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Research paper

Towards a Financial information system model using Computation Independent Model*

Kenza MBARKI[1,*], Laila BENNIS[1]

[1] *Research Laboratory in Organizational Management Sciences, National School of Business and Management, Ibn Tofail University, Kenitra, Morocco*

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ABSTRACT

Model Driven Engineering (MDE) and Financial Information System (FIS) are traditionally distinct fields, with MDE focusing on models as primary engineering artifacts and financial systems on managing financial data. However, innovative studies have bridged these fields by applying MDE principles to financial systems, enhancing their robustness and efficiency. This paper leverages the Computation Independent Model (CIM) from the Model Driven Architecture (MDA) framework to develop a financial information system model tailored to financial management needs. This approach aims to improve the accuracy, efficiency, and compliance of financial systems, crucial for business success in a dynamic financial landscape. The adaptability of CIM allows financial systems to evolve with minimal re-development, ensuring regulatory compliance and operational continuity.

1. Introduction

Model Driven Engineering and Financial Information Systems are two distinct fields with a multitude of scientific work. While the former focuses on using models as primary engineering artifacts, the latter is centered on the management and processing of financial data. Despite their differences, a few pioneering studies have managed to bridge the gap between these two fields. These innovative works have explored the potential of using Model Driven Engineering principles in designing and implementing robust financial information systems, thus opening a new avenue for interdisciplinary research. By employing the Computation Independent Model (CIM) from the Model Driven Architecture (MDA) framework, this paper aims to develop a tailored financial information system model that strategically aligns with the needs of financial management. The significance of this approach lies in its potential to enhance the accuracy, efficiency, and compliance of financial systems, which are critical to the operational success of contemporary business environments.

The dynamic nature of the financial industry, characterized by frequent regulatory updates and economic shifts, necessitates systems that can adapt quickly and efficiently. A computation independent approach allows financial systems to evolve without extensive re-development, ensuring compliance and continuity of operations. This adaptability is critical for organizations aiming to maintain competitiveness and regulatory alignment in a rapidly changing financial landscape. A computation independent perspective allows for the flexible adaptation of the system to these changes, ensuring that the financial information system remains robust and responsive to external conditions. This adaptability is crucial for maintaining compliance with financial regulations and for supporting strategic business decisions under varying conditions.

*Corresponding author. Email: kenza.mbarki@uit.ac.ma

The paper is organized as follows: after an introduction that sets the process for the integration of CIM into financial information systems, the paper proceeds with a detailed review of related work. This section digs into key studies that have explored the intersection of Model Driven Engineering (MDE) and financial systems, highlighting significant contributions and identifying gaps that this paper aims to address. Following this, a comprehensive background knowledge section is provided, outlining the foundational concepts of Model Driven Architecture (MDA) and its relevance to financial information systems. The main work of the paper presents the CIM approach to financial information systems, detailing the methodology and specific applications within the context of expenses and revenue management. Finally, the paper concludes with a summary of implications for future work, setting the stage for continued research in this promising area.

2. Related work

Model Driven Engineering (MDE) and Domain Specific Languages (DSLs) have been identified as potential innovators in the development and management of financial systems, with key studies by Selic [1], Deursen and Klint [2], and Gu and Barker [3] exploring these applications. Selic [1] emphasizes MDE's potential to increase productivity and reduce error rates in financial information systems. Deursen and Klint [2] highlight the role of DSLs in improving productivity and reducing errors in software development, particularly in specifying complex financial products or defining rules for data processing.

Gu and Barker [3] provide practical insights into MDE's real world application, demonstrating its ability to consolidate development processes, improve system quality, and facilitate the maintenance and evolution of financial information systems.

Pavaloaia et al. [4] introduces a framework for bankruptcy prediction using UML. This model enables companies to continuously track their financial status, providing vital data that can help prevent bankruptcy. The developed model can be incorporated into an ERP system within a Business Intelligence Component.

