Process-oriented information system requirements engineering: A case study

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ABSTRACT

This case provides students opportunities on system requirements engineering using tools such as requirements definition (functional requirements and non-functional requirement), USE case, and activity diagrams. This case can be used for introductory classroom teaching or professional training in the analysis phase of system development life cycle. Students will be benefited by understanding business knowledge in a business to business (B2B) scenario, and how business systems integrate business processes across functional areas including accounting, sales and distribution, production, purchasing, and inventory, and approaches to requirement modeling using UML. In this study, security and globalization factors are perceived as part of the system, not a post-component. Thus, they should be captured during the business requirement capture process.

Keyword: case study, international B2B, process-oriented, requirements engineering, UML activity diagram, use case diagram

INTRODUCTION

All new projects in the workplace are instigated in response to a business need or a business failing. Huge amounts of time and resources are usually expended to fulfill the business need but there is often a mismatch between what is delivered and what was actually needed. A thorough business requirements analysis can help to avoid this scenario by defining and clearly documenting the requirements for a specific business objective.

However, there are many challenges for students to successfully gather business requirements. The first challenge is the common lack of working experience in business in a role associated with requirements gathering, much less in the focus area of this case study of an international B2B trading company. Because students are lacking business experience and knowledge, they do not understand the business process, which cause difficulties in capturing the activities in the business information flow. The second challenge is the complexity of the business process in the international B2B scenario. The number of stakeholders and activities involved with these types of systems are numerous, which leads to additional difficulty in the requirements decision process. Third, students have difficulty in applying the guidelines associated with requirements gathering and may not understand the process is dynamic and iterative, not one time work. Last, students may not be aware that requirements outside of the business process such as security and globalization should be considered in the process as well.

This paper presents a business case in a B2B environment. By following some guidelines and procedures, the business requirements are identified and modeled with UML activity diagrams and use case diagrams. In addition, teaching notes and feedback from students within the class are provided to enumerate the process and education further. The suggested solution in this study can be used as a both a guideline and reference for students in business requirements engineering.

BUSINESS CASE DESCRIPTION

Eric was hired by an information technology (IT) consulting company in China. He was assigned as the team leader for a project designing the information system for a company named MOHO, producing and exporting construction chemicals. To successfully achieve this project, Eric decided to apply business process based approach to system requirements.

MOHO produces over 70 products, including high range water reducer, set accelerators, set retarders, anti-freezing products, etc. These products are widely used in industrial and civil engineering, public infrastructure, hydraulic electricity projects and concrete ready-mix products. In addition, MOHO provides professional services of technology know-how transfer of concrete admixtures, including process, design, manufacturing, application, and management know how. The customers are concrete batching businesses or concrete admixture distributors. MOHO has become a key exporter of concrete admixtures in China. It not only sells products manufactured by MOHO, but also sells products provided by other regional manufacturers.

Since the product is chemical material and used in big projects, the product quality (performance) is important and the order quantity from customers is significant. The

minimum order quantity is one container, about 20 tons. Usually, customers will ask for information about the product technical specifications, price, supply stability, etc. in the initial contact. Then they will ask for samples to test before any "real" order is placed. Some customers like to have a trial order with 1 ton transported by sea; others may prefer 500g transported by air.

If a customer is satisfied with results of sample tests and offering price, the customer will place an order by asking for Sales Order/Contract (Proforma Invoice), which includes product price and quantity information, package, shipping and payment terms. Most of time, the payment is made either via telegram transfer (T/T) or Letter of Credit (L/C) at sight. If it is T/T, a customer will prepay 30-50%, and then pay the remaining balance after they receive a copy of the shipping documents (Bill of Lading, packing list etc.) via email or fax.

