REPRESENTING DESIGN PATTERNS AS SUPER COMPONENTS IN COMPONENT ORIENTED SOFTWARE ENGINEERING

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ABSTRACT

REPRESENTING DESIGN PATTERNS AS SUPER COMPONENTS IN COMPONENT ORIENTED SOFTWARE ENGINEERING

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It is widely believed and empirically shown that component reuse improves both the quality and productivity of software development. This brings the necessity of a graphical editor to model the projects by using components. A graphical editor was implemented for the development of Component Oriented software development. The editor facilitates modeling efforts through application of the graphical modeling language COSEML. Both design patterns and software components have come to play important roles in software development. The correlation between software components and design patterns is apparent. In the design phase of the projects design patterns are used widely both in component and object oriented projects. Design patterns can be used as super components in component-based development . Software reuse, software components, design patterns, use of design patterns in component-based development, and component architectures are studied in details to address the need for the approach. COSE modeling activity starts with the decomposition of the target system into building blocks in a top-down order. Next, interfaces between these blocks are defined. If required design patterns can be added to model as super components.

Keywords: Component Design Patterns, Design Patterns, Component Oriented Software Modeling Language, Component Based Development

ÖZ

TASARIM KALIPLARININ BİLEŞEN TABANLI YAZILIM MÜHENDİSLİĞİNDE BİLEŞİK BİLEŞEN OLARAK TEMSİL EDİLMESİ

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Yazılım geliştirirken bileşenlerin kullanılmasının kaliteyi ve üretimi arttırdığına yaygın olarak inanılmakta ve bu deneylerle gösterilmiştir. Bu da projelerin bileşenlerle tasarlanabilmesi için grafiksel bir editör ihtiyacı doğurmuştur. Bu amaçla geliştirilmiş bir grafiksel editör bulunmaktadır. Bu editörde özellikle, Bileşen Yönelimli Yazılım Mühendisliği (BYYM) yaklaşımı desteklenmiştir. Editör, grafiksel modelleme dili BYYMMD'nin uygulanması sayesinde modelleme çalışmalarını kolaylaştırmaktadır. Hem tasarım örnekleri hemde yazılım bileşenleri yazılım geliştirirken önemli bir role sahiptirler. Yazılım bileşenlerinin ve tasarım örneklerinin arasındaki ilişki barizdir. Gerek nesneye yönelik gerekse bileşen yönelimli projelerde tasarım aşamasında tasarım örnekleri sıkça kullanılmaktadır. Tasarım kalıpları bileşen yönelimli tasarımda gelişmiş bileşenler olarak kullanılabilir. Yazılımı yeniden kullanma, tasarım örnekleri, tasarım örneklerinin bileşen yönelimli tasarımlardaki kullanımı ve bileşen mimarileri bahsedilen yaklaşımın gerekliliğini belirtmek için detaylı olarak incelenmiştir. BYYM modelleme aktivitesi, hedef sistemin yukarıdan-aşağıya yaklaşımına göre alt parçalarına bölünmesi ile başlar. Daha sonra, parçalar arasındaki arabirimleri tanımlar. Gerektiğinde tasarım örnekleri de üst seviye bileşen olarak tasarımlara eklenebilmektedir.

Anahtar Kelimeler: Bileşen Tasarım Örnekleri, Tasarım Örnekleri, Bileşen Yönelimli Yazılım Modelleme Dili, Bileşen Tabanlı Uygulama Geliştirme

To My Father

ACKNOWLEDGEMENTS

I would like to thank my supervisor, Dr. Ali Hikmet Doğru, for his guidance and encouragement throughout this research. To my family, I offer sincere thanks for their emotional support.

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CHAPTER 1

INTRODUCTION

A brief look at the history of the computer science suggests that important developments had happened through raising the abstraction levels in development and introduction of tools associated with this new paradigm. In the early days of computer science, programmers had to write op-codes of the entire program. Later on mnemonics were introduced which abstracted the machine code into instruction names. A tool associated with the abstraction was a piece of software that converted the instructions to op-codes.

This phase was followed by introduction of another abstraction mechanism and its associated tool: the assembler. The assembler is a software tool that converts not only instructions but also labels into such codes that a machine can understand.

As the complexity of software grew and the number of programmers in projects increased, assemblers become inadequate. The problem was resolved by introduction of another level of abstraction and its associated tools: high level programming languages and compilers. Programming languages provided means to control and implement software development that is closer to human thinking and understanding. Programmers would learn a computer language that is similar to a natural language in many ways, and the tool, the compiler, would convert this human made language to the language the computer understands: the machine code.

Over the time the increase in software complexity and failure rate of software engineering projects required new approaches to be invented and as a result object oriented programming came to rescue. The tools for object-oriented techniques were new languages that supported this new paradigm. Object-oriented programming techniques promote a new approach to software engineering in which reliable and open applications can be largely constructed, rather than programmed, by reusing software components.

With ever-increasing software complexity no single individual, however talented, could deal with the entire complexity of the projects. Though object oriented programming supported software reuse and better effort division, there were and still are different individuals implementing same things over and over for different projects and in some cases in the same project.

It became apparent that for better software reuse a new method was required. Software components and component based development were the apparent answer to this problem. Although the dream of a components-based software industry is relatively old, only now does it appear that we are close to realizing the dream. The reason for this is twofold:

- Modern applications are increasingly open in terms of topology, platform and evolution, and so the need for a component-oriented approach to development is even more acute than in the past.

- Objects provide an organizational paradigm for decomposing large applications into cooperating objects as well as a reuse paradigm for composing applications from pre-packaged software components.

Software reuse is the main issue in component based software development. Software reuse is reusing the inputs, processes, and outputs of previous software development efforts. Not only the source code of previously developed systems can be reused, but also data, architecture, program, technology transfer and utilization knowledge, and development and application-area knowledge reuse can be applied to the software development processes.

Software reuse improves productivity and quality. A suitable example of software reuse is reusing the software components. A software component is any standard, reusable, and previously implemented unit that has a function in a well-defined architecture. When the quality software components are used in a target system, the overall product quality and reliability of that system improves.

In component based software development software components are used to develop a bigger system. Component-based development transforms the development from code writing to integration of components. To achieve this first the specification of the target system is defined. Based on this specification the target system is decomposed according to the components available (since there exists a large set of components in the market). Since the components are defined their adaptation and creation are performed. After acquiring the needed components, these components are integrated to build the target system.

