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MASTERARBEIT

Titel der Masterarbeit

„A process model template for the support of IT-based logistics planning in the context of Chinese ports”

Verfasser

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Deutsche Abstract

In den letzten 10 Jahren hat die Verwaltung chinesischer Häfen große Fortschritte bei IT-Systemen gemacht. Aber im Vergleich zu anderen Industrieländern sind chinesische Häfen in Bereichen wie Design, Entwicklung und Implmentierung des IT-Systems noch am Anfang. Die meisten Probleme sind, dass das aktuelle IT-System nicht genügende Austausch von Informationen und Kommunikationsmöglichkeiten liefern kann. Die Situation lässt sich durch isolierte Informatiosinseln, Redudanz der Systemstruktur, ineffiziente Entwicklung und in einigen Fällen sogar fehleranfällige Entwicklung kennzeichnen.

In dieser Magisterarbeit wurde ein neues „Design-Prozess-Modell“ für die logische Modellierung des gesamten Informationssystems in chinesischen Häfen entworfen. Das „Design-Prozess-Modell“ gilt nicht nur als ein Standard-Prozess-Modell für die Unternehmen, das IT-System zu entwerfen, es ist sondern auch eine Sammelung von einigen Methoden, Mustern und Regeln für die Designer, das Design-Konzept anzuwenden.

Der Hauptzweck des geplanten "Design-Prozess-Modell" besteht darin, ein kohärenteres, besser strukturiertes und dokumentiertes System für die Entwicklung des IT-Systems zur Verfügung zu stellen und logische Beziehungen und Zusammenhänge zwischen den verschiedenen Modellen zu gewährleist.
Folgende Schritten sollen im „Design Process Model“ inkludiert werden.

1) Identifikation der eigneten Modelle für Entwicklung des IT Systems
2) Spezifikation von transformation rules zwischen unterschiedliche modele.
3) Semantik, Syntax und Notifikation des Vorgangsmodels zu formulieren.
4) Entwicklung der eigneten “Software Development Management Approach“.

Schlagwörter: Vorgangsmodel, Software Entwicklung Management, MDA, Model Transformation

Master Thesis

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Abstract

In recent years, Chinese harbor administrations have made great progress in IT development. But in the aspect of design, development and implementation, China is still in its infancy compared with other industrialized countries. Most problematic is that current information systems cannot provide enough information sharing and communication capabilities. The situation is best characterized by isolated information islands, system structure redundancies, and inefficient development and in some cases even failure-prone development.

In this thesis, a tailored “design process model” is utilized for the logical modeling of more holistic information systems in Chinese harbors. The “design process model” is not only envisaged to serve as a standard process model to design the IT system in the enterprise, but also a collection of some methods, patterns and rules to help designers to finish the design concept. It does therefore go beyond a model and does incorporate some components of a framework.

The main purpose of the planned “design process model” is to create more coherent and better-structured and documented system models for IT system development automatically and to ensure logical relationships and coherences between different models.

To build the model the approach has to include the following steps:

1) Identification of a suitable model for developing IT systems
2) Specification of transformation rules between the different models.
3) Formulation of Semantics, syntax and notification for the process model.
4) Development of a sustainable software development management approach.

Keywords: Process model, software development management, MDA, Model transformation

1. Introduction

1.1. Motivation

With economic globalization, global trade liberalization and intergradations of international transport market, the growth rate of international trade is significantly higher than the speed of economic growth. Therefore, as land & water transportation hub and goods distribution& logistic center, harbors face challenged as never before. In China, there is a similar situation: with high growth rate of Chinese economy, the volume of international imports and exports grows very fast in recent years. Meanwhile, due to its important role in the whole imports and exports transaction, Chinese harbors are always under public attention. There are significant amount of research put the development of Chinese harbors. Meanwhile, experts, scientists and managers in China are striving to find out the appropriate way to develop Chinese harbors to make them meet the requirements of high rates of development of international imports and exports.

Meanwhile, as an important part and a criterion of modernization level of harbors, the information system is now another hot topic in Chinese harbors development.

In recent years, Chinese harbors have made great progress in Information system development. Most logistics center, marine harbors have already had complete information system to support harbors business activities. But there are still a lot of problems, for example, in the aspect of system design, development and complexity of system, China is in its infancy compared with other developed countries. The information system cannot provide enough information sharing and communication. The situation is characterized by isolated information island, system structure redundancy, inefficient development and false development.

Furthermore, there is not yet a standard way to develop IT systems for supporting the harbor business. The pattern is generally like that the developer designs or develops IT systems in harbor directly according to the requirements from customer; the updating of development is unsustainable and not logical. Therefore, the affectivity and quality of information management systems is very difficult to guarantee.

On the other side, the trend of developing information management systems in harbors is based on business processes. Thus, with the development of the SOA Architecture and clouding technology, those new technologies are more and more applied in Information system in harbors. So the emphasis of research in China has moved from implementation technology to optimizing the integration of new techniques into old systems. Therefore, a topic like how to develop and integrate new

system into old system is very popular.

Under these circumstances, a standard and logical development method is needed and stakeholders who are involved in development procedure hope through this method to improve quality of development and information system itself. Therefore, this thesis tries to provide a new concept to improve the way and method in the field of designing and implementing of Information systems for Chinese harbors and also to find out a solution for development, optimal integration and sustainable updating in aspect of Designing.

1.2. Focus of this thesis

Developing or updating an IT system basing on often changed business process is a very complicate procedure. It includes knowledge such as Software engineering, project management, business management and so on. It is impossible to descript exactly how to develop and update a system optimally in a thesis. However, people always say: "Well begun is half done". As first step for system developing, the design is a very important phase in whole developing procedure. If we can solve the problem in design phase, then the success is not far away from us.

Meanwhile, as an important method describing design concepts, system modeling is used widely in design phase of software developments. In additional, OMG organization has already provided a trail of modeling standards and methods to help people to describe system design and development. MDA, Model2code transformation technologies let implementation more comprehend, so from these points, we assume, perhaps the problems in above can be voided by using a logical modeling method.

Therefore, according above assumptions and experiences in past developments, a new system design process is created for improving quality of system development in this thesis, the theory of this "design process model" is introduced to readers at first and then through a concrete example the "design process model" will explained deeper.

To achieve and finalize the design process model, following aspects should be processed:

1) Identification of a suitable model for developing IT systems
2) Specification of transformation rules between the different models.
3) Formulation of Semantics, syntax and notification for the process model.
4) Development of a sustainable software development management approach.

1.3. Expected outcomes of this thesis

The main purpose of this “design process model” is to create different system models for IT system development automatically and to ensure logical relationships and coherences between different models.

In additional, The “design process model” is not only a standard process model to design the IT system in enterprise, but also a collection of some methods, patterns and rules for helping designers to finish design concepts. It is more like a framework which rules logics between system models and users.

Therefore, through creating and utilizing the “design process model” for designing information system in Chinese harbor in this thesis, a new approach to design and model information systems will be present. Meanwhile, through researching the transformation methods and technologies, this thesis provides a plenty of modeling patterns and realization approaches for model transformation. This methods and transformation technologies can be used in many aspects of software modeling and software development.

Thus, as a part of process model, a lot of software development management methods are also developed in this thesis. Developers and designers in different teams or in different development phases can more easily understand philosophies of design and to ensure the quality of system in aspect of organization.

Generally, the goal of this design process model is to reduce risks of integration mistake, false development and to improve efficiencies of software development.

2. Some of the major current problems of information systems in Chinese ports

As discussed in the introduction, the development of Information systems in Chinese harbors is not mature and systematic; there are many problems in the scope of information system development and application. In past few years, the growth rate of the Chinese GDP has been maintained at 8%- 9% in average. The life quality for Chinese has also been changed in accordance to the high-level economy rates. Similarly, in the field of business, global cargo and bulk transfer quantity has been increased significant. The situation of marine transport in 1996-2006 can been seen in the following table, from which a growth of 10% with regard to the volumes of marine transport can be witnessed in past decade. These Data indicate that the economy and business grow rapidly in China, reflecting which, the business process in Chinese harbors has been changed accodingly. However, the abovemetioned situation brings out a couple of issues: how can designers or developers make sure that IT systems in harbors meet the the requirements of the evolving business scales? Are existing systems and experiences of system development from other countries applicatable for Chinese harbors? If not, how can they be improved and modified?

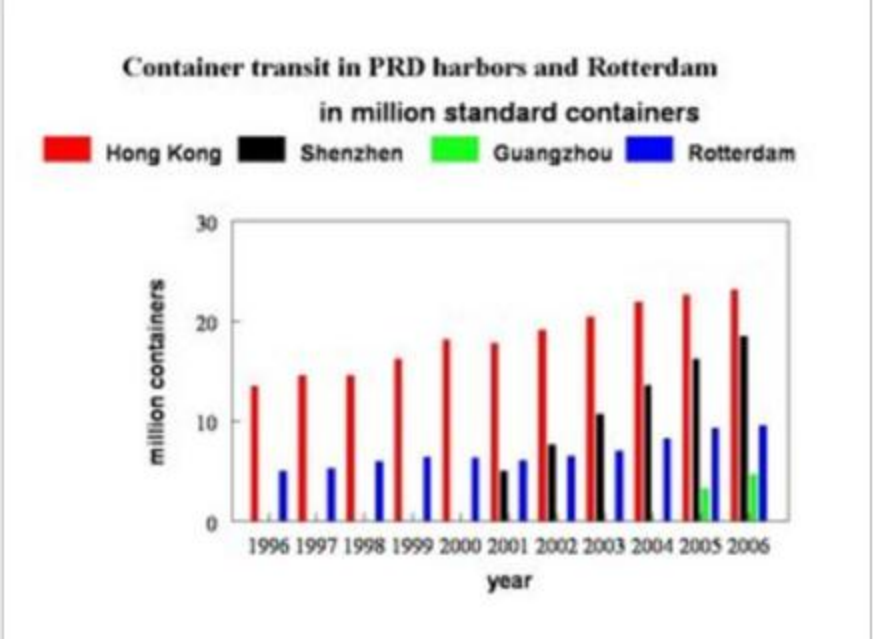


Figure 1, Development of container transit in Chinese harbors and in Rotterdam [1]

Besides, there are some similar problems in the field of continual integration between new and old systems:

[1] Source: China statistical yearbook 2006

The information system of Harbor should be modularized, standardized and easy to integrate or to take off. The IT system in Chinese Harbors is required to be updated frequently to keep abreast with the requirements of the growing business modes and user demand, which brings difficulties to developers in standardizing and integrating information systems. It can also cause problems, such as Data redundant or information lost.

In addition, it is not practical to implement the requirements from business directly into IT system. Considerable amount of business and logical information could be lost by the direct implementation method, which also can lead to problems in the integration and further expansion. Integration or new module development would become “mission impossible” without a clear designing concept and a standardized method.

And from the point of IT management, an overview of whole IT concept helps users to understand and control the whole system. Different aspects of system are usually described by different models. However, in this way, each model corresponds to a particular aspect and the relationship between different models cannot be identified. Therefore, it is a challenge to organize the models in a logical overview and to describe relationships between them.
In this chapter, the issues mentioned above will be discussed systematically. In addition, the research approach and a proposal to resolve these problems will also be suggested.

2.1 Information lost or redundant in communicating with partners of developments

As discussed in the introduction above, the Information management System in harbors is rather complicate. It includes certain amount of sub-systems and extra-systems from other business partners, which makes the completion of development a challenging task. In this section, the problems in communicating with other stakeholders of system development will be addressed.

Firstly, from the very beginning of the development, the developers must have a thorough understanding of the requirements of customers and the business processes. Development methods and plans have to be defined accordingly, based on the demand. However, a particular piece of information can easily be converted to various implementation concepts. For example, very often, one project can be taken by more than one development teams, which are responsible for different parts in the integration. Despite the adoption of same implementation technologies and efficient communication, problems such as mapping, information lost and integration mistake are still unavoidable.

Secondly, different models are used by system designers to describe, communicate and present to other partners. However, an IT system includes a number of aspects that the designer or developer have to consider, such as business description, data concept, and system architecture. The corresponding models that used by the designer to explain those aspects and the relationship between them may not necessarily be understood by other stakeholders, such as business managers, users, code developers, and even designers of other sections. For example, a business manager drafts a business process to explain the flow and requirements of business realities, based on which a system designer is required to design a system model. The system designer must consider: firstly, if the business models provide enough information to finish further system design; and secondly, if there is a general rule on the “business to system” transformation and if the design is actually based on the business process. Similar problems can also be found in the following case: If a model is designed by more than one development teams, different parts of this model from different teams must be coordinated and mapped. The mapping can however not achieve a 100% match without semantic checking, communication and coordination. Nevertheless, this procedure is not cost-effective and efficient. Therefore, a solution or method to avoid the mapping procedure is urgently in demand.

2.2. Lacking of a coherent logical design in different steps of software development

There are several levels in software development: system designers define the developing concept, code programmers implement this concept, and IT manger control and plan the whole development lifecycle. For the purpose of understanding the logic and ensuring the coherence of development in different levels, a standardized method to describe and define the whole development process must be adopted for all the team members to achieve this goal.

Waterfall model, one of the most famous software development process models, is a good example to explain the relationship between development phases and process model. It divides the whole development process into 5 individual processes, each of which has its own development target and result.

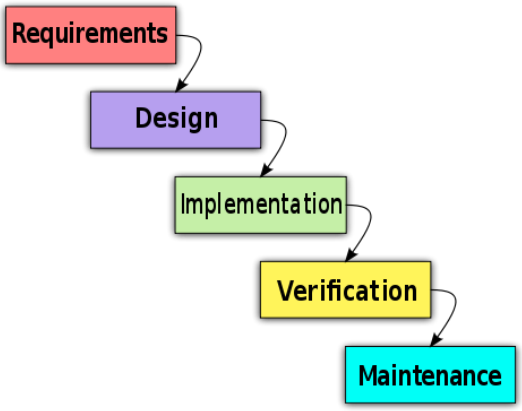


Figure 2 waterfall model [2]

This model not only provides an "overview" for software developing but also raises a few issues: 1) if there is a sub process model for each step in "waterfall"; 2) how to present the results for each step; and 3) how to identify the relationships between the two steps.

The software process model defines standard developing phases and steps in software development, as well as monitors the entire developing process. Before the development process starts, process model is usually utilized to describe how development must/should/could be done, which provides the development manager with an overview of the whole development project. On the other hand, the process model separates development process into a number of separated sub-steps and defines targets for each step, the results of which could be retrieved as basic

[2] Waterfall diagram, http://en.wikipedia.org/wiki/Waterfall_model

knowledge for next steps in developing. This loosely connected module can not only ensure the coherence and logic of software development but also meet requirements for ad-hoc developing.

The concept of process model may have further indication on the following questions: 1) if it is possible to design or if there is an existing standardized process model in the system design phase? 2) If this process model can make sure the coherence of information and transfer of logical thinking. 3) How can this design process model integrate in existing software development process model?

2.3. Lacking of a systematic overview for IT management and control

IT system in a corporation or enterprise, for the consideration of management, must be administrated by computer section or CIO, who is in charge of the whole IT relative issues, such as planning, managing, and maintaining of IT system. The IT management covers the gaps between enterprise business activities and technologies.

The six primary responsibilities of CIO are:[3]

1) Understand the business and the markets in which the firm sells its products and services.
2) Establish credibility of the IS department, thereby increasing the confidence of executive management in ideas presented by IS management
3) Develop a competent IS staff and IT Savvy users. So the enterprise can leverage IT.
4) Create a vision of the future and sell it, by working to set a goal for the use of IT within the enterprise and convincing others to embrace this vision.
5) Implement an information system architecture that will support the vision and the company in future.
6) Foster relationships with senior management, line executives, suppliers, alliance partners, and customers, both external and internal.

Seen from the above listed six responsibilities, CIO is head of the IS Management and controls the whole IS development Trend. The CIO may not necessarily aware of each details of the system, but he/she must understand the general situation and status of the IT system. In this way, the CIO focuses not only on the IT system, but also on other aspects in the enterprise, such as IT strategy, development plan, development cycles control, cost calculation and demand for IT system. Therefore, a CIO and whoever is in charge of a section of IT system would need a method to provide an detailed overview of IT system in enterprise, with which the CIO or manager can understand the general information about IS systems.

It would be idea to use a model to present the whole concept of IT system. However, as mentioned in the previous discussion, integrating various models in an “overview” is a problem that needs to be resolved. The system model can provide an overview of system like a blueprint in the construction field. Similar to the blueprint, different aspects of the IT system is designed initially with a defined progress and then integrate into an “overview map”. The issues are: how to integrate these separate

[3] Information systems management in practice fifth edition, by Barabara C. Mcnurlin, Ralph H. Sprague,JR

“concepts” into one “overview” and how to ensure the logical relationship among different “concepts” in “overview” in software development.

2.4. Summary of this chapter

Seen the three sections above, problems about designing and developing IT system in enterprise can be summarized into three aspects:

1) **Information variation generated in the communication with other stakeholders**

Despite efficient communication and coordinating protocol between different development teams or developers, problems such as information lost and redundancy can be caused by different understanding of designs. Frequent meeting and timely coordination can reduce the possibility of unexpected changes. However, the alternation of information cannot be totally avoided. Therefore, the first challenge is to ensure the coherence of system design and reduce information variation.

2) **Lacking of logically coherent design steps in different phases of software development**

There is not yet a standardized way to develop IT systems that support the harbor business. The present operation mode is that the developer designs or develops IT systems in harbor directly according to the requirements from customers. However, the update of development is unsustainable and illogical. Therefore, the affectivity and quality of information management systems is guaranteed.

3) **Lacking of a systematic overview for IT management**

System designers describe their designs with different system models. But those designs are just parts of a model. However, the integration of these separate “concepts” into one “overview” and the insurance of logical relationship among different “concepts” in an “overview” remain as challenges in the system development.

3. Requirements derived from existing unsolved problems:

The problems of system development in Chinese harbors are addressed in the previous chapter. These problems can be considered as requirements expected by stakeholders who involve in the development procedure. This chapter will therefore discuss the demand of a new design process model based on the above-mentioned problems. These requirements are discussed not only a summary of existed problems, but also as the basis and motivation of creating and researching new design process model.

According to the problems in the previous chapter, the requirements are summarized into the following 3 aspects:

1) From the design and development aspects

1.1) A standardized process model for software design process and design sequence should be defined by using this process.

1.2) The design sequence describes not only the process of design but also results and sequenced activities for each step.

1.3) The process model should also maintain the coherence of logic and design thinking.

1.4) The process model must also have logical rules for results transaction. For example, the rules and methods for transaction from business model to data model.

1.5) The process model is also a framework, which provides method for integration of different Models

2) For integration and updating

2.1) for further updating and integration of new system, each result from each phase in process model should be presented separately.

2.2) presentation of design logic and design thinking

2.3) this process model must be iterative and each result in each step can be changed for further developing.

3) In IT Management aspect

3.1) This process model can provide an overview of system

3.2) This process model can help CIO or IT management to make IT development plan and strategy

3.3) This process model should be a bridge between IT engineer and enterprise normal employees.

3.4) Blue print about the enterprise's information system.

In this chapter, all above aspects in requirements will be further explained and the basis of creating a new design process model can be established from these requirements.

3.1. Requirements from design and development aspects

Seen from chapter 2, information lost and redundancy can be caused in the communication among development members and there is also no method to guarantee the transmission of design logic among different develop members. Therefore, the first requirement summarized from the problems is that a new developments plan should have a very clear method to determine the way stakeholders in development communicating and coordinating with each other. Thus, the maintenance of coherence of logic and design is another basic requirement.

On the other hand, design and developing after certain process model is considered as a good approach to manage and control the whole development. Therefore, after considering both sides of the problems, more detailed requirements can be concluded:

Firstly, the design process model is like a normal process model, which rules and determines the whole design process steps as well as defines results from each step. This standard process provides developers and designers with a common basis for communicating and coordinating design results. Considering problems of information lost and redundancy, the design process model should contain methods to record logics and ideas behind each design. These records should be comprehended easily and completely, so that they can be transmitted among different stakeholders.

Generally, the new design process model should be a standardized modeling process, which can provide developer with clear information and business logic as well as transformation rules, design patterns, modeling steps. By adopting this “standard modeling process”, the end-user who has no IT knowledge should easily understand the logic and philosophy of the design. The situation such as information lost data redundant and mapping procedure can therefore be avoided. All the requirements from design and development aspects are illustrated in following diagram:

3.2. Requirements in different development phases

The design and development from different teams or stakeholders in one development phase can be observed as horizontal development process. In the same way, design and development between different phases can be observed as a vertical development process.

Similar to the horizontal development process, the vertical development process also requires guarantee on design and development coherence. Therefore, the design process model should have not only methods to record logics behind design, but also the logic in transformation between different models. These logical transformation methods can ensure that there are no logical changes in different development phases.

The present method of customers bringing up some requirements, and then developers or designers implementing the system accordingly is thus strictly forbidden. If information systems are developed in this way, structures and architectures of system can be confused, which could be a disaster for further developments and system integrations. Therefore a gradual process with clear design goals is crucial and necessary, which rules different phases and sub-goals of fulfilling customers' requirements. Furthermore, through the method of dividing general concept into sub concepts can better ensure the logic and coherence of design.

On other side, the general–sub concept organization is helpful for iteration. The final design concept usually cannot be finished in one time. Constant improvements and alteration are necessary to meet the changing requirements. Therefore, an iterative system is another requirement of our design process model, which allows designers to improve or change designs without confusion through evaluation of business request.

3.3. Requirements from IT management's aspect

The IT Management is responsible for the whole information system. They manage some of the most important tools that can influence the firm's future. Presenting IT manager with an overview of the whole system situation optimally is a priority, which brings up another requirement for the design process model. It should provide an overview to IT manger, which can help IT management plan and control entire system development and make corresponding decisions.

Design process model should also provide architecture for information system, like a blueprint. It shows how the overall system, house, vehicles, or other product look like and the way different parts interrelate. The design process model should also organize those aspects together as well as plan and control tools.

In additional, another mission of IT management is to overcome the gap between technical issues and business issues, which means that IT management is responsible for popularizing and introducing information system to non-technical members in the enterprise, so that they can understand features of systems. However, tedious technical reports and different analyzing data create difficulties for other stakeholders to understand and accept the systems. It is also not an easy task for technical members to introduce their products with a clear system model.

Lastly, the design process is required to be easy to understand and clearly presented. The IT managers can therefore present IT system with it and involve other stakeholders in the further development and updating.

4. Development of a modeling approach

In previous chapters, the problems and requirements in the development of Information system have been discussed, which brings up the question that whether there is a way or method to fulfill the needs?

After analyzing the requirements in above chapters, it can be concluded that a good design concept should present not only the design logic, but an overview of the IT system for CIO or IT management to control. From another point of view, different models can be utilized as a common method to present design concepts. Therefore, it is assumed that there is a design process model, which can organize the whole design phase and also explain the relationship between different models.

Further issues are: if there is a standard developing procedure; whether it can be utilized to avoid situations like information lost or information redundancy in the system integration; and in this standardized development procedure, whether information about the developing itself can be acquired to reduce the possibility of system errors.

A standardized process model for IT system design is considered by this paper as an effective method to solve the problems, such as expression of logical thinking or controlling the software development. With regard to the establishment of this process model, the following sub-questions must be resolved:

1) **What should be modeled?**

   Generally speaking, in the design phase, the overall concept about IT system should be fixed. Therefore, it is required to model the aspect and scope of the design concept; decide the steps or phases in this process model, anticipate the results that may gain from those steps, the sequence of the steps, determine the potential requirements of information system development for Chinese harbors.

2) **Meta-model and transition rules.**

   The meta-model is a semantic and syntax base of a model, that we cannot avoid this step to jump to the direct design and use our process model. Whereas, the types of model language or method which this meta-model should be designed and developed is yet to be decided.

   On the other side, different models and results can be developed in different phase of the process model. The transition or integration rule to ensure the deducing among two or three different models should also be considered.

3) **Useful existing methods and tools**

What kind of research method should be chosen? Are there any existing methods that can be used directly? Which one can be used to develop the process model? What kind of tools are helpful to develop the process model?

4.1. Tasks and steps

The initial consideration is the tasks or steps in the process model and logical relationships among these steps. For example, in the waterfall model, the software development is divided into different steps, such as “requirement”, “design”, “implementation”, and “validation”. Whereas, what are the tasks or steps in the design process model? Which aspects should be considered in the design phase?

An effective way to solve these issues is to base the design phases in various existed process model, which defines exactly what kind of tasks or work should be carried out in the design phrase.

In chapter two, the waterfall model is used as an example to explain why we need to design model. But in the research about the necessary activates in design, all different kinds of process models should be gathered as much as possible to analyze features of design.

There are many process models to help people manage and control the software development:

- Waterfall model
- Spiral model
- V-model
- Prototype development

Depending on the above software development models, there are also some methodologies for software development. Through research on these software development methodologies, features about methodologies can be concluded and inspiration can be found.

Representative examples of existing methods:[4]

Example 1

SSADM

(Structured Systems Analysis and Design Methodology) specifies in advance the modules, stages and tasks, which have to be carried out and therefore could be described as prescriptive in its approach to systems development. SSADM adopts the Waterfall model in that it prescriptively develops the deliverables to be produced and, in turn, the techniques which are employed in production of deliverables. The SSADM approach is primarily data flow oriented, therefore while using this approach, the DFD (Data flow diagram) is mostly used as a system design tool. The focus of the system design is on the data and its transformation between the modules and, also, data dependencies.

The major tools to support implementing the SSADM are

1) Logical Data Modelling
2) Data Flow Modelling
3) Entity/Event Modelling

Example 2

STRADIS

(Structured Analysis, Design and Implementation of Information Systems) was developed by Gane and Sarson (1979). STRADIS is based on "Top-Down" functional decomposition and uses Data Flow Diagrams almost exclusively.

Example 3

YSM

YSM (Yourdon Systems Method) was originated by Edward Yourdon in 1989. He was known as a consultant in the business world, and also a lecturer of information systems. YSM is similar to STRADIS in functional decomposition methodology, but a middle-out approach is adopted and rather more emphasis is put on the importance of data structures.

Example 4

MERISE

(Methode d'Etude et de Realisation Informatique pour les Systemes d'Enteprise) developed by Quang and Chartier-Kastler in 1991 is used quite widely in France,

4 Software Design Methodology, http://it.toolbox.com/wiki/index.php/Software_Design_Methodology

Spain and Switzerland. MERISE has three development cycles-- decision cycle, life cycle and abstraction cycle. In the abstraction cycle both data and processes are viewed on a conceptual level, then on a logical or organizational level and finally on the physical or operational level.

Example 5

EUROMETHOD

EUROMETHOD is funded by the EEC (European Economic Community) on behalf of the European Member States under the sponsorship of the PPG (Public Procurement Group), a cross European grouping of public procurement bodies from different member states consisting of 10 partners from 8 different Member states. Euromethod project has been running since November 1989 which was the start of Phase 1 where essential requirements were agreed upon. EUROMETHOD's Phase 3a has now been completed with the initial version of Euromethod as a result.

Example 6

SCRUM

Scrum is an agile approach for software development. It doesn't provide complete and details description to define how everything is to be done, it leaves everything to developers and motive them to overcome difficulties and to solve problems. A development unit in SCRUM is called "sprint". A sprint planning meeting defines the desired outcomes instead of a set of entry criteria, task definitions, validation criteria, and so on.

Example 7 [5]

AGILGE

Agile software development is a group of software development methods based on iterative and incremental development, where requirements and solutions evolve through collaboration between self-organizing, cross-functional teams. It promotes adaptive planning, evolutionary development and delivery, a time-boxed iterative approach, and encourages rapid and flexible response to change. It is a conceptual framework that promotes foreseen interactions throughout the development cycle.

Agile methods break tasks into small increments with minimal planning and do not directly involve long-term planning. Iterations are short time frames (time boxes) that typically last from one to four weeks. Each iteration involves a team working through a full software development cycle, including planning, requirements analysis, design, coding, unit testing, and acceptance testing when a working product is demonstrated

[5] http://en.wikipedia.org/wiki/Agile_software_development

to stakeholders. This minimizes overall risk and allows the project to adapt to changes quickly. Stakeholders produce documentation as required. Iteration might not add enough functionality to warrant a market release, but the goal is to have an available release (with minimal bugs) at the end of iteration.[6] Multiple iterations might be required to release a product or new features.