Based on the inquiry and discussion with a customer, a salesperson creates a Sales Order. Before emailing this Sales Order to the customer for confirmation and payment, the salesperson should notify accounting and warehouse person respectively. A cashier in the accounting department will check the customer's credibility. If the customer has a good record and has no unpaid balance, the cashier should inform the salesperson and change the order status as "Good". The warehouse person will check the product availability to make sure they have sufficient quantity with right specifications in the warehouse. If they have sufficient stock, the person will change the order status as "Available" and notify the salesperson too.

After the customer makes the payment based on the instructions specified in the Sales Order, the cashier will get the bank notice for the pre-paid via T/T or the L/C. Next, the cashier will label the order status as "Partially paid", "Fully paid", or "L/C". Then, the cashier will inform the salesperson.

To fulfill the Sales Order, the salesperson will arrange the shipment and notify the warehouse person to prepare the product and supervise loading. When the shipment is released, the warehouse person will label the order status as "Released" and inform the salesperson who in turn can notify the customer of their order status. When the shipment leaves the port, the salesperson will notify the customer about the departure date and estimated arrival date.

In addition to these activities, the warehouse person also updates and maintains inventory records.

The shipping documents will be prepared and mailed to customers (if it is T/T) or delivered to the bank (if the payment method is L/C) by the salesperson. Only with these documents can the customer clear the customs after the vessel arrives at the destination port. In the case of T/T, to reduce the payment risk, only a copy of the shipping documents is sent to the customer. The original shipping documents will not be mailed until the customer pays the remaining balance.

The cashier should track the payment status for this order to make sure the full amount is received. If not, the cashier should inform the salesperson to remind the customer till the full amount is received. Then, the cashier should update the order payment status to "Fully paid".

When the salesperson receives the "Fully paid" notice from the cashier, the original shipping documents is released and the order status will be labeled as "Docs delivered".

After the customer receives the shipment, the salesperson will change the order status to "Received" and the process for this order is closed.

Of course, sometimes customers might file complaints. To improve customer satisfaction, the company has a special mechanism to handle the complaints.

Currently MOHO employees use Google email, Skype and Microsoft documents as tools for business communication and transaction. Many times, the orders are out of track, the communication with customers is not prompt, internal collaboration across departments is not smooth. Even business confidential information was not well protected. To meet the new business requirements and challenge, MOHO decides to design a web-based system so that it can list the product information, manage customer information, tracking orders, and record order payments. To design a successful system, it is necessary for a system analyst to analyze the business needs.

THEORETICAL BACKGROUND

Business Process

Business processes emphasize that how businesses produce their products and services to customers. This process is not only a core for businesses itself, but also a crucial point for IT professionals whether correctly understanding requirements or not.

Davenport (1993) defined that a business process is a series of activities with particular structure and measure to produce certain output for a specified client or market. This process highly focuses on how output is done instead of what output is produced within an organization. Accordingly, the business process of trading companies is specified as a set of structured and measured activities related to trading goods. Goldkuhl (1998) presented a model with six phases (Business Action Theory), to address the procedure between suppliers and customers in trading firms. This model does not only describe the actions in each phase, but also delivers the sequence of the actions (Figure 1 in Appendix).

Modeling Language

Modeling is an approach to explicitly document the implicit business processes in a semi-formal way (Becker, 2009). The Unified Modeling Language (UML) and Business Process Management Notation (BPMN) are two modeling languages used widely by recent practitioners (Recker et al, 2009). UML is a graphical model language to describe and design object-oriented software systems (Fowler & Scott, 2004). UML Activity Diagrams (AD) and BPMN are two easily readable graphical notations for business processes (Kalnins & Vitolins, 2006). However, due to the complexity of BPMN and the best practice that UML is adopted in modeling techniques and software engineering, UML AD is the prime choice to understanding business processes for IT practitioners (Arlow & Neustadt, 2005). In this paper, UML activity diagram and USE case diagrams are used as the means to model the business requirements.