The integration stage heavily depends on the interfaces. A framework architecture is developed such that components communicate without any knowledge of the details of each other. This is facilitated by the set of well-defined interfaces belonging to the components.

In summary, component-based software development is associated with a shift from statement-oriented coding to system building by plugging together components. The idea is not new and some progress has been made over the past decades. Nevertheless, today's software development practice is still not fully matured in this respect. In recent years, the term component-ware has become the vogue in the software engineering community. There are lots of design tools available in the market. But none of them is specialized for component oriented software development as defined in the " build by integration " paradigm.

The software reuse problem was not the only obstacle for the success of large software projects. In the late eighties, it became obvious that the tools and methods in hand were not good enough to assure the success of the projects. The main cause of failure was the missing of sharing knowledge and experience among the members of developments groups. The group members lacked a common language and understanding of problems. Towards the end of eighties and early nineties, the concept of design patterns emerged in parallel with the work on components. Design patterns literature provided a common language, and the work on patterns provided well thought solutions to problems that are common to most of the software projects.

As it is pointed above, so far the most powerful abstractions and paradigms have tools that help the developers implement them with little effort and high efficiency. “Design patterns” is also mostly a print media effort yet. There is no powerful tool that helps the developer use design patterns with little effort and high efficiency except for just a few design patterns (such as model-view-controller implemented in Java Swing).

The aim of our work is close this gap by implementing a visual tool that implements a Component Oriented methodology which makes it possible to hierarchically decompose a system’s requirements. Modeled in Component Oriented Software Engineering Modeling Language (COSEML) developed before, such a hierarchy corresponds to the structural relations among components [1]. Today’s technology is Component Based (CB) that is; components are accounted for during only limited development phases. A top-down approach envisioning components at every level has been missing. This is like the history of Object Oriented (OO) technologies: languages were developed before methodologies.

The graphical editor, partially implemented in this research, presents only the structural views of target systems. So, it enables the user to hierarchically decompose a system’s requirements, and to view structural relations among components graphically. It also introduces the design patterns to the picture by treating them as super components.

1.1. Motivation for Implementing Design Patterns in COSEML

Both design patterns and software components have come to play important roles in software development. The correlation between software components and design patterns is apparent.

Design patterns are well suited to describe the power of different strategies in component-based software development. Programmers developing components can take advantage of already defined design patterns, when developing new components. Also the design pattern community might extract new or improved design patterns from existing successful component-based applications that can later bring benefits to other component developers.

There are design patterns offering guidance on how to make loose connections between different subsystems, but also, when it comes to the inner workings of a module or a component, there are patterns helping the programmer to identify a suitable implementation.

Design patterns are important to Component Based Development (CBD), even if they are not a panacea. When developing components, one very obvious goal is to make them as usable as possible. For example, it is important that the components become maintainable and flexible. Design patterns are very good tools to capture the pros and cons of different solutions. The advantages of taking existing patterns into account when developing components will probably be even more apparent as time advances by, when more patterns suitable to CBD will be discovered.

CBD is a promising concept, even if there is much work to be done in this very young and rapidly changing field. In the future when component technologies have matured, they might form the foundation of software construction. In the development process ahead, design patterns might provide assistance and guidance to new solutions.

As a result design patterns can be thought as super components or a strategy to develop components. There are lots of design patterns for new component based technologies such as Component Object Model (COM), Distributed COM (DCOM), Enterprise JavaBeans (EJB) and etc. This brings the requirement to use design patterns while designing component-based systems.

1.2. Organization of the Thesis

Beyond this first chapter, the thesis is organized as follows: In chapter 2, necessary background on component-based modeling, component architectures, background for design patterns and use of them in COSE (Component Oriented Software Engineering) are presented. Chapter 3 describes the COSE approach and defines this modeling language. Chapter 4 describes the improvements to the CASE tool COSEML by representing added capabilities and design overview. Chapter 5 presents conclusions and further work.

CHAPTER 2

BACKGROUND

Developing large software systems with very high reliability and availability requirements entails enormous costs. Many software organizations have begun to consider implementing such systems using reusable components to decrease the costs and cycles of development process, and the time to specify the requirements, design, test, and maintain the system as well. Thus, software reuse is a logical choice for these organizations.

New generation of software reuse is through utilization of using software components. They obey all the rules defined in software reuse, and they promise improvements in software quality and productivity.

Software components lead to component-based development style. This style focuses on the reuse of software components, and it changes the software development from line by line coding to system integration from well-defined software components.

Component based development style makes it possible to bring together software components written in different languages, compiled by different compilers, and run on different platforms. This heterogeneity problem of the systems can be solved by component architecture.

2.1. Component Based Software Engineering

Component-based Software Engineering (CBSE) is concerned with the development of systems from software components, the development of components themselves, and system maintenance and improvement by means of component replacement or customization. Building systems from components and building components for different systems require established methodologies and processes not only in relation to development / maintenance phases, but also organizational, marketing, legal, and other aspects of the system lifecycle. There are a number of software engineering disciplines and processes that require methodologies to be specialized for application in component-based development that are specific to CBSE, in addition to objectives such as component specification, composition, and component technology development. Many of these methodologies are not yet established in practice; some have not even been developed yet.

Experiences from other fields, such as system engineering can be successfully applied to component-based development, as there are many similarities in the basic concepts (for example, relations between systems and components). Also, with its focus on components and their specifications, CBSE can provide better understanding of building systems in general, and in particular of computer-based systems whose significant part is software. It is widely believed both in academia and the industry that the progress of software and system development in the near future will depend very much on the successful establishment of CBSE [9].

2.2. Building Systems and Building Components

There is one significant difference between the challenges and problems addressed by CBSE and those encountered elsewhere in software engineering. CBSE specifically focuses on questions related to components and in that sense it distinguishes the process of "component development" from that of "system development with components". There is a difference in requirements and business ideas in these two cases and different approaches are necessary. Components are built to be used and reused in many applications, some possibly even not yet imagined. Marketing factors play an important role, as development costs must be recovered by future earnings. System development with components focuses on the identification of reusable entities and relations between them, starting with the system requirements stage. The availability of components already existing, should also be considered.