Seen from these design methodologies, the following types of activities or aspects in design phase people are worth paying attention to:

Example 8[7]

Preliminary Data Structure Design—a design for the organization of all the data needed to support a business area. Although still only a Logical representation, the target DBMS is considered and data is shown in the form of record types and the linkages between them;

Procedure Design—determining how an individual process will be carried out by one or more procedures and the design of fallback procedures;

Dataflow Diagrams—a method of representing the various procedures required to support a given process, the physical data, which flows between them and the data stores required;

Code Design—deciding what fields are to be encoded, the style and format most appropriate in each case and defining who will create/maintain the codes;

System Structure Design—techniques to determine how the various procedures will be linked together, security, control and audit procedures required etc.;

Prototyping—a technique primarily for building a 'quick and rough' version of a desired system or parts of the system. The prototype illustrates the system to both users and designers, allowing them to see flaws and invent ways to improve the system. Such features as security, auditability, recoverability, ability to handle large volumes of transactions/users etc. are not normally included in a prototype. The prototype is usually regarded as a throw-away, but can be built such that it can be further enhanced to become the production version;

Data Structure Refining—reviews of the data structure to consider any additional requirements for privacy, integrity etc. 'Refinements' are not for performance reasons at this stage.

Man-machine Interface Design—various considerations aimed at

[6] Beck, Kent (1999). "Embracing Change with Extreme Programming". *Computer* **32** (10): 70–77. doi:10.1109/2.796139

[7] http://computing.unn.ac.uk/staff/CGPV1/downloadables/CD3005/ch8-12.pdf

Physical Database Design—starting with the refined data structures and transaction volumes, adjustments are incorporated to allow for performance criteria, recovery/backup requirements, hardware constraints etc.;

Program Design—the finalization of dialogue flows etc. and the translation of the various Business System Design outputs into units of program work appropriate to the target hardware/software environment;

Operational Procedure Design—defining the archiving and recovery/backup procedures, audit trail provisions, hardware and system software implications.

The above aspects of designs can be classified into 3 categories:

1) **Information related design**

   In this category, business process relevant exchanged information will be found, defined and designed, such as procedure design and dataflow design.

2) **Data structure related design**

   In this category, data structure related design would be carried out. Interface design, data structure design, data structure refining, and database structure design, belong to this phase.

3) **System related design**

   In this category, system structure will be finalized. System structure design, program design and code design belong to this phase.

Besides, all basic design information comes from the phase "requirement". In "design "phase it is difficult for model to describe or to reunite different types of requirements. The "business process" must therefore be used for understanding the whole basic business process and requirements. The different types of design activities could be summarized into 4 aspects:

1) Business process
2) Information
3) Data concept
4) System structure

Meanwhile, based on the experiments of practical software development, the business process is considered as the basis for all other designs. It provides all types of basic information for design. In addition, business process model also clearly illustrates

exchanged information. The sequence of whole design tasks can now be defined.

Corresponding models should be developed in each phase as results.

- Business process:
  Business process model, organizations model

- Information:
  Data model, information type model

- Data concept:
  Data structure model

- System structure:
  System structure model, hardware overview, software overview

4.2. Meta-model and transition rules

The tasks and sequence are the partial content of this model. The expression method, the syntax of model and the meaning of notation which are responsible for presenting the content, should be defined by the Meta model.

The Meta model is a model of model. It rules concern syntax, notification and semantic of a model. The structure a meta-model is like the following[8]:

[8] Univ.-Prof.Dr. Dimitris Karagiannis, Mag, Srdjdan Zivkovic: Method Engineering: basis of integration in business engineering,

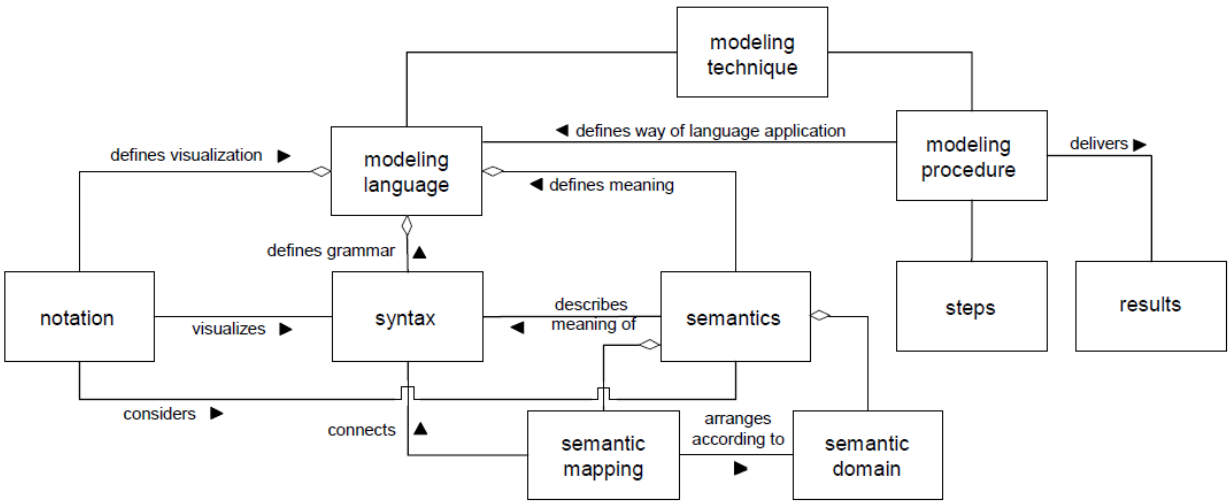


Figure 3 Structure of modeling

The above diagram shows that the Meta model should contain primarily two aspects of model: “Modeling technique” and “mechanisms and algorithms”.

The modeling technique focuses on the contents and procedures of the model, which covers the issues, such as how to present the model, what is the rule for this presentation, what is the meaning of presentation and so on.

The modeling procedure focuses on the sequences and organization of the model. The steps of modeling and results of each step belong to this modeling procedure.

On the other hand, the results of each step in design tasks describe different aspects of the information system. The Meta model must define or explain the integration of different aspects. The integration rule and mapping rule is therefore other crucial information which must be defined in Meta model as well.

In this research, the Meta model is used only for defining the form of process model. The corresponding model, as results of each step in process model, will be defined by own corresponding Meta model. For example, in business process phase, the business process model and organization model should be the results of modeling. This business process model and organization model is defined by own business process model Meta model and organization Meta model. Neither of this two Meta models are relevant to our process Meta model.

4.3 The Research plan

The approach of developing design process model has three aspects:

1) Constant improvement for the process model

2) Integration rules and mapping rules development

3) Test of the process model performance by developing different system models

This research approach is iterative process. The developed process model should be tested and improved by developing corresponding system model in each step of this process model.

The overall research approach is presented in following diagram:

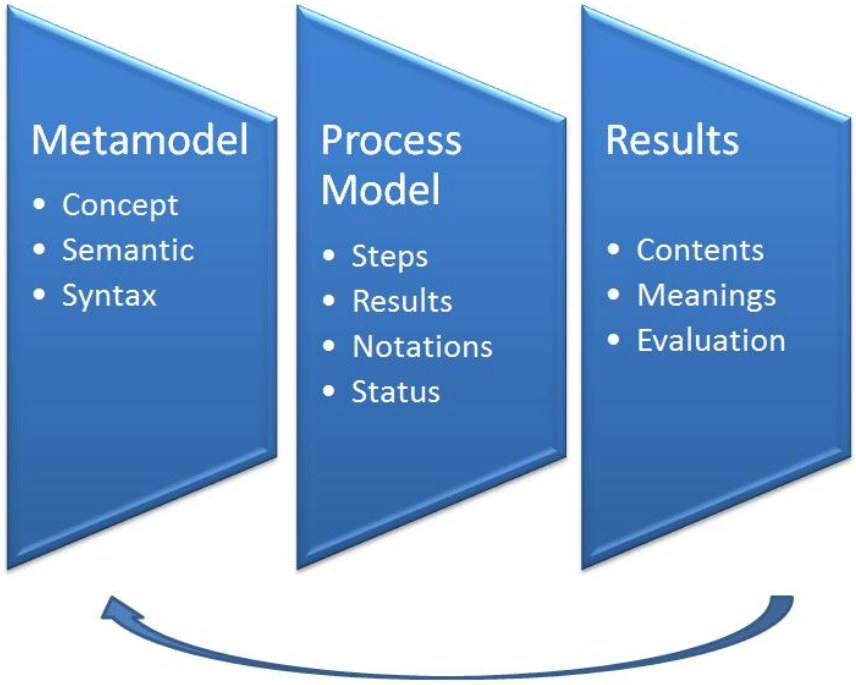


Figure 4 research approach

The above diagram shows three layers of designing our process model. In the meta-model layer, the concept, syntax and rules of design process model as well as the whole system design and relevant tasks are defined. As results for each step in

process model, different system models should be presented in the third layers. In this layer, the process model is utilized and applied. With this system models, the process model can be evaluated and improved.

The purpose of this design process model is to provide software developers a framework for designing Information system. Therefore, after developing this information model, the design process model should have a capability to organize a whole procedure of Information system development. It can also support designers to finish design concepts by providing different patterns, methods and transformation rules. This design process model is therefore significantly different from other software development frameworks. It is more specialized to provide concrete methods and codes to help developers rather than the basic functions such as organizing and managing development cycles.

5. Overview of design process model

Based on the research and analysis on the requirements of system designing, the overall structure of design process model is designed as shown in the following diagram:

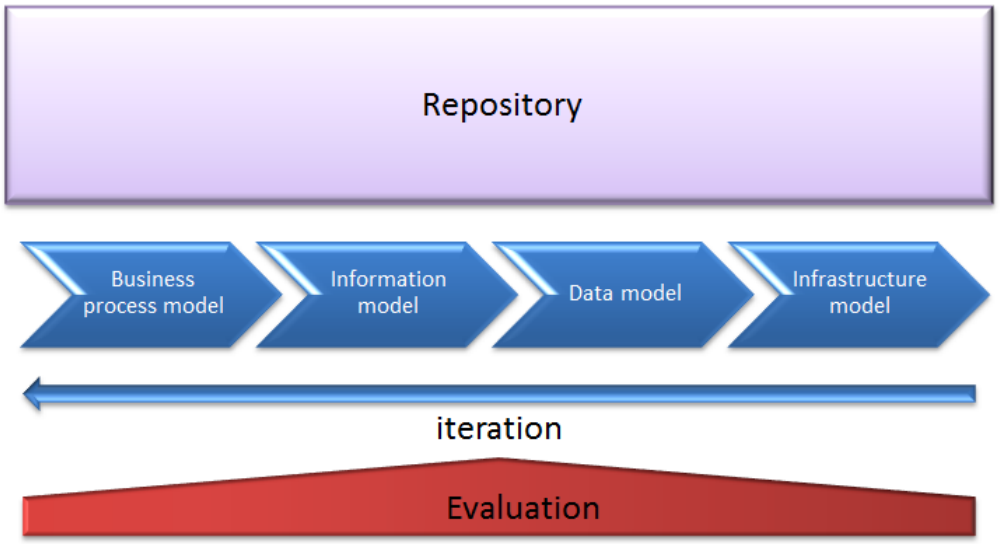


Figure 5 Overview of design process model

In the middle of this diagram are the core steps which indicate the steps and phase of design process model. By following each step, the designer can create corresponding system model, and each system model should be a basis for further modeling in the next steps. The whole modeling process is iterative, since the models in each step can be constantly improved through the evaluation of stakeholders who are involved in the designing.

The repository provides the patterns and transformation rules for transformation. It includes three levels: modeling concept, transformation rule, technology and realization. The purpose of this repository is to ensure the logical design and reduce the modeling time.

This diagram is aimed to present the overall structure of the design process model. However, the diagram itself is not a model. In following section, details on the overall design process model will be explained.

5.1. Process model

The process model is the core of the overall design process. It includes four steps, which allows the designer to give a final design concept step by step. In this section, the semantic and organization about process model will be explained.

As a type of model, the process model should include three major aspects that has been explained in the last chapter. Therefore, in this chapter the UML-Model language will be used to express the Meta model of the process model. The grammar and notification for process model will also be defined.

5.1.1. The notification for process model

In process model, four types of meaning should be expressed:

1) Steps
2) flow chart
3) status
4) decision

1) steps

The steps mean activities and phrase in process model. It expresses what exactly must be done immediately. Each step in process can also be divided into many sub steps.

2) Flow chart

Flow chart represents the sequence and order of steps. With flow chart, different steps in process model can be organized. The logical meaning of derivation can also be presented with flow chart.

3) Status

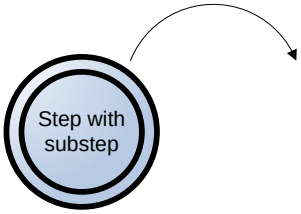
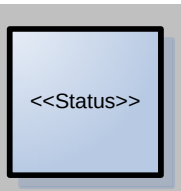
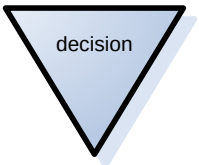
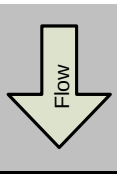
The status explains the state of modeling, which is useful to check logical relationships and special requirements among different types of model. For example, a business process model is established, which presents the requirements and situations of business realities. However, due to the shortage of information, some data, which are exchanged among distinguish business activities can not be defined. In this case, undefined data can be remarked and in the “status”.

4) Decision

The decisions provide a possibility to decide whether the process of modeling can progress to the next step. In the reality, all the needed information is not guaranteed to be enough for modeling and designing. The quality of modeling must therefore be tested and “decision” activity indicates whether the model is qualified for next modeling.

The notifications about above meanings are listed in following table:

Table 1, the notifications of design process model

Notification	**explanation**
	The steps mean activities and phrase in process model
	Each step in process can contain many sub steps
	The status explains the state of modeling. That could help us to check the logical relationship and special requirement among the different types of model
	The decisions give us the possibility to decide whether the process of modeling moves to next step
	Flow chart represents the sequence and order of steps

By using UML Meta model, the grammars of process are defined.

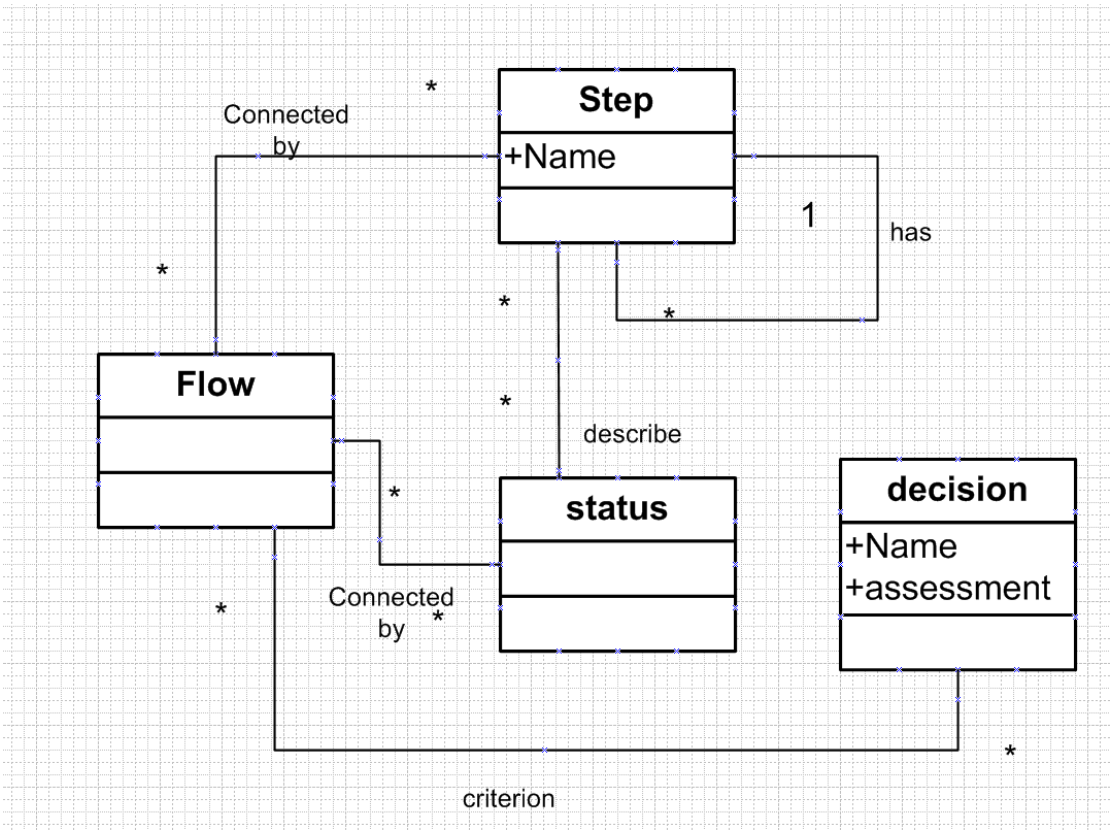


Figure 6 Meta model for design process model

Each step can contain more than one sub step, but each sub step has only one super step. Each class in the process model should be connected with the flow. The "decision" can only be connected by flow, and in flow there is a criterion to decide whether the model meets requirements and expectations of the designers. The "status" describes the information on steps and provides criterions for decision.

This diagram shows the general structure of design process model. However, the "status" and "decision" are not defined. The reason is simple: the concrete conditions and status cannot be defined in a general manner. Therefore, it has to be complemented later in the analysis of concrete cases.

According the Meta model and notation discussed above, the general process models is as below:

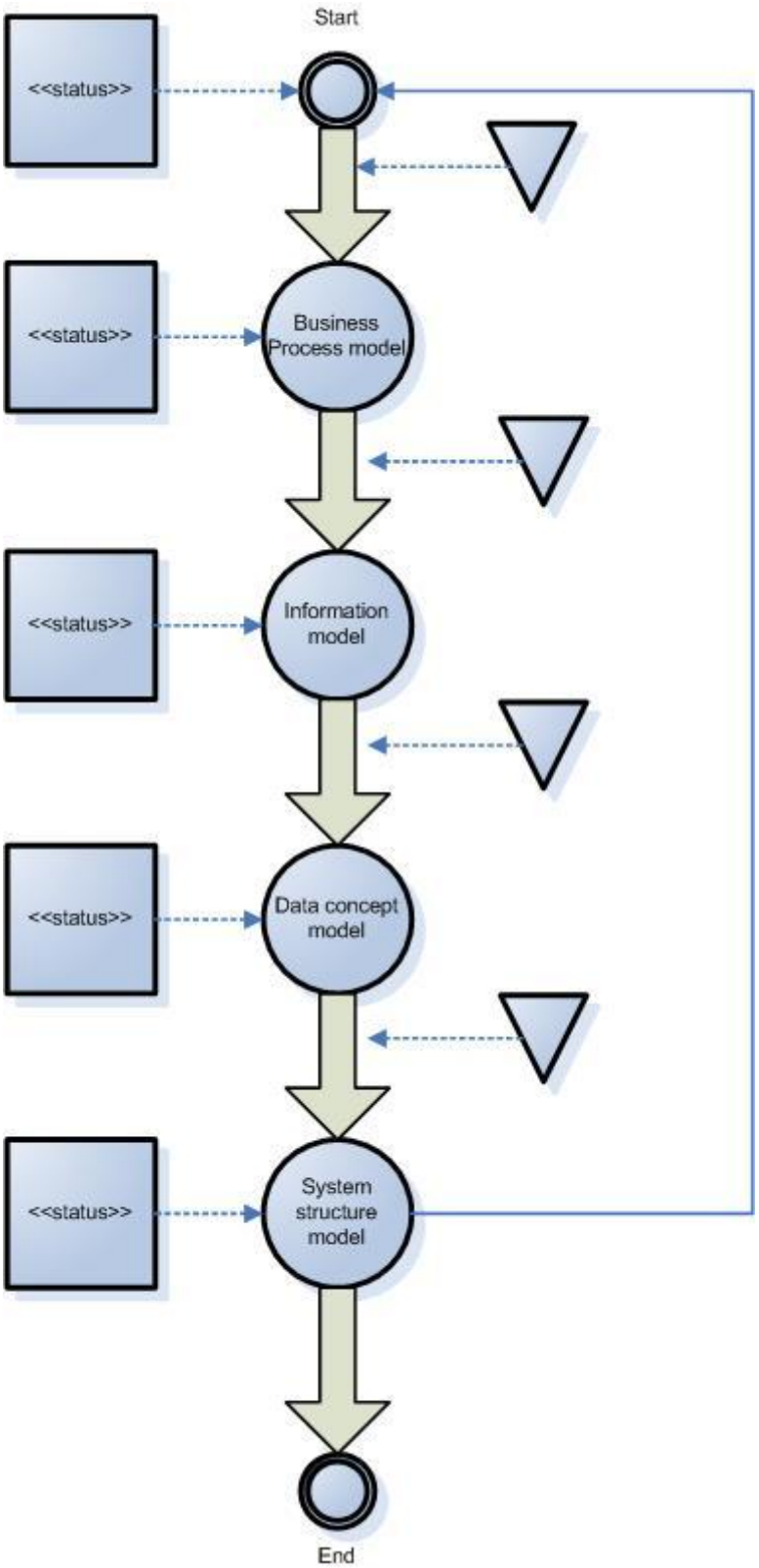


Figure 7 design process model

Meanwhile, results that acquired in each step are different types of model. Therefore, these models can be observed as an input for the next step and they are translated into other types of model. A transition rule and mapping rule are then needed for this transformation. These rules can be helpful to understand the logical and business relationship among different aspects of designs in an easier way.

5.2. Model transformation approaches

The purpose of the design process model is to provide a complete and logical concept for information system. Therefore, conducting different system models are required for the final system structure concept. The procedure of the conduction can be seen as a model to model transformation.

In addition, the quality of transformation influences the final results of design concept. Appropriate transformation rules between models are therefore of significant importance.

There are two general model transformation types at present[9]:

- Vertical transformations

  It runs through modeling levels -- the model from the higher level of abstraction is transformed into more specific model on the lower level, by adding some specific details.

- Horizontal transformations

  Models on the same abstraction levels are transformed.

As for transformation approach, the model transformation can be classified as below:[10]

- Model to model Transformation:

  In this transformation, the source model will not be modified and according to this source model, one or more target models should be produced. The Meta-model of source model and target model could be different.

[9] Uni-Prof. Dr. Dimitris Karagianis, Haradkühl, Franz Bayer, Stefan Junginger: Enterprise model Integration, September 2003, LNCS 2738, pp. 379-392.

[10] Uni-Prof. Dr. Dimitris Karagianis, Haradkühl, Franz Bayer, Stefan Junginger: Enterprise model Integration, September 2003, LNCS 2738, pp. 379-392.

- Model to text transformation:

In this transformation, the code or text will be generated from source model. Through this mechanism, the user can traverse model and generate code. The user can also use templates to generate code.

It can be seen that the model transformation presented by this paper belongs to the vertical transformation. Meanwhile, it is also a model to model transformation.

On the other hand, from Meta model of process model and process model itself, the transformation structure can be classified as indicated in the following diagram:

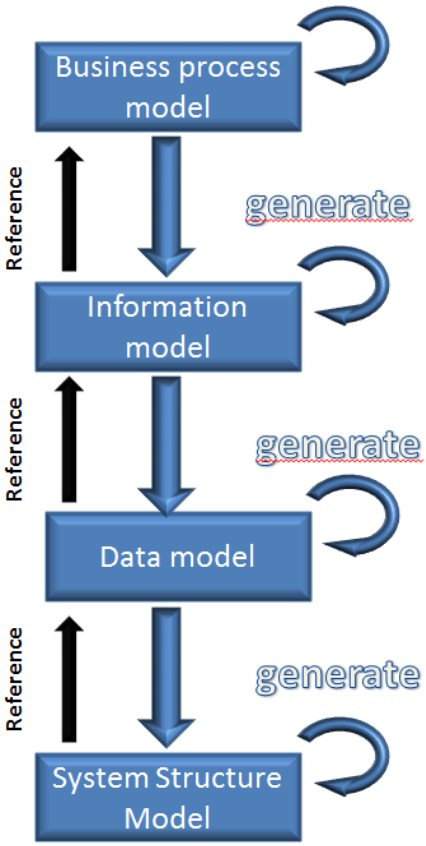


Figure 8 Transformation-process

In this diagram, the blue arrow means transformation of models from lower level into higher level. The black arrow illustrates the reference relationship between the two models.

Concrete meanings of transformation are like the following:

- Business process model -> Business process model:

  The transformation from Business process model to another business process model indicates improvement of a new business process model, which belongs to horizontal transformation. This transformation could execute through modeling tools.

- Business process model -> Information model:

  This transformation is the first phase of the overall transformation procedure. The necessary information will be retrieved from business process model and transformed into information model by using UML class diagram. The transformation rules and transformation approaches will be explained later in following chapters.

- Information Model -> Information Model

  The transformation from information model to another information model means improvement of an information model. That belongs to horizontal transformation. This transformation could execute through modeling tools.

- Information Model -> Data Model

  This transformation is the second level in the whole transformation. The information model will be reified. The information includes data will be presented in model. And structure of data will be fixed.

- Data Model -> Data model

  The transformation from data model to another data model means improvement of a data model. That belongs to horizontal transformation. This transformation could execute through modeling tools.

- Data Model -> System Structure Model

  This transformation is the third level in the whole transformation. The system structure model would be defined from data model. The system structure model is final system design concept.

- System Structure Model-> System Structure Model

In this transformation the system structure model will be improved.

5.2.1 Transformation Approach

Transformation is a complicated process and the whole transformation approach is divided as below:

1) **Transformation :**

In this step, the model will be transformed automatically to other types of models by using transformation technology such as QVT, domain-specific language (DSL) or other transformation languages.[11]

Thus we can also define the general steps for model transformation[12]

1. Searching a model to identify appropriate elements transform.
2. Transforming elements.
3. The retention of tracing information recording which elements in a model are related by the transformation to elements in other models.
4. Detecting updates in one model involved in the transformation and performing relevant operations in the transformations other affected models.

2) **refinement:**

In this step, the transformed model will be manually complemented. Some necessary information which cannot be transformed directly from previous model will be complemented in this phase. The whole changing should be noticed in a monitoring method.

3) **Evaluation**

The model should be evaluated after finishing transforming. The evaluation criticisms are defined by vendors and stakeholders who attend this modeling. The results of evaluation should be recorded and it is also a basis of "status". The process model provides some basic evaluation criticisms. The user can also add some customized evaluation criteria according concrete modeling. But, for ensuring flexibility and

[11] Uni-Prof. Dr. Dimitris Karagianis, Haradkühl, Franz Bayer, Stefan Junginger: Enterprise model Integration, September 2003, LNCS 2738, pp. 379-392.

[12] Model transformations and tool integration, Laurence Tratt, http://tratt.net/laurie/research/publications/papers/tratt__model_transformations_and_tool_integration.pdf

coherence of modeling, the design process model doesn’t provide any concrete evaluation methods.

5.3. The Repository

The Repository of design process model is a set of modeling concepts, modeling patterns, transformation rules and concepts etc. The system designers or other users can model and transform necessary distinguish models after the sequence of design process model more easily. The whole design procedure will become more automatic. The part of manual modeling and transforming would be reduced.

The Repository is however not a standard or definition which forces designers to use. The Repository provides merely advices or concepts, which help system designer to design the model and transform it more easily. It is very familiar in code programming: each program language such as java, C#, PHP etc., provides countless functions or methods for the realization of the complicated functions. It is nevertheless the programmers who decide which and how to use those methods. The Repository of design process model functions in the similar way: system designer can decide what and how to use the methods from design process model‘s Repository for their own modeling targets.

The Repository consists of three parts: Modeling concept, transformation rule and technical issues:

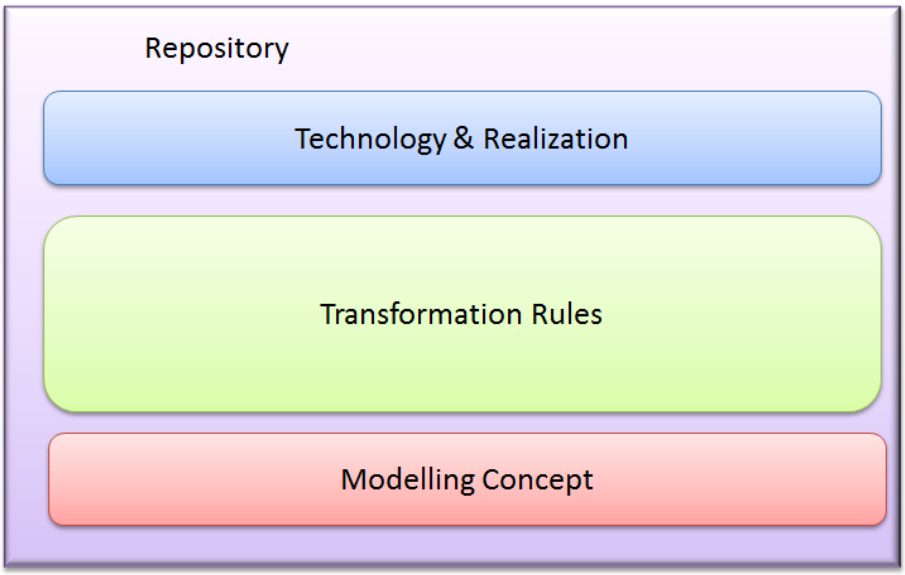


Figure 9 The structure of repository

The first level in Repository is modeling concept. In this level the issues such as modeling language, modeling tools, and transformation concept will be described and fixed. That is the overview of modeling and it controls the whole modeling in each step of process model. Thus, the Transformation rules level and technology and realization level can be part of modeling concept, in order to allow the users to define, design and transform the model better.