REQUIREMENT IDENTIFICATION

To align IT/IS with business, the first step in the development of a new information system is frequently to elicit user requirements and develop a requirements definition document. This document is a straightforward text-based report, perceived as the formal agreement between the project developer and the client/users. It states exactly what will and will not be included in a project and what the end-user can expect once the project is completed. Requirements can be either functional or nonfunctional. A functional requirement is related directly to a process a system has to perform; while nonfunctional requirements refer to the properties that the system must have, such as performance and usability (Dennis et al.).

A requirement is a statement of what the system must do or what characteristic it must have. It describes a system feature, capability, or constraint. Generally requirements focus on what a system should do, rather than how it should do it. A requirements definition must satisfy several needs. First, it must capture and describe user information requirements in a form that is *precise and easily understand* by users. Second, the requirements should be *complete* or no necessary information should be missing. However, this completeness must be within a limit or scope and cannot be over specified. Third, the requirement must be *modifiable*. People are able to revise the requirement when necessary and maintain a history of changes made to each requirement. Last, requirements should be *traceable*. Requirements are uniquely labeled and are written in a structured, fine-grained way, as opposed to large, narrative paragraphs or bullet lists.

According to (Goldkuhl 1998), the communication process between suppliers and customers in a trading firm is divided into six generic phases. Along this communication process, the goals of system are classified into six categories (Table 1): offering products, customer inquiry, ordering, confirming order, delivering and paying, and claiming satisfaction or dissatisfaction.

The procedure of capturing the requirements used in this study is a unified process, based on phases and iterations eventually leading to a formalized and unambiguous requirements specification (Nuseibeh and Easterbrook 2000). The iteration is used to cope with the various changes. This iterative process continues throughout analysis and each time the requirements refined or added. Beware, this evolution of requirements definition must be managed and make sure each requirement fit within the scope of the system. One of the important purposes of the requirement definition is to define the scope of the system in order to avoid "scope creep" issue.

As the result of analysis, the functional requirements are presented in Table 1 (Appendix), and non-functional requirements are presented in Table 2 (Appendix).

Here are a few guidelines for students to keep in mind as they document systems requirements.

- Define the requirements from the developer's perspective. Make sure they are complete and understandable by developers.
- Use the active voice and keep statements short. Avoid long narrative paragraphs.
- Regarding to the level of granularity, write each requirement in a way that can be tested. If a small number of related tests to verify correct implementation of a requirement, it is probably written at the right level of detail. If many different

kinds of tests are envisioned, perhaps several requirements have been lumped together and should be separated.

- Avoid multiple requirements aggregated into a single statement. Conjunctions like "and" and "or" in a requirement suggest that several requirements have been combined.
- Make the requirement concisely and avoid redundancy. The multiple instances of the requirement may cause modification difficulties and inconsistency issues.
- Write requirements at a consistent level of detail throughout the document.
- Use terms consistently and define them in a glossary or data dictionary.

REQUIREMENT MODELING

Activities Diagrams

Business process typically cut across functional departments, and business process models are very powerful tools for communicating the analyst's current understanding of the requirements to the user. Activity diagrams can be used to model everything from a high-level business workflow that involves many different use cases, to the details of an individual use case, all the way down to the specific details of an individual method (Dennis et al., 2011). In this study, the abstract level of activity diagram is restricted to documenting and modeling high-level business processes.

Scott (2001) suggests the following guidelines when creating activity diagrams:

- Set the context or scope of the activity being modeled
- Identify the activities, control flows, and object flows that occur between the activities.
- Identify any decisions that are part of the process being modeled
- Identify any parallelism in the process
- Layout and draw diagram

For presentation purpose, the UML activity diagram is split into two parts (Figure 2a and 2b). The upper level depicts the process from target product selection to the sales contract preparation. The lower level shows the process from fulfill the contract to receive the payment and after-sales service.

Use Cases

A use case communicates at a high level what the system needs to do. It is the building blocks by which the system is designed and built. Use cases capture the overall functional requirements, typically the interaction of the system with end users or system users. These interaction represent external or functional view of the system from the perspective if the user. Each use case describes one and only one function.

