Chapter 1

Introduction

In large-scale software developments, especially in those for industrial applications, domain models are usually used to analyze the structure, constraints and user requirements which reside in a problem domain. Those models are called "enterprise models" and various modeling methodologies have been proposed. They include ARIS [62], CIMOSA [43], PERA [61], [81], TOVE [26], [33] and so forth, which claim their contribution to improvements in productivity, quality and maintainability of software systems.

Whereas the above methodologies adopt "top-down" approach that captures a whole problem structure first to decompose it into detailed parts for implementation, there is another "bottom-up" approach that defines the elements first, which compose the implementation of domain problems, in order to build the adaptable software systems. This approach is called "Component Based Software Development" (CBSD), and various component assembly mechanisms or System Component Infrastructure (SCI), such as COM, DCOM [63], CORBA [71], or RMI [21] are proposed along with commercial software components, often referred to as COTS (Commercial Off-The-Shelf) components or shrinkwrapped software [12], [13], [54].

Two intensive researches on model-based and component-based software development have been done. They are Model Based Software Engineering (MBSE) [28], which focuses on *models*, and Component Based Software Engineering (CBSE) [11], [17], [37] which focuses on *components*. In these researches, MBSE is defined as "a disciplined engineering approach that relies on constructing models of software applications within a product family to achieve the benefits of reuse, shorter time to market, and higher quality", and CBSE is defined as an approach to "advocate the acquisition, adaptation, and integration of reusable software components, COTS products, to rapidly develop and deploy complex software systems with minimum engineering effort and resource cost". MBSE is mainly a solution for early stages in software developments such as requirements analysis or requirements definition, while CBSE is that for later stages in software developments such as software design and implementation.

The combinational usage of those technologies is expected to be a solution for the whole stages of software lifecycle, however, there are the following difficulties when we apply them to real industrial applications.

1. In requirements modeling, we have to deal with many pieces of knowledge on a problem domain, which are provided by domain-experts. Since those pieces are biased by the roles and the missions of the experts who have their own domain experience, they could mutually conflict and must be integrated consistently.

2. After the requirements are modeled, we have to select the software components which satisfy the requirements, even though they are not designed for those requirements, and there are possibly conceptual gaps between the requirements and the components.

3. The selected components must be combined together properly, however there are no guidelines provided to compose the adaptable software systems from those components.

4. In the verification of the resultant systems built from the above components, we have no appropriate way to evaluate the adaptability of the software systems to the requirements.

This thesis presents a formal approach in model based and component based software composition, which includes solutions to the above difficulties.

The thesis mainly focuses on enterprise back-office applications, such as "trading and settlement" applications in banking industries, "underwriting and payment" applications in insurance industries, "production planning" applications in manufacturing industries or "human resource management", "asset management" and "customer management" applications in cross industries. Those back-office applications configure the core part of business processes in an enterprise, and software systems which support them are often called "operational systems".

The thesis is organized as follows. Chapter 2 summarizes background and premises of this thesis, along with the related work to it. Chapter 3 presents a formal way to identify the structure of problem domains to be modeled, including the facts and the requirements in the domains. This structure is represented in the form of a set of model units or model elements and their relationships. Rough Set Theory (RST) is used to extract consistent model units and their relationships from many pieces of knowledge which are provided by various domain-experts, and could be mutually inconsistent. Those units and their relationships are assembled into the requirements models expressed by Colored Petri Nets (CPN).

Chapter 4 discusses an approach to compose the adaptable software systems to the requirements models. The proposed approach consists of two steps. The first step is devoted to mining the adaptable software components from available sources. Σ algebra is used to evaluate adaptability of software components, whereas RST is used to adjust differences in sorts between two algebras representing the requirements and the components respectively. The second step is devoted to composing software systems by the selected components, which satisfy the behavioral aspect of the requirements model. Decision tables extracted from the requirements CPN model are used to implement this behavioral aspect, while RST is used to optimize those decision tables. Chapter 5 introduces two methods for evaluating adaptability of the composed software systems to the requirements. The first is a method for evaluating adaptability from functional viewpoints. The composed software system is represented by Σ algebra, and algebraic equivalency to the requirements is evaluated. The second is that for evaluating adaptability from behavioral aspect. A Calculus of Communicating Systems (CCS), one of process algebras, is used to evaluate this adaptability.

Figure 1.1 shows the overview of the proposed approach discussed in this thesis.

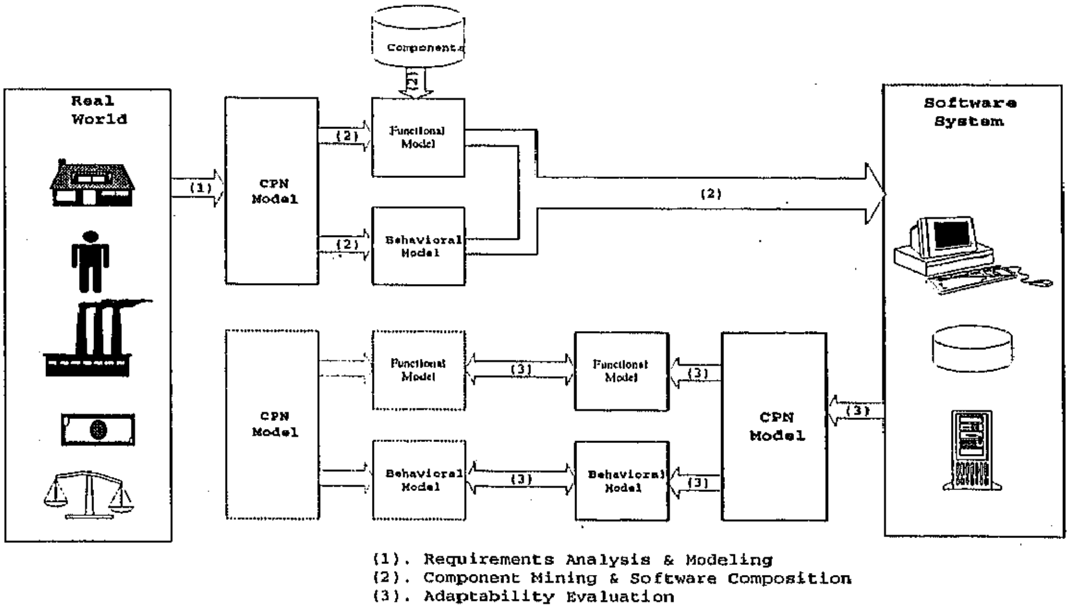

Figure 1.1: Overview of the proposed approach