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Evaluating the Suitability of UML for Modeling Inventory Control Systems: A Case Study

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تقييم مدى ملاءمة لغة النمذجة الموحدة (*UML*) لنمذجة أنظمة إدارة المخزون: دراسة حالة

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Abstract:
This study evaluates the suitability of Unified Modeling Language (UML) for modeling business processes, focusing on inventory control systems. A case study of the inventory control system at Elmergib Cement Factory in Libya is used to demonstrate how UML diagrams represent real-world processes. Various UML diagrams, including use case, activity, class, and sequence diagrams, are applied to capture functional, structural, and behavioral aspects of the system. The results indicate that UML provides a clear, flexible, and structured modeling approach that improves understanding and communication among stakeholders. However, limitations are observed in modeling complex processes and the lack of business specific constructs compared to BPMN. The study concludes that UML is a suitable and effective tool for modeling inventory control systems when multiple diagram types are used together.

Keywords: UML, Inventory Control Systems, Business Process, Modeling, Case Study.

الملخص
تقوم هذه الدراسة بتقييم مدى ملاءمة لغة النمذجة الموحدة *(UML)* لنمذجة العمليات التجارية، مع التركيز على أنظمة مراقبة المخزون. تم استخدام دراسة حالة لنظام مراقبة المخزون في مصنع المرقب للأسمنت في ليبيا لتوضيح كيفية تمثيل مخططات *UML* للعمليات الواقعية. طُبقت مجموعة متنوعة من مخططات *UML*، بما في ذلك مخططات حالات الاستخدام*(Use Case)* ، والنشاط*(Activity)* ، والفئة*(Class)* ، والتسلسل*(Sequence)* ، وذلك لالتقاط الجوانب الوظيفية والهيكلية والسلوكية للنظام. تشير النتائج إلى أن *UML*توفر نهج نمذجة واضح ومرن ومنظم، مما يعزز الفهم والتواصل بين المعنيين. ومع ذلك، لوحظت بعض القيود عند نمذجة العمليات المعقدة، بالإضافة إلى افتقارها إلى بنيات خاصة بالأعمال-*(Business specific constructs)* مقارنة بـ *BPMN*. وتخلص الدراسة إلى أن *UML* تعد أداة مناسبة وفعالة لنمذجة أنظمة مراقبة المخزون عند استخدام أنواع متعددة من المخططات معاً.

الكلمات المفتاحية: لغة النمذجة الموحدة (*UML*)، أنظمة مراقبة المخزون، العمليات التجارية، النمذجة، دراسة حالة.

1. Introduction

In today's highly competitive business environment, organizations continuously strive to improve their performance by enhancing product and service quality, reducing operational costs, and minimizing lead times. Achieving these goals requires a deep understanding and optimization of internal operations, which can be effectively supported through business process modeling.[1]

Business processes represent the structured set of activities that define how work is performed within an organization. Modeling these processes enables organizations to analyze, simulate, and improve workflows before actual implementation. Traditional representations based on hierarchical organizational structures are no longer sufficient to capture the complexity and dynamic nature of modern business operations.[2]

Business Process Modeling (BPM) has emerged as a critical component in software development and organizational analysis. It provides a clear and structured representation of processes, facilitating better communication among stakeholders and improving decision-making. Moreover, BPM helps reduce misunderstandings in system requirements by offering visual and comprehensible models that accurately reflect business activities.[3]

As business processes grow more complex, the need for effective modeling techniques becomes increasingly important. Various modeling approaches have been proposed, each with different notations and capabilities. Among these, visual modeling techniques are widely preferred due to their ability to simplify complex processes and enhance communication.[1]

Unified Modeling Language (UML) is a widely used visual modeling language originally designed for software systems. It provides a rich set of diagrams, including use case, activity, class, and sequence diagrams, which can also be applied to model business processes. Its standardized notation and flexibility make it a potential candidate for business process modeling.[4]

This paper aims to evaluate the suitability of UML for modeling inventory control business processes through a case study approach. The study investigates how UML diagrams can represent key inventory operations and assesses their effectiveness in terms of clarity, flexibility, and ability to capture real-world processes.