A general use case diagram at the abstract level is presented here (Figure 3 in Appendix). It is suggested to provide the use case diagram at both abstract level and detailed level.

TEACHING NOTES

Course Applications

The case is recommended towards courses in System Analysis and Design at undergraduate and graduate levels, depending on course objectives. The case requires students to understand general system development life cycle and analysis methods to explore new system requirements gathering approach in Management Information System (MIS) fields. UML (activities diagram and use cases) as modeling language to present analysis results for this case is preferred to know.

Learning Objectives

1. To understand basic business knowledge and process in B2B model.
2. To learn system requirements gathering process and techniques.
3. To apply business process based approach to system analysis for complex systems.
4. To assess the effectiveness of different system requirement methods.

Assignment Questions and Answers

1. Ask students first to identify the major business processes for functional requirements. Show students about the abstraction level. Some students may focus on the details such as the search engines for advertisement whereas others may even do not know how to begin.
2. Students are asked to draw an UML activity diagram representing this process and to write a brief explanation of the process to clarify the activity diagram.
3. Ask students to create UML use case diagram based on their understanding of business requirements.

Evaluation

Modeling a business process is a very constructive activity that can be used to gather system requirements. This assignment is looking for whether students can follow the approaches and guideline and notations to develop requirements definition reports, create activity diagram and use case diagram. This process is an iterative process, thus there is no “wrong” answer. The assessment may use the criteria such as approaches (process or steps learned in the class), using required notations and symbols, and the completeness of major components covered. For example, to assess the activity diagram, following tool (Table 3 in Appendix) may be used.

LESSONS LEARNED

1. Difficulties in understanding the "business process". This may be because students do not have a real life experience or because the business process description depicted here is incomplete or detailed enough; or because students could not

access the real business users to clarify some assumptions and validate the requirements. This understanding gap can lead to requirements being missed, misrepresented, or over specified. Although each business may be different and unique in some way, but the business process is very generic. The majority of the process is very common to businesses. Let students be aware of the process of MOHO is very similar to other organizations.

2. Difficulties in defining the system scope. Students may have difficulties regarding to the scope and level of simplicity or granularity. In addition to presenting the guidelines of identifying system requirements, show students some examples of good statements. This can be started with the basic and major business requirements from the system. Remind students, the process is iterative. Repeat the process to identify more detailed and hidden requirements because some requirements are not clear at the beginning, but watch for scope creep. Following are some feedback from students:
    a. Except for the instructor, students have no access to the actual user to very and validate the requirements.
    b. It is not clear whether the scope of what needs to be included was sufficient or not.
    c. Answering which activity should be included or excluded was the biggest challenge.
    d. Connecting different processes and organizations were the most difficult part.
    e. How far each process should be broken down.
3. The purpose and usage of use case *diagram versa an activity diagram* in requirements engineering should be addressed.
4. Difficulties in creating the diagrams
    a. Felt difficult to put the whole diagram to fit into one page without over-crowding everything.
    b. Faced difficulty in a verb-subject form.
    c. Understanding the process, rules and style guidelines in creating the activity diagram.
    d. Identifying the actors is bit more difficult and real challenge.

CONCLUSION

From this business case, students have a better understanding about business process and the process to create activity diagrams such as set the scope, identify activities, and determine whether to include certain activities and decisions. Drawing the diagram is just one easy step of the process. Students became familiar with the symbols, notations and syntax when use them in the UML diagrams. Students also learned the ability and skills on how to break down a business process into small manageable steps.

To improve the teaching effect, some suggestions and recommendations are provided. If possible, provide more detail about the business process and description to prevent confusion. It would be good to have more practice before doing the assignment. Instruct students not to over think the process, but to keep it simple. Let student "volunteer" present their exercise results to class and have a critique. It would provide additional

understanding to others. When students doing assignments away from campus, a recommended online and free diagramming software will make the students life easier.