The transformation rules is the second level of Repository, with which the concrete transformation rules should be defined. In addition, there are also some mapping patterns or transformation patterns, which can be used in model transformation.

The third level of the Repository is Technology and Realization. In this level the technical concept for modeling concept and transformation shall be provided, such as the concrete transformation code for transformation rules.

1) Modeling concept:

The first function of the Modeling concept is a summary, which describes the general modeling plan from choosing modeling tools, modeling methods to final technical realization. The modeling concept provides samples to advice users on how to choose the corresponding modeling methods, transformation rules from the view of modeling and planning in advance.

Actually, the modeling concept plays a role like "pattern" in soft Engineering. For example, if a designer chooses BPMN as business process modeling language, the modeling concept would then suggest in which way information model and data model should be further developed. Meanwhile, transformation rules and technical solutions can be provided as well. In this way, designers can get an overview or plan about modeling in advance so that they can avoid some unexpected problems in the transformation and realization.

Table 2, an example of modeling concept

Models	Situation description	Modeling tools	Modeling language	Transformation Approach	Technical solution
Business process model	1, what 2, how 3,where 4,who 5, when 6, why	● Bizagi modeler: Export: XPDL ● Eclipse STM modeler: Export: xmi file	BPMN	● ● Updating	● QVT transformation language ● Manuel ● Tools: mediniQVT
Information model	● Getting information From BPM ● Complementing information manual	● Eclipse UML2 Tools ● Import: xmi file, ● Export: xmi file.	UML	● Updating ● Transformation rule BPMN to Information model ● Transformation rules from Repository	● QVT transformation language ● Manuel ● Tools: mediniQVT
Data model	● complementing Data structure ● Complementing data design	● Eclipse UML2 Tools ● Import: xmi file,	UML	● Transformation Information model to data model	● QVT transformation language ● Manuel

	manual	● Export: xmi file.		● Transformation rules from Repository	● Tools: mediniQVT
Infrastructure model	● From data to design infrastructure model	● Eclipse UML2 Tools ● Import: xmi file Export: xmi file.	UML	● Transformation Information model to data model ● Transformation rules from Repository	● QVT transformation language ● Manuel ● Tools: mediniQVT

A simple example for modeling concept is presented in the above table. With modeling tools, modeling language and transformation rules are defined in advance in this table. The technical solution is also fixed.

The first Column "Situation description" describes the general situation about design and modeling.

The "transformation approach" should include transformation rules, and steps in modeling concept. Concrete contents about transformation rule for each transformation will be explained in transformation rule level of Repository. In modeling concept, only names of applied rule are listed.

Technical solutions define the concrete tools and technologies to implement the transformation rule. The implementation should be present with code format.

Another function of modeling concept is to provide a control template. The user can plan the whole modeling process with this template control.

Table 3, an example of control template

Model	**Results**	**People**	**time**	**why**
Business process model				
Information model				
Data model				
Infrastructure model				

The above table is an example of control template. The Colum "Results" records the corresponding model and design results. In the "people" Colum, the responsible stakeholders are indicated. The "time" means milestone and schedules of the modeling. The Column "why" provides the goal and evaluation critics on modeling.

2) Transformation rules

On the level of the transformation rule, the distinguish model transformation concepts and mapping concepts are summarized. Through these transformation rules, the models in a higher level can be automatically transformed from model in a lower level. Transformation rules in Repository are however not transformation standard for designers. The transformation rule provides only “suggestions” or “advices” for users to reduce design time and to make sure the rationality and logic in design.

Besides, the transformation rules cannot perfectly finish the whole modeling task. The transformed model is only a basis for further designing and to ensure the consistency of modeling.

In addition, the process model provides only concepts on how to design the model of IT system. Therefore, these concepts should be classified through modeling languages and transformation types.

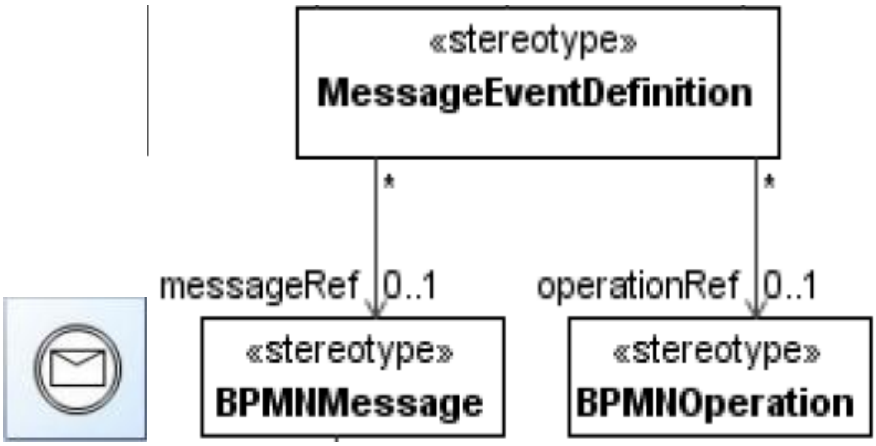
Transformation rules are represented in the table form. In the table, there are few attributes to describe the general transformation rules.

An example of transformation rule is given below. In this example, BPMN is used as business process model and UML is used as information and data model, which illustrates the structure and general design for transformation rule.

Table 4, an example of transformation rule

Rule ID	R123456
Name	BToITimeEventMapping
Domain	Business process model to Information model
Language	BPMN to UML
Method	BPMN Message Event to UML
Abstract	Representation of BPMN Message in UML
Content	

BPMN Message Event:



In the table above, there is a representation of a transformation rule for mapping between two elements in different models. Each rule should have a unique rule ID. This rule ID can help people to navigate the rule and its concrete contents easily.

In addition, the basic information about this rule should also be listed in rule description table. For example, the domain attribute explains in which phase of process model is the rules applied to and the "Language" attribute describes the modeling language etc.

- **Rule ID**
  The ID of rule helps users to navigate the rule in Repository. It is also a unique Identifier of rule.

- **Name**
  The Attribute "Name" describes the name of rule

- **Domain**
  The attribute "Domain" provides the information like in which steps of process models should be used. In the above example, this rule is appropriate for transformation from business process model to information model.

- **Method**
  In process model, the concrete modeling language is not defined. The "method" attributes to explain which kind of language the rule used is therefore needed.

- **Abstract**
  In case the rule is very complicated, the "Abstract" provides the user an overview about the concrete rule. With the abstract, the user can easily understand the content of rule.

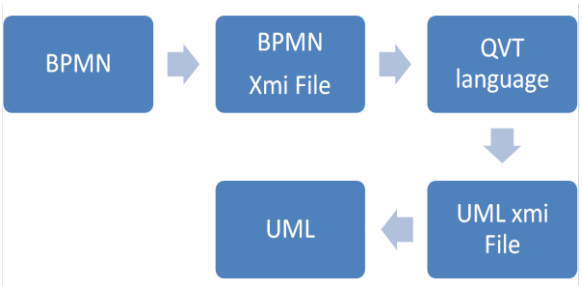
- **Content**
  The content describes the concrete information about rule. The details about rule should be explained in this part. The "Content" is the most important part of the table.

3) Technology and realization

The "technology and realization" is the third level in the Repository. In this part, the Repository provides the concrete implementation about "transformation rule". It concludes the information such as developing technology, developing tools, developing methods and concrete implementation. Meanwhile, the "technology and realization" is presented in table form and referenced with rules ID.

The implementation in "technology and realization" is shown in the example below:

Table 5, an example of technologies and realization methods

Developing Concept ID	DC12345
Reference transformation rule	R123456
Developing concept	
With QVT language to transform from BPMN to UML 	
Developing tools	mediniQVT

Code or implementation

relation FlowNodeToActivityNode
{ checkonly domain bpmn fn : FlowNode { };
enforce domain uml an : uml::ActivityNode { };
where {
//map Events
StartEventToInitialNode(fn, an);
IntermediateCatchEventToAcceptEventAction(fn, an);
BoundaryEventToAcceptEventAction(fn, an);
//map Gateways
//map Activities
}
}

Seen from the table above, the implementation advice is shown to have following attributes:

a) Developing Concept ID

This attributes is similar to Rule ID. It is a significant mark of ID and used for identifying or navigating the developing concept.

b) Reference transformation rule

The reference transformation rule is Rule ID, whose rule should be implemented. With this attribute, the user can find out relevant transformation or mapping rule in level "transformation rule".

c) Developing Concept

Developing concept explains the concepts, such as technologies, methods or approaches to implement the transformation rule. In above example, this implementation at first converts the BPMN to BPMN XMI file, by using QVT language the BPMN XMI file then converts to UML XMI file and finally gets to UML file.

d) Developing tools

The Attribute "Developing tools" suggests the tools are used by the users to realize the developing concept. In this example, the tool "mediniQVT" is recommended. This suggestion, however, does not force the designer to use this tool. The designer can also choose any other tools that one desires.

e) Code or implementation

The code or implementation is the core of "technology and realization". In this part the concrete details about implementation will be presented. In this example, the QVT language code is the content of this part.

5.4. Evaluation

The Evaluation is a process which developers and designers control and examine the modeling results. It includes following aspects:

1) Information checking
   The information or important issues should be covered in model.

2) Transformation validity and logic
   Used transformation rules should be checked again from view of general model to ensure that the transformation is logical and rational.

3) Completeness controlling
   Some additional information has been added in the refinement phase. The validity of completed information is therefore required to be checked again.

4) Requirements checking
   After checking syntax and semantic, the quality of model should be evaluated. The model should be tested to decide whether it can meet the modeling requirements and needs for transformation of next step. In additional, some customized requirements should be also checked.

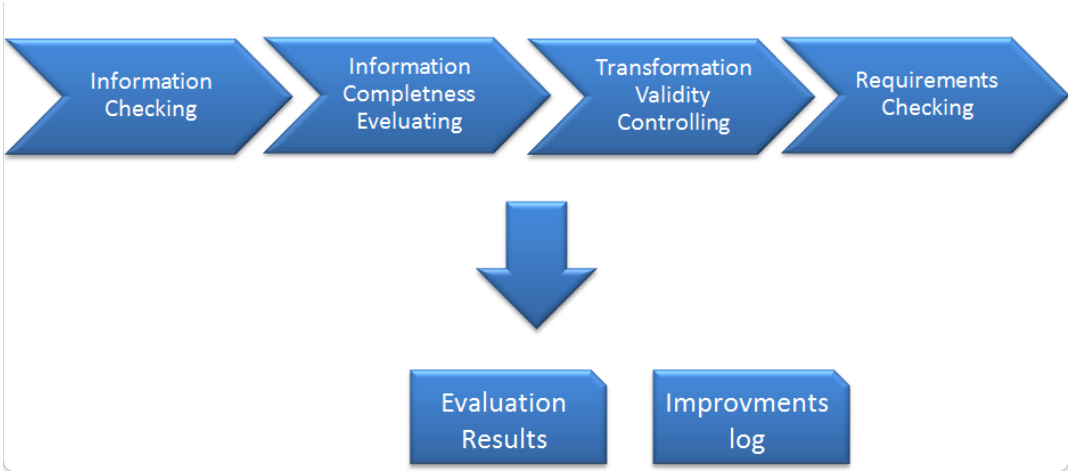


Figure 10 important steps of evaluation

Since evaluation criterions depend on the concrete requirements of modeling, the design process model does not provide concrete method to ensure the quality of modeling. Nevertheless, it suggests the aspects in the model that should be checked and controlled. The results of evaluation are also a basis for further improvements. Protocol is also subject to continuous improvement. Therefore, each modeling process should be an iteration process and results of evaluation can be seemed a log information.

5.5. Overview of modeling procedure

As discussed in the previous chapters, the design process model includes four steps for system designing: business process modeling, information modeling, data structure modeling and system infrastructure modeling. These four model types present different aspects of system design and also give IT managers a overview of IT system.

The modeling procedure in design process model is also an organized design phase. It is a kind of management to help developer to organize and manage development. It should always be like the following steps:

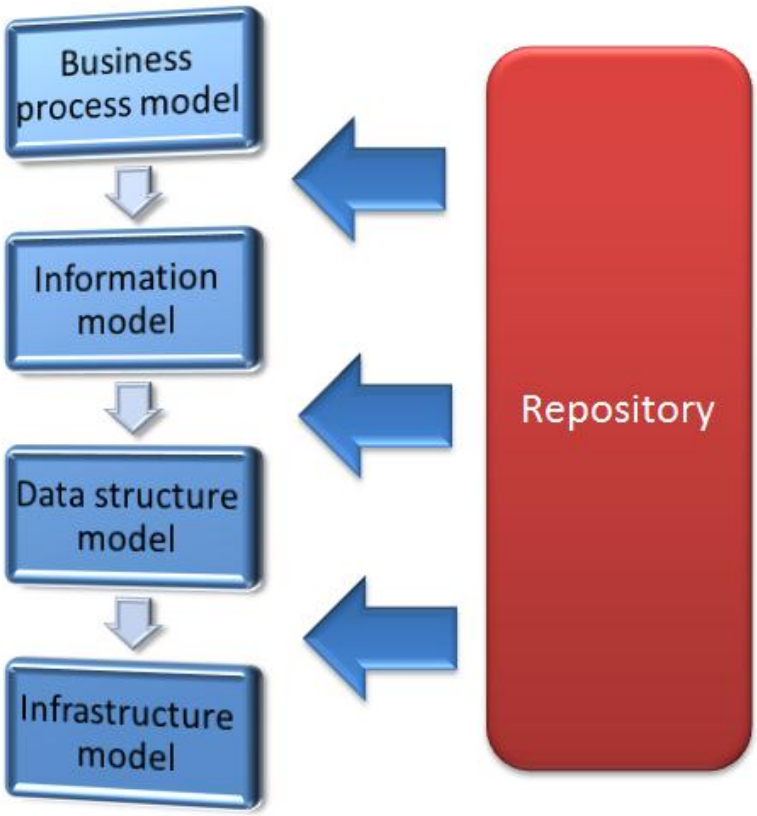


Figure 11 Overview of modeling procedure

The whole design process begins with business process model, which gathers all information about enterprise business. From this business model, developers can also define information that need to be handled and then summarize the information into information model. The information model is the basis for designing data structure of information system. It provides developers with scopes and domains about data.

Data model is a more detailed information model. Data structure about information system, database and business logic will be modeled in this model. It is the final concept for IT data structure.

After defining data structure, the structure of whole system in infrastructure model can be finalized.

The overall process is supported by the repository. The repository provides methods, patterns, transformation rules to help developer to finish modeling and designing in a more convenient way.

5.6. Summary of this chapter

In this part, the theory and concept of design process model for designing harbor logistic planning system is explained. Generally, this design process model is a framework for rational and logical designing information systems in enterprise. It provides not only a method to organize and control software development, but also defines the general transformation or mapping rule to ensure the consistency of modeling.

The purpose of developing the process model is to avoid problems, which occurred in designing and later updating. For example:

- IT strategy cannot be implemented or executed in later design or implemented phase.
- Inconsistency in system design
- Integration or updating problem
- Black box developing

The Inspiration of design process model is based on the MDA and model transformation in MDA. Some technologies, definitions and standards in MDA would therefore be used to realize process model. Meanwhile, this process model is considered as a complementation from CIM to PIM in MDA development. With this design process model, the information in the real business world is easier to implement in UML based PIM model.

Nevertheless, this process model is not like MDA which rules much coerciveness to make sure the execution of final code. This design process model provides just some suggestions and advices to reduce modeling time and make sure the flexibility of design at the same time.

- Repository is warehouse to conserve main transformation rules and concepts. It is a library to ensure logical and rational design.
- Process model is the core of the general structure and provides steps and organization for development of system model.
- Evaluation is influenced by designers, which are criticism for further improvements.

6. Overview Architecture

Architecture is a blueprint; it shows how the overall system and different parts of system interrelate will look like. The system architecture in this thesis is based on “design process model”, which consists of five parts: business process architecture, information architecture, information system architecture, data structures and final system infrastructure architecture. These five aspects should be created in four phases of design process model by using different system models and it should also be implemented in further development process.

The design process model is different from overview architecture. It is only a methodology to create and organize the system models. Relevant architecture of these models can be finalized accordingly. The design process model is a method or tool while architectures are a product of this design process model.

In this chapter, the general system architecture and relationship between design process models will be explained. The usages of design process model and different models to create information architecture will also be present in following chapters.

6.1. System Architecture

As discussed above, the system architecture is a blueprint of the overall system, which describes system structures, technologies, and organization. Besides, the most distinctive feature of design process model is that it can organize different aspects of system architecture systematically. The system architecture in this thesis is therefore based on system models from design process model and inherited from the logical structure of system models.

The whole system architecture is illustrated as below:[13]

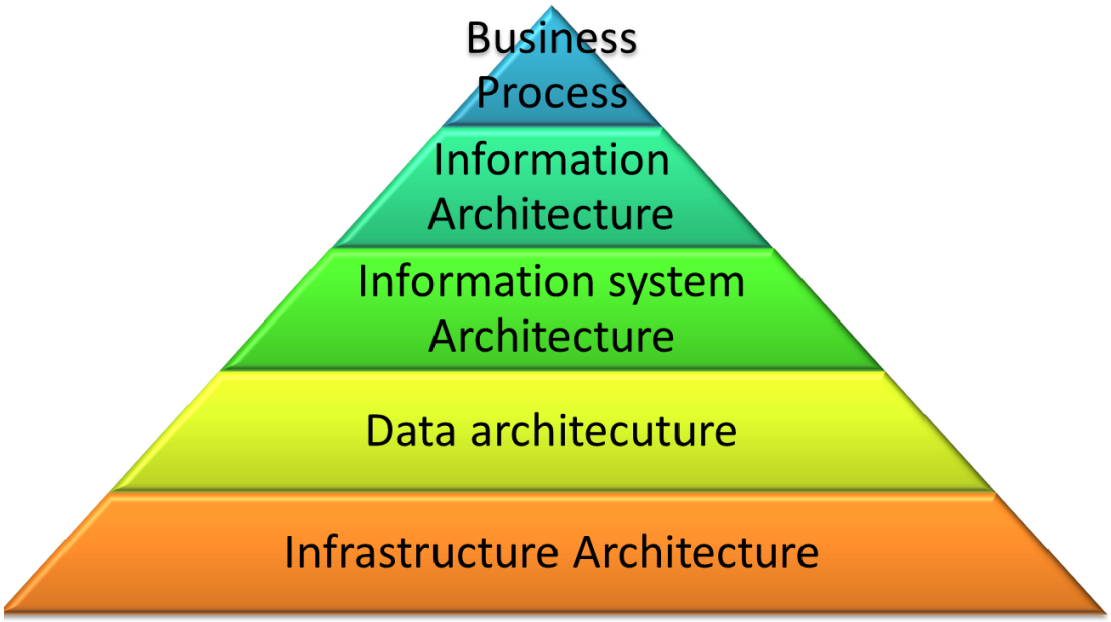


Figure 12 Information system architecture

This architecture is described in the book "information systems management in practice" by Barbara c. Mcnurlin. The architecture in this thesis is based on the architecture in this book and the design process model will be extended further accordingly. It consists of five parts of system: business process architecture, information architecture, information system architecture, data structures and final system infrastructure architecture. These five aspects should be created in four phases of design process model by using different system models and it should also be implemented in further development process.

[13] Barbara C. Mcnurlin, Ralph h.Sprague, JR.: Information systems management in practice 5 edition, Upper Saddle River, NJ 07458

The first level in architecture is business process. It describes business activities of enterprise. It is the cornerstone for the overall information system. In business process developers and designers can retrieve necessary information that are needed to process. This information is described in information model and this information model is the basis of information architecture.

Besides, with the information architecture, the main components of system can be designed and database structures can be defined. Finally, after summarizing the information from above models, software, hardware, and network information will be gathered in the final infrastructure architecture.

6.2. Relationship with design process model

The design process model has a very close relationship with system architectures. The design process model ensures the logic and coherence of different system models, while these system models are the basis of system architectures. Therefore, the design process model also defines and organizes system architectures.

The design process model can be seen as a supportive tool for information architectures.

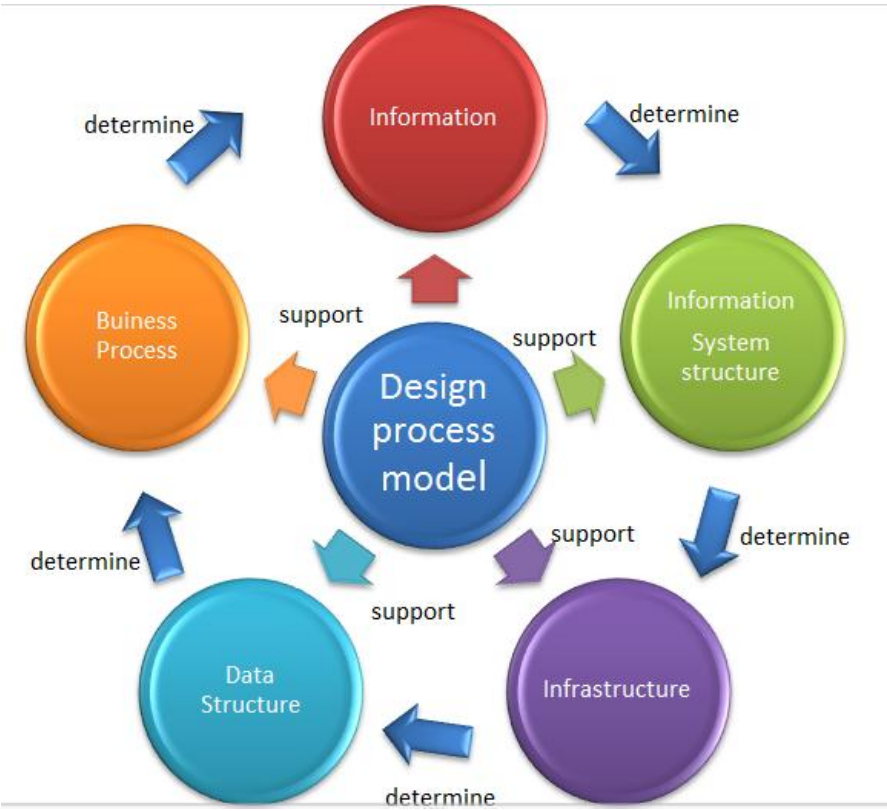


Figure 13 Relationship between design process model and information system architecture

7. Business process model

After discussing the features of the overall design process model and the system architectures, a practice phase will be addressed in the section. In this phase the design process model will be utilized to organize modeling different system models and provide corresponding modeling methods.

Information about business processes in Chinese harbor logistics is summarized in the previous chapters. Each step and corresponding system models will be established in following chapters. Furthermore, transformation rules, mapping approaches and model researching will be elaborated in a precise manner during modeling. Through the following examples, advantages and disadvantages of the design process model will be discussed.

The business activities in Chinese harbor are complicated. They are not merely simple transport and dispatch activities. Instead, the harbor is a marine and land logistic center. It includes various tasks such as custom clearance, warehouse management, dispatching, communicating with shipping agency, executing freight forwarding and so on. Meanwhile, as a logistics center, the harbor should also have the ability of coordinating the transport schedule with other land transport center or logistics center.

Accordingly, the information system of harbor is also rather multiplex to meet requirements of various tasks. It is usually a huge system which includes OA system, data warehouse system, EDI system, communicating interface, ERP system, GIS system and so on.

Given the length of a master thesis, it is unrealistic to model the whole complete Information system. In this paper, one of those business processes and relevant information system is analyzed and modeled by using design process model. The core meanings and thoughts of “design process model” are also elaborated.

In this chapter, the first step of design process model would be carried out. The business process model simulated requirements and business realities for enterprise. Therefore, business process can specific order the activities with clearly identified inputs and outputs. The business process chosen by this paper is a core logistics process of harbor. It contains the set-up of work schedule, marine logistics, warehouse management and land logistic. In following chapters, details about these four topics will be explained and the relevant transformation will be presented as well.

7.1. Business process modeling foundations used in this thesis

The business process model is groundwork for the business process design. It summarizes the information from “gathering requirement” phase and translates that information into abstract and sustainable model.

The business process model simulates requirement and business realities for enterprise, which allows the users to order the activities specifically with clearly identified inputs and outputs. For example, a request from customer can be submitted through web page and the corresponding results will be selected. Therefore, through the business process model the designer and user can analyze the information, which will be involved for business activities.

In addition, through simulation of business process in business process modeling tools, the users and managers are able to find out the weak points or shortcomings in business processes in order to improve the business process to make more business values.

Considering the purpose of business process modeling, the optimizing business process is not the major research focus in this thesis. The business processes to be modeled will therefore be seemed as optimized business processes.

In this chapter, the first step of our process model – “business process modeling” will be practically explained and applied into modeling a business process model for harbor logistic center. In addition, from modeling of practical example, the “decision” criterion in process model and the status of business process model will be complemented. On the other hand, we could also clearly identify sub steps in business process modeling. However, we cannot determine the transformation rules and mapping rules before understanding the exact request of information model. Therefore this part should be identified in next chapter.

7.2. The selection of modeling methods and tools

There are many available modeling tools and modeling methods for business process modeling. Given the importance of business process model in business management, IT developing and business process management, each organization and institute has developed many different types of modeling to describe the business process. In following table, the popular modeling techniques are listed[14]:

- Business Process Modeling Notation (BPMN)
- Cognition enhanced Natural language Information Analysis Method (CogNIAM)
- Extended Business Modeling Language (xBML)
- Event-driven process chain (EPC)
- ICAM DEFinition (IDEF0)
- Unified Modeling Language (UML), extensions for business process such as Eriksson-Penker's

Selection of modeling technique for the business process modeling of this thesis is not an easy task; since each modeling technique has its own technical pros and cons. The technique should be applied cannot be selected merely from model's features. The general selecting process must meet following conditions:

- Clearly defined the activities in business process model
- Clearly defined the exchange information
- Views from IT aspects
- Easy understandable
- The organizational structure

After comparing the modeling techniques, the Business Process Modeling Notation (BPMN) is chosen for the business process modeling techniques in this thesis.

BPMN provides a number of advantages for modeling business processes compared to the Unified Modeling Language (UML). Firstly, it offers a process flow modeling technique which is more conducive in the way business analysis model.

Secondly, its solid mathematical foundation is designed to map business execution languages, whereas UML is not. BPMN can map UML, and provide a more solid business modeling front end to systems design with UML. The Business Process Modeling Notation (BPMN) is a new standard to model business process flows and it can also describe the corresponding web services. It is created by the Business Process Management Initiative (BPMI). The first purpose of BPMN is to provide a notation that is easily understandable by all business users. This includes the business analysts that

[14] http://en.wikipedia.org/wiki/Business_process_modeling

create the initial drafts of the processes to the technical developers responsible for implementing the technology that will perform those processes.[15]

Thirdly, the BPMN can also express XML languages that designed for the execution of business processes with a common notation, such as BPEL4WS (Business Process Execution Language for Web Services) and BPML (Business Process Modeling Language). This feature is useful for further Information and data design.

Selection of tool is crucial. The user can choose whichever tools that he/she wishes. In this thesis, the BizAgi process modeler is selected.[16]

15 Martin Owen and Jog Raj, Popkin: BPMN and Business Process Management, http://www.omg.org/bpmn/Documents/6AD5D16960.BPMN_and_BPM.pdf

16 http://wiki.bizagi.com/en/index.php?title=Introduction

7.3. Core requirements of modeling

The goal of modeling the business process is to gather the basic business information for Information system. The stakeholders' requirements in IT aspect should focus on the business activities. With this business process model, the blueprint of business process with IS support should be illustrated and evaluated. Meanwhile, the system designer from business process model can get basic knowledge about exchanged information in business transaction. The requirements of business process model can therefore be summarized into two aspects:

1) **Business process modeling**

   The business process model is a type of model which should meet all requirements of model. Clear physical steps, sequences and organizational structures are the basic requirements of model. Meanwhile, roles and responsibilities of individuals, decisions from workers and documents produced should also be considered in model. Thus, as a first step of information system development, the link between internal and external process, the parts of the process supported by IT systems and the matched of the IT systems are very important aspects in business process modeling.

2) **Purpose of business process modeling**

   The purpose of model business process should be embodied with emphasis of model. For example, if the purpose of business process modeling is to understand the structure of human resources, the aspects such as organizational structures, roles and responsibilities of individuals should be illustrated precisely in the model. Other aspects of model can be simplified.

