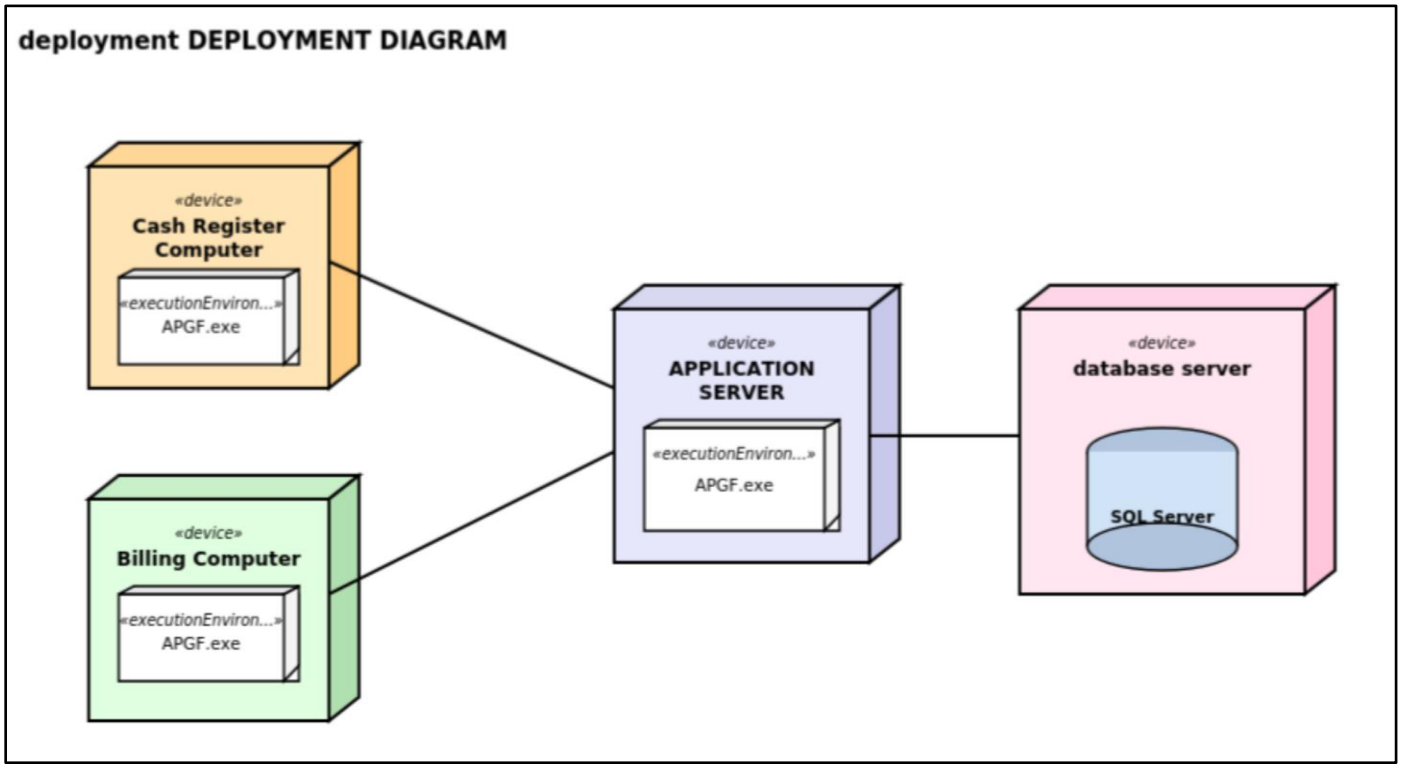

Fig 12 Deployment Diagram

Analysis: Figure 12 illustrates a standard client-server architecture. The system is deployed across four devices: the local client machines (Cash Register Computer and Billing Computer) run the client-side application (APGF.exe). These connect to a centralized APPLICATION SERVER, which hosts the business logic, and is, in turn, connected to a dedicated database server (SQL Server). This centralized model ensures all agents access a single, unified data source, guaranteeing real-time data consistency and high availability across the Kolwezi Distribution Center (Objective 1 and 3).

- *System Interfaces and User Experience (UX)*

Based on the analysis of the workforce profile (Section 5.2, Figure 5.4), which showed a mixed educational background, Objective 5 prioritizes a highly intuitive and user-friendly interface. The initial interaction with the system is the application startup, which provides immediate feedback to the agent.