2.2.1. Building Component Based Systems – a top-down approach

A standard approach in a system development is the top down approach; the system design starts with specification of the system architecture. The architecture defines the components of a software system as well as their interactions and can be used to analyze its quality attributes [10].

The system design process, i.e. the software architecture design process, typically consists of three phases, which might be performed in several iterations. The first phase includes functionality-based design. Although nonfunctional requirements are not explicitly addressed at this stage, software designers usually keep an eye on them during the design phase. Functionality-based design consists of four steps: defining the boundaries and the context of the system, identification of the types, decomposition of the system into its main components and, finally, the first validation of the architecture by describing a number of system use scenarios.

The second phase is the assessment of the quality attributes of the software architecture in relation to the quality requirements [10].

The third phase of the software architecture design process is concerned with the transformation of the design solutions to improve the quality attributes while preserving the domain functionality captured by the software architecture. These transformations result in a new version of the software architecture which in general improves over the old ones in terms of quality.

The final result of this stage is the system software architecture which identifies the components and the interaction between them. Up to now the design model is not specific to component-based approach. In, what many would consider, a “classical” approach the next step would have been to implement the components identified by the design. In a component-based approach the main idea is to re-use the existing components, i.e. to find the most suitable components. The implementation effort in system development will decrease but the effort required in dealing with the components; locating them, selecting those most appropriate, testing them, etc. will increase [10].

2.2.2. Building Systems from Components

The architecture of the system is heavily influenced by the types of components that compose the system. The framework into which components are to be plugged influences the architecture of the system in a similar way as the type of the selected components, influence the system design process [10].

Design freedom is limited to component selection and the way the selected components are integrated. This restricted freedom points out the importance of managing and controlling component integration. Component specifications in the form of APIs do not normally provide enough information about how the component will behave when used in a given environment. The lack of complete information raises issues related to understanding of the behavior of the components and in verifying both the functional and non-functional properties of the components and in accurate prediction of overall system behavior. The verification of component properties is required in order for developers to have confidence that a system will behave as its architect predicted it would. In many cases a component property alone cannot be used to predict the system behavior, but clusters of components (assemblies) must be analyzed separately.

The examples briefly mentioned above show that much of activity in the design and development phases belong to the component properties and composition issues. This shows that a component-based design can have difficulties in using top-down approach. Rather a mix of a top-down and a bottom-up approaches should be followed.

2.3. Design Patterns

Designing object-oriented software is hard, and designing reusable object-oriented software is even harder. A reusable design should be specific to the problem at hand but also general enough to address future problems and requirements. When a good enough design is found it is reused again and again. At each use the solution becomes more flexible. This gives the ability to use it next time. By time these design solutions are used to solve specific design problems and make the object oriented design more flexible, elegant, and ultimately reusable. These designs help designers reuse successful designs by basing new designs on prior experience. A designer who is familiar with such patterns can apply them immediately to design problems without having to rediscover them.

2.3.1. What is a Design Pattern ?

Each pattern describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same twice [2]. Patterns are about communicating problems and solutions. Patterns enable us to document a known recurring problem and its solution in a particular context, and to communicate this knowledge to others. The main goal of a design pattern is to foster conceptual reuse over time. Each design pattern is a three part rule, which expresses a relation between a certain context, a certain system of forces which occurs repeatedly in that context, and a certain software configuration which allows these forces to resolve themselves.

The main common characteristics of design patterns can be classified as:

- Patterns are observed through experience.
- Patterns are typically written in a structured format.
- Patterns prevent reinventing the wheel.
- Patterns exist at different levels of abstraction.
- Patterns undergo continuous improvement.
- Patterns are reusable artifacts.
- Patterns communicate designs and best practices.
- Patterns can be used together to solve larger problem.

In general a design pattern has four essential elements:

- “**The Pattern Name** is a handle we can use to describe a design problem, its solutions, and consequences in a word or two. It lets us design at a higher level of abstraction” [2].

- “**The Problem “**describes when to apply the pattern. It explains the problem and its context. It might describe specific design problems such as how to represent algorithms as objects” [2].

- “**The Solution “**describes the elements that make up the design, their relationships, responsibilities, and collaborations. Note that the solution does not describe a particular concrete design or implementation” [2].

- “**The Consequences “**are the results and trade-offs of applying the pattern. Though consequences are often unvoiced when we describe design decisions, they are critical for evaluating design alternatives and for understanding the costs and benefits of applying the pattern” [2].

During the last ten years design patterns, frameworks and software components have become very promising as different tools available to increase reuse in software development projects. The two most common techniques for reusing functionality in systems are class inheritance and **object composition**. Class inheritance lets to define the implementation of one class in terms of another’s.

Object composition is an alternative to class inheritance. Here, new functionality is obtained by assembling or composing objects to get more complex functionality. A good pattern show ways to solve problems and are structured in a style that lends itself well to explaining the aspects of the problem and solution at work. From this view it is clear that a design pattern is a reusable component itself. And also design patterns can be reused by using object composition. Each design pattern has responsibility for one specific problem solution.

2.3.2. Cooperation and Co-existence of Design Patterns and Component Based Development

There exists a strong interaction, cooperation and co-existence between software components and design patterns. Components can benefit from design patterns. Design patterns are well suited to describe the power of different strategies in component-based software development. Programmers developing components can take advantage of already written design patterns, when developing new components and the design pattern community might extract new or improved design patterns from existing successful component-based applications that can later bring benefits to other component developers. There are design patterns giving guidance on how to make loose connections between different subsystems, but also, when it comes to the inner workings of a module or a component, there are patterns helping the programmer to identify a suitable implementation.

Another interesting reuse technique is frameworks. A framework is a highly reusable design for an application, or part of an application, in a certain domain. It often defines the basic architecture of the applications that can be built by using it. Another way to view a framework is as an abstraction of a set of possible solutions to a problem. A framework is different from a design pattern, though. A framework is a concrete powerful solution that can be described in source code, Whereas a design pattern is more abstract. Only example usage or applications of a design pattern can be described in source code. Furthermore, a framework is often built by the application of a number of design patterns, and thus, patterns describe microarchitectures often used in frameworks.