7.4. Important business process modules in harbor environments

As noted in the above chapter, the overall original intention for this thesis is to design a harbor-logistics-oriented IS design process model. Therefore, the harbor logistics business is taken as an example throughout the whole modeling phase.

The business activities and process of harbor logistic consist of four main aspects:

1) Setting up work schedules
2) Marine transports and logistics
3) Land transports and logistics
4) Warehouse tasks

The harbor company firstly makes a company's general business schedule for a season. This schedule includes all information about the shipment, cargos and ports. Meanwhile, this schedule assigns the basic transport and depot tasks for each working team. After discussion with working teams, working units or responsible managers, the schedule should be improved and complemented.

The completed schedule will be assigned to each corresponding working unit. The working unit must make their own work plans after the assignment and carry out the Marine and land transport tasks.

The warehouse tasks should depend on the situation of marine shipment and land transport, in case a replacement of the cargo is needed.

1) Making work schedules

In a harbor, there are two levels of organizations to manage the business operation. One is Harbor Co. Group, the other one is Port Company.

The Harbor Co. Group is usually a holding company that runs the business such as harbor constructions, harbor developments, investments, and logistics etc. The main business responsibility of Port Company is port logistics. Therefore, according to the requirements of the enterprise, the harbor Co. Group should firstly give the port company information about shipment and cargo. At the same time, after receiving the information from Co. Group, the port company should make work schedules for one business season. After discussing with responsible departments, the work schedule and work assignment for whole harbor will be issued.

With this work schedule, the relevant information of work schedule will be saved in a backup in Harbor Co. Group. The information will also be reported forward to relevant official government later.

The business process of the work schedule is illustrated in the following model:

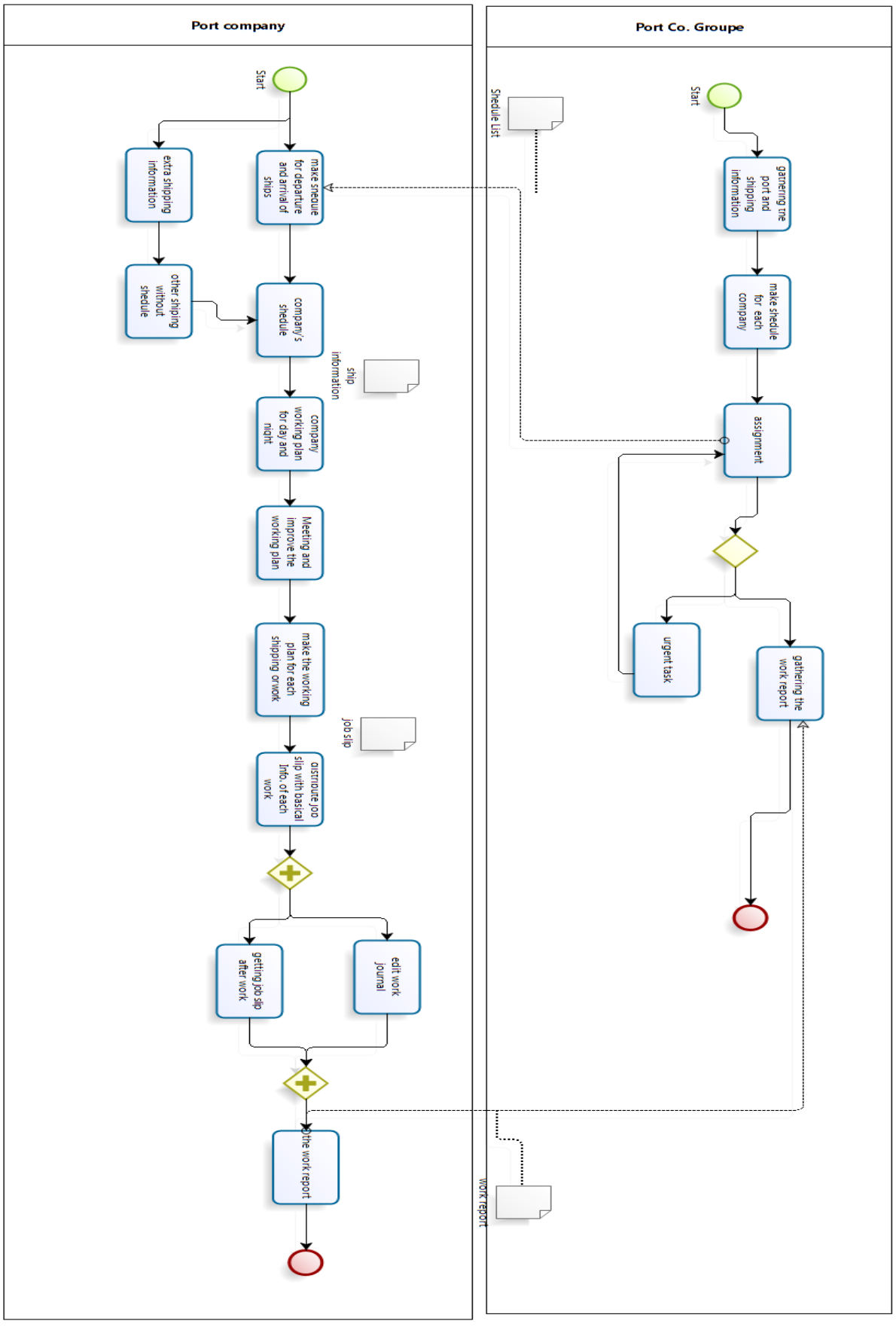


Figure 14 business process of making work schedule

2) Shipment departure and arrival

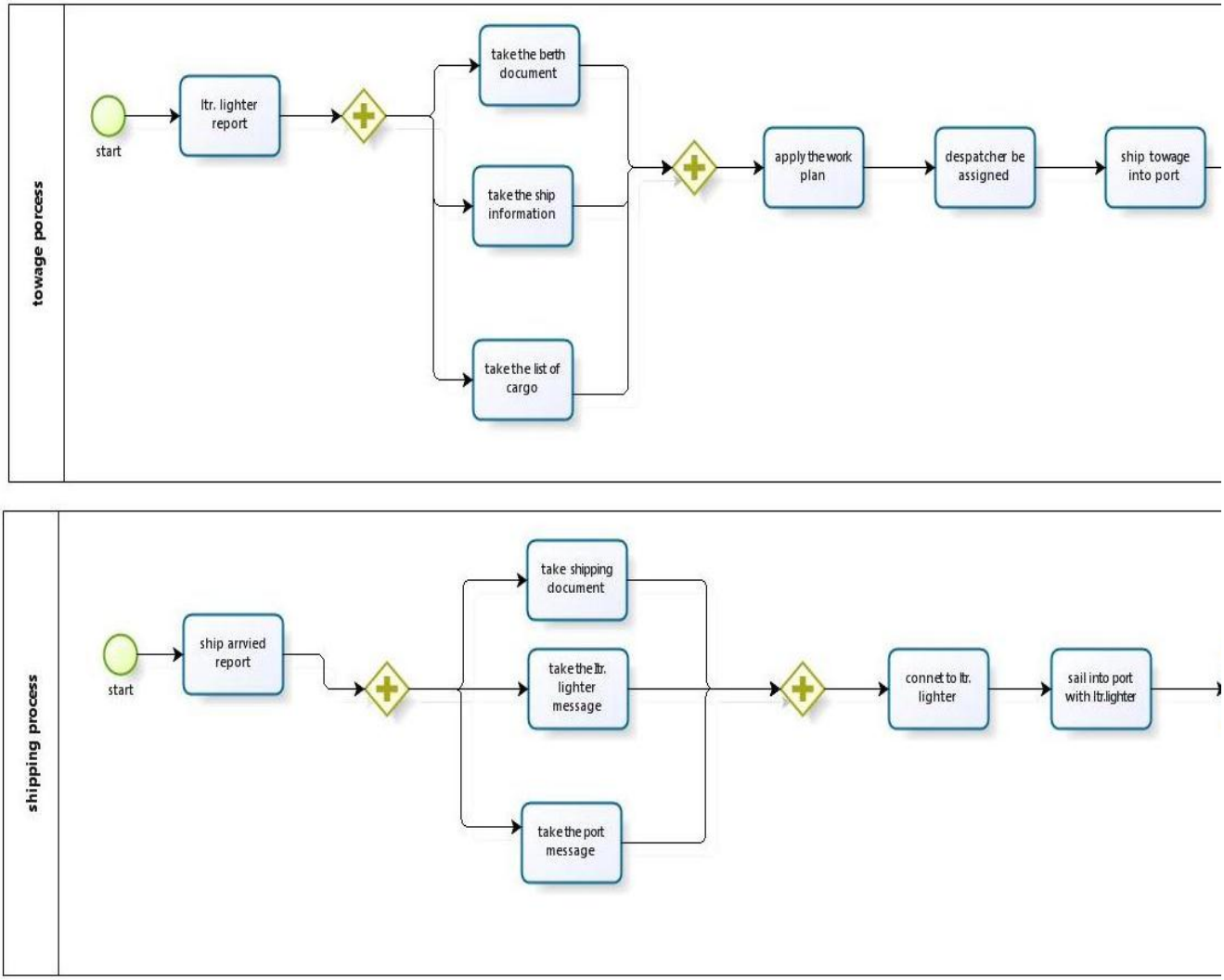


Figure 15 Ship departure and arrival part 1

The marine transport and logistics from the port's point of view mainly contains two processes. One is ship arrival; the other one is ship departure.

Seen from the above model, the arrive process is: firstly, the towage from port reports to the port dispatcher about the status and position of towage. The towage then gets the information for port dispatchers such as berth document, ship information and cargo information. According to this information the towage arranges a work plan which issues the details of towing and sends to dispatcher. After summarizing all information from different towages, the towage will be assigned for a towing work by a dispatcher, the ship and towage can communicate with each other during the towing process. The towing work is finished when the ship reaches the planned port successfully.

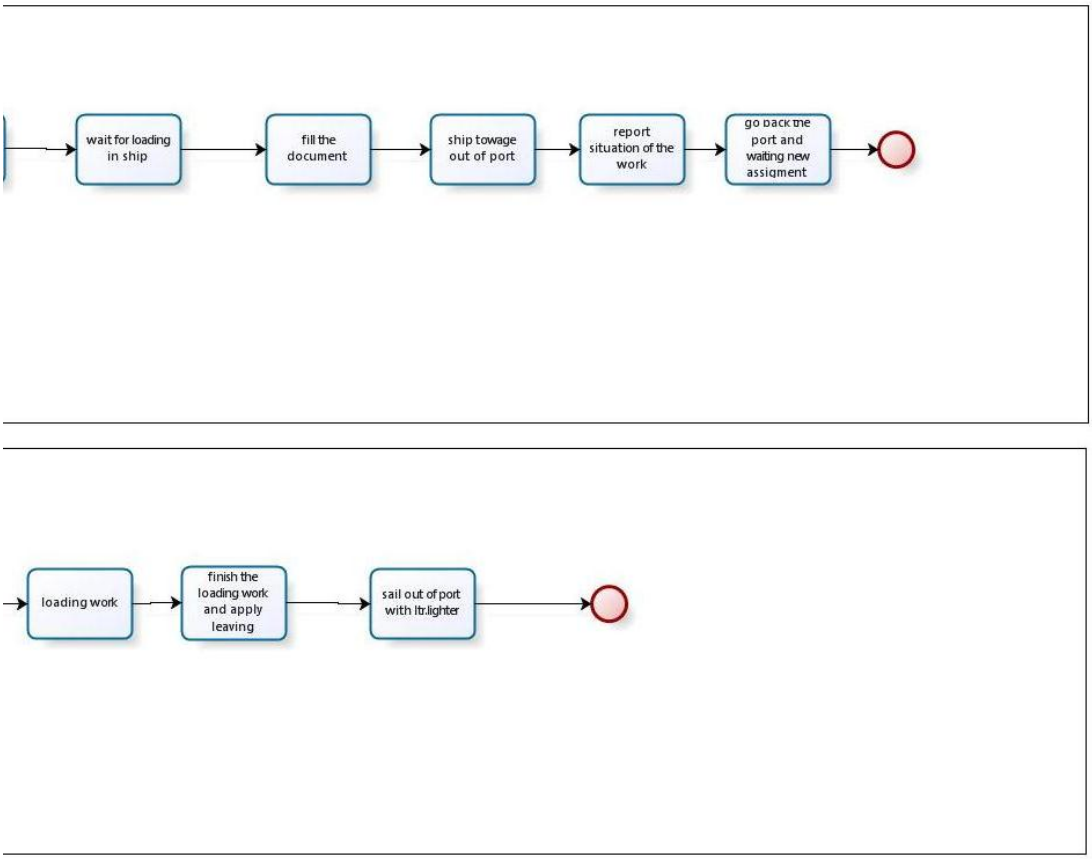


Figure 16 Ship departure and arrival part 2

After loading the cargo, the departure process must be issued, which is similar to the arrival process. The whole process is thus not illustrated again.

3) Land transport and logistic

Land transport and logistics is another aspect of the marine harbor logistics. Land traffic vehicles are the main transport tools for land logistic work. The general business process is as below:

Firstly, vehicles which plan to load or unload the cargo from port, arrives at the harbor's station. The information about this transport tools and corresponding transported goods should be delivered to responsible dispatchers. The dispatcher will inform colleagues in warehouse and gather information from warehouse.

The loading work is assigned by dispatcher by distributing the work sheet with loading plan and local information. Vehicles will then carry out the loading work accordingly.

The dispatcher will also have a work record after finishing loading work is finished , which must be confirmed by other business partners or agencies, such as ship agency, cargo agency, and the custom.

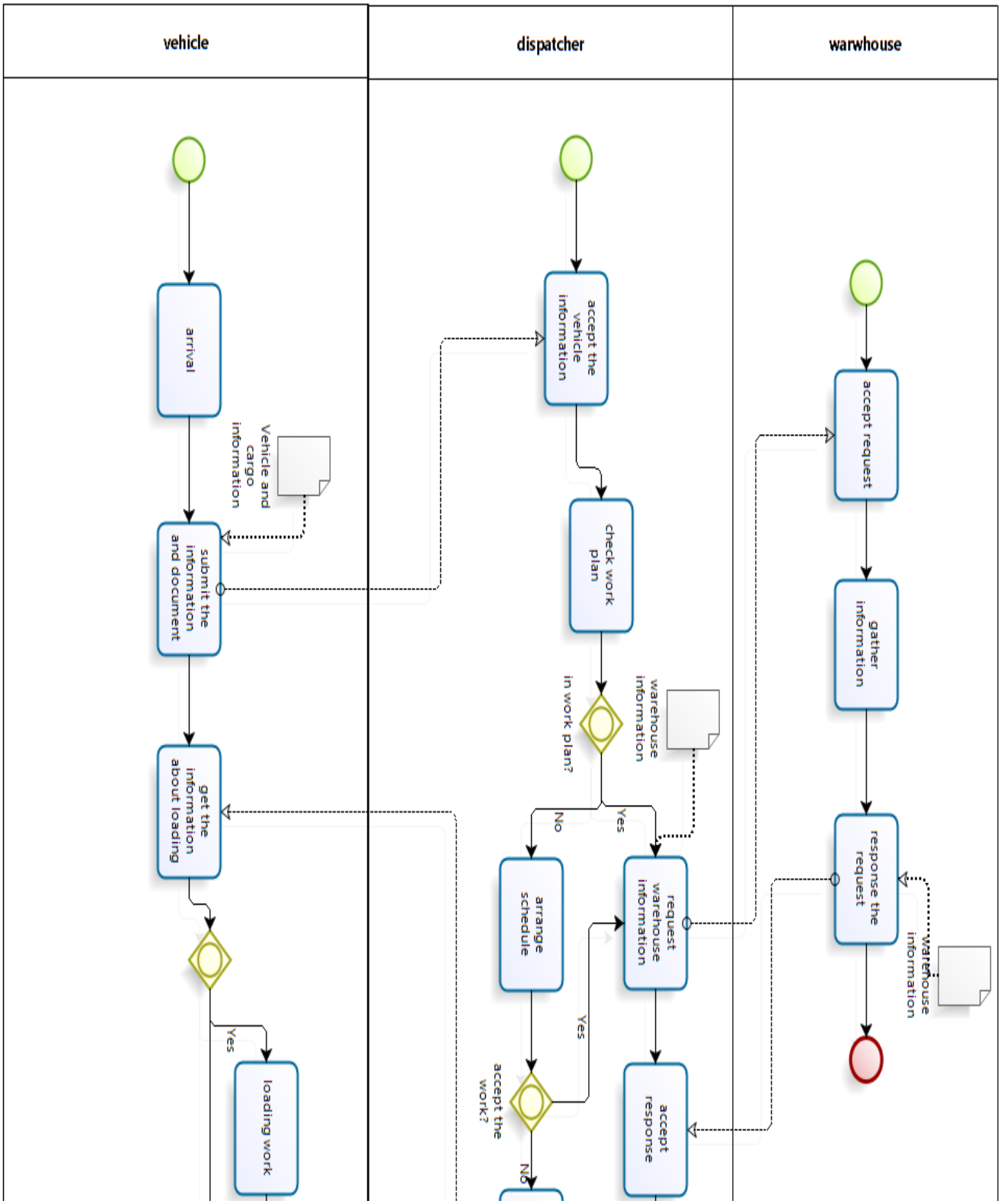


Figure 17 Land transport and logistics part 1

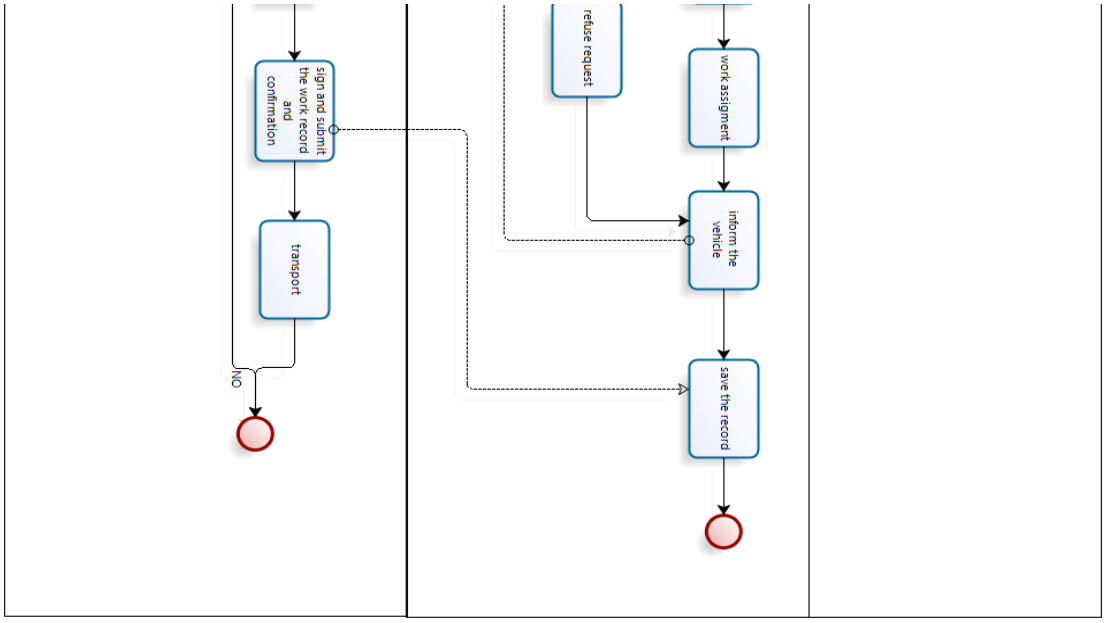


Figure 18 Land transport and logistics part 2

4) Warehouse task

The warehouse task includes all container transport activities, such as the connect-point inside the warehouse between the land logistics and marine logistics.

The purpose of warehouse tasks is to avoid the shortage of warehouse room and to manage the cargos in warehouse more efficiently. Concrete activities are as below:

The warehouse manager coordinates cargos positions, according to the storage plan and transport plan. If he finds the situation such as overtime storage or unpunctual transport, he reports to central dispatcher and also adjusts the position of cargos to make sure enough room in the warehouse to keep merchandises in plan. Meanwhile, the manager also needs to assign the worksheet to responsible workers and receive the situation reports from workers.

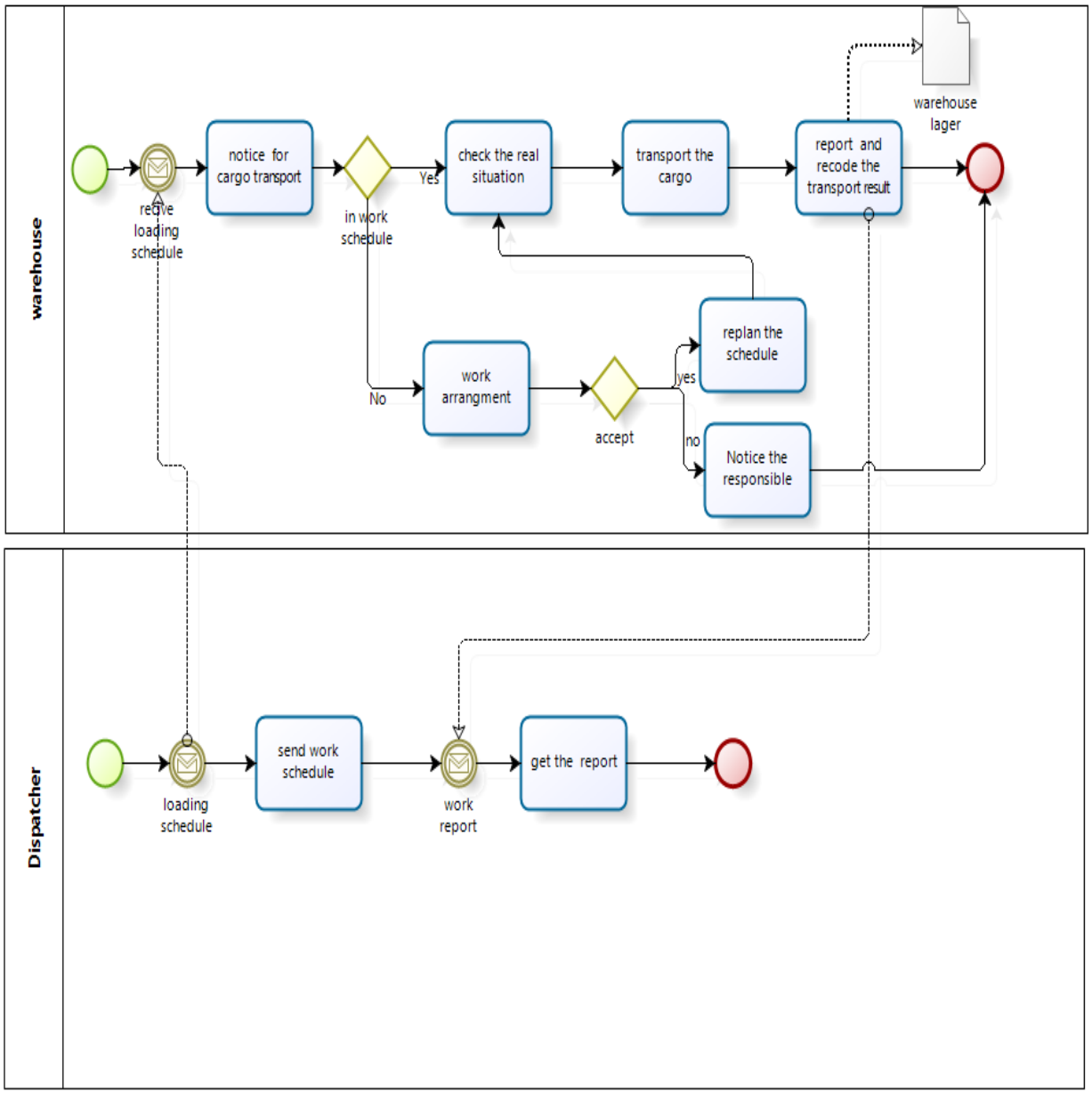


Figure 19 the business process of warehouse task

7.5. Summary of this chapter

In this chapter the business process model is researched and modeled. The business process model is the first model in design process model; the business process model can be seen as information gathering phase in the whole design process model. The important business activities and exchanged information between business partners is already modeled in this part. In the example in this chapter, the whole cargo transport inside of harbor is abstracted into a business process model. With this business process model, the designer can have an overview of the situation with business partners and stakeholders in cargo transport.

However, the business process model provides designer with a basic “platform” or “background”. It is like a “domain” or “scope” to restrict the explanation of the IT system. The business process model is however not able to provide the system designer with more structural information which can direct applied in IT system. The designer therefore needs to transform the Business process model into information model with further design by following steps of design process model.

The business process modeling in design process model has minor difference from general business process model: the business process model in design process model modeled is more information-oriented than normal business process model. The emphasis of modeling should be in a range of information events, exchanged information, information relevant business activities and partners. The irrelevant activities such as hand work, carrying cargo should not be playing an important role.

8. Information model

Information modeling is the second step in the process model. The main purpose of an Information model is to model the managed objects at conceptual level. It should be independent of any specific implementation or situation. Therefore, the information model should also hide all protocol or implementation details to ensure this "independent". But, the necessary relationship between managed objects should be defined.[17]

In our case, the information model should be transformed from previous business process model. So the managed objects in our information model are all exchanged and relevant information in business process model. But another question we must consider before researching transformation between business process model and information model is: how the information model should be expressed?

The representation method of information model is various. It can be defined by using a formal language or a semi-formal structured language. But through class diagrams of the Unified Modeling Language (UML) to present the information model is very popular today. The reason is very simple: UML is standardized by the Object Management Group (OMG) and UML presents the advantage of being widely adopted in the industry. In our case, the information modeling is the basis of further data modeling. Using UML to describe the data model is first choice for every programmer or system implementer. Therefore, using UML to model the information model can avoid complicated work in transformation for different types of model.

Therefore, we could treat the transformation between business process model and information model as BPMN to UML. But it is very important that this transformation is not 1:1 transformation, since only information element in business process model should be retrieved.

17 A. Pras, J. Schoenwaelder ,On the Difference between Information Models and Data Models, http://www.ietf.org/rfc/rfc3444.txt

8.1. Transformation

It can be seen from the theoretical framework of this thesis that the general model transformation includes 3 parts: transformation, refinement, and evaluation.

1) Transformation rules:

The information model is abstracted from information and data elements of business process model. Therefore, the transformation rule should be defined in advance.

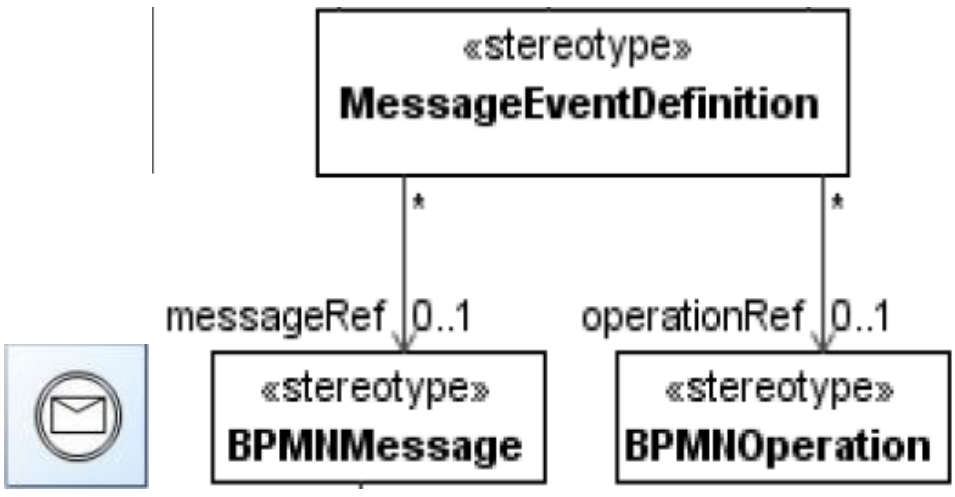
From theoretical framework of the thesis, it can be seen that in the repository there are many rules that can be used for transformation of information elements in business process model to information model. Besides, by modeling business process model, the modeling concepts are also defined. From modeling concepts the relevant rules can be found as the below:

a) Rule "information event"

Table 6 transformation rule of "information event"

Rule ID	R123456
Name	BToITimeEventMapping
Domain	Business process model to Information model
Language	BPMN to UML
Method	BPMN Message Event to UML
Abstract	Representation of BPMN Message in UML
Content	

BPMN Message Event:



b) Data exchange

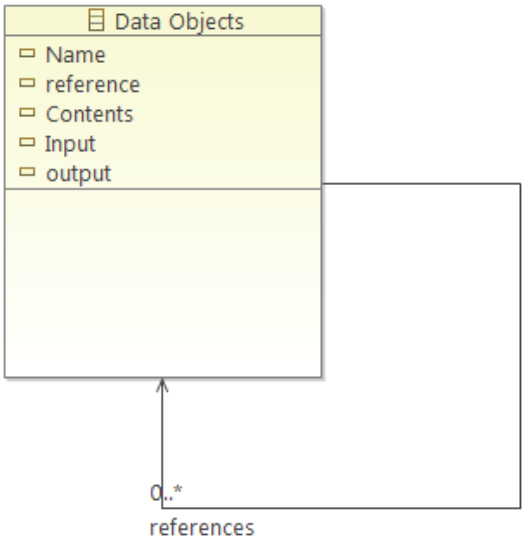
Table 7 Transformation rule of "Data exchange"

Rule ID	R123457
Name	BToIDataMapping
Domain	Business process model to Information model
Language	BPMN to UML
Method	BPMN data to UML
Abstract	transformation of exchanging data into UML Class
Content	

BPMN Data : 

- Data Objects are Artifacts that are used to show how data and documents are used within a Process
- Data Objects can be used to define inputs and outputs of activities
- Data Objects can be given a "state" that shows how a document may be changed or updated within the
- Process

transformation to UML:

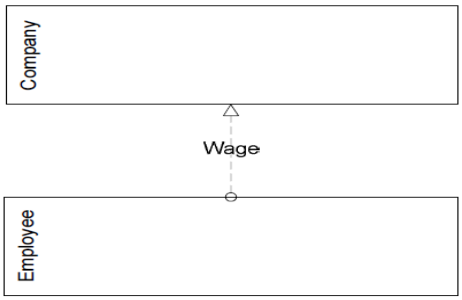


- Data Objects is a class in information model
- Data class has attributes: name, reference, contents and input, output
- Attributes input and output define the flow of data
- Data class can connect other data class.

c) Message flow

Table 8 Transformation rule of "Message flow"

Rule ID	R123458
Name	BToIDataMapping
Domain	Business process model to Information model
Language	BPMN to UML
Method	BPMN data to UML
Abstract	transformation of exchanging data into UML Class
Content	



BPMN message flow :

A Message Flow is used to show the flow of messages between two participants of process In BPMN, separate pool are used to represent the participants

A Message Flow can connect to the boundary of the pool or to an object within the pool

Message Flow are not allowed between objects within a single pool

transformation to UML: 

- identify the flow of information
- has attributes name and constraint

The rules about information elements transforming from BPMN to UML are mapped.