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APPENDIX

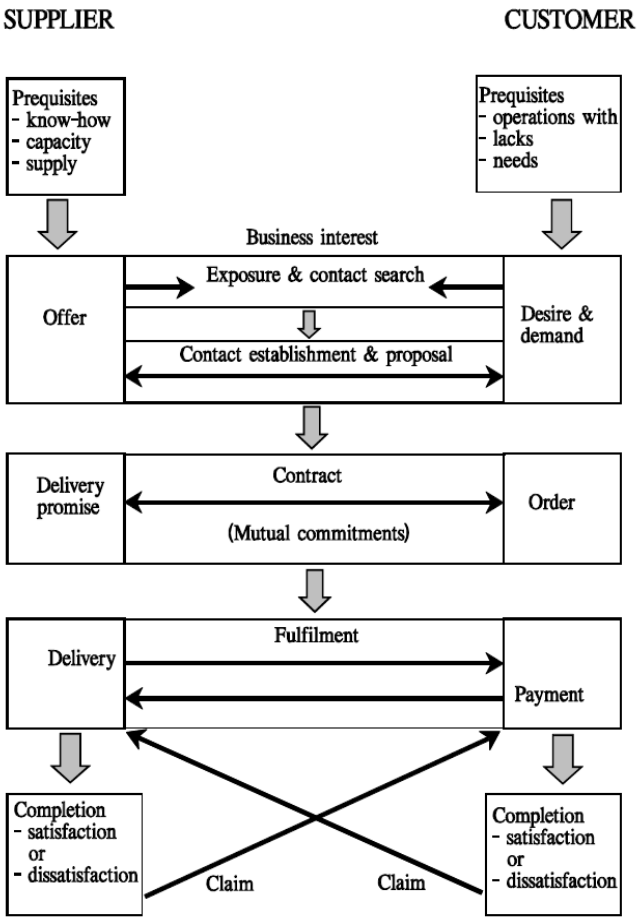

Figure 1. Business Action Theory: A phase model (Goldkuhl 1998)