Developers use existing frameworks by adapting them to form their particular application. So called whitebox frameworks let developers reuse and extend functionality by inheriting from base classes in the framework and provide application specific implementations. In blackbox frameworks, developers use object composition to plug in new functionality. Blackbox frameworks are generally easier to use and extend than whitebox frameworks, since developers need to have much more detailed knowledge about the internal parts in whitebox frameworks.

Component-based development has been presented as a very promising technology. A component is a replaceable part of an application. It has well-defined interfaces, which are separated from its implementation. The purpose of this dividing of a component into two parts (the interface and the implementation) is to achieve flexibility in how a component can be connected to other components and replaced by other components [7].

There is a strong relation between design patterns and components. Actually, one or more design patterns can be applied to build a component. Also, as a realization of a design pattern one or more components can be used. Furthermore, components can be used as parts in for example a framework and a framework can even be viewed as the glue code that makes components work together. In fact, technologies like Java Beans, COM/DCOM or Corba, are different specialized frameworks making it possible to connect components. Figure 1 illustrates the relationships (using UML syntax) between patterns, frameworks and components.

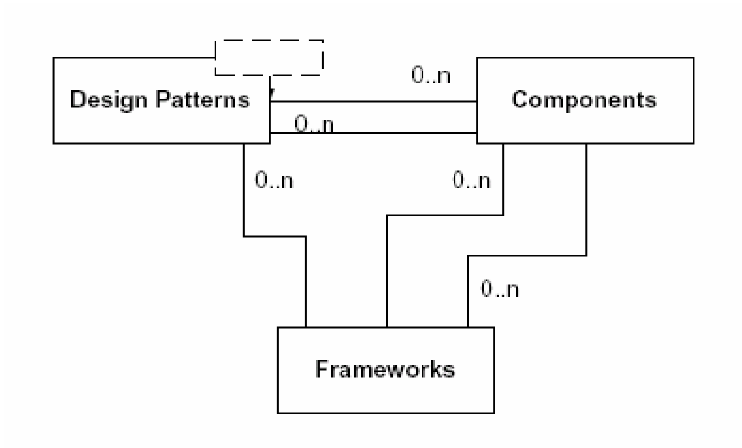

Figure 1. The relationships among patterns, frameworks and components [7]

The relation and hierarchy between these reusable techniques and applications which use these is shown in Figure 2.

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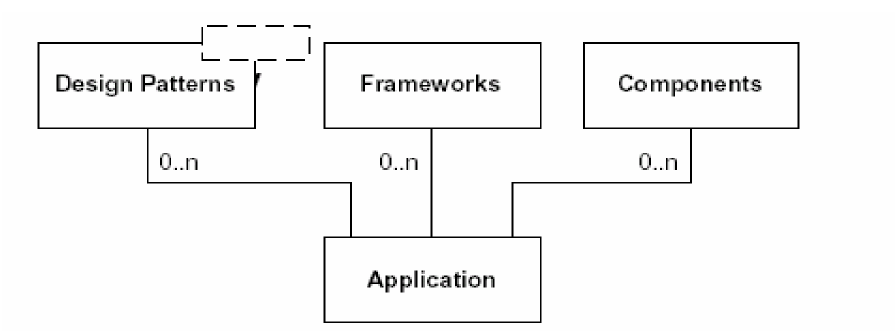


Figure 2. The relation between reusable techniques and an application [7]

2.3.3. Design Patterns and Frameworks in COSE

COSE regards any kind of development units as components. These components could be composite (super-components) or atomic. Any other concept is better represented somehow, as a logical or physical-level component. In this regard frameworks are considered as the largest-granularity components where care has to be taken about the more "physical" or implemented nature of the frameworks. The next large granularity components are design patterns. Mostly, a design pattern will represent a collaborating set of 2 to 7 components.

Design patterns are by definition abstract entities. COSEML allows the abstract-level representation of components. Hence, a design pattern can directly be represented as an abstract composite-component. This research however, allows the instantiated versions of design patterns also. Consequently, it is possible to accommodate a design pattern as a completely abstract entity (as it is), as a completely implemented set of components or a mixture. Practically all these forms can correspond to some area (or a sub-tree) in the decomposition view of a COSEML model. The designer has to be careful about the abstraction levels such super-components (frameworks and design patterns) while embedding them to a system with existing components. Figure 3 displays the conceptual relations among these elements.

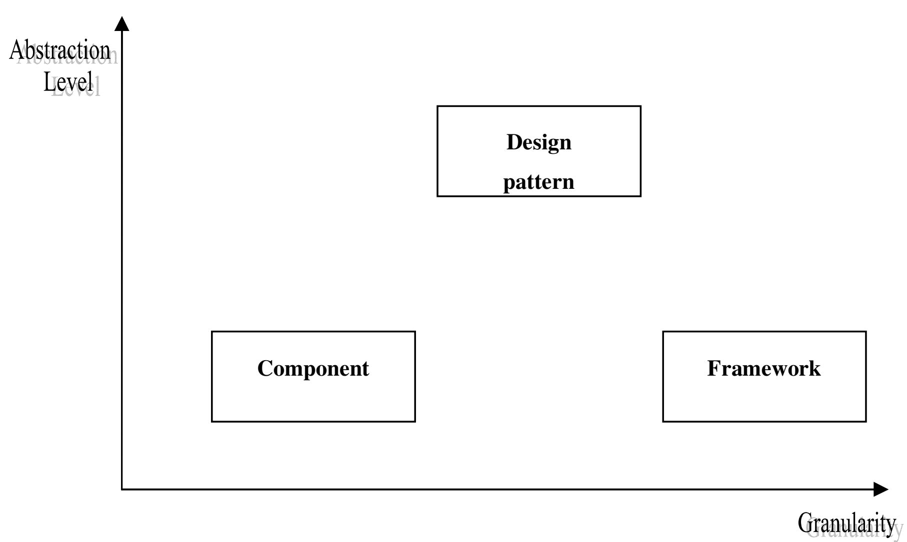


Figure 3. Design patterns, components and frameworks within COSE perspective

2.3.4. The Catalog and Brief Explanation of Main Design Patterns

There are 23 different design patterns extracted from several successful frameworks and domains. These patterns are accepted as the main design patterns.

- **Abstract Factory:** Provide an interface for creating families of related or dependent objects without specifying their concrete classes [2].