From a practical side, the study also gives a simple example for organizations that still depend on manual inventory procedures and need a clear starting point for documenting and improving their internal process [31], [32].

2. Literature Review

Conceptual modeling represents real-world phenomena using visual languages. Over time, modeling techniques evolved from early graphical notations to modern approaches such as UML and BPMN.

Studies show that business process modeling improves communication and system understanding [19]. Nikolaou et al. [18] demonstrated its effectiveness in banking systems, while Alzubidi et al. [19] highlighted its importance in organizational communication.

UML has been widely adopted due to its flexibility and ability to represent multiple system perspectives [1]. However, it has limitations compared to BPMN in modeling complex business processes [14], [15].

Recent studies also show that the usefulness of process modeling depends not only on notation coverage, but also on model comprehensibility, notation selection, and the context in which the model is used. Winter et al. [20] proposed a framework for measuring process model comprehension, while Farshidi et al. [21] discussed the importance of selecting a modeling language according to project needs. In addition, Skouti et al. [22] showed that BPMN extensions continue to evolve for more complex process contexts, and recent applied studies confirmed the relevance of process modeling in both requirements elicitation and inventory

information system design [23], [24]. Cognitive aspects related to process model comprehension were also reviewed in recent work [25].
This means that a modeling language may be considered suitable when it helps users describe the process clearly, follow the flow easily, and connect the model with practical system analysis activities [25]–[27].

3. Methodology

This study adopts a case study approach to evaluate the suitability of UML for modeling business processes in inventory control systems. The selected case study is the inventory control system (ICS) at Elmergib Cement Factory in Libya.
Data were collected using multiple techniques, including interviews with employees, analysis of system documents, and direct observation of workflows. These methods ensured an accurate understanding of the real system.
The collected data were transformed into UML models using Rational Rose software. Four main UML diagrams were used: use case diagrams to represent system functionality, activity diagrams to model workflows, class diagrams to describe system structure, and sequence diagrams to illustrate system interactions.
The evaluation of UML was conducted based on criteria such as clarity, flexibility, completeness, and ease of use, in order to assess its effectiveness in representing real business processes.
In this study, these criteria were considered through the readability of the diagrams, the consistency between diagrams, and their ability to reflect the actual workflow of the inventory request process in a simple and understandable way [20], [25], [26].
This qualitative evaluation approach is also consistent with recent studies that emphasize process model comprehensibility, language selection, and user context as important factors in assessing modeling effectiveness [20], [21], [25].

4. Results and Discussion (Final Structured Version)

A real-world case study of an inventory control system (ICS) at Elmergib Cement Factory was modeled using UML diagrams. The system was originally manual, which resulted in several operational challenges such as data inaccuracy, delays in processing, and difficulty in tracking inventory levels.
The modeling process transformed real business processes into UML representations using different diagram types to capture multiple system perspectives.

Use Case Modeling

The use case diagram is presented in Figure 1. It provides a high-level representation of the system by identifying the main actors and their interactions with the system.