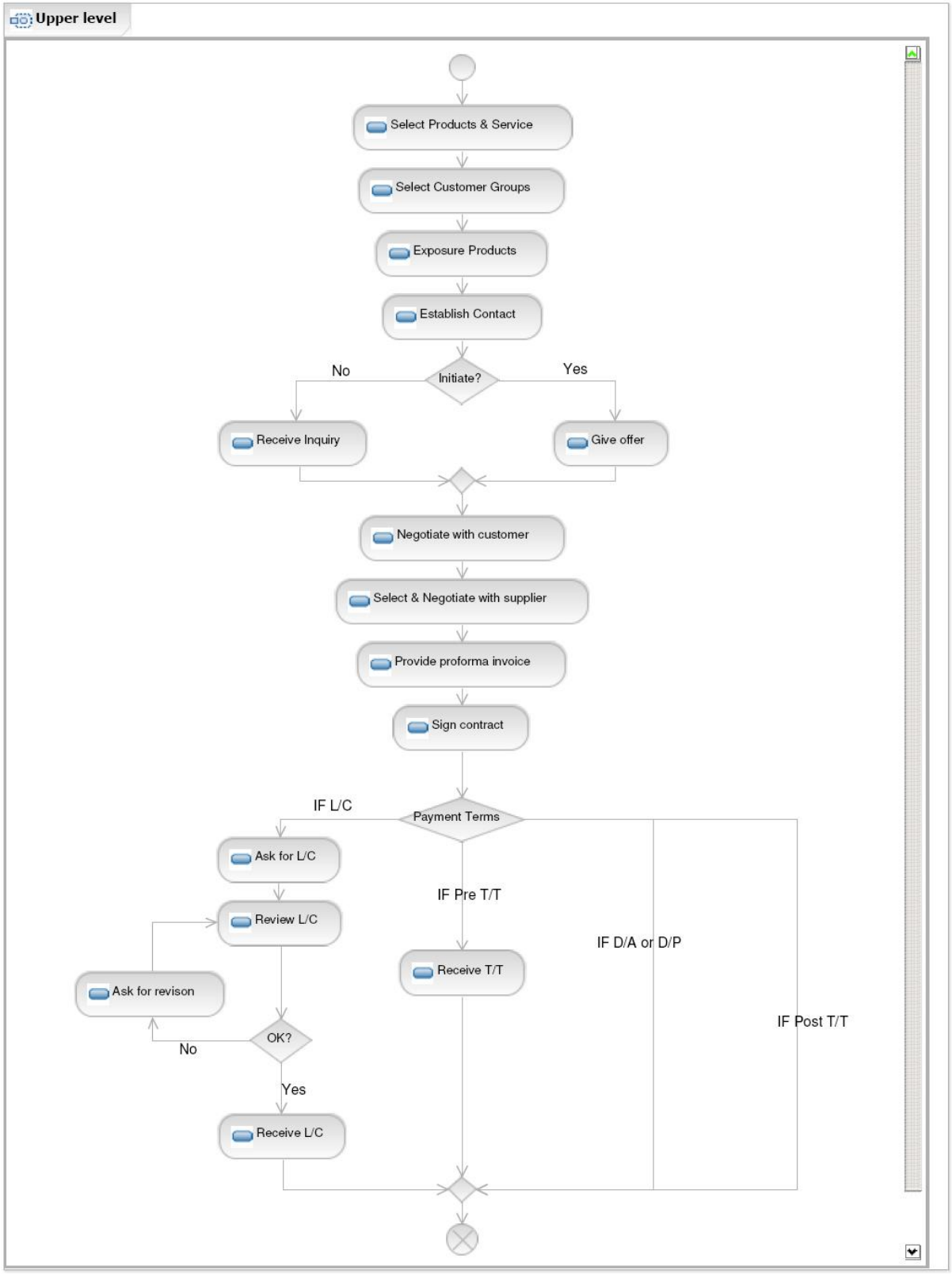

Figure 2a. UML Activity diagram (upper level)