- **Adaptor:** Convert the interface of a class into another interface clients expect. Adaptor lets classes work together that could not otherwise because of incompatible interfaces [2].

- **Bridge:** Decouple an abstraction from its implementation so that the two can vary independently [2].

- **Builder:** Separate the construction of a complex object from its representation so that the same construction process can create different representations [2].

- **Chain of Responsibility:** Avoid coupling the sender of a request to its receiver by giving more than one object a chance to handle the request. Chain the receiving objects and pass the request along the chain until an object handles it [2].

- **Command:** Encapsulate a request as an object, thereby letting you parameterize clients with different requests, queue or log requests, and support undoable operations [2].

- **Composite:** Compose objects into tree structures to represent part-whole hierarchies. Composite lets clients treat individual objects and composition of objects uniformly [2].

- **Decorator:** Attach additional responsibilities to an object dynamically. Decorators provide flexible alternative to subclassing for extending functionality [2].

- **Façade:** Provide a unified interface to a set of interfaces in a subsystem. Façade defines a higher level interface that makes the subsystem easier to use [2].

- **Factory Method:** Define an interface for creating an object, but let subclasses decide which class to instantiate. Factory method lets a class defer instantiation to subclasses [2].

- **Flyweight:** Use sharing to support large numbers of fine-grained objects efficiently [2].

- **Interpreter:** Given a language, define a representation for its grammar along with an interpreter that uses the representation to interpret sentences in the language [2].

- **Iterator:** Provide a way to access the elements of an aggregate object sequentially without exposing its underlying representation [2].

- **Mediator:** Define an object that encapsulates how a set of objects interact. Mediator promotes loose coupling by keeping objects from referring to each other explicitly, and it lets you vary their interaction independently [2].

- **Memento:** Without violating encapsulation, capture and externalize an objects internal state so that the object can be restored to this state later [2].

- **Observer:** Define a one-to-many dependency between objects so that when one object changes state, all its dependents are notified and updated automatically [2].

- **Prototype:** Specify the kinds of objects to create using a prototypical instance, and create new objects by copying this prototype [2].

- **Proxy:** Provide a surrogate or placeholder for another object to control access to it [2].

- **Singleton:** Ensure a class only has one instance, and provide a global point of access to it [2].

- **Strategy:** Define a family algorithm, encapsulate each one, and make them interchangeable. Strategy lets the algorithm vary independently from clients that use it [2].

- **Template Method:** Define a skeleton of an algorithm in an operation, deferring some steps to subclasses. Template method lets subclasses redefine certain steps of an algorithm without changing the algorithm's structure [2].

- **Visitor:** Represents an operation to be performed on the elements of an object structure. Visitor lets you define a new operation without changing the classes of the elements on which it operates [2].

2.3.5. Useful Design Patterns for Component Development

Component-based development (CBD) is in no way a silver bullet to complex software development, but it helps and is a stepping-stone to a better development model. The problem domains inherent to CBD are interface versus implementation, interdependencies, interaction and responsibility. Design patterns focusing on these issues could be of great help. Design patterns can be used as super components in a component-based design. However this does not mean that all design patterns can be used as super components directly. To use a design pattern as a super component in the component-based design, this design pattern must be usable as a component by itself. Also it must contain information about how to use; not how to code. It is observed that creational design patterns can not be used as super components but some structural and behavioural design patterns can be used as super components in component based system designs. Creational design patterns can be incorporated through the in methods of a component but this is not in the concern area of component based development. Structural and behavioural design patterns that are concerned with the objects can be used as super components.

2.3.6. The Design Patterns, Which Can be Used in Component Based Systems Designs

Design patterns are widely used In object-oriented approach. As a result there are lots of special design patterns for object-oriented approach. Component orientation is a new approach for software design. Since it is not as widely used as the object oriented approach, it does not have specialized design patterns such as component design patterns. However the question “can all design patterns be used in design phase ?” is the same for the object oriented approach.

Design patterns can be classified into three groups according to their purpose. These are creational design patterns, structural design patterns and behavioural design patterns. Each group can be divided into two subgroups according to their scope (specifies whether the patterns applies primarily to classes or objects). Creational patterns are concerned with creation of objects. Structural patterns are concerned with the composition of classes and objects. Behavioural patterns characterize interaction of classes and objects.

When designing an object oriented system, designers are usually concerned with classes. If one of the creational patterns (for example factory or singleton design pattern) is used in creating classes in the design there is no need to specify this information. Therefore UML does not deal with whether an extra class architecture for classes are created from creational design patterns or not. But this information is given in the operations defined in the class. Like UML, COSECASE behaves in the same way with respect to this problem. In COSECASE most creational patterns take role only in methods defined in the interfaces. Since in component orientation the implementation of a component is not represented, there is no need or a way to show creational concerns, therefore the concern is only on the usage of the component.

Structural design patterns differ from creational patterns. For example adapter design pattern (also known as wrapper design pattern) can be used as a super component in component based system design. Adapter design pattern is used for mainly converting the interface of a class into another interface. The use of this design pattern in component based systems is adding a component between the component that interacts with each other, and this new component converts the interaction of these components into an appropriate form for each other. This new component is a super component since it is derived from the adaptor design pattern. COSECASE allows the use of this as a super-component and reuse whenever needed.

Like structural design patterns, behavioural design patterns can be used as super components in component based development. For example command design pattern can be used as a super component in component based system design. Command design pattern is used to encapsulate a request as an object, thereby allows the parameterisation of the clients with different requests, queue or log request, and supports undoable operations. For example, in a store automation design the 'store sale', 'e- sale' and 'inventory' components all interact with the sale component. Each component has different clients. In design phase command design patterns can be used as a super components between the sale component and other components, thus the operations can be controlled from this super component.

In order to use a design pattern as a super component in the COSECASE, this design pattern must be usable as a component by itself. This means it must provide information on how to use, not how to code. The main issue in COSE is not coding, using with no or less adaptation in coding. Structural and behavioural design patterns can be used in component based system designs but this does not mean all structural and behavioural design patterns can be used.

2.4. A useful set of design patterns for C.O.S.E.

Section 2.3.3. contains a selection of very useful design patterns, and some of them fit especially well into C.O.S.E. For example, Observer, Proxy, Mediator and Facade would solve some of the implementation difficulties of interdependencies and interaction of components. Here follows a short description about how these patterns can be used as component:

- The Adapter pattern (also called Wrapper) allows a client to use a target with an incompatible interface. It translates requests done according to the expected interface into corresponding request to the target with an otherwise incompatible interface.