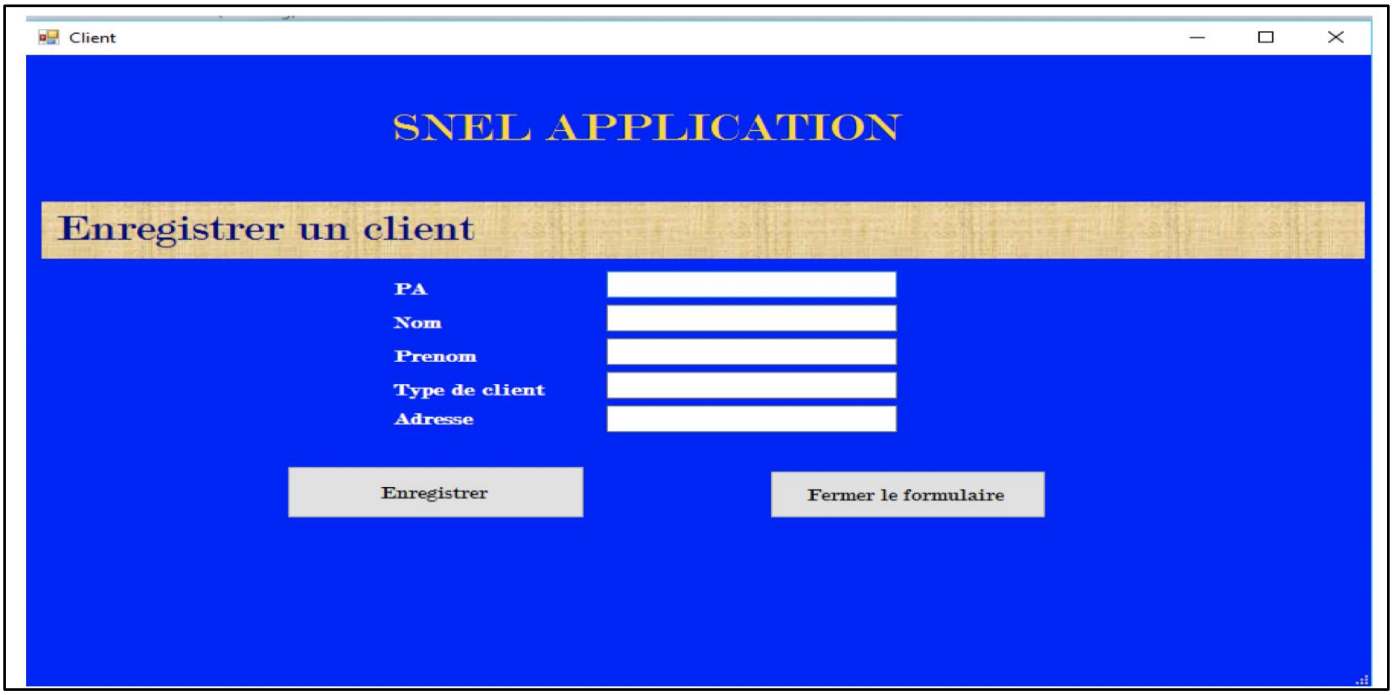

Fig 13 Application Initialization Screen (Startup UX)

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This screen provides visual feedback during the application's loading process, reassuring the user that the system is preparing for use.

Analysis: The initialization screen, as shown in Figure 13, is the first point of contact for the agent. The system immediately provides clear feedback with the progress bar and the percentage indicator ("Initializing... 91%"). This simple, visual communication addresses Objective 5 (User-Friendly Interface) by reducing uncertainty and perceived wait times, thereby promoting a positive initial user experience and contributing to rapid agent adoption.

- *Interface Design (IHM - Interface Homme-Machine)*

Based on the dynamic models (Section 5), the two most critical initial interfaces are the Authentication Screen (a prerequisite for all operations, per Objective 1) and the Invoice Registration Screen (the core function of the Teller, addressing Objective 2 and 3). The design prioritizes simplicity and clear labeling to meet the User-Friendly Interface requirement (Objective 5).

Fig 14 Authentication Interface (Login Screen)

This screen provides the mandatory entry point for all agents (Tellers and Cashiers) to securely access the system.