In his paper, Mangiuc [5] proposes a novel approach for financial audit professionals to use business modeling to construct models for audit processes, in compliance with ISA 315. This method enhances the understanding of the audited entity in a structured way. It is considered fully compatible with the objectives of the financial audit mission, the interests of the auditor, and the requirements of ISA 315.

Drljača et al. [6] present an innovative model for auditing information systems in public administration, highlighting its importance despite not being mandatory in certain regions. Utilizing UML diagrams, the model visually represents the audit process, leveraging UML's advantages over other standards for this purpose.

David Kiwana [7] presents an exploratory study of the factors affecting the implementation and use of financial information systems (FIS) in developing countries. The analysis was carried out as a within case analysis and supports the findings of nine factors that are of specific importance. The results can help decision makers guide the implementation processes of large scale enterprise systems, particularly in the disciplines of accounting and financial management. Abdelouahad Es-Sabir et al [8] have shown that a fuzzy expert system can help the auditor to include qualitative information to identify the anomalies most worthy of investigation. The fuzzy expert system normalizes the audit process by providing a formal model structure. This can facilitate reporting within the audit organization and improve the consistency of the audit process. Jiang Guo [9] analyzes the combined application of big data technology and financial information management, and uses big data technology and information technology to build a financial budget management system. The conclusion is that the financial information system based on big data management makes it possible to live in a high performance corporate financial management mode. Fábio Albuquerque and Paula Gomes Dos Santos [10] takes technological issues in accounting as its object of research, and proposes a documentary analysis using archival research as a method and content analysis as a technique. Data from 2000 to 2022 have been selected to provide an evolutionary analysis since the beginning of this century, with particular emphasis on the most recent period. The proposed analysis can contribute to the profession, to academia and to the scientific community as a whole, by identifying the state of the art of the literature in the technological field of accounting. Qin Dai [11] utilizes the model and technology in the design of an accounting information management system by simply explaining the idea of cloud technology and examining its logical structure of cloud technology. After that, it designs the cloud platform architecture of the accounting information management system by building the SaaS model. Finally, the system operation time, local rows of data, and load balancing are tested experimentally.

3. Background knowledge

3.1 Model Driven Architecture (MDA)

Model Driven Architecture (MDA) is an approach to software design, development and implementation proposed and supported by the Object Management Group (OMG). It is a variant of the Model Driven Engineering (MDE) paradigm, which aims to use models as the primary artifacts of software development. MDA provides guidelines for structuring software specifications that are expressed as models, and for transforming these models from platform independent to platform specific levels (Object Management Group).

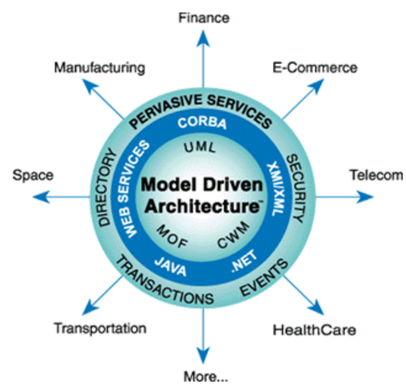

Fig. 1. OMG's Model Driven Architecture [12]

Figure 1 represents the Model Driven Architecture (MDA), and it highlights its potential applications in various fields. MDA can significantly impact the finance industry. By applying MDA principles, financial systems can become more robust, adaptable, and cost effective. The ability to generate code from models streamlines development, reduces errors, and accelerates time-to-market for financial applications.

MDA has several potential applications in various domains, such as finance, where software systems need to be adaptable, interoperable and compliant with changing regulations and standards. For example, MDA can be used to model the business processes and rules of a financial institution or the financial service of a company, and then generate code that implements these specifications on different platforms, such as web services, .NET, Java, etc. This way, MDA can reduce the development time and cost, improve the quality and maintainability, and facilitate the integration and evolution of financial software systems.