- The Proxy pattern introduces an intermediate that handles all communication with the target. This can increase efficiency and protection of the target. The proxy interface can also provide easier access to the target.

- The Observer pattern (also called Publisher-Subscriber) regulates how a change in one object can be reflected in an unspecified number of dependant objects. It helps to avoid a tight coupling between the involved objects, which increases the flexibility and reuse possibilities.

- The Mediator pattern hides how a set of objects communicates with each other. It instills a loose coupling by not allowing direct reference between a set of objects. Instead these objects communicate through the mediator.

- The Facade pattern provides a single and simpler interface to a complex subsystem. This makes the subsystem easier to use and it also helps to decouple the subsystems from its clients. The facade doesn't provide any new functionality and the classes in the subsystem don't know anything about it. Hence, its protocol is unidirectional.

- Here follows some mostly used design patterns that are suited directly or indirectly for CBD. These patterns are obtained by the union of one or more main design patterns which are described in section 3.4. briefly.

- The Blackboard pattern is useful to solve problems where no known strategies exist. A collection of independent programs or subsystems is able to work together on the solution. Results found during the problem solving process are stored on the so-called blackboard.

- The Broker pattern solves the problem of coordinating communication in a distributed software system. It depicts how components interact by remote service invocation. Further more; it takes care of how to forward requests to appropriate servers and also how to transmit results and exceptions back to the client. The solution is flexible and reduces the inherent complexity in distributed applications.

- The Whole-Part pattern solves problems when a combined set of components acts together as a semantic unit. Aggregation encapsulates and prohibits direct access to the individual parts. It also organizes the internal part collaboration and stipulates a strict component interface.

- The Master-Slave pattern describes a solution to a working N redundant or parallel computing problem. A master controls a set of slaves and issues commands and work to the slaves. It then combines the partial results returned from the slaves into a final result. A client only communicates with the master.

As already stated, the above-mentioned patterns are examples of useful patterns for CBD. They show the intent of design patterns and, hopefully, they constitute a shortcut in the software development process when used. There are other patterns, however, that could have been mentioned equally well.

2.5. Design Patterns as Super Components

As time goes on, probably more and more specialized component patterns will be presented. Such domain specific patterns could be collected to form a useful component pattern catalog. This has already happened in other fields. For example, patterns aimed at business modeling. Another kind of domain specific patterns is patterns aiming at distributed computing, which is also very interesting and essential in CBD. For example, the major component models of today support distribution and the usage of distributed applications [7].

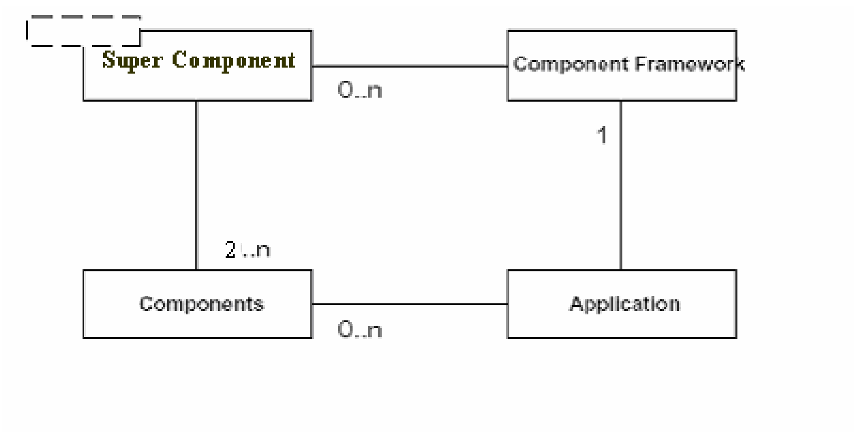


Figure 4. The role of super-components in CBD [7]

Domain specific patterns for CBD would work as some sort of super components, that is, components that can help to create other components that conform to a certain set of constraints. This set of constraints could be the implementation of a set of design patterns. As an example, a component framework (system that promotes the use of components i.e. COM/DCOM, CORBA or EJB) could be described as a set of collaborating design patterns [7].

Looking at design patterns as super components might inspire the pattern community to develop pattern languages for CBD. In Figure 4 an idealized view of super components role in CBD is presented. The application developer uses some component framework and integrates suitable components into the application. Super components were used to form the component framework and also to create the individual components themselves.

CBD might also benefit from a formal method of describing design patterns. Research is done in the field to formally specify design patterns and mathematically describe and transform design patterns. This is not mainstream research and has many adversaries due to the fact that design patterns are described in a natural language that accommodates ambiguity. This kind of research in the design patterns field could contribute to CBD. It could stimulate the discovery and invention of new component patterns, the classification and description of them and also, automatic application of patterns.

2.6. Component Based System Design Pattern

Component-based systems result from adopting a component-based design strategy, and software component technology includes the products and concepts that support this design strategy. Design strategy is something very close to architectural style - a high-level design pattern described by the types of components in a system and their patterns of interaction. Software component technology reflects this design pattern, which is depicted graphically in Figure 5. This reflection is due to the fact that software component technology does not exist only in development tools but also becomes part of the deployed application or system. This pattern is found in commercial software component technologies such as Sun Microsystems' Enterprise JavaBeans™ and Microsoft's COM+ [8].