The Login Screen implements the required $\ll$include$\gg$ relationship established in the Use Case Diagram (Figure 7). It is minimal and direct, requiring only the Login ID and Password (as defined in the AGENT table of the PDM). This dual-factor check ensures the traceability and non-falsifiability of all subsequent actions (Objective 1), eliminating the anonymous nature of the old paper-based system.

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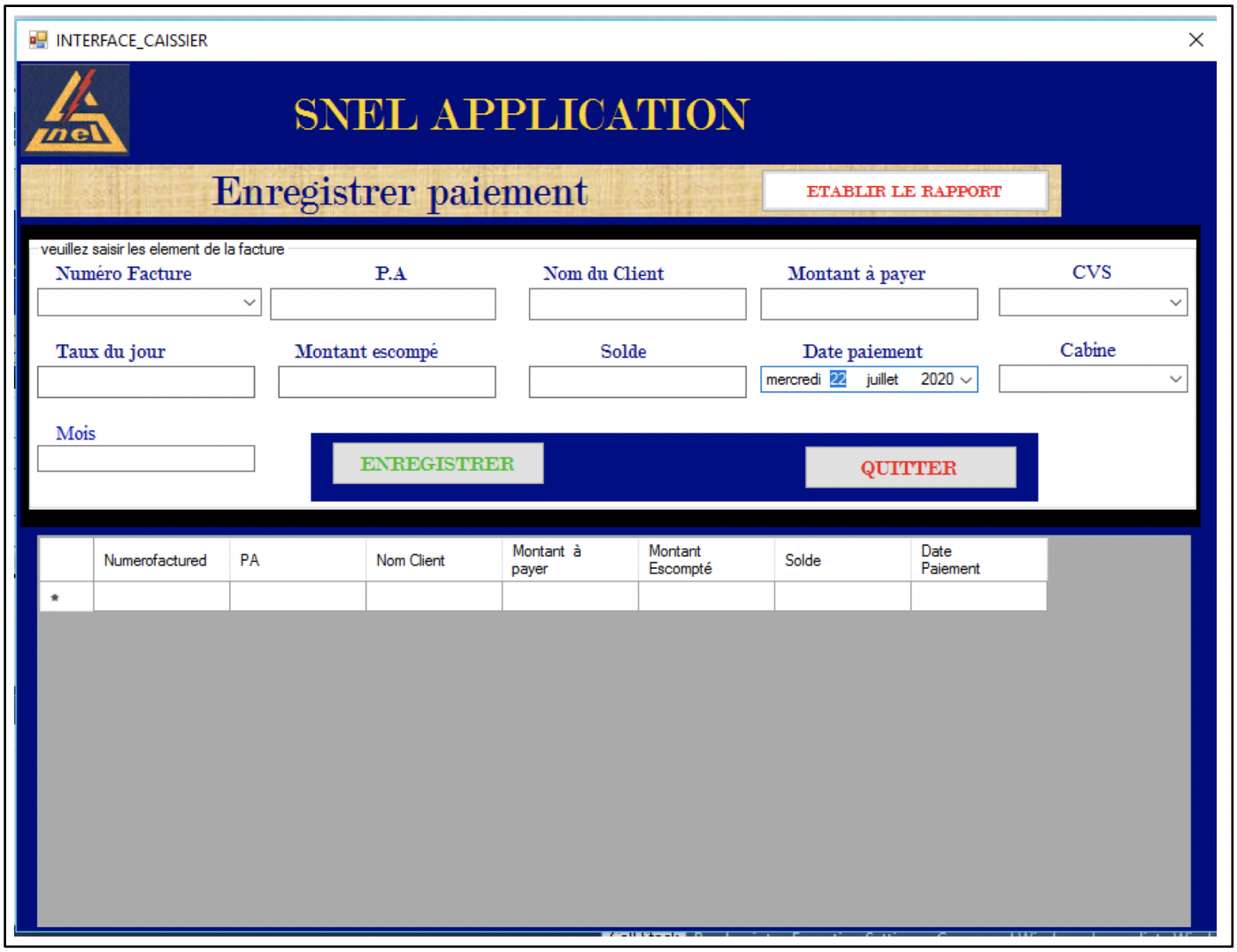

Fig 15 Invoice Registration Interface (Teller/Billing Screen)

This is the Teller's primary operational screen, designed to capture consumption data and automatically generate the corresponding invoice.