In addition, considering the further modeling of information model in refinement and evaluation parts, the information model has to be more structural, so as to carry out the complementation later easily.

For this purpose the information class after business partner who is involved into business activities is separated. The "Swim lane" elements are needed to be transformed into scope class.

2) Technology and realization

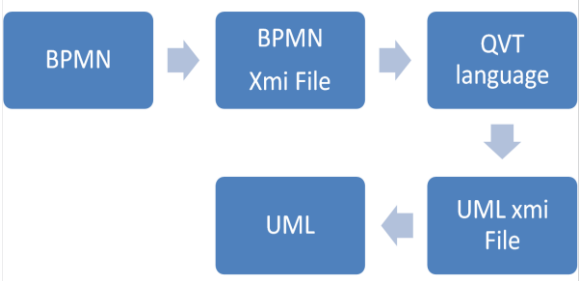
After defining the transformation rule, how to realize the model transformation has to be considered. The technology and tools selection are the main content in this section.

From theory parts, the repository has also technology suggestion in level "technology and realization". Firstly, it is required to find out whether there is any appropriate implementation suggestion in Repository. If the users do not like the implementation method saved in Repository, they can also develop their own implementation methods. These implementation methods must however, recorded in the transformation rule and modeling concepts in advance.

For an easier understanding, in this example implementation methods which have been already in Repository are applied.

a) Implementation of BToITimeEventMapping

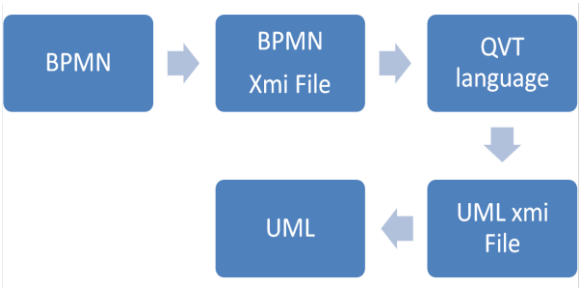
Table 9 Implementation of transformation rule "information event"

Developing Concept ID	DC12345
Reference transformation rule	R123456
Developing concept	
With QVT language to transform from BPMN to UML 	
Developing tools	mediniQVT
Code or implementation	

```
top relation MessageEdge2InfoPackage{
   infoName:String;

  enforce domain BusinessProcessModel s:bpmn::MessagingEdge{
           name = infoName,
           source = sou: bpmn::MessageVertex {},
           target= tar:bpmn::MessageVertex {}
       };

  enforce domain InfoModel i:SimpleUML::UmlPackage{
           umlName = infoName

       };
      }

top relation MessageEdge2InfoPackage2{
   infoName:String;

  enforce domain BusinessProcessModel s:bpmn::MessagingEdge{
           name = infoName
       };
  enforce domain InfoModel i:SimpleUML::UmlPackage{
           umlName = infoName

       };
      }

 top relation MessageEvent2InfoClass{
   infoName:String;

  enforce  domain BusinessProcessModel s:bpmn::MessageVertex {
        incomingMessages = incoming : bpmn::MessagingEdge {},
        name=infoName,
        outgoingMessages = outcoming : bpmn::MessagingEdge {}
       };

  enforce domain InfoModel i:SimpleUML::UmlClass{
          umlName = infoName,
     umlNamespace = pack : SimpleUML::UmlPackage {}
       };
    when{
    MessageEdge2InfoPackage(incoming,pack);
    MessageEdge2InfoPackage2(outcoming,pack);

    }
}
```

b) Implementation of Data exchanging

Table 10 Implementation of transformation rule "data exchanging"

Developing Concept ID	DC12345
Reference transformation rule	R123456
Developing concept	
With QVT language to transform from BPMN to UML 	
Developing tools	mediniQVT
Code or implementation	

```
top relation DataObject2InfoClass{
   infoName:String;

  enforce domain BusinessProcessModel s:bpmn::DataObject {
         name = infoName
      };

  enforce domain InfoModel info:SimpleUML::UmlClass {
         umlName=infoName
      };

}
```

3) Results of first transformation:

After defining transformation rule and determining the implementation approach, the transformation can be executed. From the part of theory, the general transformation steps are like the below[18]:

1. Searching a model to identify appropriate elements to transform.
2. Transforming elements.
3. The retention of tracing information recording which elements in a model are related by the transformation to elements in other models.
4. Detecting updates in one model involved in the transformation and performing relevant operations in the transformations other affected models.

The first version of Information model is like the following:

a) Making work schedules

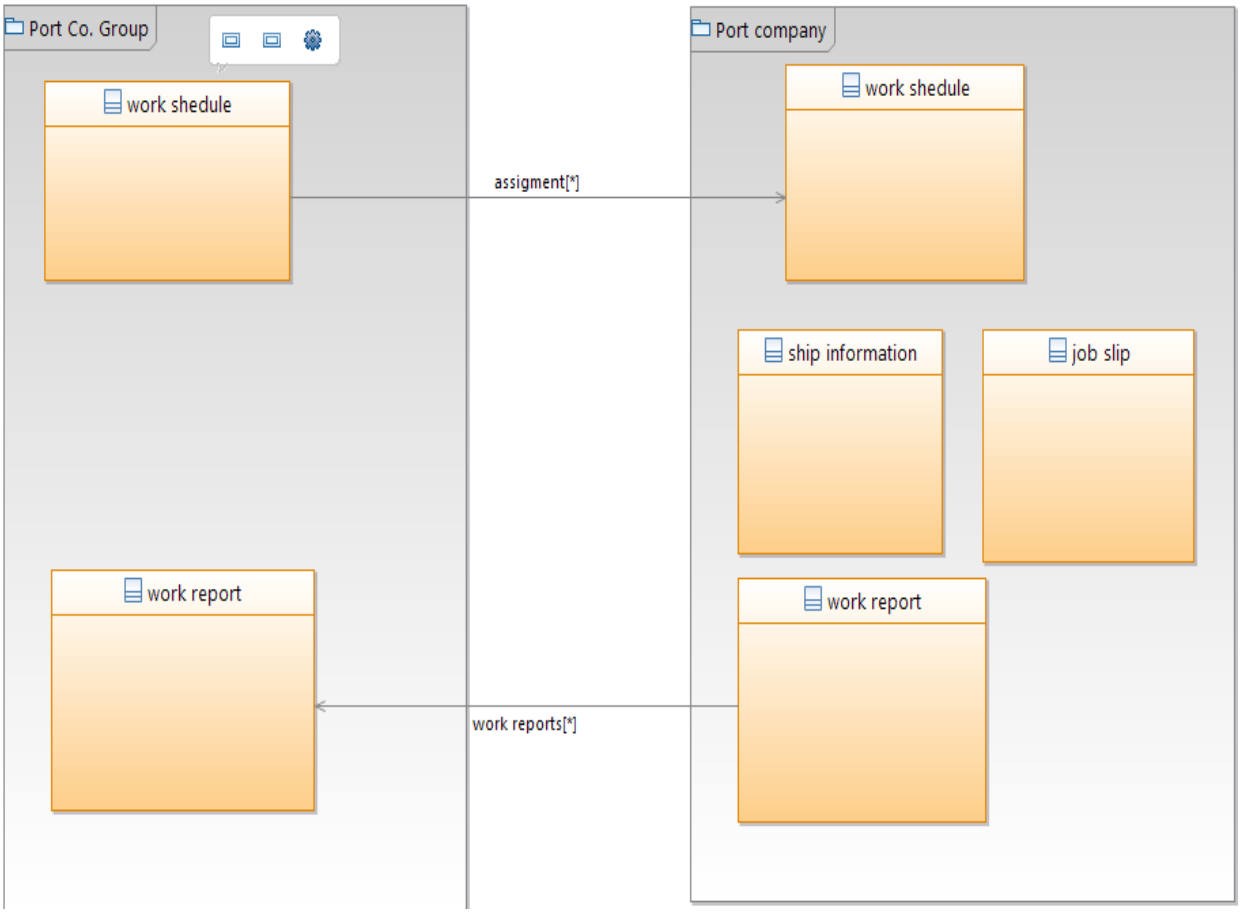


Figure 20 Information model in aspect of "Making work schedules"

[18] Enterprise Model Integration by Uni-Prof.Dr.Dimitris Karagiannis, Mag.Srdjan Zivkovic

From model above, it can be seen that the first information model has two packages. These two packages are mapped from swim lane in business process model. They also mean the two business partners, who exchange business information. In these two packages, there are many classes; they are transformed from information or message items of business process model. The association lines among different classes mean information exchange approaches. In above model, “work report” and “work schedule” is information which must be processed by both site of business partner, so the classes “work report” and “work schedule” should locate in both package. Information such as ship information, job slip is only processed inside of Port Company. Therefore, they are located only in package “Port Company”.

This model is only a simple and preliminary draft. It transforms directly from business process model and describes the general information items and their relationships in business process model. That is basis for further modeling and refining.

b) Marine transport and logistics

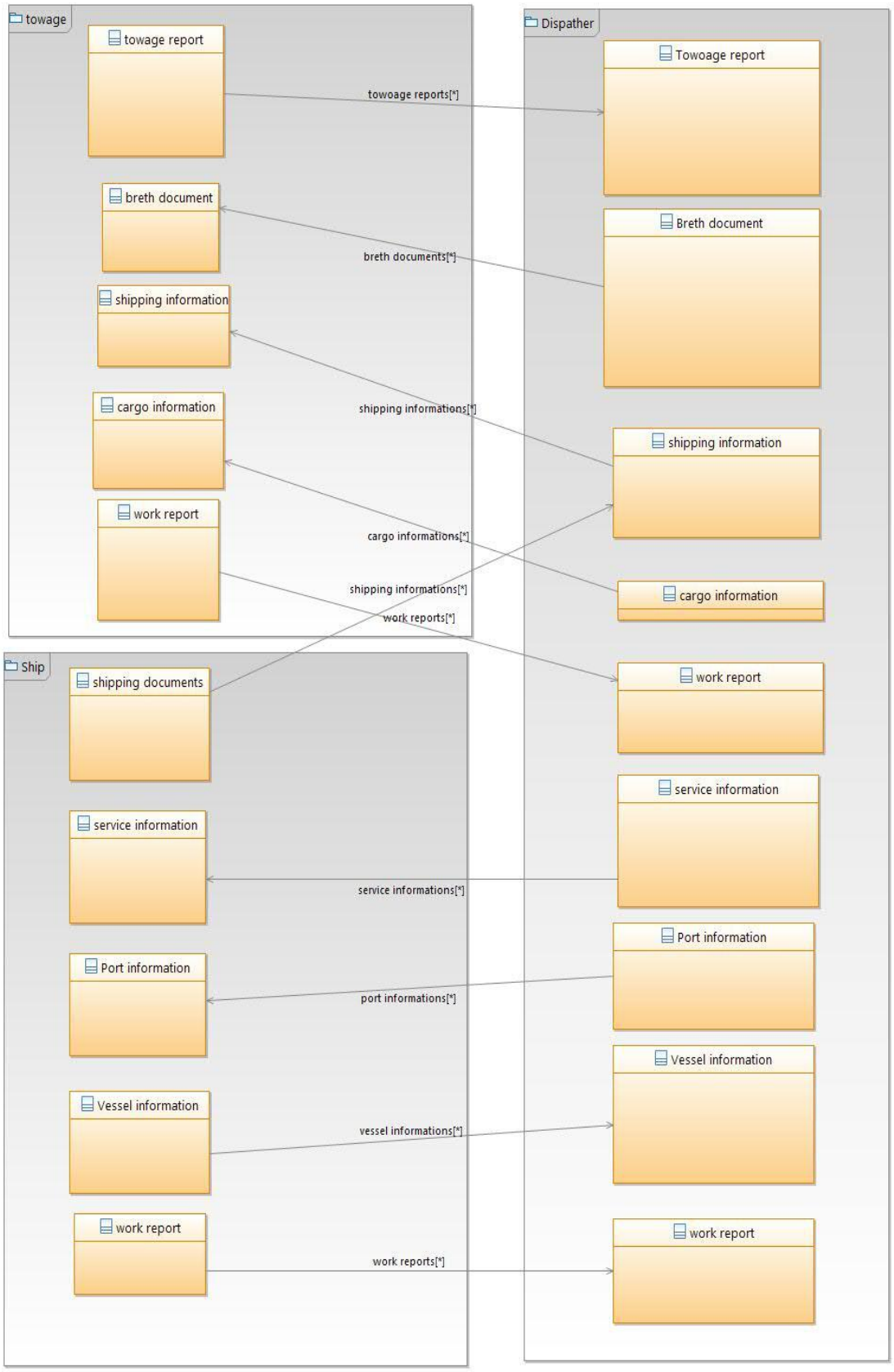


Figure 21 Information model in aspect of "Marine transport and logistics"

In aspect of marine transport and logistics, information exchanging is more complicated than making work schedules. According to business process model, the information such as cargos, harbor and ships is exchanged among ship site, towage and dispatcher in harbor frequently. Therefore, in this diagram, association relationships which indicate information exchanging are much more than previous model. Thus, the information such as vessel information, work report, ship information is processed in each site. The relevant information classes should therefore be located in each package and duplicated.

c) Land transport and logistics

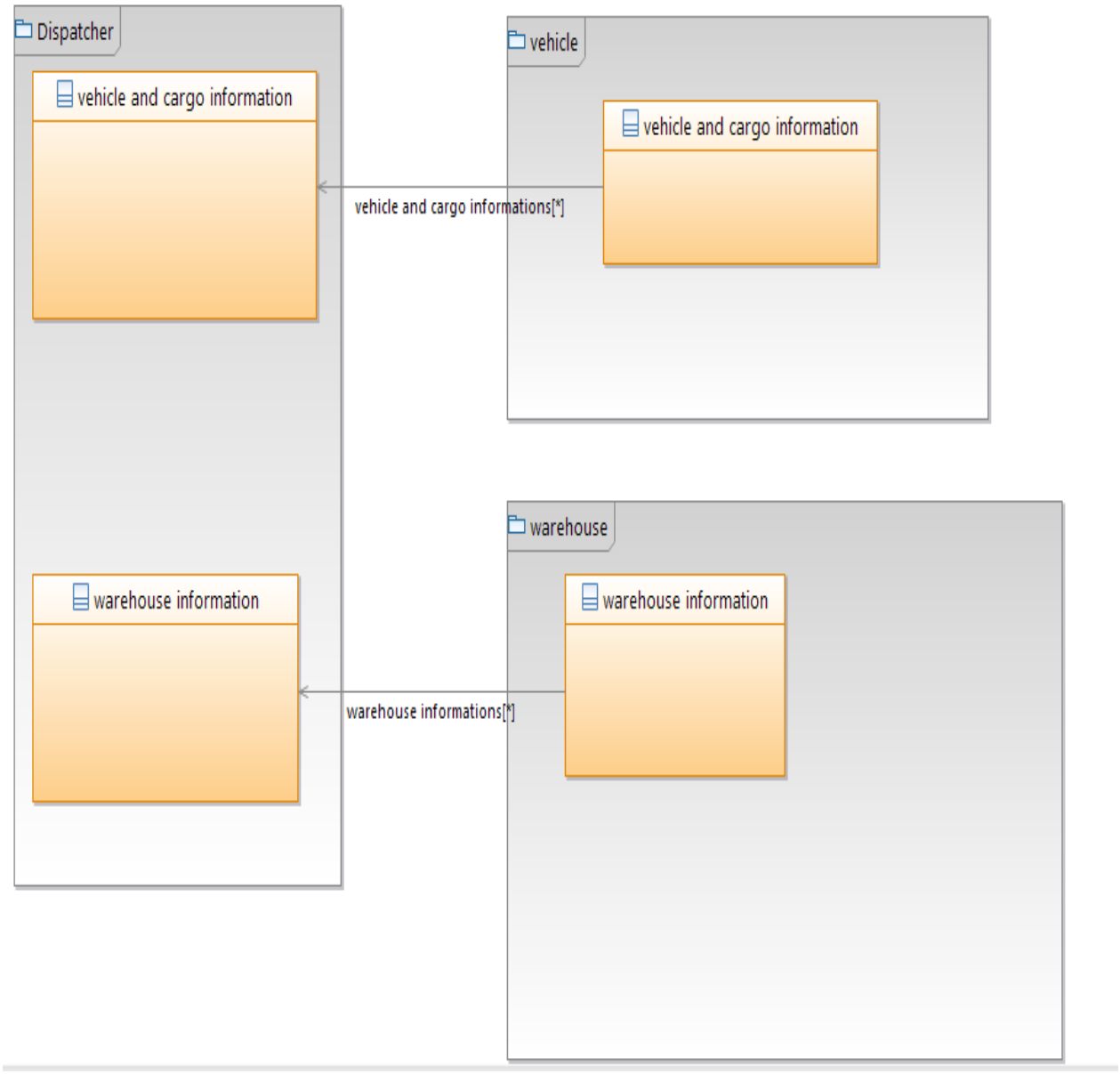


Figure 22 Information model in aspect of “Land transport and logistics”

Land transport is another side of whole harbor logistics. The information that has to be processed in harbor site is a substantial amount. The information model in this aspect is therefore simple. Dispatcher receives all information about warehouse and vehicle and according this information to arrange transport to vehicles.

d) Warehouse task

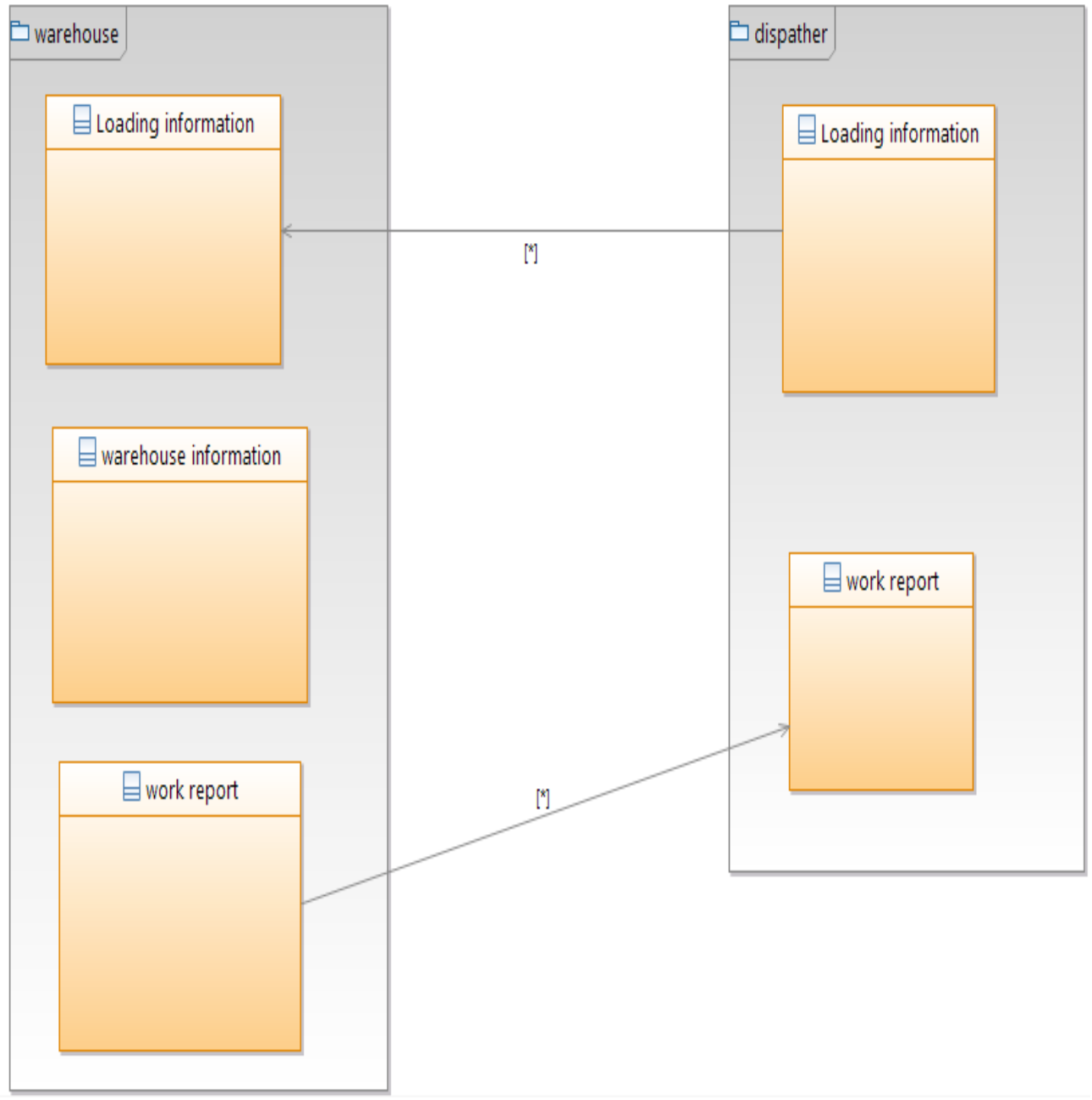


Figure 23 warehouse task

According to the transformation rule, in aspect of warehouse management information such as warehouse information, work report and loading information can be retrieved, which do not include all the information of warehouse management. However, respecting logical transformation, missing information should be added in refinement phase.

After transformation, the information elements in BPMN are already converted into UML classes. However, from the above diagrams, a situation is noticeable: the converted classes are redundant and always repeated in different packages. Therefore, a further improvement of this information model is needed in the refinement phase.

8.2. Refinement

The second step of modeling information model is refinement. The transformed information model will be complemented and newly designed. The completed information model should be presented in this part.

The refinement phase is different from transformation phase: the transformation phase ensured the logic and ration of the modeling. However, it could ignore the semantic feature of a model. Besides, 1:1 transformation is not able to find out the some implicated meaning of a model. For example, in harbor logistic system, the weather and water condition is also very important information for harbor logistic planning system. However, this information may not be presented in business process model. Therefore, this “refinement” part is needed to complete the information model.

In complementing and sorting information model, three aspects must be paid attention:

1) The structure and logical relationship among classes, attributes and so on.
2) Complementing the implicated meaning of model
3) Correction of mistake in transformation phase.

Besides, the refinement should be also declared and noticed in model, which allow other design partners to understand the meaning of changing.

A table for monitoring is suggested for this purpose:

Table 11 a suggested monitor table

activities	description	People	time	why

In this monitoring table the name of changing should be noticed in attribute "activities". The "description" is to explain the details of model changing. "People" is responsible for recording who did the change. Meanwhile, changing time and reasons are summarized into "time" and "why".

The result after finishing activities of refinement is like the following:

a) Making work schedule

As diagramed in transformation phase, the information about work schedule is structured like following:

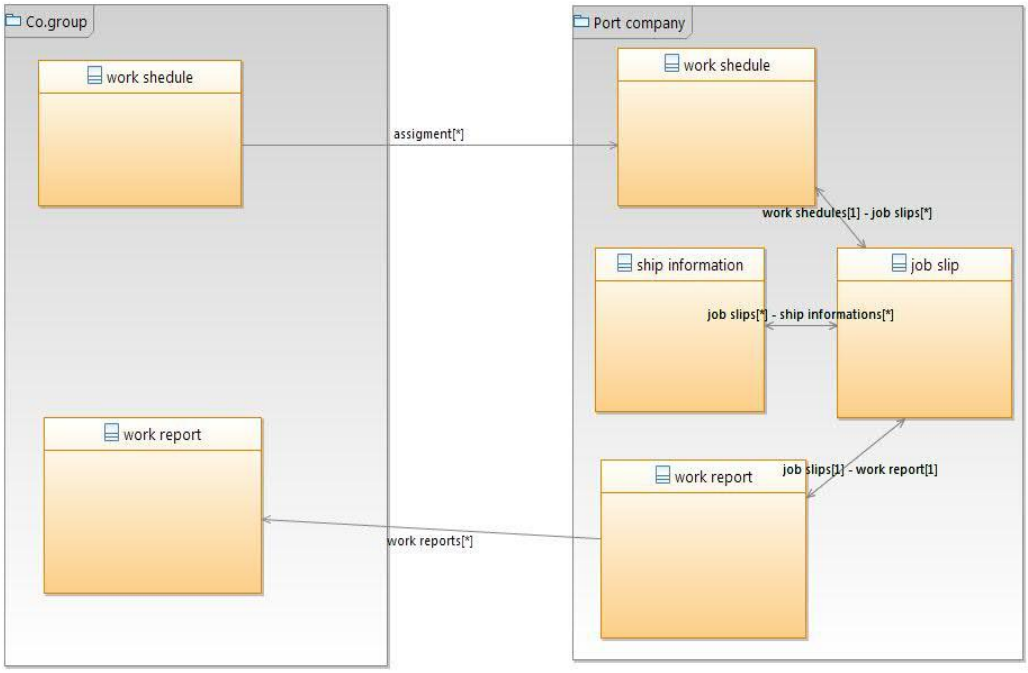


Figure 24 improved information model of "Making work schedule"

Monitoring Table recorded the meaning of this improvement.