The history of MDA can be traced back to the emergence of the Unified Modeling Language (UML) in the late 1990s, which was designed to be a standard notation for modeling software systems. UML was adopted by the OMG as the basis for MDA, along with other standards such as the Meta Object Facility (MOF), the XML Metadata Interchange (XMI), and the Common Warehouse Metamodel (CWM). The first version of the MDA Guide was published by the OMG in 2001, and revised in 2003 and 2014 [12].

The benefits of using MDA are mainly derived from the separation of concerns between the business and application logic and the underlying platform technology. By using Platform Independent Models (PIMs) to capture the essential features and behavior of a software system, MDA enables the software developers to focus on the problem domain, rather than the technical details. Moreover, by using automated or semi-automated model transformations, MDA allows the generation of Platform Specific Models (PSMs) and code that are optimized for the target platforms, without losing the traceability and consistency with the original specifications.

To use MDA, software developers need to follow a series of steps, which can be summarized as follows:

- Define the system requirements and scope, and select the appropriate modeling languages and tools.
- Create a Computation Independent Model (CIM) that describes the system context and objectives, without any reference to the implementation details.

- Create a Platform Independent Model (PIM) that specifies the system functionality and behavior, using a standard notation such as UML.
- Apply model transformations to derive one or more Platform Specific Models (PSMs) that refine the PIM according to the chosen platforms, such as Java, .NET, etc.
- Generate executable code from the PSMs, using code generators or compilers.
- Deploy, test and maintain the code on the target platforms.

The different modeling types and layers of MDA are defined by the OMG as follows:

- A model is an abstraction of a system or a phenomenon, which represents its relevant aspects and omits the irrelevant details.
- A metamodel is a model that defines the concepts and rules for constructing and manipulating a certain type of model.
- A meta-metamodel is a model that defines the concepts and rules for constructing and manipulating metamodels.
- A model transformation is a process that converts a source model into a target model, according to a transformation specification.
- A modeling language is a language that enables the creation and manipulation of models, using a concrete syntax and a semantic domain.
- A modeling framework is a set of modeling languages and tools that support a specific modeling approach or domain.

The layers of MDA are based on the four layer metamodeling architecture of the OMG, which consists of the following levels:

- M0: The instance level, which contains the actual data and objects that are manipulated by the system at runtime.
- M1: The model level, which contains the models that describe the structure and behavior of the system, such as UML class diagrams and state machines.
- M2: The metamodel level, which contains the metamodels that define the concepts and rules for creating and transforming models, such as the UML metamodel and the QVT transformation language.
- M3: The meta-metamodel level, which contains the meta-metamodel that defines the concepts and rules for creating and transforming metamodels, such as the MOF meta-metamodel.

3.2 Financial Information System

An information system is a set of interrelated components for collecting, processing, storing and distributing information. The aim is to support processes such as finance, sales, marketing, human resources and so on. The usefulness of information systems extends to other aspects such as communication, decision making and coordination within an organization [15].

Organizations typically use information systems to perform their tasks. These include processing the financial transactions required to run a business (e.g., recording a charge or receipt) and communicating digitally with the tax authorities.

A competitive advantage enables an organization to generate more sales or achieve a higher bottom line than its rivals. There are several ways to achieve this competitive advantage:

- Providing the same value as competitors, but at a lower price (Price perspective)
- Charge higher prices to provide products that are perceived by the customer as being better (Quality perspective)

- Work in a target market better than others (Concentration market perspective)

Companies are called upon to make intensive use of information systems to gain competitive advantage.

Leavitt's Diamond [13] [16] emphasizes the need for a global approach to information systems. Managers forget to take into account people, process and human elements. This can lead to system difficulty, frustrated employees and unmet organizational goals. Finance and sales managers are the potential users of this new information system. The use of an information system implies the implementation of and compliance with associated processes and procedures. Organizations use information systems to control and monitor processes, and to ensure efficiency and effectiveness. Information systems are therefore external to the supply chain management process, and serve to monitor or control it. Modern information systems are often closely involved and form part of the process itself. It therefore plays an important role in the process, at input level, product transformation and output production.