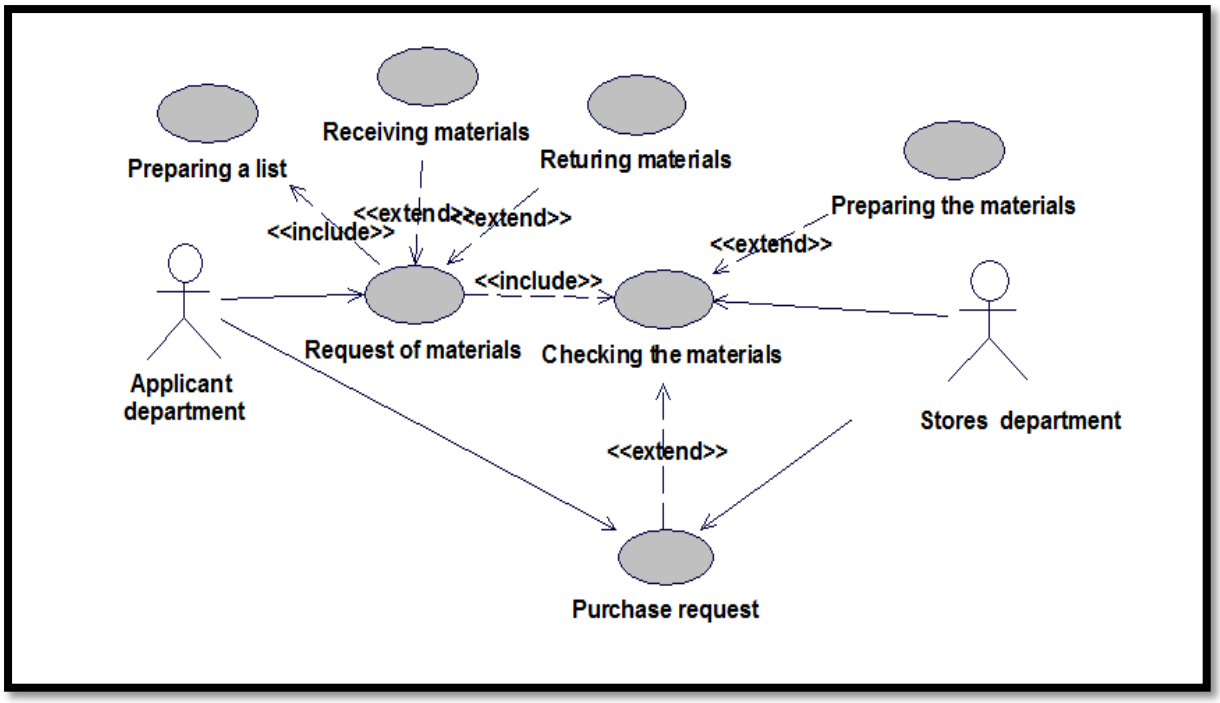

Figure 1: Use Case Diagram of the Material Request Process.

This diagram illustrates the main actors, including the applicant department and the stores department, and their interactions with the system. It highlights key functionalities such as requesting materials, checking availability, and processing approvals. The diagram is effective in defining system scope and requirements; however, it does not represent the sequence of operations in detail.

Activity Modeling

The activity diagram is shown in Figure 2 and represents the workflow of the inventory control process.