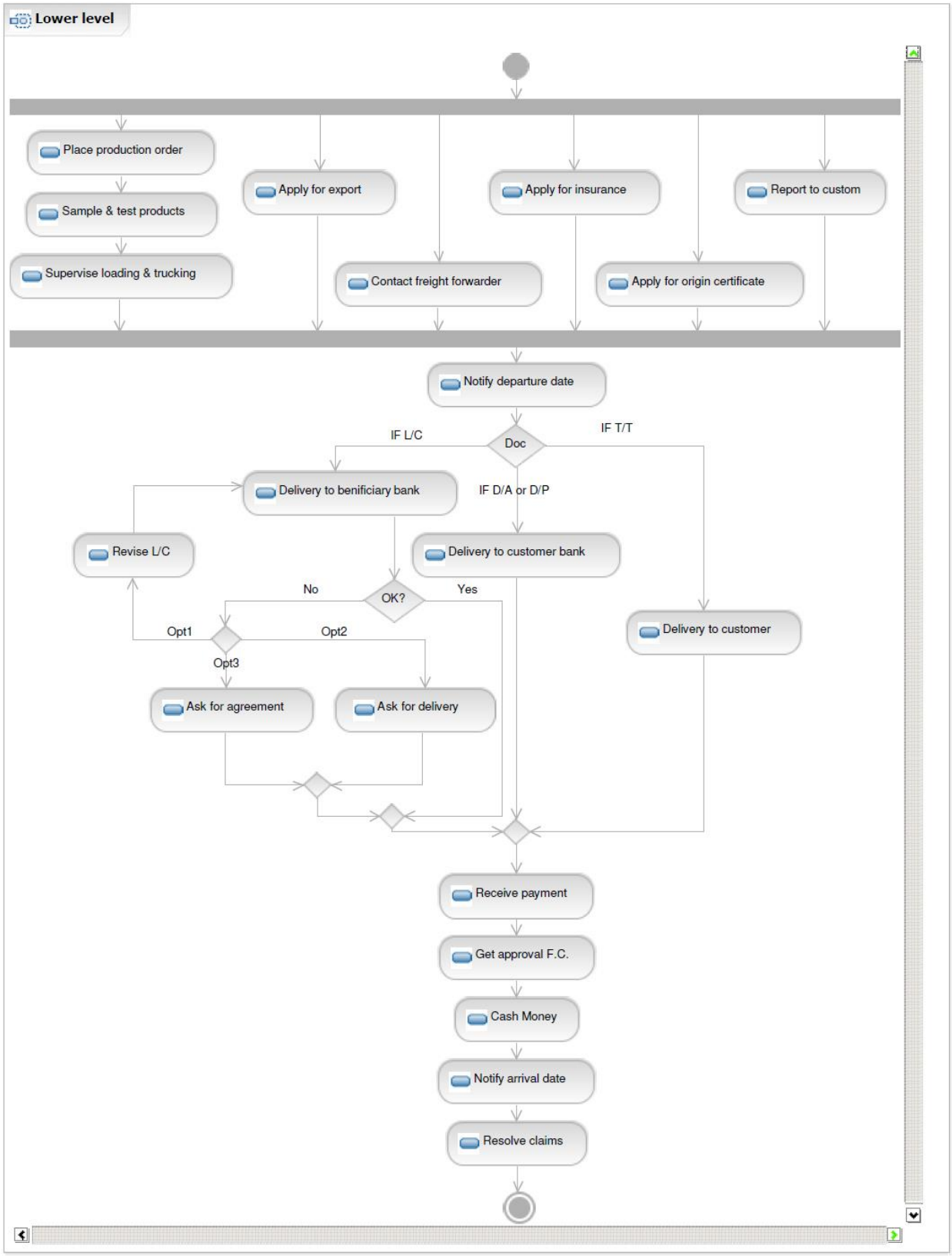

Figure 2b. UML Activity diagram (lower level)