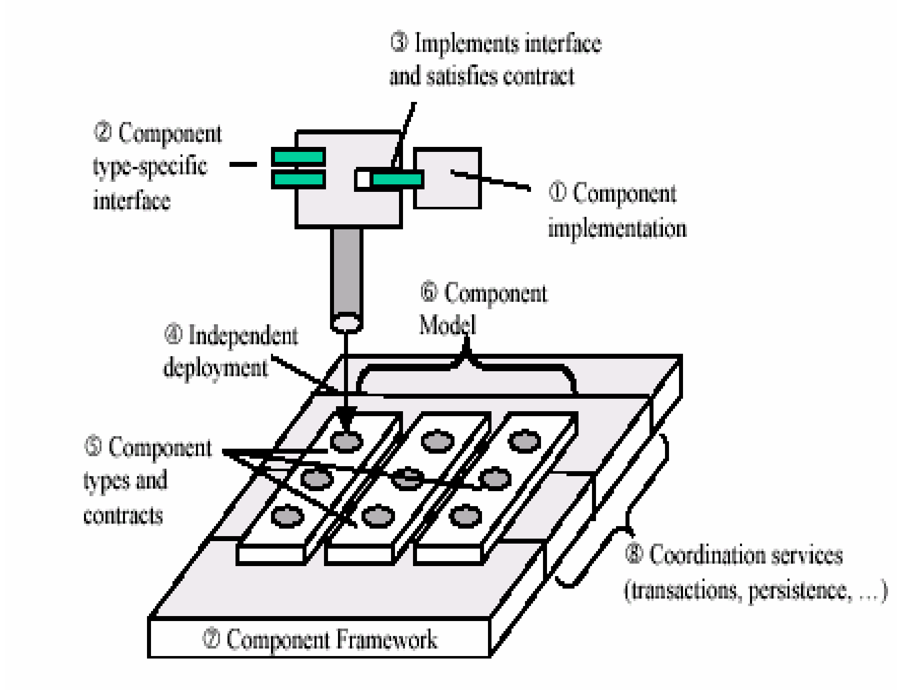


Figure 5. The component based design pattern [8]

A component (1) is a software implementation that can be executed on a physical or logical device. A component implements one or more interfaces (2) that are imposed upon it. This reflects that the component satisfies certain obligations, which is described as a contract (3). These contractual obligations ensure that independently developed components obey certain rules so that components interact (or can not interact) in predictable ways, and can be deployed into standard build-time and run-time environments (4). A component-based system is based upon a small number of distinct component types, each of which plays a specialized role in a system (5) and is described by an interface (2). A component model (6) is the set of component types, their interfaces, and, additionally, a specification of the allowable patterns of interaction among component types. A component framework (7) provides a variety of runtime services (8) to support and enforce the component model. In many respects component frameworks are like special-purpose operating systems, although they operate at much higher levels of abstraction [8].

Figure 5 is a reference model for component-based concepts. Some approaches equate component model and frameworks, and suggest that the framework may or may not include services. Microsoft's COM+, on the other hand, embeds the component framework into the operating system itself obviating the need for a separate entity called "component framework". Indeed, it is difficult to find categorical distinctions between component frameworks and operating systems, as both provide coordination mechanisms that enforce a particular model of component interactions. Nevertheless, we assert there are qualitative distinctions; for example, component frameworks will support a more restricted range of coordination schemes than a general-purpose operating system.

Figure 5 depicts the component based system design pattern. The motivation of this pattern can be listed as follows:

• **Independent extensions**. One problem that plagues legacy software is lack of flexibility. Components are units of extension, and a component model prescribes exactly how extensions are made. In some cases the framework itself may constitute the running application into which extensions (components) are deployed. The component model and framework ensure that extensions do not have unexpected interactions, thus extensions (components) may be independently developed and deployed.

• **Component markets**. Component models prescribe the necessary standards to ensure that independently developed components can be deployed into a common environment, and will not experience unanticipated interactions such as resource contention. The integration of support services in a framework also simplifies the construction of components, and provides a platform upon which families of components can be designed for particular application niches.

• **Reduced time-to-market**. The availability of components of the sort just described also promises to drastically reduce the time it takes to design, develop and field systems. Design time is drastically reduced because key architectural decisions have been made and are embodied in the component model and framework. Component families such as those found in the Theory Center obviously contribute to reduced time to market. Even if such component families are not available in an application domain the uniform component abstractions will reduce development and maintenance costs overall.

• **Improved predictability**. Component models and frameworks can be designed to support those quality attributes that are most important in particular application areas. Component models express design rules that are uniformly enforced over all components deployed in a component-based system. This uniformity means that various global properties can be "designed into" the component model so that properties such as scalability, security and so forth can be predicted for the system as a whole. For example, EJB™ is touted as promising scalable, secure, and distributed transactions by virtue of its component model and framework services.

CHAPTER 3

COSE APPROACH

Traditional methodologies are heavily oriented towards functional decomposition of the system. Unlike object oriented methodology, component oriented methodology is structure-oriented. It suggests a hierarchical top-down system decomposition while foreseeing the integration of components as a bottom-up inclusion. In component based software development software components are used to develop a bigger system. Component-Oriented development transforms the development from code writing to integration of components. To achieve this first the specification of the target system is defined. Then, according to this specification, the target system is decomposed according to the components available. Since the components are known next the adaptation and creation of resulting components are performed. After getting the needed components, these components are integrated to build the target system.

COSE approach starts with a structural decomposition that is conducted layer by layer. During the decomposition, arriving at existing components is taken into account. Intermediate concepts such as frameworks and design patterns are considered as super-components in COSE approach. The decomposition is performed according to two views: Abstract design and existing components [1]. In this chapter, first, COSE Modeling Language (COSEML) is defined. Next, an example model in this modeling language is presented.

3.1. Modeling Language

COSE Modeling Language (COSEML) is designed as the primary modeling language for the component oriented software engineering approach [1]. COSE transforms the system specification into a set of components and a set of connectors. The set of connectors connects the set of components to produce the target system like a skeleton of a human body. Components and other abstraction mechanisms provide the solutions to the subproblems of the whole target system. The network formed by the connectors is the interface specification for the entire system. A pair of interfaces at component level is represented by a connector at a higher abstraction level. Super-components provide an abstraction that defines large subproblems [1].

Modeling a system starts top-down to introduce the building blocks. While the activity continues towards lower level blocks, interfaces between the blocks are defined. When the module is expected to correspond to a component, a temporary bottom-up approach is applied: If desired capability can only be achieved by a set of components, they should be integrated into a super-component. Finally, the super-component is imported into the system to end of the temporary bottom-up task. Design patterns can also be used as super-components by themselves.

Packages correspond to the abstract components and they are represented by Unified Modeling Language's (UML) Package symbol. Internals of the Packages are represented by the Data, Function, and Control abstractions. System level functions are shown as function and like UML's Use CASE symbol, are represented by an oval. Implementation level components are represented by *Events*, *Properties* and *Methods*. Figure 6 shows the graphical symbols in COSEML.