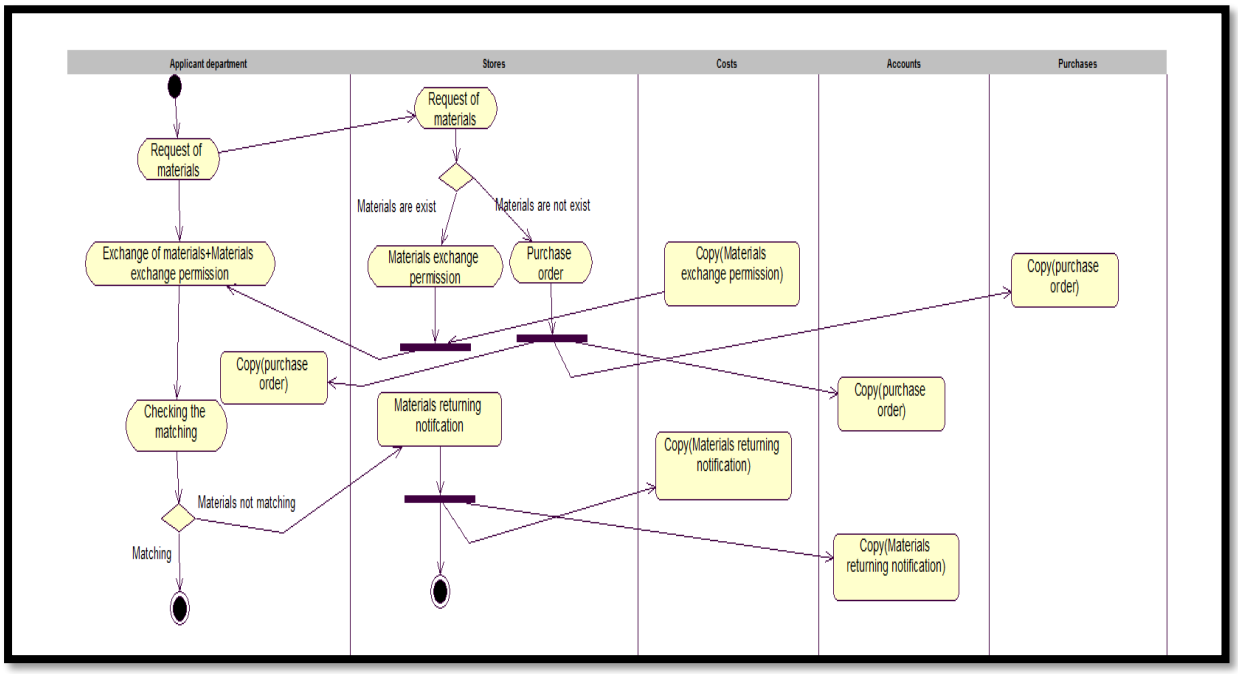

Figure 2: Activity Diagram of the Material Request Process

This diagram describes the sequence of activities involved in the process, including decision points such as approval or rejection. It provides a clear understanding of the workflow and helps identify inefficiencies in the system. However, as the process becomes more detailed, the diagram may become complex and harder to interpret.

Structural Modeling (Class Diagram)

The structural aspect of the system is represented using the class diagram in Figure 3.