Table 12 Monitor table of this improvement

activities	description	People	time	why
Association Relationship work schedule and job slip	.add association relationship	Zhan Chen	08.02.2012	Depending on work schedule the job slip is assigned, so there is 1:n relationship between these 2 information classes
Association Relationship ship information and job slip	.add association relationship	Zhan Chen	08.02.2012	Job slip have relationship with ship information
Association Relationship work report and job slip	.add association relationship	Zhan Chen	08.02.2012	According job slip the work report will be finished after working

Seen from the table above, in this refinement phase, the relationships among classes are defined. The structure of this information model is more detailed. Meanwhile, from monitoring table the reason of improving this part of model and who did it can be seen. Therefore, the whole refinement phase can be monitored and controlled.

b) Marine transport and logistics

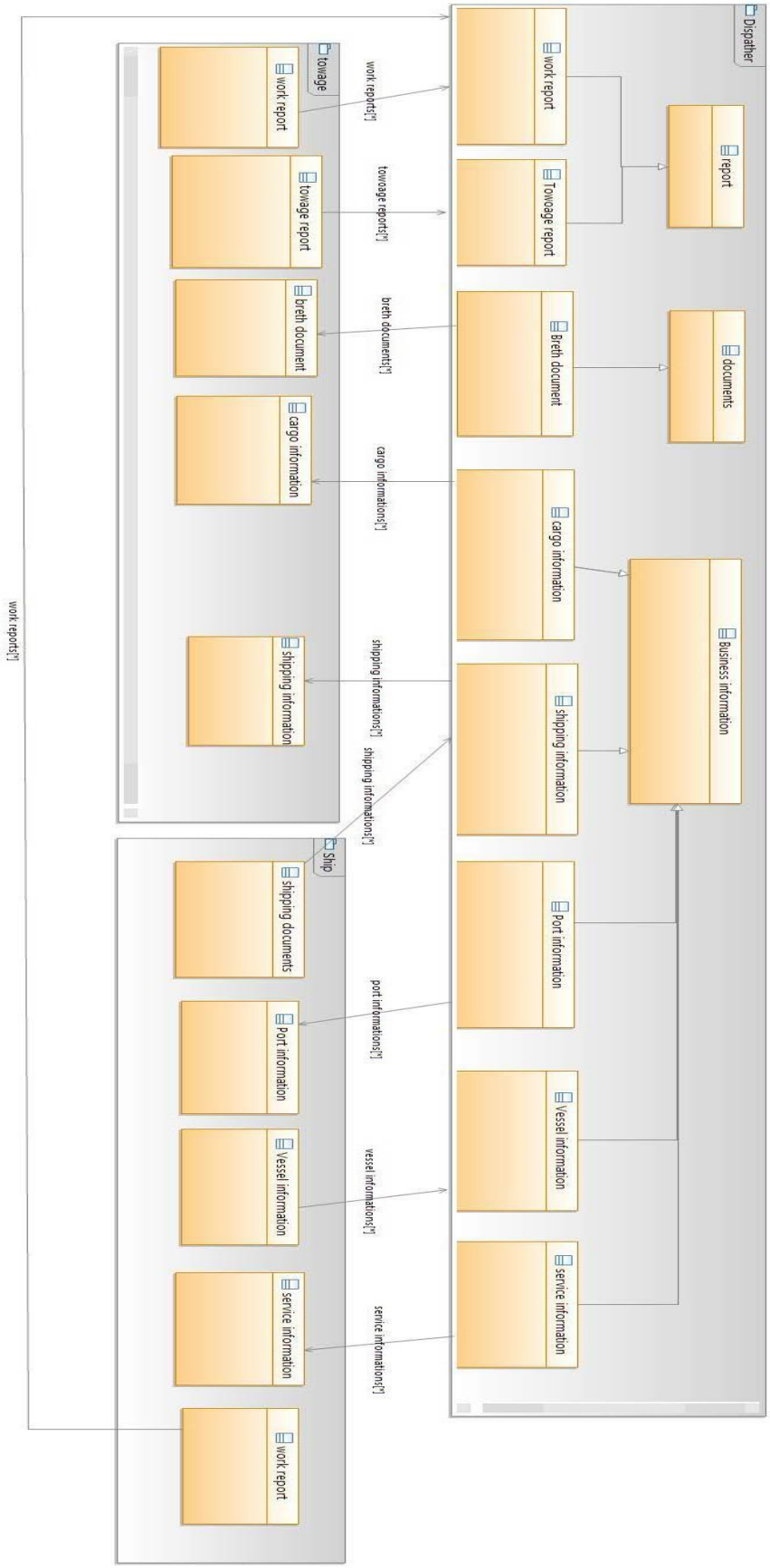


Figure 25 improved information model of "Marine transport and logistics"

Monitoring Table recorded the meaning of this improvement.

Table 13 Monitor table of improvement

activities	description	People	time	why
Business information class	add super class Business information class	Zhan Chen	08.02.2012	Classify the information type
Generalization relationship among information classes and business information class	add generalization relationship	Zhan Chen	08.02.2012	Classify the information type
Report class	add super class report class	Zhan Chen	08.02.2012	Classify the information type
Generalization relationship among report classes and report class	add generalization relationship	Zhan Chen	08.02.2012	Classify the information type
document class	add super class document class	Zhan Chen	08.02.2012	Classify the information type
Generalization relationship among documents classes and document class	add generalization relationship	Zhan Chen	08.02.2012	Classify the information type

Considering the complexity of information classes in this model, in the refinement phase, classes in this model are summarized and classified after type of information.

This generalization process also has been recorded in monitoring table. Therefore, from monitor table, it can be seen that classes in this model are generalized into three super classes: report, business information and documents.

c) Land transport and logistics

As discussed in the transformation phase, because of the gap between transformation rules and concrete situation, some information items or information exchanging processes have been not mapped and transformed in information model. Therefore, in this phase, those items and processes should be completed.

Table 14 Monitor table of improvement

activities	description	People	time	why
Add loading information class	add loading information	Zhan Chen	08.02.2012	Loading information for cargo will be exchanged between dispatcher and vehicle which wants to carry out the cargo transformation
Add response information class	Add response information class	Zhan Chen	08.02.2012	Warehouse gives the dispatcher the response whether they accept this transformation task.
Add request information class	add super class report class	Zhan Chen	08.02.2012	Dispatcher asks the warehouse whether they accept this transformation task.

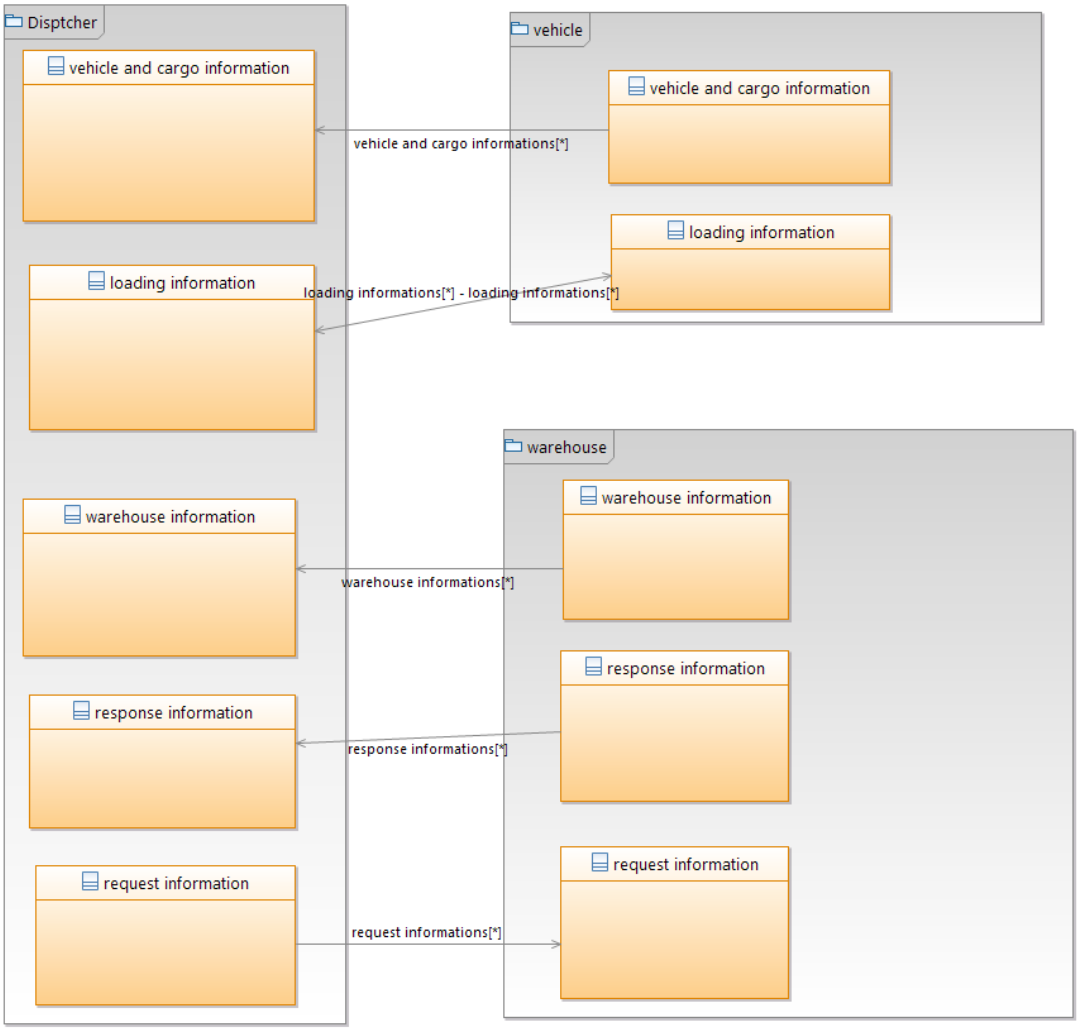


Figure 26 improved information model of "land transport and logistics"

d) warehouse task

The information model of "warehouse task" is not complicated. In refinement part, no additional information is required. This model is therefore not changed in refinement phase.

8.3. Important points for evaluation

The evaluation part is the controlling and monitoring phase of modeling. In this part, the whole finished model is evaluated and controlled. Some advice of other stakeholders such as business managers, workers or other designers should be also listened or followed. After accumulating these advices, the modeling work would come back to the refinement phase to achieve further improvement. This iteration can not only ensure the quality of model transformation, but also help designers to take all factors of modeling into consideration.

The business process Repository does not provide concrete methods to evaluate the quality of model. However, the aspects of evaluation are already defined. They are like the following:

1) Information checking
   The information or important issues should be covered in model.

2) Transformation validity and logic
   The used transformation rule should be checked again from view of general result to determine whether it is logical.

3) Completeness controlling
   Some additional information has been added in refinement phase. It is therefore needed to check the validity of completed information again.

4) Requirements checking
   After checking of syntax and semantic, the quality of model should be evaluated. The model should be tested whether it can meet the modeling requirements and needs for transformation in next step. In additional, some customized requirements should be also checked.

The concrete evaluation process should base on the above aspects. The user can also add some customized evaluation points to complete the whole evaluation. The results of evaluation can be a check list or a report. These results must be a basis of further improvements.

Here is a simple example which uses table and check list to evaluate model.

Table 15 an example of evaluation table

In aspect of Information checking			
Item	**status**	**Improvement suggestion**	**date**
1) Warehouse information	perfect	no	23.11.2011
2) Cargo information	Only finish basic transformation	add cargo information	23.11.2011
3) Weather information	Added in refinement phase. no log information	Add log information	23.11.2011
4) Work schedule	Perfect	no	23.11.2011
5) Association relationship between report and documents	Not modeled	Modeling association relationship between report and documents	23.11.2011

The above table presents the evolution phase in the aspect of information checking. Some evaluation items have been evaluated. The corresponding status and improvement suggestion have also been recorded. According to the status and suggestion, the model can be further improved and changes should be recorded in Monitoring Table.

Actually, the evaluation process is an improvement process. It ensures the quality and refinement of a model and brings the advantage of teamwork. However, this thesis will present how to utilize this process model to build a system concept and to complete this model alone. The evaluation part is therefore not emphasized in the following chapters and will not be further discussed in each model.

8.4. Summary of this chapter

Information modeling is the second step in the process model. The main purpose of an Information model is to model the managed objects at conceptual level. It should be independent of any specific implementation or situation. Therefore, the information model should also hide all protocol or implementation details to ensure this "independent". However, the necessary relationship between managed objects should be defined

In this chapter the information model is transformed from the business process model. However, this transformation is not 1:1 transformation. Only information of relevant elements in business process model have been retrieved and redefined after UML rule. The automatic transformation could not meet all requirements of information model; therefore, in the second phase this model must be complemented. The process of refinement is recorded as well.

In addition, the transformation happens not only between different models, but also inside of model. The disadvantages may be found after evaluating. Therefore, updating or model transforming from old version to new version is necessary, which is also a main purpose for evaluation.

9. Data Model

Data modeling is the third step in design process model. In this step the retrieved information will be further developed and structured. The information will be converted into concrete data which should be processed later.

Actually, the data model (DM) is an abstract model which describes all business or organization relevant data. These data will be stored and processed in business IT system.

Therefore, a data model determines all details about processed data, which is not only a model, but also a plan that the system developer can use for database implementation.

The relationship between data model and information model (IM) is very close. The data model is defined at a lower level of abstraction and includes many details. Information model always provides a conceptual/abstract model.

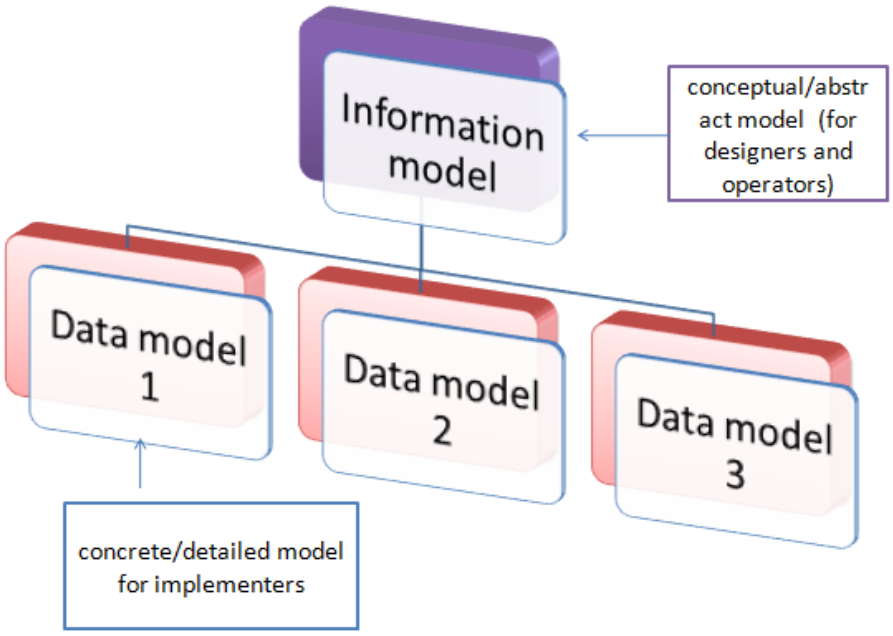


Figure 27 differences between data model and information model

The relationship between an IM and DM is shown in the Figure above. Since conceptual models can be implemented in different ways, multiple DMs can be derived from a single IM.[19]

[19] A. Pras,J. Schoenwaelder ,On the Difference between Information Models and Data Models, by http://www.ietf.org/rfc/rfc3444.txt

Although IMs and DMs serve different purposes, it is not always possible to precisely define what kind of details should be expressed in an IM and which one belongs in a DM. There is a gray area where IMs and DMs overlap -- just like there are gray areas between the models produced during the analysis, high-level design and low-level design phases in object-oriented software engineering. In some cases, it is very difficult to determine whether an abstraction belongs to an IM or a DM.[20]

In our design example there is similar situations as described above. The main task of information model is retrieving information elements from business process model, and it provides a conceptual idea about processed information needed. The data model is the third level of design process model. It is an extension of the information model. The conceptual information would be converted into concrete data and planned to stored or accessed in IT system.

On other side, considering architecture of whole system, information systems architecture and data architecture should be determined in this phase. The information system architecture describes the structure and component of system application, and data architecture is mainly for database design. Therefore, the information model can be detailed in this chapter into 2 different data model. One is for system application design, another is for database design.

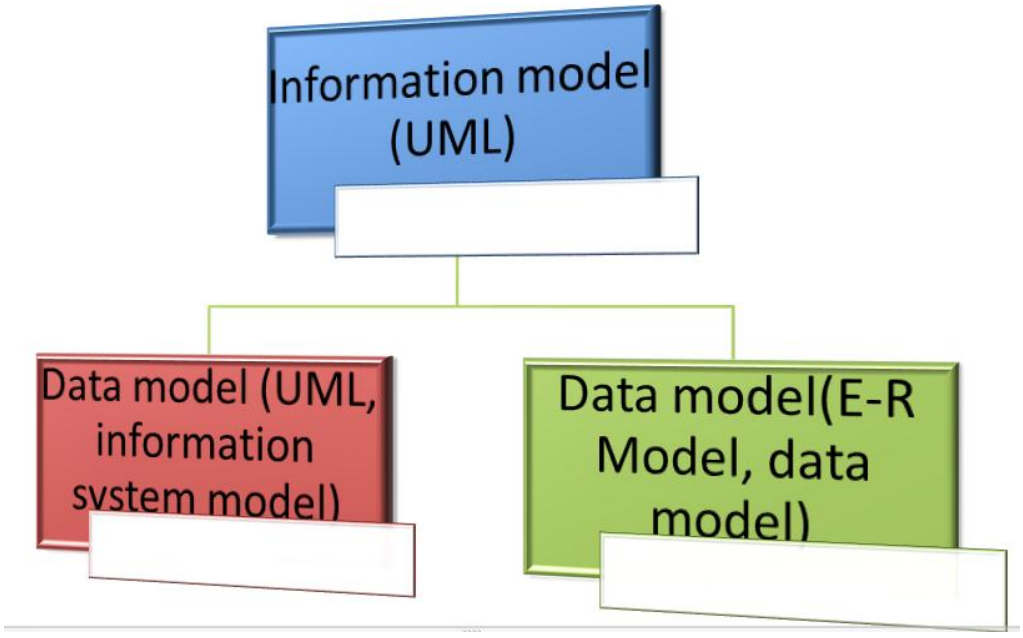


Figure 28 our example's level structure in application of design process model

[20] A. Pras,J. Schoenwaelder ,On the Difference between Information Models and Data Models, by http://www.ietf.org/rfc/rfc3444.txt

9.1. Types of data models

As discussed in introduction, in this phase, two types of data model should be conducted from information model for information system architecture and data architecture. These two architectures can be described with information system model and data model. Meanwhile, the object-orient programming language is now a main current to implement design concepts. Entity-relation table is the basis of designing database. Therefore, UML is used for further information system modeling and E-R model for database model

Considering the UML is a modeling method of information model in our example, UML can be used as the modeling method for information systems model. There are two reasons:

1) **Avoid missing of semantic meaning**
   When a model is transformed to another model, the missing of semantic meaning would definitely happen. Therefore, if the same method is used to model, the set of missing of meaning could be reduced. Meanwhile, the volume of work transforming can also be reduced.

2) **Traceability of model**
   By using same modeling method, the consistence of logic and ration can be ensured. Thus, it is much easier for the designers to trace the source model, if they cannot understand some meaning of data model.

The designers can choose any modeling method they want. This thesis will present only the relationship between data model and information model in design process model. The discussion about feature of models and modeling is not the emphasis and will not be explained further.

The tools which have already used in transformation phase of “business process model to information model” as modeling and transformation tool for “information model to data model” can therefore be utilized.

9.2. Transformation approach

Like transformation from business process to information model. The transformation phase is also the first phase in transformation from information model to data model. However, because two types of model should be created in this phase, the transformation phase is slightly different from transformation. Considering the data architecture depends on the information systems architecture, the information system model for describing information system architecture should be defined at first. According to this information system model, the data model to describe database and relevant data architecture can be finalized. The transformation approach in this phase can be seen from the following diagram:

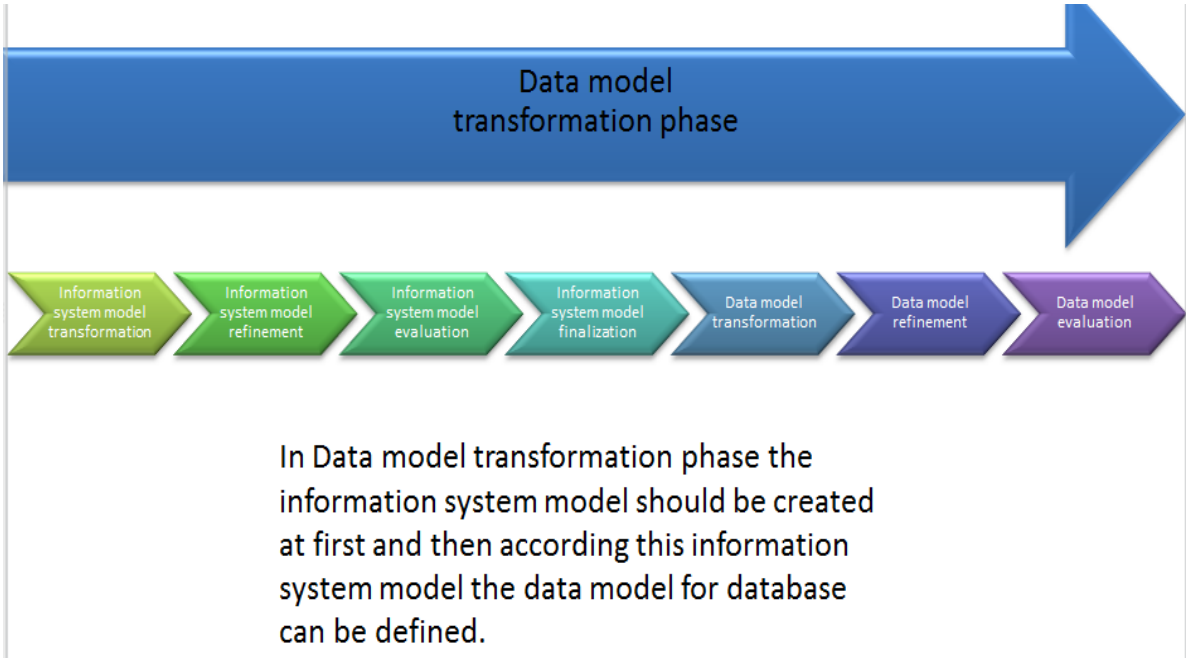


Figure 29 concrete transformation steps in data model transformation phase

The transformation should therefore be divided into two parts. Firstly, creating information system model must be finished and then in second part, data structure model can be conducted from information system model.

9.2.1 Information model transformation

Information system model describes the system design in software aspect. It is a concept to describe how business logics in information system implement. The UML, in our example, is a modeling method of information model, which can be used as our modeling method for information systems model.

As discussed in pervious chapters, transformation rule must be defined at first.

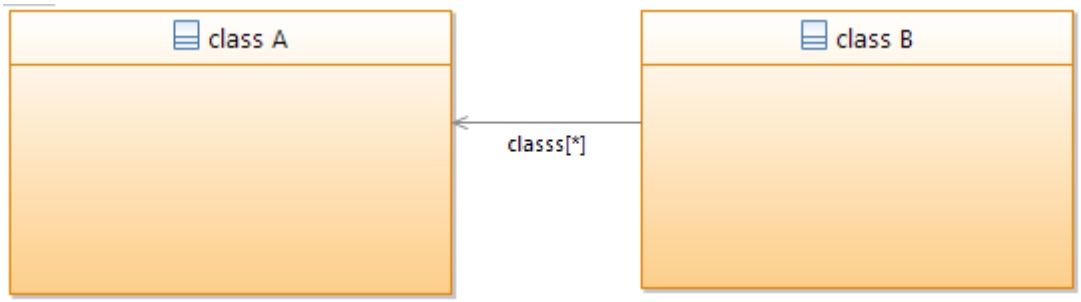
1) Transformation rule

The Information system model is more detailed than information model. Therefore, the structure inside of data model should be determined at first. The transformation rule like following:

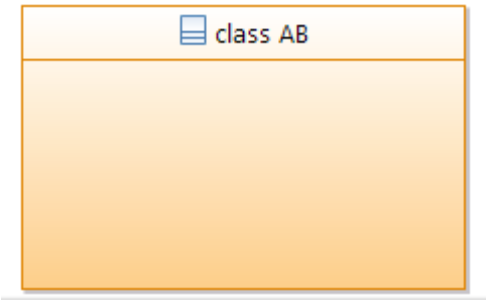
i. Reducing references

Table 16 transformation rule of "reducing references"

Rule ID	R134570
Name	ItoDRefMapping
Domain	Information model to data model
Language	UML to UML
Method	Reduce the reference
Abstract	Reduce the number of class through reducing reference
Content	



Mapping to:



- Reduce the reference the class

- New class includes the feature of source classes.
- Reduce the number of class

This rule can reduce the number of class and remove duplicated class in different package, which makes the model discussed in this thesis more structural and clearer.

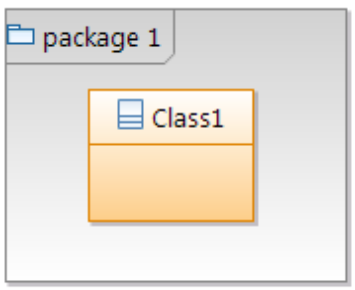
ii. Restructure of duplicated classes in model

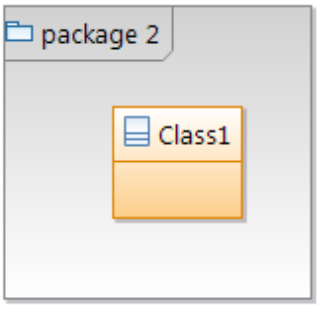
Table 17 transformation rule "restructure of duplicated classes in model"

Rule ID	R134571
Name	ItoDRefMapping
Domain	Information model to data model
Language	UML to UML
Method	Reduce the reference
Abstract	Reduce the number of class through reducing reference

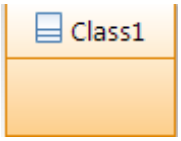
Content

If there are same class in different package





Mapping to:



- Without package
- New class includes the feature of source classes.
- Reduce the number of class

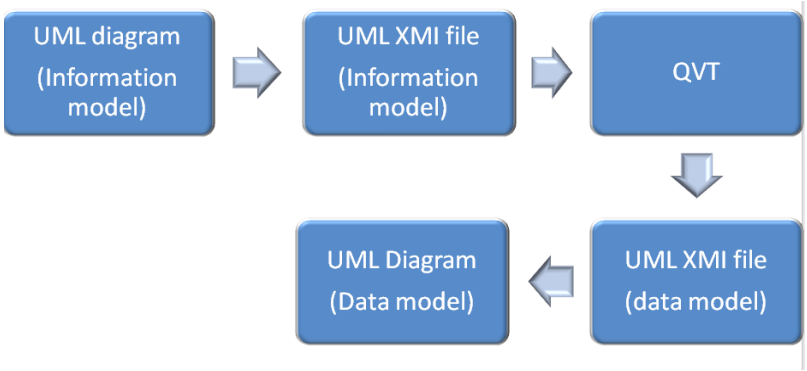
Concluded from the theory, many rules in Repository can be used for transformation of information elements in business process model to information model. Besides, by modeling business process model, the modeling concepts are defined, from which the relevant rules can be found. The transformation rules listed above can be generated by designer or stored in Repository in advance.

2) Technology and realization

The technology is similar to technology in transformation between business process models to UML model. However, in the case here, it is UML to UML.

a) Reducing references

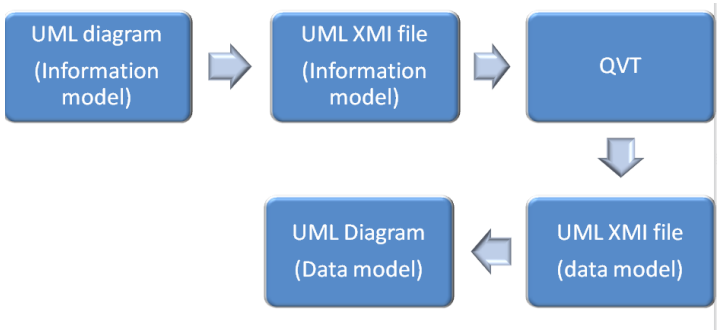
Table 18 implementation of rule" reducing references"

Developing Concept ID	DC134570
Reference transformation rule	R134570
Developing concept	
With QVT language to transform from BPMN to UML 	
Developing tools	mediniQVT
Code or implementation	

```
top relation ClassMerge {

                    nm:String;
                    source:SimpleUML::UmlClass;
                    target:SimpleUML::UmlClass;
        checkonly domain InfoModel i :SimpleUML::UmlAssociation{
        umlSource=source,
        umlName = nm,
        umlDestination=target
      };

        checkonly domain DataModel d  :SimpleUML::UmlClass{

        umlName = source+target

      };
         when{
         -- checking whether  source class and target class has a reference relationship
         ReferenceRelationship(source,target);

         }
         where {
         --- Attribut in target into source
        ElementMapping(source,target);
      }
      }
```

b) Restructure of duplicated class in model

Table 19 implementation of rule" restructure of duplicated classes in model"

Developing Concept ID	DC134571
Reference transformation rule	R134571
Developing concept	
With QVT language to transform from BPMN to UML 	
Developing tools	mediniQVT
Code or implementation	

```
top relation ReduceClassMumber{
        nm:String;
        bm:string;
       enforce domain InfoModel i :SimpleUML::UmlClass{
        umlName = nm

      };

       enforce domain DataModel d :SimpleUML::UmlClass{
        umlName = bm

      };

 when{
        not( samenameClass(bm,nm));

         }

}

relation samenameClass {

    nm:string;

 enforce domain  InfoModel i: SimpleUML::UmlPackage{
         umlName=nm

    };

enforce domain  DataModel d: SimpleUML::UmlPackage{
         umlName=nm


  };

}
```

After considering the aspects of harbor business activities, the first version of Information model is created as below:

1) Making work schedule

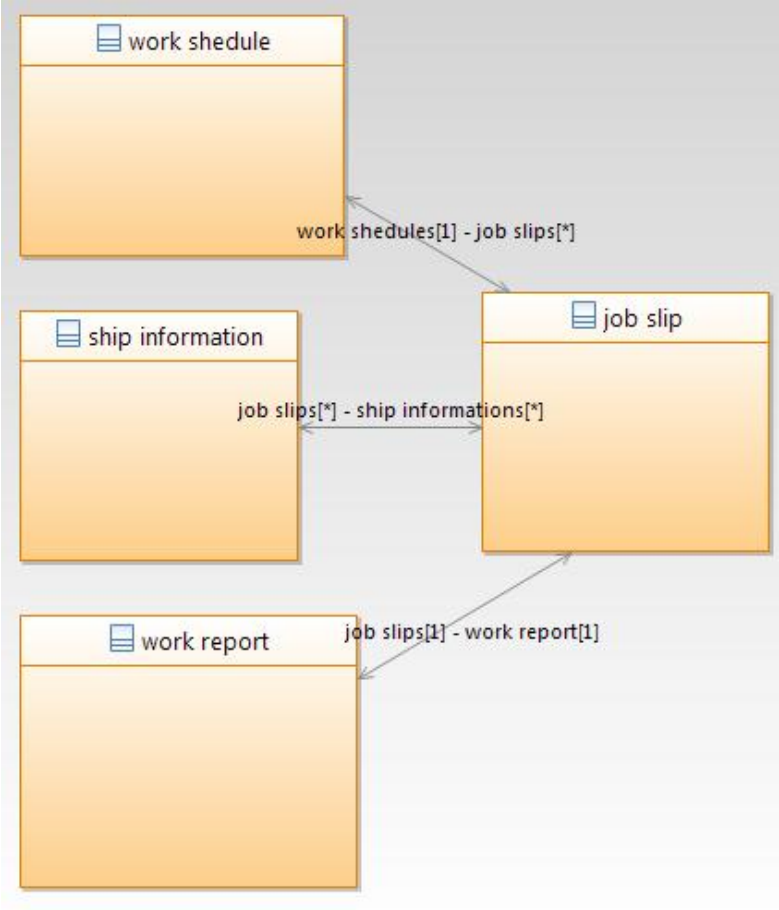


Figure 30 data model in aspect of "making work schedule"

After transforming, packages are eliminated in information system model. Seen from the model above, general structure of information system for "Work schedule" can be identified.