Accounting and finance are data identification, collection, and storage process as well as an information development, measurement, and communication process. By definition, accounting and finance is an information system, since an AFIS collects, records, stores, and processes accounting and other data to produce information for decision makers [14].

AFIS fulfill three important business functions:

- Organizations have a number of business processes, such as making a sale or purchasing raw materials, which are repeated frequently.
- Transform data into information so management can plan, execute, control, and evaluate
- Provide adequate controls to safeguard the organization’s assets and data Control.

A well-designed AFIS can add value to an organization by:

- Improving the quality and reducing the costs of products or services.
- Improving efficiency.
- Sharing knowledge
- Improving the efficiency and effectiveness of its supply chain.
- Improving the internal control structure.
- Improving decision making.

4. CIM approach to Financial Information System

The principal key of MDA consists in the use of models in different phases of the development cycle of an application. Specifically, MDA recommends the development of the Computation Independent Model (CIM), Platform Independent Model (PIM) and the Platform Specific Model (PSM). The first level of MDA is the CIM presented as models used by all the stakeholders. The second level is the PIM which allows defining the models used by analysts and the software designers to realize an independent analysis and a conception of the developed software. The third level is the PSM which is considered as models of code used by software developers.

Transformations between the different levels of MDA begin with the transformations from CIM to PIM that aim to partially build PIM models from CIM models. The goal is to rewrite the information that existed in the CIM models into PIM models. These transformations are going to ensure that business information is conveyed and followed throughout the MDA process. Then, the transformation from PIM models to PSM models adds PIM technical information related to a target platform. CIM means that this model does not disclose any information related to the computer system. The CIM level is presented to be representative of the real world. In our case, the real world is the finance department of a company. We are going to focus on expenditure and revenue management.

This choice is valid for several reasons. First, the importance of this management for cost accounting and management control in general. Secondly, it is simple modeling. Finally, the modeling of this process can be generalized, with an iterative and incremental logic, to other processes such as:

- Budget management
- Cash management
- Financial planning
- Financial performance
- Financial auditing

The financial process is part of a systemic view of the company containing the following process:

- Purchasing
- Production
- Marketing
- Logistics
- IT
- Human Resources

The monitoring processes are : management control, performance management, quality management and so on.

The support processes are : human resources management, IT infrastructure and financial management.

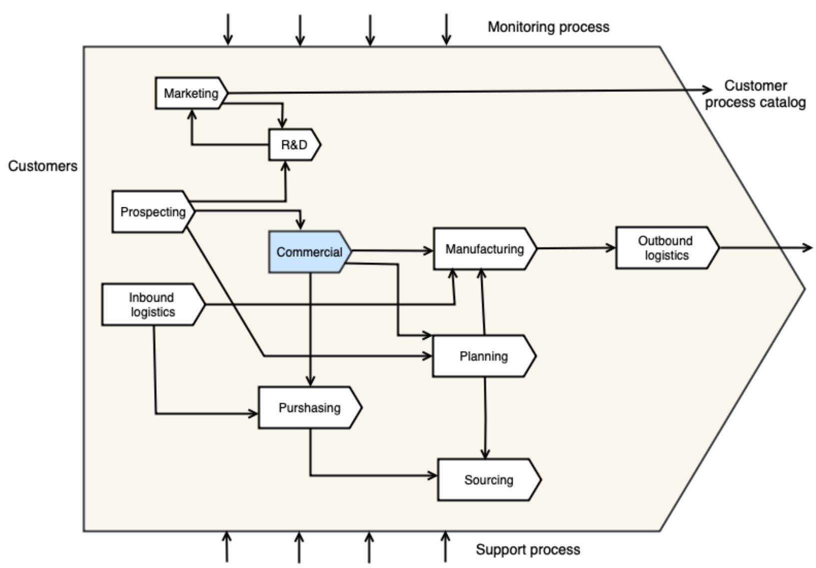

Fig. 2. Interconnected business processes in an organization

In a first future work, we will elaborate the PIM model which will focus on the entities derived from the CIM model such as: Costs and expenses object. These entities are linked in a class diagram. In a second future work, we will develop the PSM model, which will focus on the target financial information system, and which will be used by end users, i.e. financiers who are not necessarily IT specialists.