The Invoice Registration Interface is a direct implementation of the Register Invoice use case. It is structured logically to maximize Operational Efficiency (Objective 2):

- Meter Lookup: The Teller enters the Meter_Number (from the SUBSCRIPTION_POINT table), which automatically retrieves client details (Subscriber Name/Address).
- Data Input: The Teller inputs the Initial_Index and Final_Index (required for the CONSUMPTION table).
- Automated Calculation: Upon input, the system automatically calculates the Consumed_Quantity (Final - Initial), applies the corresponding TARIFF, calculates VAT, and determines the Total_Amount.

This single screen replaces the error-prone, sequential, and manual transcription process with a fast, validated, and automated workflow, directly fulfilling Objective 3 (Automate Core Functions).

VI. DISCUSSION AND IMPLICATIONS

The comprehensive analysis and modeling phase confirms that the proposed Information System directly addresses the critical operational deficiencies identified at the Kolwezi Distribution Center. The design choices, from the Conceptual Data Model (CDM) to the user interfaces, are strategically engineered to mitigate the risks inherent in the former paper-based system and align with the workforce's demographic profile.

➢ *Mitigation of Paper-Based Risks and Enhanced Security*

The core finding of the initial analysis was the 100% consensus on the system's weaknesses: data falsifiability, loss, and doubtful long-term conservation (Table 5). The proposed system overcomes this by implementing a centralized, secured, and relational database, as defined in the PDM.

- *Traceability and Integrity (Objective 1):*

The mandatory Authentication step (Figure 13), combined with the ID_Agent foreign key in the PAYMENT table, ensures that every single transaction is digitally traceable to a specific, authorized employee. This rigorous

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non-falsifiability directly replaces the insecure "visa" register used previously (Section 5.4).

- *Centralized Data Source:*

The Deployment Diagram (Figure 10) confirms a robust, centralized database architecture, which guarantees all agents operate from a single source of truth, eliminating the risk of data fragmentation and physical document misplacement.

➢ *Operational Efficiency and Process Automation*

The design significantly streamlines the core business process: billing and payment. The initial manual payment scenario involved five sequential, document-dependent steps (Section 5.4), characterized by inefficiency and accounting cumbersomeness.

- *Automated Billing:*

The Invoice Registration Interface (Figure 15) collapses the complex manual calculation and document creation process into a single, automated screen. By calculating the Consumed_Quantity, applying the TARIFF, and determining the final Total_Amount in real-time, the system maximizes Operational Efficiency (Objective 2) and dramatically reduces human error in calculation, fulfilling Objective 3 (Automate Core Functions).

- *Validated Transactions:*

The sequence diagrams (Figure 9 and 10) prioritize immediate data validation through the Loop and Alt control structures, preventing invalid data from ever reaching the database. This enforces integrity at the point of entry, which was impossible in the former manual system.

➢ *Alignment with Workforce Profile (UX Implications)*

The system design has been carefully tailored to the specific characteristics of the Kolwezi workforce (Section 5):

- *Addressing the Aging Workforce (52% Over 50):*

The large proportion of older agents highlights the need for a non-intimidating and highly intuitive system. The User-Friendly Interface (Objective 5) principle is paramount, favoring clean, simple screens (Figures 14 and 15) with clear labels over complex, multi-layered menus.

- *Addressing Knowledge Loss:*

The digitalization effort transforms tacit knowledge held by long-serving agents into a structured, easily retrievable knowledge base within the database. The system, therefore, serves as a crucial tool for knowledge preservation against upcoming retirements (Figure 2 analysis).

- *Mixed Educational Background:*

The interface design's reliance on graphical presentation and automated calculation (Figure 15) minimizes the requirement for complex arithmetic or extensive procedural memorization, making the system accessible across the entire spectrum of educational backgrounds (Figure 4 analysis).

In conclusion, the proposed system is not merely a digital replacement; it is a strategic solution designed to enhance security, enforce data integrity, and boost the overall productivity and institutional knowledge conservation of the Kolwezi Distribution Center.

➢ *Applications and Operational Implications*

The implementation of the new system extends beyond simple data entry and processing, creating new strategic and operational advantages for the Kolwezi Distribution Center.