2) Marine transport and logistics

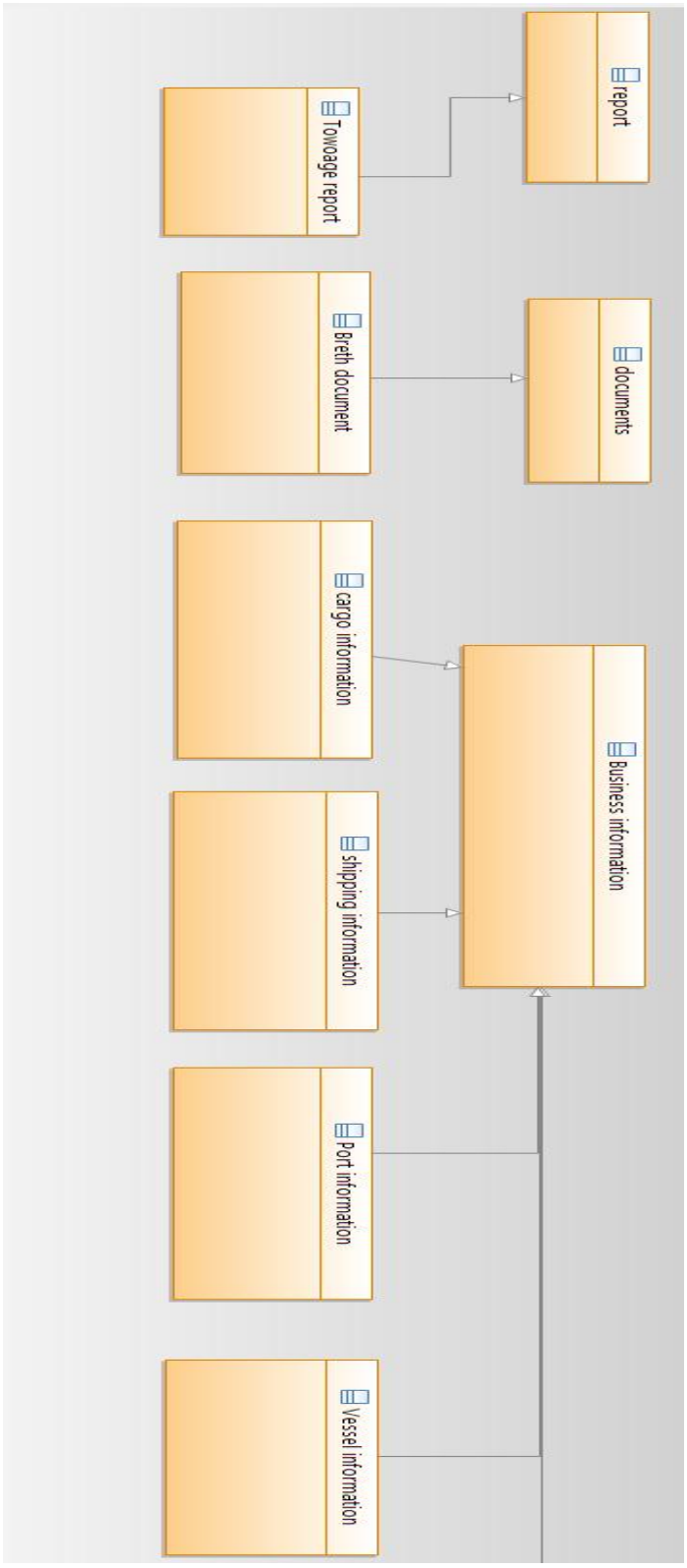


Figure 31 data model in aspect of "marine transport and logistics"

Additionally, similar to “work schedule”, the number of class of marine logistics is reduced.

3) Land logistics

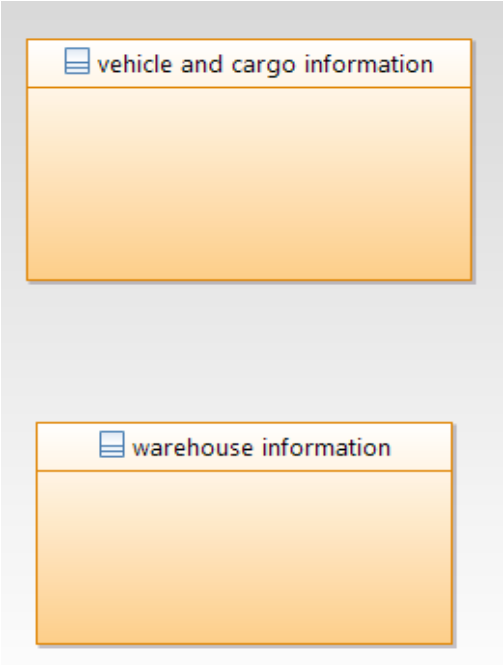


Figure 32 data model in aspect of “land logistics”

4) Warehouse task

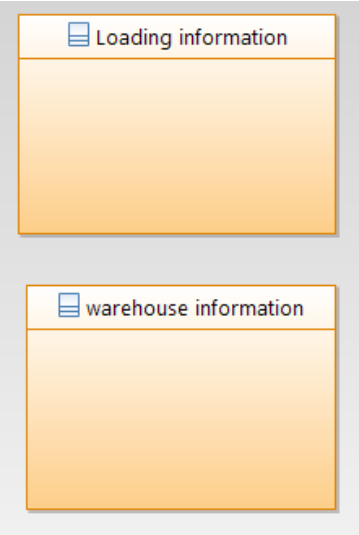


Figure 33 data model in aspect of “warehouse task”

Seen from the diagram above, the redundant information classes are vanished. However, the structure of model is not very good. So the logical structure and detail information about each class must be defined in refinement phase.

9.2.2 Information model refinement

In this phase, the information models of different aspects will be summarized into one structured model and detailed data will also be defined.

1) Structure of data model:

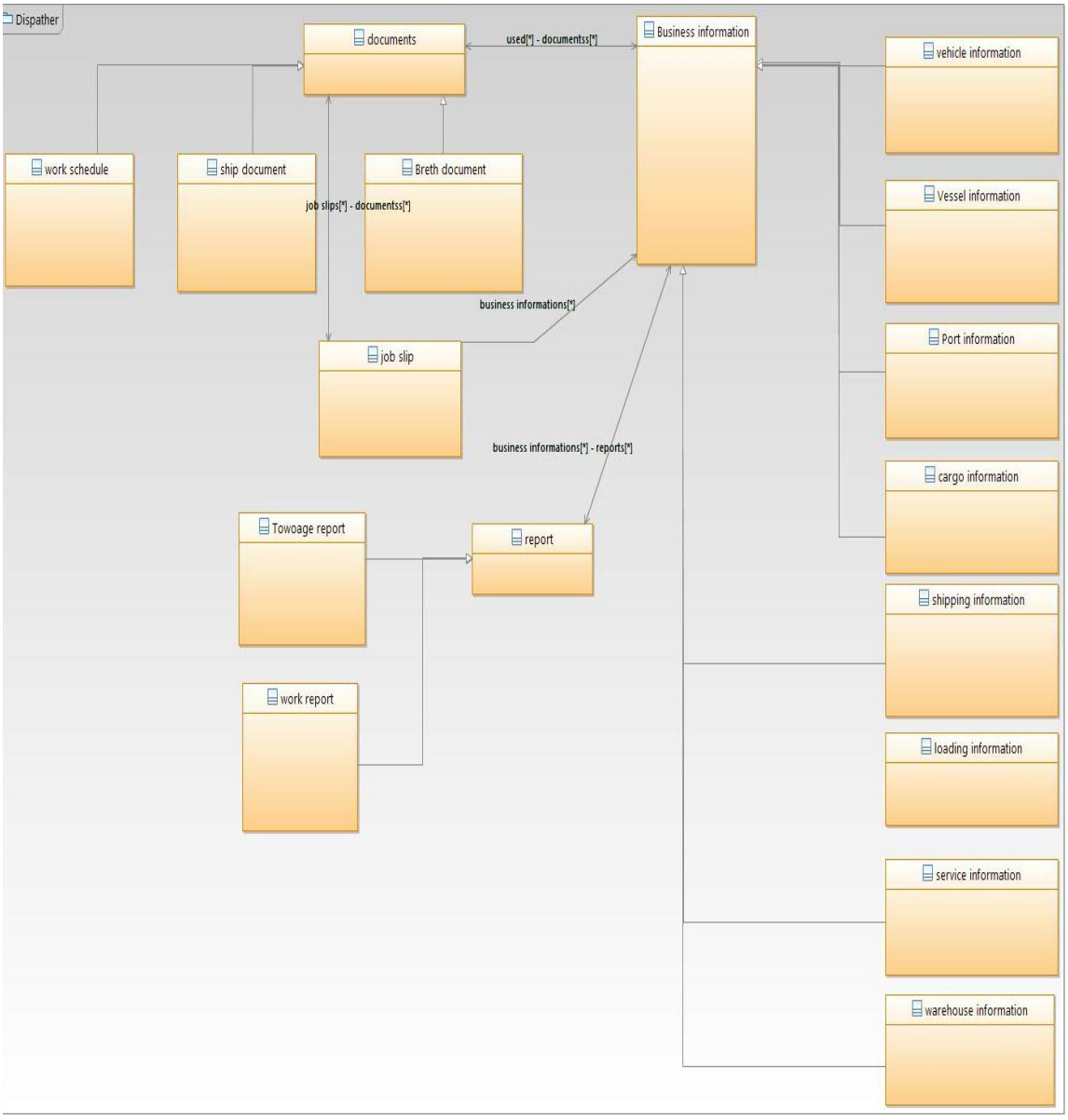


Figure 34 overview of improved data model

In this step, separated models are integrated into one universal model. This model describes main components of information system and through which the structure of

information system can be identified. However, the above model still requires further improvement, given some information is missed. Therefore, the following steps are needed to complete the missing information.

2) Detail data for each information class

After defining the whole structure of information system model, details of data such as attributes will be defined. The structure of information system model is more detailed; developers can implement system according to this model. This model can be also observed as a PIM model for MDA development to serve furthermore PSM modeling and code realizing.

Seen from the following model, all information has been summarized in three types: reports, documents and business information, according to concrete business activities, relevant documents and reports will be created in system by referencing different business information. These created documents and reports are also exchanged among business partners and support whole harbor logistics process.

Still, this refinement phase should be companied by monitoring table to control and record this complementation procedure. However, considering the emphasis of this thesis, the concrete monitoring table will not be shown here.

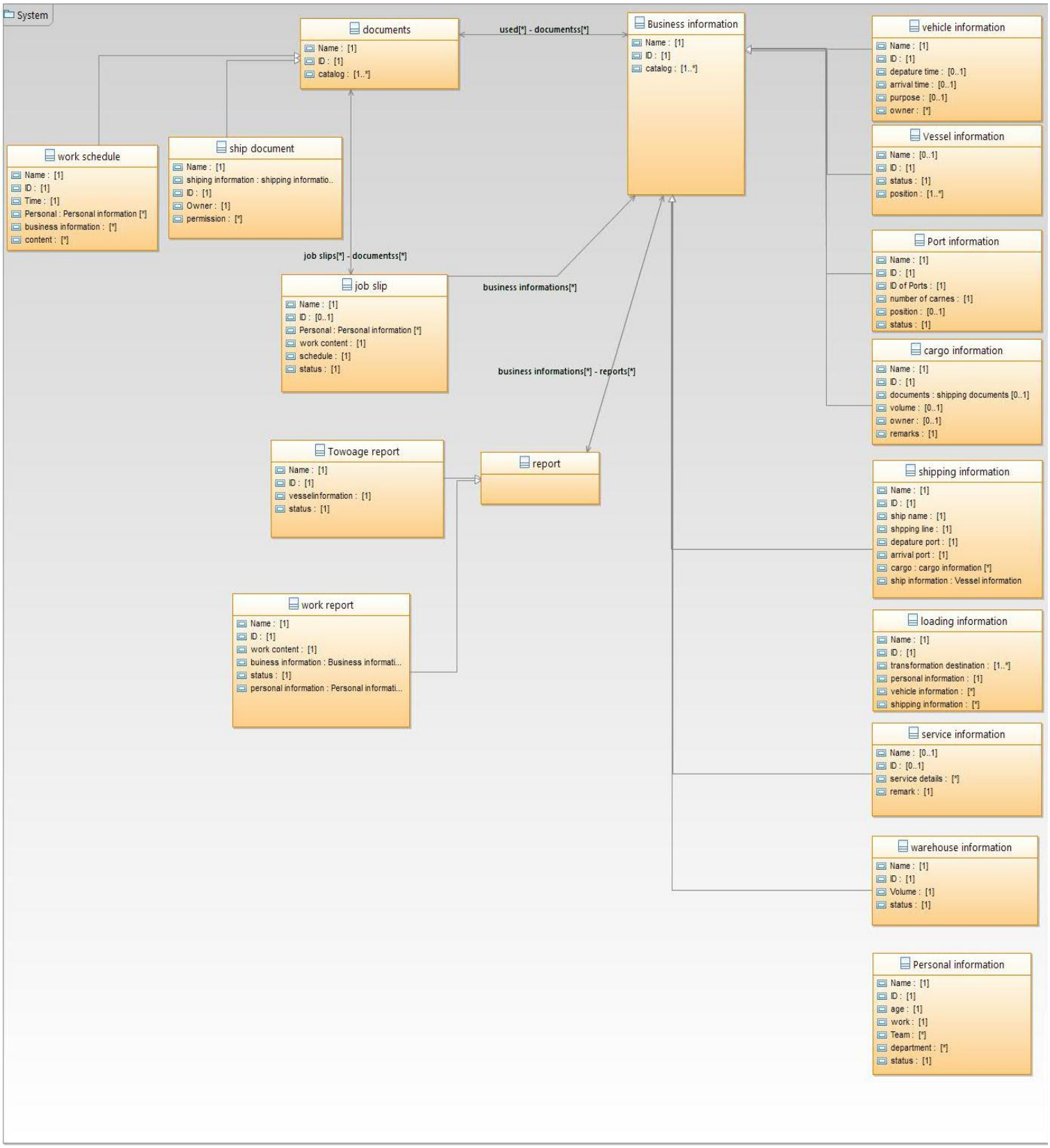


Figure 35 finished information system model

.

9.2.3. Data structure model transformation

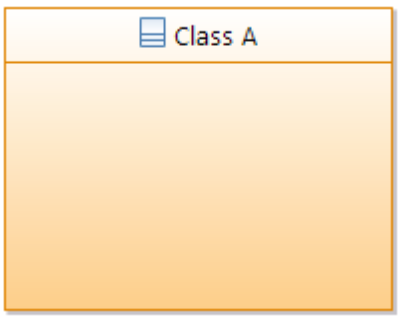
Data structure model is different from information system model; information system model describes the business logics and the process of these business logics in information system; while the emphasis of data structure model provides a concept or method to describe how to save or store necessary information. From the software engineering's point of view, information system model is like business logic server while data structure model is more like database server behind of business logic server. Therefore, data structure model must depend on information system model and should be retrieved from information system model.

On other hand, data structure model is a concept of designing database or information storage. Besides, the present popular database technologies are mostly based on rational table and SQL language. Therefore, the transformation should focus on transforming UML to rational table.

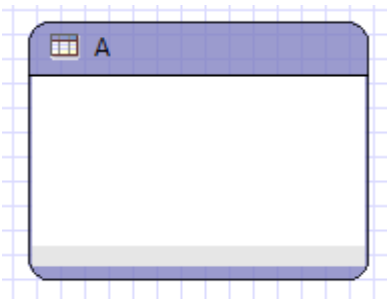
1) Transformation rule

As similar with pervious transformation, some transformation rules must be defined at first to help transforming:

a) Table 20 class to table:

Rule ID	R143568
Name	ClassToTableMapping
Domain	Information model to data model
Language	UML to RDBMS
Method	Mapping class to table
Abstract	Convert class to table
Content 	

Mapping to:

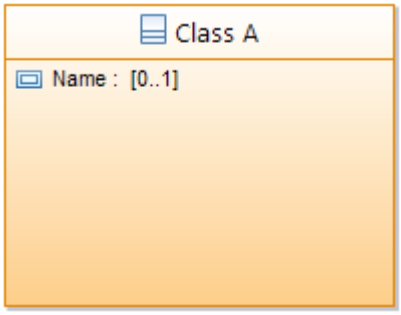


- Convert UML element class A to Table A

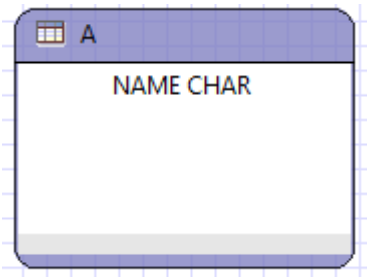
b) Table 21 Attribute to column

Rule ID	R143569
Name	AttributeToColumnMapping
Domain	Information model to data model
Language	UML to RDBMS
Method	Mapping attribute of class to column in table
Abstract	Convert attribute to table

Content



Mapping to:

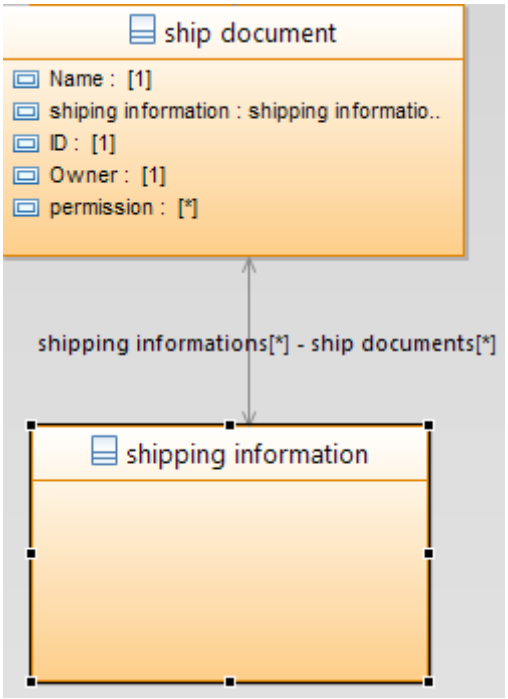


- Attributes of a class can be converted in a column of table.
- Class should be mapped to table at first.

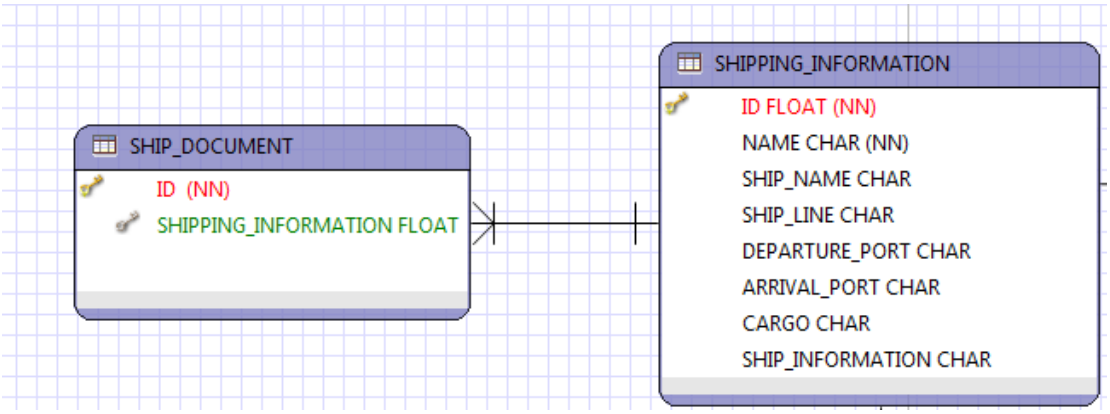
c) Table 22 map each association between persistent classes to a foreign key

Rule ID	R143570
Name	AssocToForeignKeyMapping
Domain	Information model to data model
Language	UML to RDBMS
Method	Map each association between persistent classes to a foreign key
Abstract	Map each association between persistent classes to a foreign key

Content



Mapping to:

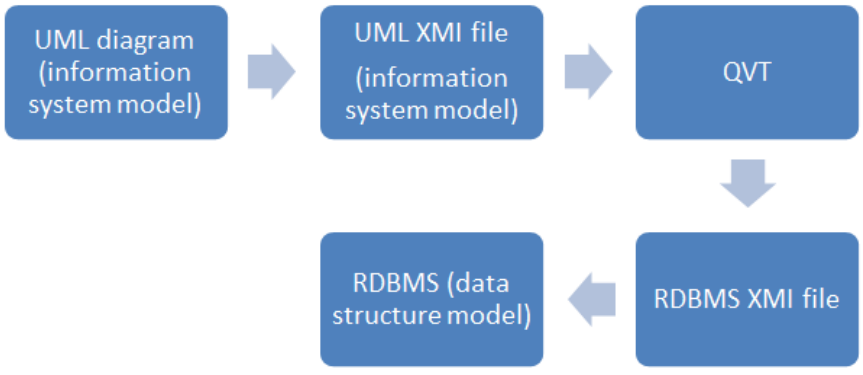


- Attributes of a class can be converted in a column of table.
- Class should be mapped to table at first.
- Map each association between persistent classes to a foreign key

2) Realization and technologies

a) class to table:

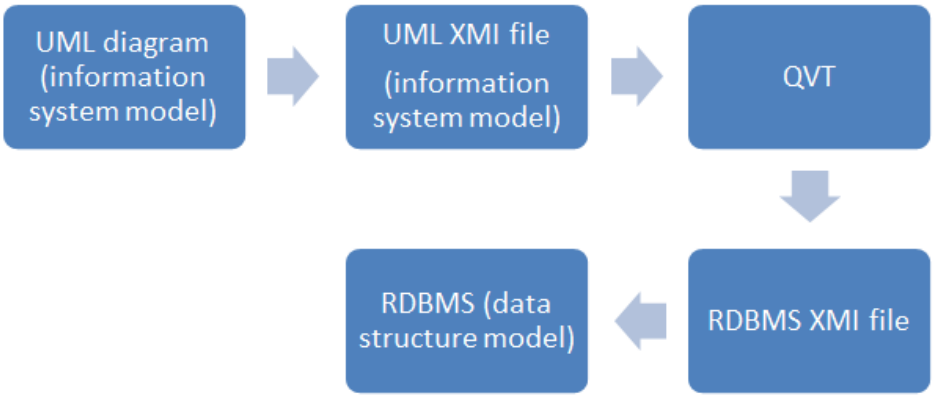
Table 23 implementation of class to table

Developing Concept ID	DC 143568
Reference transformation rule	R143568
Developing concept	
With QVT language to transform from BPMN to UML 	
Developing tools	mediniQVT
Code or implementation	

```
top relation ClassToTable {

  cn : String;
  prefix : String;

  checkonly domain uml c : SimpleUML::UmlClass {
    umlNamespace = p : SimpleUML::UmlPackage {
    },
    umlKind = 'Persistent',
    umlName = cn
  };

  enforce domain rdbms t : SimpleRDBMS::RdbmsTable {
    rdbmsSchema = s : SimpleRDBMS::RdbmsSchema {
    },
    rdbmsName = cn,
    rdbmsColumn = cl : SimpleRDBMS::RdbmsColumn {
      rdbmsName = cn + '_tid',
      rdbmsType = 'NUMBER'
    },
    rdbmsKey = k : SimpleRDBMS::RdbmsKey {
      rdbmsColumn = cl : SimpleRDBMS::RdbmsColumn{}
    }
  };

  when {
    PackageToSchema(p, s);
  }

  where {
    ClassToPkey(c, k);
    prefix = cn;
    AttributeToColumn(c, t, prefix);
  }
```

b) attribute to column

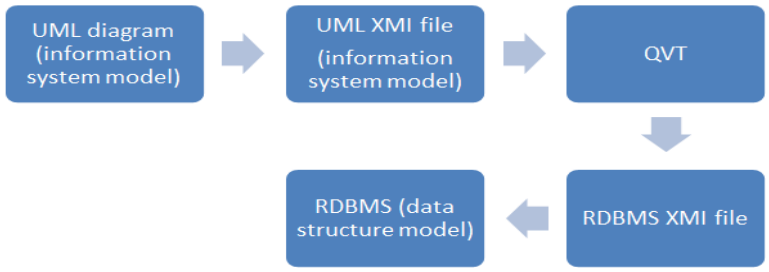
Table 24 implementation of rule "attribute to column"

Developing Concept ID	DC 143569
Reference transformation rule	R143569
Developing concept	
With QVT language to transform from BPMN to UML 	
Developing tools	mediniQVT
Code or implementation	

```
relation AttributeToColumn {

  checkonly domain uml c : SimpleUML::UmlClass {
  };

  enforce domain rdbms t : SimpleRDBMS::RdbmsTable {
  };

  primitive domain prefix : String;

  where {
    ComplexAttributeToColumn(c, t, prefix);
    PrimitiveAttributeToColumn(c, t, prefix);
    SuperAttributeToColumn(c, t, prefix);
  }

}
```

c) Map each association between persistent classes to a foreign key

Table 25 implementation of "map each association between persistent classes to a foreign key"

Developing Concept ID	DC 143570
Reference transformation rule	R143570
Developing concept	
With QVT language to transform from BPMN to UML 	
Developing tools	mediniQVT
Code or implementation	

```
top relation AssocToFKey {

  an : String;
  scn : String;
  dcn : String;
  fkn : String;
  fcn : String;

  checkonly domain uml a : SimpleUML::UmlAssociation {
    umlNamespace = p : SimpleUML::UmlPackage {
    },
    umlName = an,
    umlSource = sc : SimpleUML::UmlClass {
      umlKind = 'Persistent',
      umlName = scn
    },
    umlDestination = dc : SimpleUML::UmlClass {
      umlKind = 'Persistent',
      umlName = dcn
    }
  };

  enforce domain rdbms fk : SimpleRDBMS::RdbmsForeignKey {
    rdbmsName = fkn,
    rdbmsOwner = srcTbl : SimpleRDBMS::RdbmsTable {
      rdbmsSchema = s : SimpleRDBMS::RdbmsSchema {
      }
    },
    rdbmsColumn = fc : SimpleRDBMS::RdbmsColumn {
      rdbmsName = fcn,
      rdbmsType = 'NUMBER',
      rdbmsOwner = srcTbl
    },
    rdbmsRefersTo = pKey : SimpleRDBMS::RdbmsKey {
      rdbmsOwner = destTbl : SimpleRDBMS::RdbmsTable {
      }
    }
```

After defining transformation rule and determining the implementation approach, the transformation can be executed. The result is like following:

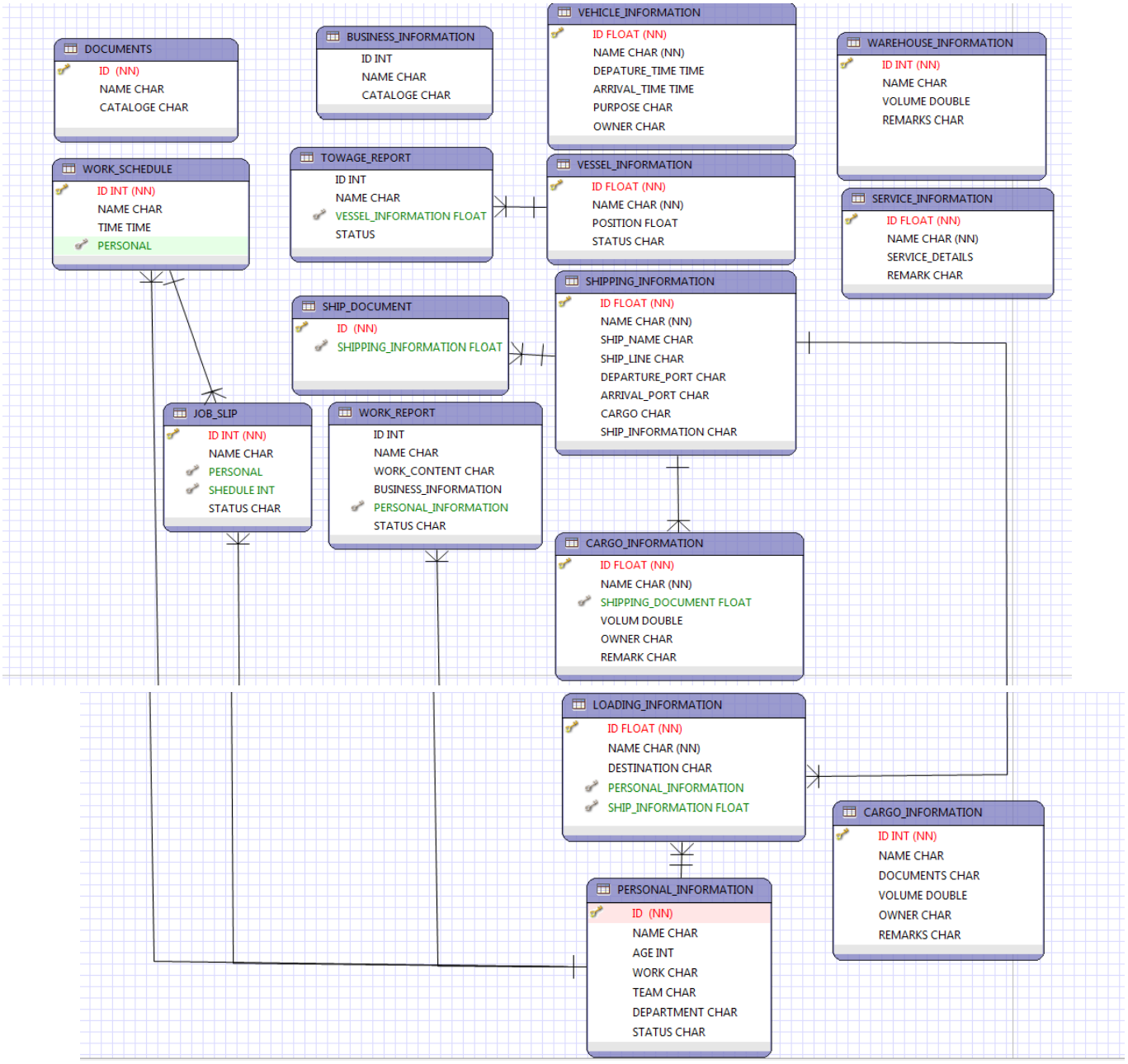


Figure 36 data structure model

This model looks like a class diagram, the meaning is nevertheless different. Each rectangle means a table; in each table there are also many columns to describe relevant attributes in class diagram. Relationships among tables are connected with primary keys and foreign keys. However, this model is seen to be structural. For example, in relation tables, there is no heritage relationship. Therefore, super classes

such as “report”, “document” and “business information” are transformed into tables, which however, are not connected with other tables. On other hand, a lot of columns repeat in different tables, which means data redundant and data superfluous. Therefore, in the next refinement, the structure of data model must be redesigned according to requirements of real business to make sure optimal storage of data.