For now, our CIM model contains three UML diagrams : Activity diagram, use case diagram and sequence diagrammes.

4.1 Components of the CIM model:

A. UML Activity Diagram: It focuses on sequential and parallel activities involved in each functional requirement of the system. In our case, the activity diagram relates to the financial management process.

B. UML Use case diagram: It focuses on the identification of functional requirements of the system under consideration. In our case, these are the use cases related to the costs and revenues

C. UML Sequence Diagram: It depicts the objects involved in the scenario and the sequence of messages exchanged between the objects needed for the functionality.

In what follows, we give the example of an activity diagram. These activities are distributed across the four columns:

- Column#1: The purchasing manager
- Column#2: The sales representative
- Column#3: The accountant
- Column#4: The management controller

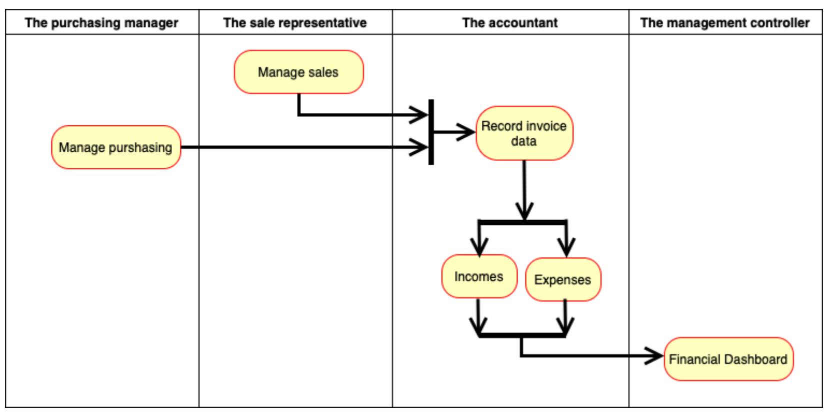

Fig. 3. The activity diagram of the financial management process

In this section, we focus on the transformation rules that will allow us to transition from the CIM level to the PIM level, and more specifically from the activity diagram model to the sequence diagram model. These rules, expressed in natural language, can be formalized and expressed in a dedicated language such as QVT. The transformation rules from activity diagram models (both inclusive and exclusive of swimlanes) to the use case diagram model are outlined as follows:

Transformation rule 1:
Each "action" corresponding to a system functionality is transformed into a "use case".

Transformation rule 2:
Each "swimlane" becomes an "actor".

Transformation rule 3:
Each "decision node" between two "actions" becomes an "extend" relationship between two "use cases.".

Transformation rule 4:
Each "control flow" between two "actions" becomes an "include" relationship between two "use cases".

Transformation rule 5:
Any "control flow" that loops back is non transformable.

Transformation rule 6:
Each "activity" is transformed into a "package".

These rules provide a clear set of guidelines for transitioning from activity diagram models to use case diagram models, ensuring a structured and systematic conversion process.

After applying these rules to our activity diagram, we obtain the following use case diagram:

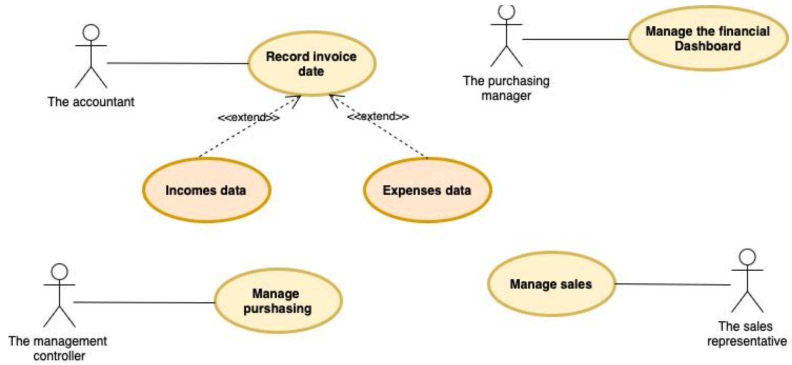

Fig. 4. Use case diagrams related to costs and revenues

The sequence diagram representing a system's external behavior provides a dynamic view of the system, even at a high level of abstraction [17]. This diagram can be derived from the lower-level activity diagram, which captures the same system dynamics and is constructed using the activity diagram notation.