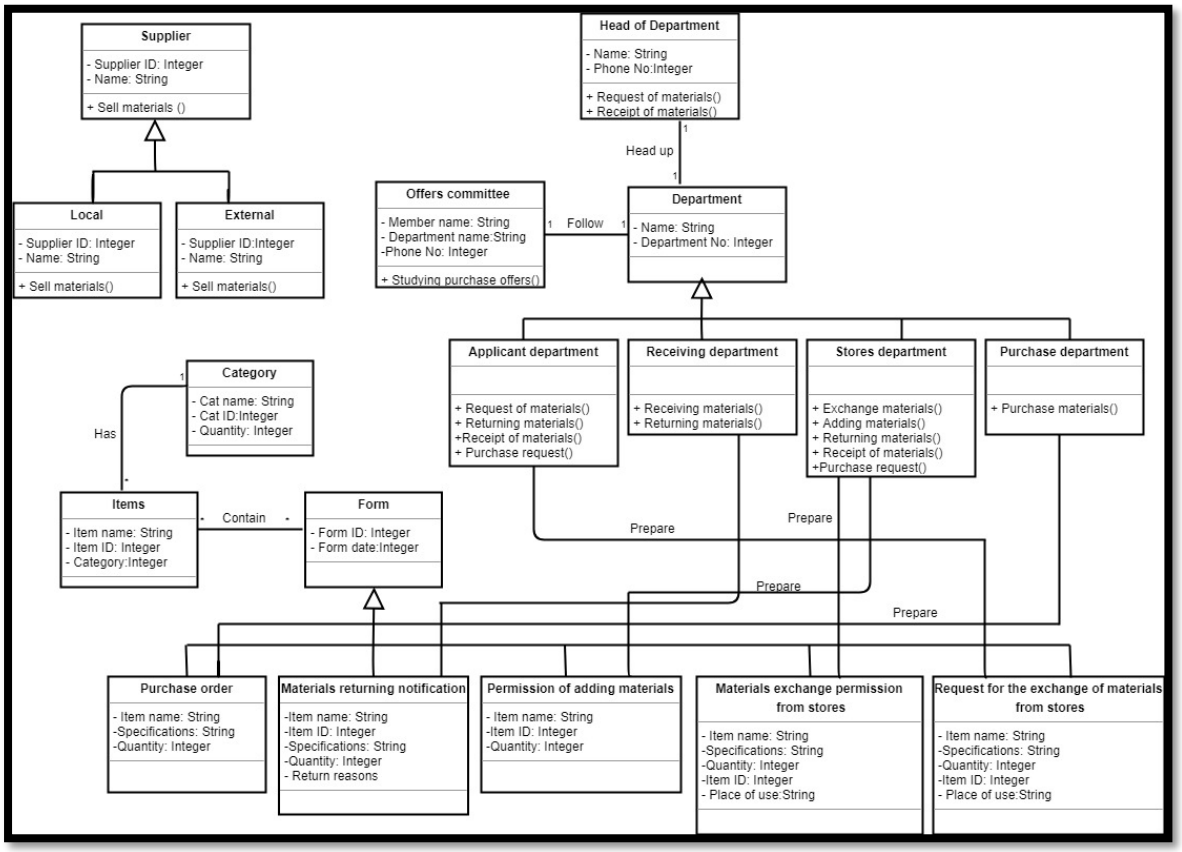

Figure 3: Class Diagram of the Inventory Control System.

This diagram illustrates the main system entities such as suppliers, departments, and items, along with their attributes and relationships. It provides a clear view of the system architecture and data organization. However, it does not capture the dynamic behavior of the system.

Dynamic Modeling (Sequence Diagram).

The dynamic behavior of the system is illustrated using the sequence diagram shown in Figure 4.