9.2.4. Data structure model refinement

In this phase, the from information system model converted data structure model will be refined further to reach an optimal solution for data storage.

According to the problems in above section mentioned, redundant attributes and tables must be removed to ensure our model clear and structural.

1) **Reducing number of tables and cleaning redundant attributes in the table**.
   The first step of refinement is to reduce unnecessary tables and relevant columns, the purpose of this step is making model more structural and readable. That is also a basis of further redesigning and optimizing data structure model.

   Thus, like other refinement phase, this refinement must be recorded in monitor table for evaluation and iterative development.

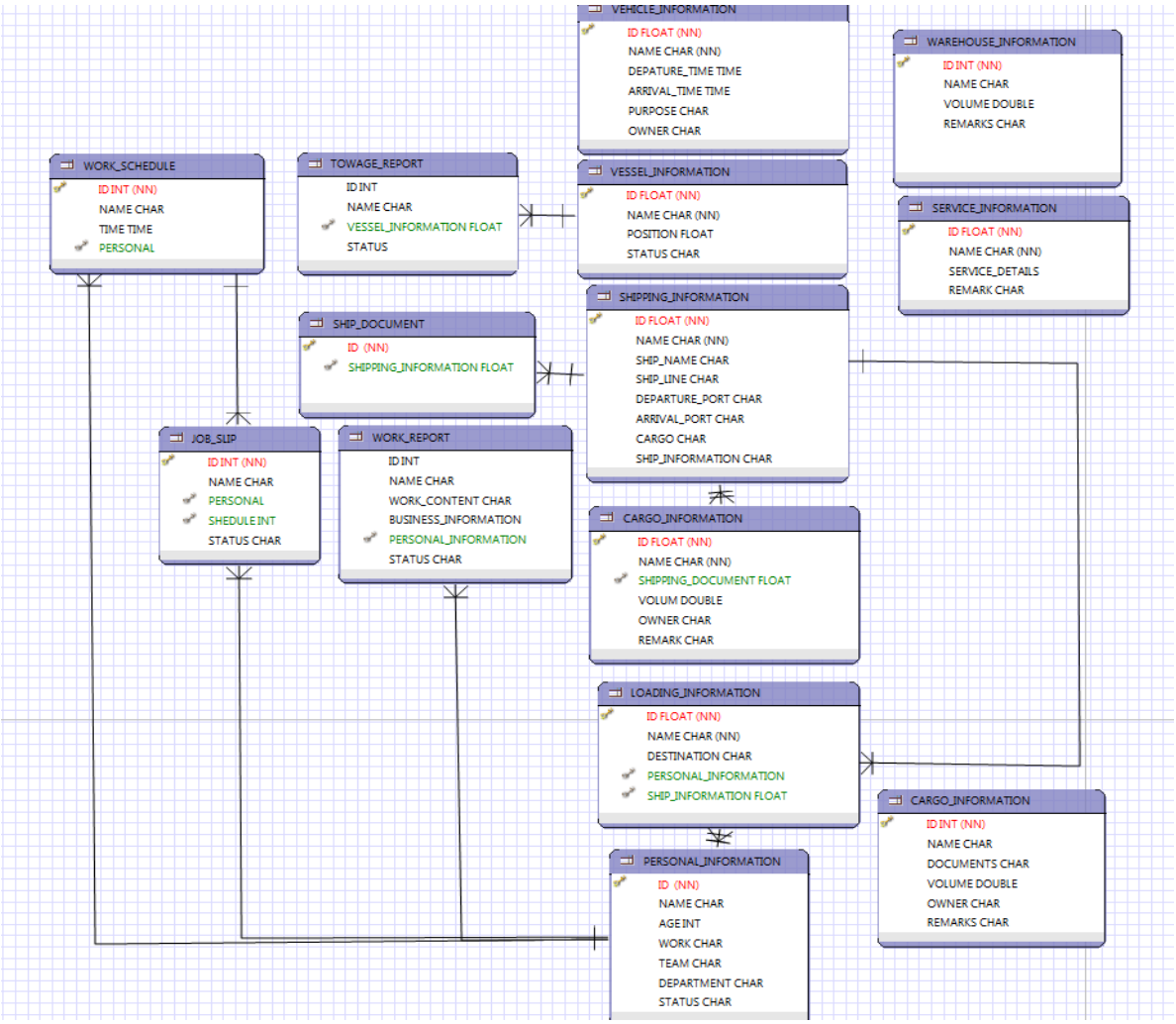


Figure 37 improved data structure model

The data structure model after first refinement step is shown in the above diagram. Super classes such as “report”, “document” and “information” are removed from this model. Relationship among reports, documents and saved business information connected tighter than before. Primary keys for each table are notified with red color and foreign keys are notified with green color.

9.3. Summary of this chapter

In this chapter , the order “transformation – refinement” is used to model the data model.

Comparing with information model, the data model is more detailed and structured. In our example, the UML and RDMS are used as the model languages. Interpreters or developers can develop directly the database and server system with these two data models. Thus, seen from information system model, the data are summarized into three super classes which will be the basis for further design of infrastructure model.

On other side, these two models can be the final concept of our system in aspect of software. They provide developers with general requirements and components of system and database. They are also a basic logic idea for developing system. In addition, IT manager can control and manage information system by using these two models.

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10. Infrastructure model

Infrastructure model is the last layer in our design process model and whole system architecture. After defining system requirements from view of software, infrastructure model is a model to describe the platform which applications or systems can run on it. For different stakeholders in developing, infrastructures have different meanings. For example, for developers, infrastructure is the platform to run their applications on. For network managers, infrastructure is collections of all network equipment. For system administrators, infrastructure is all equipment he manages, and for IT architects it is the basic layer to build business services on.[21]

Different meaning of the infrastructure therefore causes different models. From only the data model, it is not an easy task to get the whole infrastructure model for all aspects of system. Therefore, the transformation from data model to final infrastructure model becomes difficult.

However, from the definition about the transformation in process model, the infrastructure model from software component view can be defined. Firstly, the data model can be transformed to get the infrastructure model in software component view, after which the infrastructure in other aspects can be completed according the software component view in the refinements phase.

On other hand, infrastructure model is based on above models. Requirements analyzing can be helpful to finalize the whole system infrastructure. Therefore, after 1:1 transformation and mapping in transformation phase a requirement analyzing method in refinement phase can be used to define our infrastructure model.

[21] IT Infrasturcture model, by Over Sjaak Laan
http://www.sjaaklaan.com/archives/archive_2006-m08.php

10.1. Definition of the Infrastructure model

Definition of IT infrastructure is as below:

IT infrastructure is the total set of components that enables applications to function[22]

In addition, the following model presents the structure of the IT infrastructure[23]:

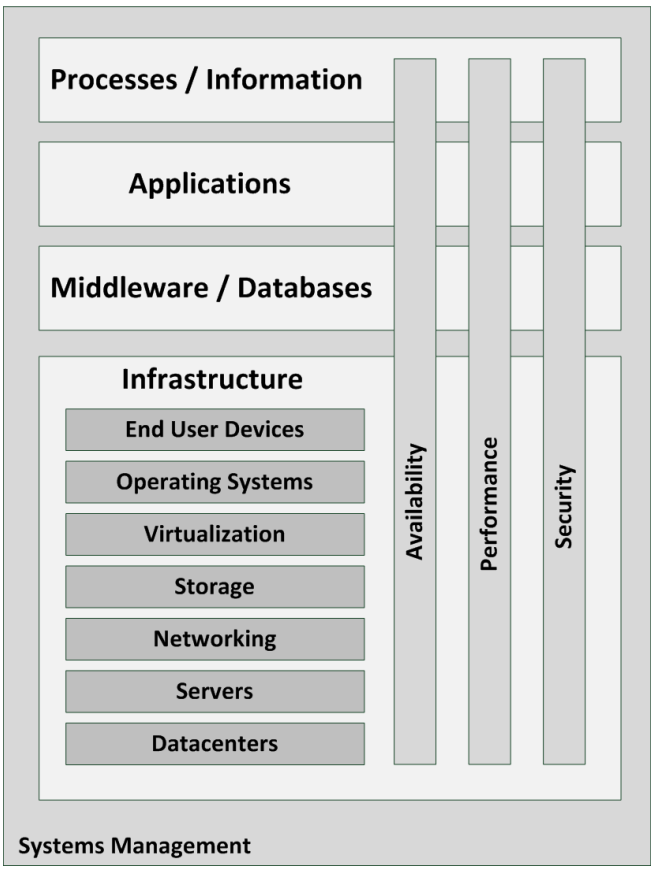


Figure 38 the structure of the IT infrastructure

This model shows the components from which an infrastructure is built. From this diagram, the following elements should be presented in IT Infrastructure model:

Components

22 Revised Infrastructure Model, by Over Sjaak Laan,http://www.sjaaklaan.nl/pivot/entry.php?id=142

23 http://www.sjaaklaan.com/pivot/entry.php?id=2

- Hardware

Hardware is the basis of whole IT infrastructure, which includes a servers, network components and disk storage.

- Operating Systems

The operating system is the other basis to run different applications and to provide service to customers. There are a lot of operating systems. It is better to define at first the type applications are needed and their purposes.

- Networking

The network is a crucial part of any infrastructure. It is associated with different components; the network can be rather complicated depending on the system environment. It can contain routers, switches, NAT, Firewalls, WAN, LAN, dial-in, Internet access, VPN's, etc.

- Storage

Storage is usually considered as external storage of server. However, most servers have also internal storages. The storage component contains DAS, NAS, SAN, FC-AL, iSCSI, etc. Backup and recovery solutions, and ILM and ECM are part of storage as well.

- Applications

The Applications in this case are the basis to design the whole system infrastructure.

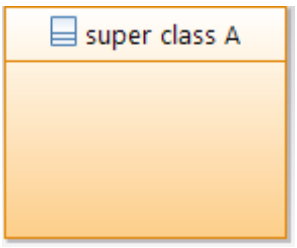
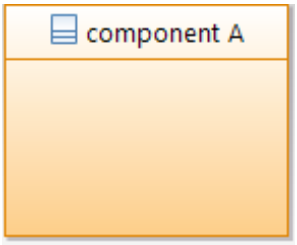
10.2. Transformation

As discussed in the above section, infrastructure means so many things in system developments. Therefore, to determinate a completed infrastructure by only using transformation rules from data model is not possible. According features of data model, the corresponding application components have to be identified first before conducting and finishing the whole infrastructure model in the refinement phase.

Therefore, like transformations in previous chapters, the transformation phase is also the first phase in transformation from data model to infrastructure model.

1) Transformation rule

Table 26 transformation rule "define the application component"

Rule ID	R134580
Name	DtoInfraCompentMapping
Domain	data model to infrastructure model
Language	UML to UML
Method	Define the application component
Abstract	Reduce the number of class through reducing reference
Content  Mapping to:  ● Covert super class into component	

After this rules the data model is converted into three main components in system

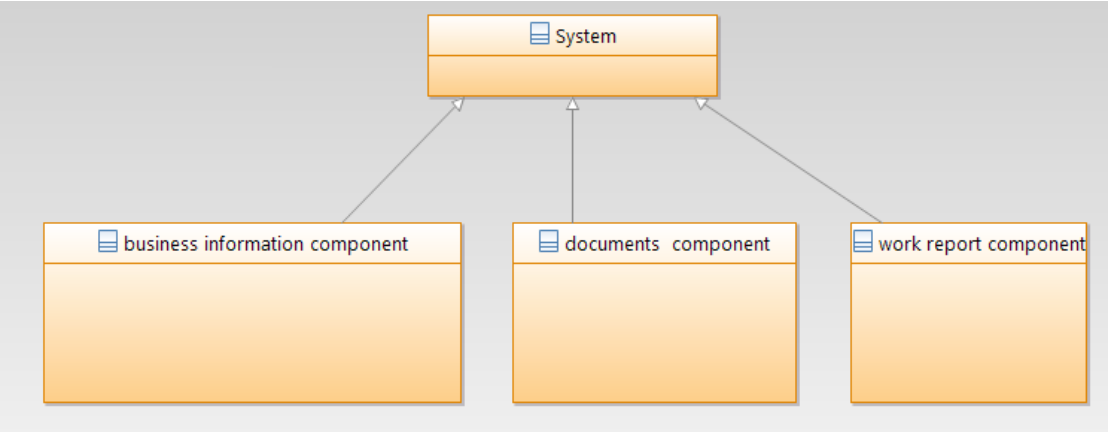
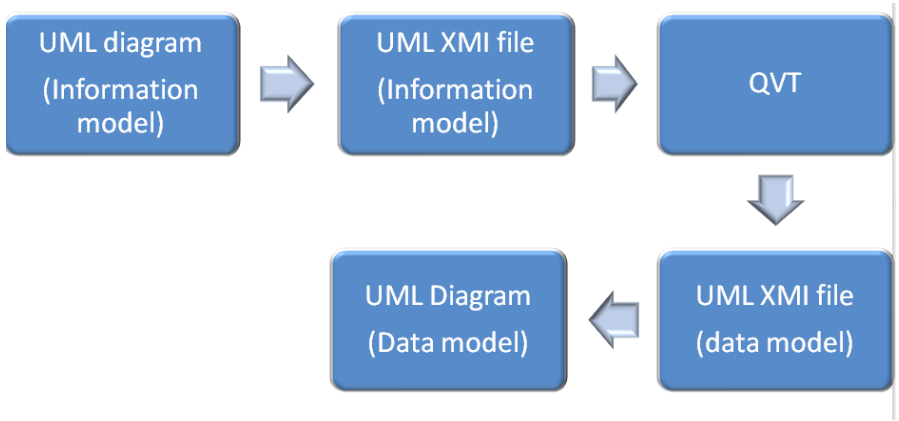


Figure 39 three main components in system

Just like the name of components, the system has three components:

- Business information component: in this component all business relevant information will be processed.
- Documents components: in this component all documents will be processed and manipulated.
- Work report components: in this component all work reports will be processed and manipulated.

The realization of this conversion is not complicated. The QVT language can be used to realize the transformation.

Developing Concept ID	DC134580
Reference transformation rule	R134580
Developing concept	
With QVT language to transform from UML to UML 	

Developing tools	mediniQVT
Code or implementation	

```
transformation Data2Infrsturcture(DataModel:SimpleUML, InfraModel:SimpleRDBMS) {

   top relation SuperClasstoComponent {

                  sn:String;

       checkonly domain DataModel d : SimpleUML::UmlClassifier {
       umlName =sn
      };
       enforce domain InfraModel i : SimpleUML::UmlClassifier {
       umlName = sn+'component'
      };


      where {
      -- to map all model elements in super class.
        ElementMapping(d,i);


      }

            }
```

10.3. Refinement

1:1 transformation cannot provide enough information to model infrastructure model. The reason is simple: a software model cannot be converted into a hardware model directly. Thus, infrastructure model includes many aspects of system. However, only from view of software, a complete system infrastructure cannot be created. Many requirements from previous models can be gathered and after analyzing those requirements details of system infrastructure can be identified. Therefore, before developing infrastructure model further, analyzing requirements from view of software is required.

Analyzing requirements and needs from view of software is very completed. This thesis will not spend much time to explain the method of defining requirements of software. The following table lists some important points of requirements which are retrieved from previous models.

Table 27 some important points of requirements

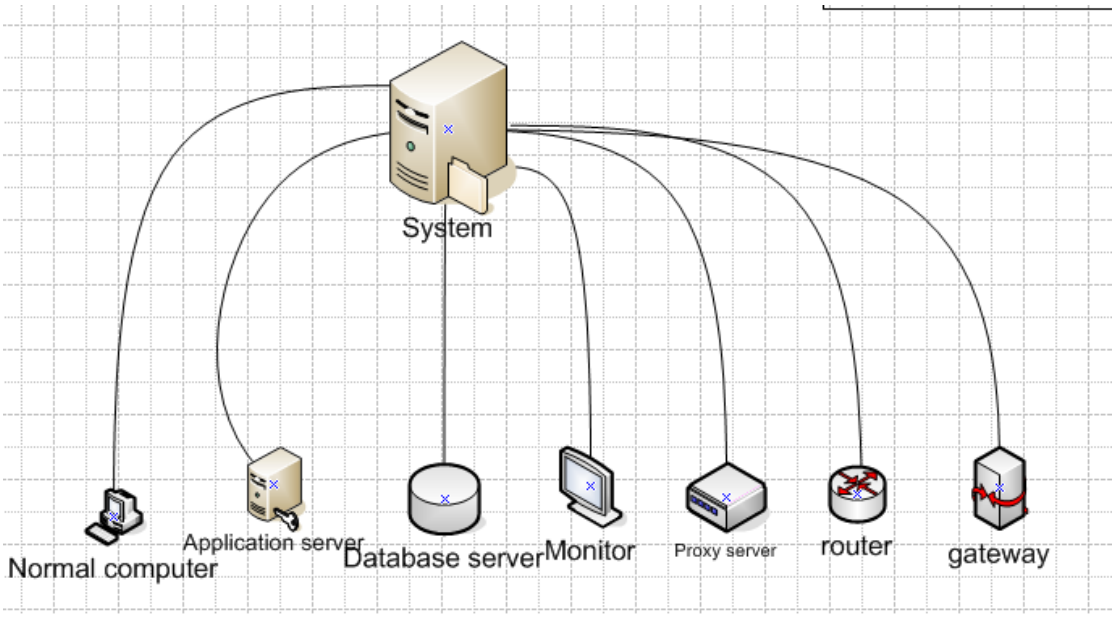
issues	From which models	Needs
Business information	Data model	Application server, database
Report generation	Data model	Application server, database
Documents	Data model	Application server, database
Network	Infrastructure model	necessary facilities for network connecting
Client side	Infrastructure model	Facilities communicating with server

After defining of the important components and requirements of system, the infrastructure information can be summarized as below:

Table 28 infrastructure model in aspect of hardware

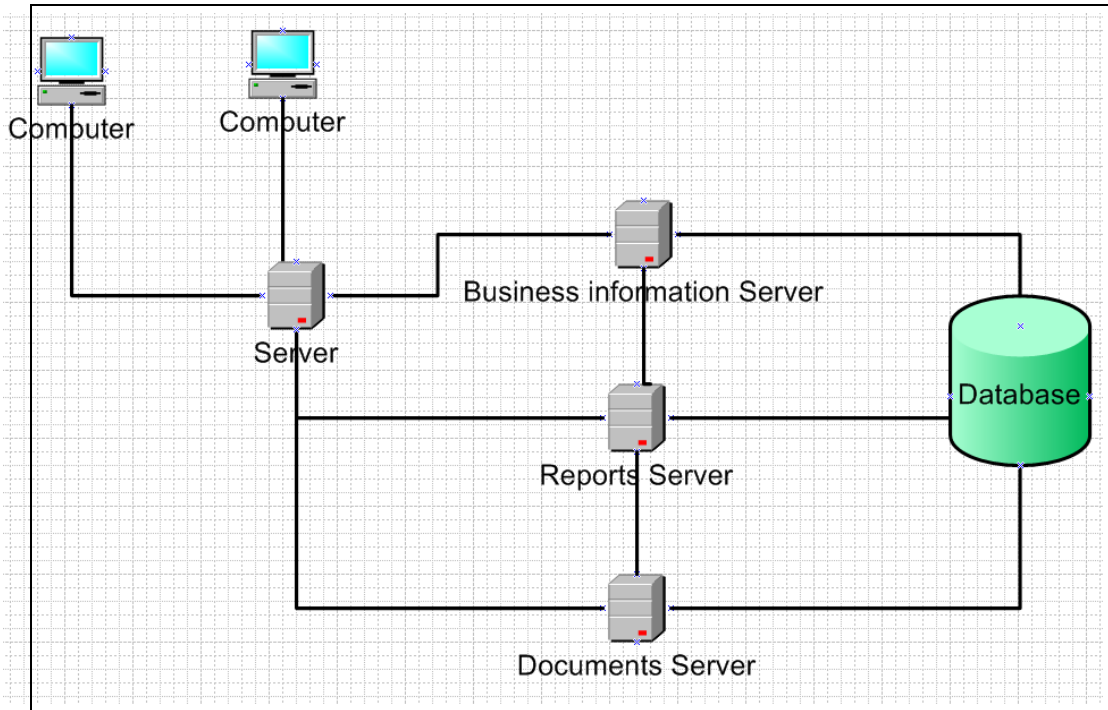
- Hardware

The hardware infrastructure is like following:



- Operating Systems
  - Client: windows7 or XP
  - Server: Windows Server,
  - Oracle server: Oracle Solaris

- Networking



- Storage

  Oracle database

Seen from above model, the server system is divided into three parts, business information server, reports server, and documents server. There is also a general server to coordinate and manage these three servers. Thus, there is only one database, in which all information should be saved.

10.4. Summary of this chapter

Infrastructure model is last layer of the design process model. It bases on other models in design process model and describes relevant system and hardware information. Therefore, the infrastructure model is extended from other models in design process model. However, its features decide that it cannot be transformed from other model directly.

The approach to transform this model is therefore like this: in transformation phase the from 1:1 transformation, requirements for building system infrastructure can be acquired, by analyzing which infrastructure model can be modeled and refined in refinement phase.

The 1:1 transformation in this part does not play a main role. However, by following steps and methods of design process model, needed model can be analyzed and modeled. The idea of logical transformation is also throughout in this part.

11. Conclusion and outlook

Design and development of IT system is an eternal research subject in field of computer science. And how to develop IT systems efficiently and optimally is emphasis of this research. Comparing with other software development frameworks and methodologies, the design process model focuses on design phase of system development and presents design concepts and logics by using different types of models. Thus, M2M transformations between 2 different models in design process model ensure the coherence and logic of design. The final concept which consists of different models is also an overview of system and provides a planning or controlling method for system management.

The biggest feature of this design process model is making the design phase standard and logic, furthermore, the design phase become more transparent through recording transformation rules and transformation steps. It can reduce probabilities of information lost and data redundancy.

On other side, this design process model organizes different system models. It is an overview of whole information system. That is more like blueprint in construction. It improves the level of transparence among different development teams and phases. It is very helpful for further integration and updating. IT managers can also understand the situation of systems through this design process model and make IT strategy for the enterprise more easily and optimally.

Therefore, the design process model not only can be used alone in system design, in additional, it can be used as a method to combine with other software methodologies for developing, updating and managing information system.

Throughout this thesis, the main technology and concept for modeling and transformation is from MDA. It inherits some features of MDA such as with code to achieve the Model to Model transformation, and also, it gives the designer own autonomy to perfect different system models. So this design process model can also as a complementation in transformation between CIM and PIM. The results of each step in design process model can be looked upon as Inputs of PIM.

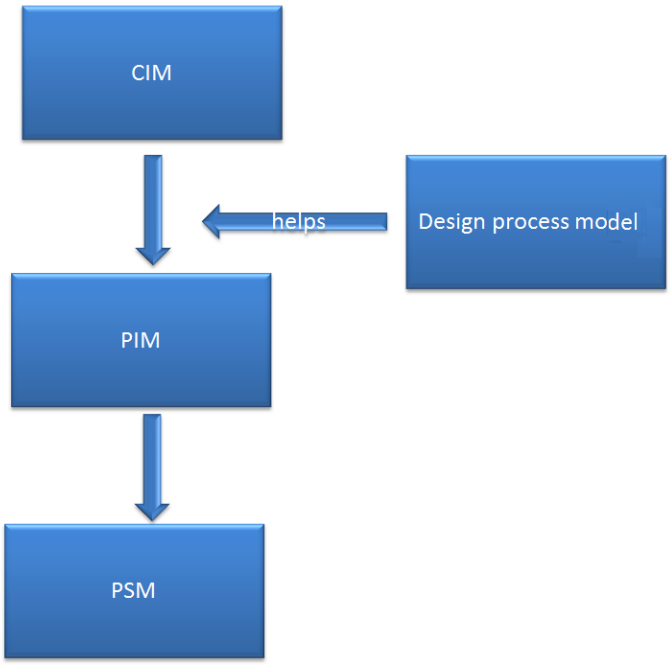


Figure 40 the relationship between MDA development and design process model

However, this design process model is now in his Infancy, there are a lot of improvements we need to do in future. It includes mainly in 4 aspects:

1) Determining Sub steps for each modeling

The design process model has already defined 4 phases to achieve final system concept. But there are not any organization structures or methods for each phase. That let creating and updating models inside of same phase become non -standardized. The next steps of research should detail this 3 phases and make a standardized modeling approach for each model.

2) Complementing the repository

Transformations rules and methods in repository should be updated and complemented. The repository should include transformation technologies as more as possible. How to summarize and manage those transformation approaches should be defined in further work.

3) Interface for other different models.

The design process model defined 4 types of models. But developers usually need some other models to describe special requirements. Therefore, the design process model needs reference or integration rules. So that users of design process model can understand and utilize other models as easy as possible.

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