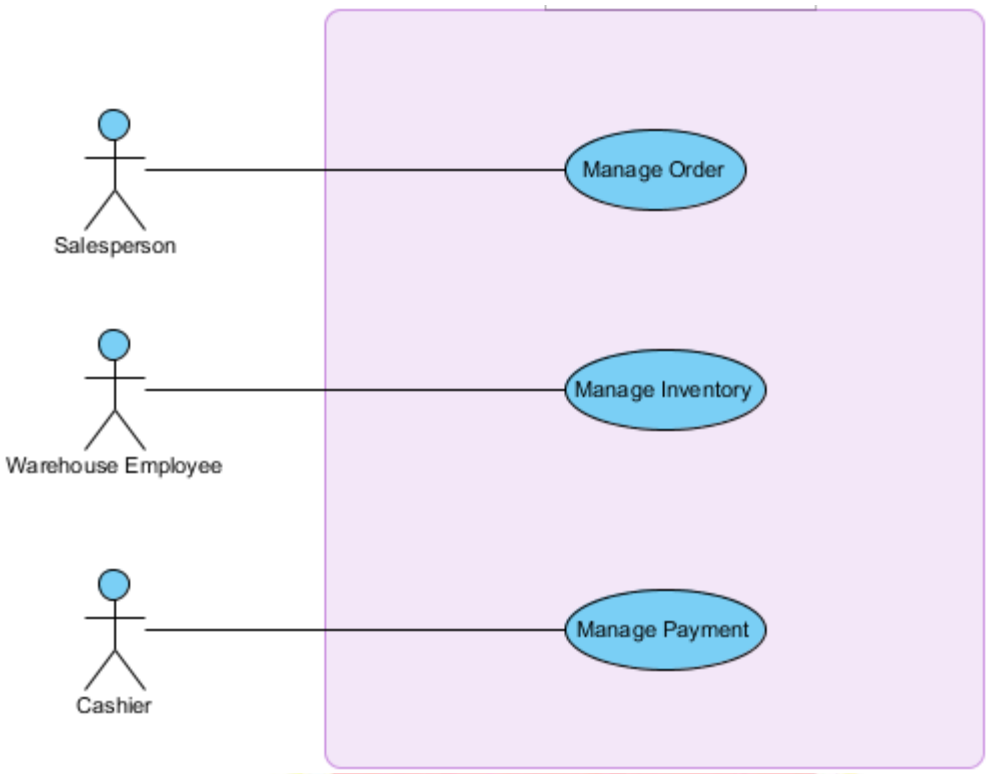

Figure 3 Use Case Diagram

Phases of Trading Process	Functional Requirements (Goals)
Products Offering and Managing	1. The system can list product information on website (List by category, List by product Name, List by price) 2. Warehouse person can manage products (add, delete, update) 3. Warehouse person can manage inventory (update) 4. Warehouse person can see the report of products
Customer managing	1. Salesperson can create/Add new record in customer table 2. Salesperson can see the report of customers 3. Salesperson can change any customer record 4. Salesperson can delete any customer record
Order Management	1. Salesperson can create/Add new order for a customer 2. Salesperson can add/update product information to an order. 3. Salesperson can add/update shipping information to an order 4. Salesperson can Add/update payment information for an order 5. Salesperson can see the summary report for any order 6. Employees can track order status
Confirming order	1. Account can create /add new record in the accounts receivable 2. Account can update record in the accounts receivable 3. Account can delete record in the accounts receivable
Delivering and paying	1. Accounting manager can see accounts receivable report based each accounts 2. Employees (sales person, account, warehouse person, manager) can change order status. 3. Employees (sales person, account, warehouse person, manager) can see order status report. 4. Sales person can manage Sample & Test Products Reports (add, update, delete) 5. Sales person can manage Shipping Documents Information
Claiming satisfaction or dissatisfaction	1. Sales person can manage Claims Information(add, update, delete)

Table 1 System Functional Requirements

1. Availability and Stability	The system should be available anywhere and at any time because the employees and manager needs to access the system conveniently.
2. Performance	Since some employees such as salesperson stay in the office most of working time, some other employees may travel and walking around such as accounting people having to visit banks and warehouse guys count the inventory and quality inspection on site. The system should be accessible with mobile device.
3. Business Security and Access Control	The manager has some concern about the current operations. For example, the salesperson knows the suppliers and purchase information such as the purchase price and profit margins, purchase people in the warehouse knows some important customers information. The access of information about some transactions and financial accounts should be restricted to individuals at certain level. Specifically, the system should address following security issue: 1. Customer information is maintained by salesperson only. 2. Customer information can be shared by accounting people, but not by warehouse people. 3. Warehouse people share the order product information, but are restricted to the selling price.
4. Localization	The headquarters of the business is located in China and most of employees may not know English. The besides translation in the menu items and button, among other things related to localization are date format, timing, and currency.

Table 2 System Non-functional requirements

Level:	0	1	2	3
Follow the Modeling guidelines	Not following the guidelines taught in the class (0%)	Some of guidelines are followed (25 – 50%)	most of guidelines are used (51 – 80%)	Almost all guidelines are followed (above 80%)
Use appropriate notations	Not using the notation required by UML standards (0 – 25%)	Some of required notations are used. (25-50%)	Majority of notations are correct. (51-80%)	Almost all symbols and flow flows are correct. (above 80%)
Identify the relevant components	No related components are identified (0%)	some relevant components are identified (25 – 50%)	most relevant components are identified (51 – 80%)	Almost all items and components are identified (above 80%)

Table 3 Rubric for Assessment business process modeling with UML Activity diagram