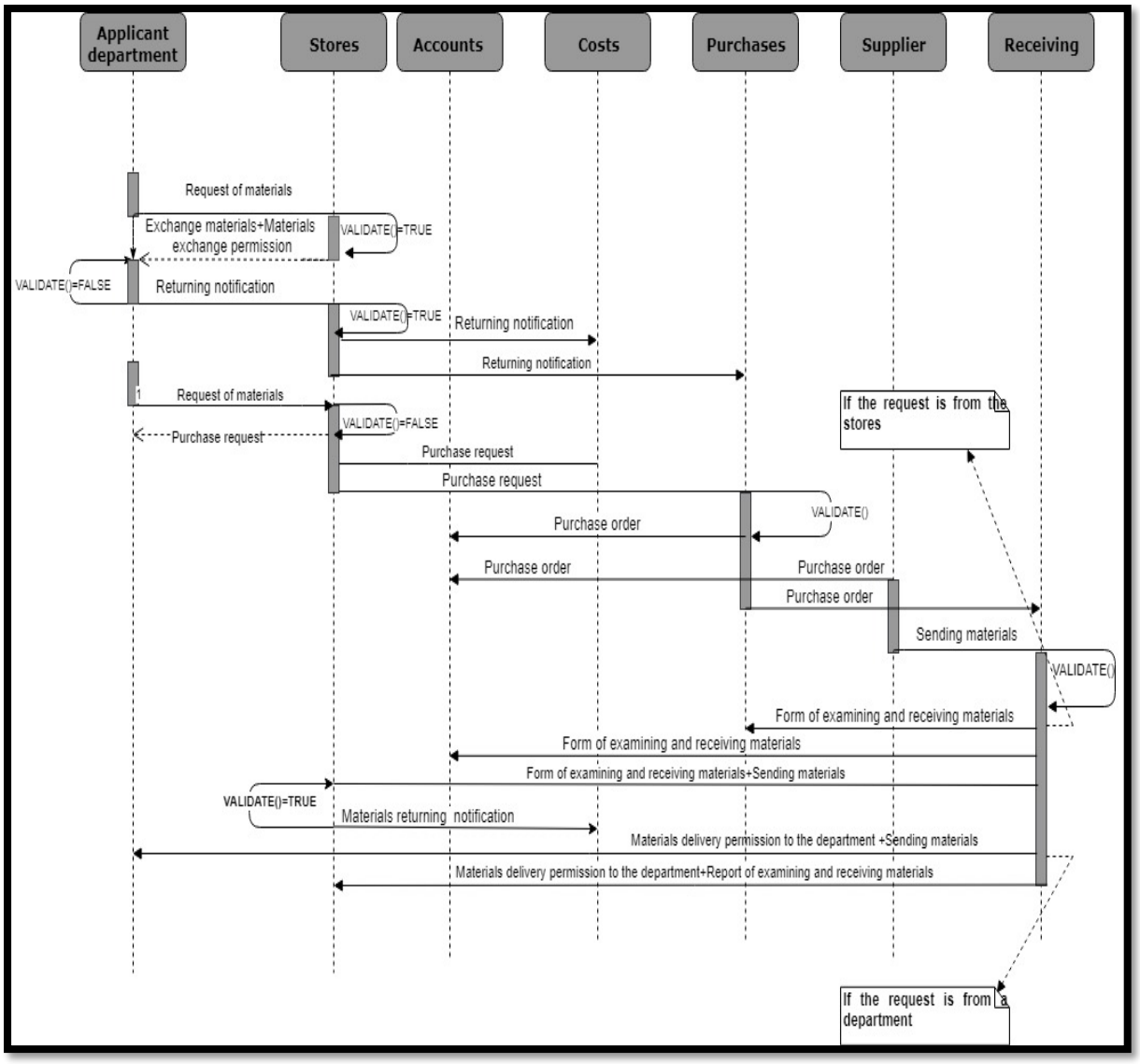

Figure 4: Sequence Diagram of the Material Request Process.

This diagram shows the interaction between system components over time, including communication between departments such as stores, accounts, and suppliers. It effectively captures the sequence of operations and system behavior. However, it requires well-defined scenarios and may become complex when modeling multiple interactions.

Overall Evaluation of UML

The integration of multiple UML diagrams provided a comprehensive representation of the inventory control system from different perspectives, including functional, structural, and behavioral views.

This combination was important because each diagram covered a different part of the process, and together they reduced the weakness of depending on one view only.

The results indicate that UML is a flexible and powerful modeling tool that enhances system understanding and improves communication among stakeholders. Its visual notation makes it easier to represent complex processes in a structured way.

However, some limitations were identified. UML lacks specialized constructs for business process modeling compared to BPMN and may become complex when modeling large-scale systems.

Overall, UML is considered suitable for modeling inventory control systems, especially when multiple diagram types are used together to provide a complete system view.

5. Conclusion

This study evaluated the suitability of UML for modeling inventory control business processes through a real-world case study. The findings confirm that UML is a powerful and flexible modeling tool capable of representing different system perspectives, including functional, structural, and behavioral aspects.

The use of multiple UML diagrams enhances system understanding, supports communication among stakeholders, and facilitates system analysis and design. UML also provides a cost-effective and practical approach for organizations to model and improve their business processes.

Despite these advantages, UML has limitations in handling complex business processes and lacks business-oriented constructs compared to BPMN.

Even so, for a medium-size case study such as the one presented here, the models still provide a useful level of detail for documentation, communication, and early system analysis [24], [27].

Nevertheless, UML remains a suitable and effective tool for modeling inventory control systems, especially when used in combination with multiple diagram types.

6. Future Work

Future research may focus on integrating UML with other business process modeling techniques such as BPMN to combine the strengths of both approaches. Additionally, further work can explore transforming UML models into executable systems and extending the modeling process to cover more complex and large-scale business environments.

A direct comparison between UML and BPMN on the same inventory case may also provide stronger practical evidence in future work [22], [26].

Recent work also suggests that future studies should examine not only notation differences, but also model comprehension, user context, and practical implementation outcomes in inventory environments [20]-[25].

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