- *Real-Time Financial Reconciliation:*

The system replaces the manual, end-of-day *Éclatement des recettes journalières* (Breakdown of Daily Receipts) with automated, real-time aggregation of payment data. This dramatically improves the speed and accuracy of accounting, providing management with immediate insight into cash flow and eliminating reconciliation delays and errors (Table 6 Advantage).

- *Enhanced Reporting and Decision-Making:*

By centralizing historical data in a structured relational database (PDM), the system enables complex querying and reporting capabilities (Objective 4). Management can instantly retrieve client consumption trends, identify high-debt subscribers, and analyze tariff effectiveness, facilitating data-driven strategic decisions regarding collections and service expansion.

- *Streamlined Client History Retrieval:*

The structured database ensures that client and payment history, previously difficult to retrieve from physical archives, is accessible instantly. This not only speeds up customer service interactions but also provides agents with a complete lifecycle view of the client, enhancing the quality of the customer relationship.

➢ *Limitations and Future Considerations*

While the proposed system provides a robust solution to the immediate problems of data integrity and operational efficiency, it is important to acknowledge certain limitations and areas for future development.

- *Implementation Challenge:*

The transition from a deeply entrenched paper-based culture to a fully digital platform requires a substantial investment in agent training and initial oversight. Despite the user-friendly design (Objective 5), resistance to change and the potential for initial errors during the transition phase must be managed through dedicated training modules for the aging workforce.

- *Limited Customer-Facing Scope:*

This system is designed solely for internal operational efficiency and security at the distribution center. It does not include customer-facing features like online payment processing or a client portal for viewing usage and bills. This remains a significant area for future IT expansion.

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- *Maintenance and Scalability:*

The reliance on a centralized SQL Server database (Figure 10) introduces a dependence on specialized IT infrastructure and expertise for maintenance, backups, and security management. Future considerations should include migrating to a more flexible, cloud-based deployment to enhance scalability and disaster recovery capabilities.

In conclusion, the proposed system is not merely a digital replacement; it is a strategic solution designed to enhance security, enforce data integrity, and boost the overall productivity and institutional knowledge conservation of the Kolwezi Distribution Center. The architecture provides a solid, traceable, and efficient foundation upon which future strategic functionalities can be built.

VII. CONCLUSION AND FUTURE WORKS

This research successfully met its objectives by comprehensively analyzing existing manual customer management practices, identifying critical deficiencies, and designing a contextually tailored Customer Relationship Management (CRM) application framework. The investigation confirmed that the Kolwezi Distribution Center's reliance on paper-based documents such as Registration Notebooks and vulnerable payment ledgers resulted in severe operational risks, including high data falsifiability, loss of payment records, and significant administrative cumbersomeness, acknowledged by 100% of the workforce. Furthermore, the demographic profile, notably an aging workforce (52% over 50) with mixed educational backgrounds, underscored the need for a solution focused on knowledge preservation and an intuitive user experience.

The proposed CRM system, built on a robust three-tier architecture and defined by a rigorous Conceptual and Physical Data Model, provides a powerful solution to these challenges. Its implementation delivers four core strategic contributions:

➢ *Enhanced Data Integrity and Security:*

The system enforces mandatory digital authentication and centralizes all data in a relational database, guaranteeing non-falsifiability and providing a traceable, single source of truth that permanently replaces the insecure paper archives.

➢ *Maximized Operational Efficiency:*

Core processes like billing and payment are automated and validated in real-time, eliminating manual transcription errors and significantly streamlining the complex, multi-step transaction process.

➢ *Strategic Shift to Customer-Centricity:*

By enabling instant retrieval of complete client history, automated service request tracking, and accurate billing, the system fundamentally improves customer satisfaction and allows SNEL to transition from a bureaucratic entity to one aligned with the performance and efficiency principles of New Public Management.

➢ *Actionable Intelligence:*

The Reporting and Analytics Module transforms fragmented data into strategic intelligence, enabling management to monitor key performance indicators in real-time and make data-driven decisions on collections, tariff application, and service expansion.

The proposed CRM framework stands as a practical pathway toward a digitally empowered electricity sector in the DRC. By tackling infrastructural constraints and investing in workforce digital skills, SNEL can transform its service delivery, enhance operational efficiency, and secure its long-term sustainability while narrowing the technological divide affecting public utilities in resource-limited settings.

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