Starting from the use case model, we identify the principal actor and any secondary actors involved in the use case. The lower-level activity diagram allows us to extract all the actions and messages exchanged between these actors and the corresponding system responses. Each swimlane in the activity diagram corresponds to an actor. Additionally, each task performed by an actor is transformed into an action or message sent to the system (e.g., "register new invoice," "update records").

Tasks performed by the system, especially those involving calculations or validations, are represented as internal messages within the system (e.g., "validate data"). Conversely, tasks where the system displays information or requests input from the actor are mapped to responses sent from the system to the actor (e.g., "cash flow insights," "budget overview").

When an exclusive gateway based on data exists, successful flows are depicted in the Sequence Diagram of System's External Behavior, while other flows are considered alternative scenarios. If a secondary flow terminates due to an error or cancellation, it is treated as an error scenario. Both alternative and error scenarios are annotated in the sequence diagram using notes.

In cases where the flow returns to a previous task, the messages and their corresponding responses are enclosed within a LOOP interaction operand (e.g., "payment reminders" and "expense tracking"). Collapsed subprocesses are mapped using the REF interaction operand, referencing the corresponding use case.

We can easily iterate to apply these transformations to various financial activities other than expense and revenue management. This work is very useful for financial modeling. We used the CIM level for this business modeling. We preferred UML, and in particular, the three diagrams: the activity diagram, the use case diagram and the sequence diagram. We can apply this work to other BPMN and DFD standards.

5. Conclusion

This paper presents an approach that combines financial information system and model-driven architecture (MDA) to develop a personalized information system platform for companies. The most widely used standards for modeling business processes are UML, with its activity diagram, and Business Process Management Notation (BPMN). In order to facilitate the modeling task for designers who are only familiar with the UML language, we have relied exclusively on this language to implement our approach, adopting the UML activity diagram to model business processes at the CIM level. In this work, we preferred to use activity diagrams to model the CIM of our financial information system. We used simple transformations to move from the activity diagram to the uses case diagram. We believe that these two diagrams form the basis of our CIM. Processes are at the heart of this approach. Processes have a prominent place in one of the key performance tools, the "balanced scorecard", and its four key concerns: Finance, Customer, Process and HR. All the company's processes must therefore be re-interpreted, to ensure that they really do serve these objectives. Finally, staff and their knowledge must be put to work in the service of these processes' goals. The company must first identify its key processes: those whose optimization has the most powerful leverage effect on the success of its strategies, and those whose performance lags behind that of companies with similar processes. Information systems and computerization are fully involved in all decisions concerning operational processes, and perhaps even more so in steering processes. Recent studies have shown that companies that have implemented information system performance and process approaches are more competitive. We have begun the first part of the design of a financial information system, particularly balance sheet management. This part focuses on the CIM, which represents the functional dimension of the information system. What remains to be done is to identify the technical objects of this information system. These include, for example, purchase orders, delivery notes, invoices, suppliers and customers and so on. These objects have the particularity of being stored in databases or other media, such as the cloud. Tools exist for this purpose. The final part consists of designing a purely business intelligence information system, such as a financial data warehouse. This work involves three stages:

- Information system CIM
- The information system's technical objects
- Design of the decision-making dimension of this financial information system

In the future, we can model the information system’s technical objects. In another article, we plan to model the decision-making dimension of the financial information system. Finally, we plan to identify the effects of AI Artificial Intelligence on the financial information system.

Conflicts Of Interest

The authors declare no conflicts of interest.

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