There are some links for connecting abstractions or components. For the abstraction elements, there is a "Composition" link represented by a diamond at the container end. "Inheritance" link is represented by a triangular arrowhead at the generalized end as in the UML. The most special link is "Connector". It is represented by a box symbol as well as a line symbol. During decomposition activity, the box version is used for interface specification. The line version is used for information hiding. The symbols for connectors are shown in Figure 6.

Since the model can have abstraction level and corresponding component level, a system function could be represented in different levels. Thus, a connector can be represented between two abstractions, as well as between two components.

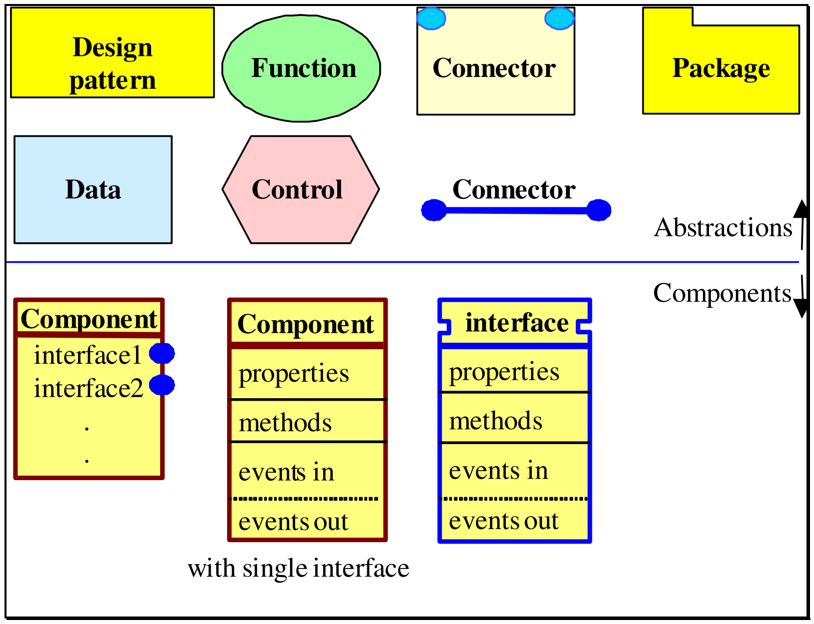


Figure 6. Graphical symbols in the COSEML

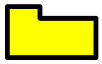
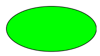
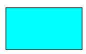
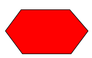
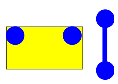
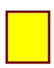
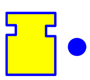
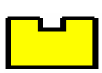
Super-components that are not design patterns can be constructed by the compositional links that are used among components. Finally, the "Represents" relation links the components to the abstractions of them. Table 1 contains explanations to the graphical symbols of COSEML [6].

3.2. An Example Model

In this section, a small business framework which can be used in J2EE platform is modeled in COSEML. This example shows that design patterns can be used in COSEML as super-components.

Frame work is designed containing Java and EJB design patterns. There is the main package that holds all the client operations. Framework connects LDAP, Content Manager (for document management system) , IBM MQSeries (for workflow operations) and a database. All of the requirements for these except database requirements are provided by the vendors. So these behave like external systems for our framework (They can also be defined as components).

Table 1. COSEML symbols and their meanings

Symbol	Explanation
	**Package:** Package is for organizing the part-whole relations. A container that wraps system-level entities and functions etc. at a decomposition node. Can contain further Package, Data, Function, and Control elements. Also can own one port of one or more connectors. Can be represented by a Component. The contained elements are within the scope of a Package: they do not need connectors for intra-package communication.
	**Function:** Function represents a system-level function. Can contain further Function, Data, and Package elements. Can own connector ports. Can be represented by a Component.
	**Data:** Data represents a system-level entity. Can contain further Data, Function, and Package elements. Can own connector ports. Has its internal operations. Can be represented by a Component.
	**Control:** Control corresponds to a state machine within a Package. Meant for managing the event traffic at the Package boundary, to affect the state transitions.
	**Connectors:** Connector represent data and control flows across the system modules. Cannot be contained in one module because two ports will be used by different modules. Ports correspond to interfaces at components level.
	**Component:** A Component corresponds to the existing implemented component codes. Contains one or more interfaces. Can contain components. Can represent abstraction.
	**Interface:** An Interface is the connection point of a Component. Services requested from a component have to be invoked through this interface.
(Red)	**Represents:** A Represents relation indicates that an abstraction will be implemented by a Component.
(Blue)	**Event:** An Event link is connected between the output event of one interface and the input event of another. The destination end can have arrows corresponding to the synchronization type.
(Green)	**Method:** A Method link is connected between two interfaces to represent a method call. Arrow indicates message direction.
	**Composition and Inheritance:** UML class diagram relations are utilized. Diamond: Composition, Triangle: Inheritance.
	**Design Pattern:** A design pattern corresponds to the existing implemented design pattern codes in an abstract form. Can contain other components and interfaces. Represents a super-component.

Since it is a J2EE framework the servlet is decided to make a connection between the application layer and the client. To make a servlet for each request the command design pattern is used as super component. This design pattern determines the external system that must be interacted and sends the request to it [3]. The only job done for the programmer is to fill the xml file (or a class) that holds the commands. If the command is something associated with external systems, the command is sent to the corresponding external system.

If the command is related with in a database operation the wrapper design pattern is activated. This design pattern is an EJB design pattern that determines which session base class or classes will be activated and in which order these will be activated.

Session Base design patterns use session beans or in other words session beans inherit session base design patterns [4]. Session base design pattern handle all the responsibilities for transactions and rollback operations. It also decides how to connect to database, by using entity beans or Data Access Object Design patterns [4]. The data access object design pattern handles all the JDBC (Java Database Connection) requirements such as providing a connection and resources from the pool, removing connections and handling exceptions. The queries that will run are decided by the Data Access Object (DAO) design pattern using the command. So another xml file (or a class) that holds commands and queries is provided by the user.

This framework is designed by using COSECASE and implemented in java. This framework can be used in other projects and may be after some use it can be a component design pattern itself. The generic and simple design for the framework using COSECASE is given in Figure 7. The design of the framework and all patterns shown in detailed mode are shown in Figure 8. The construction steps of this example model are presented in Appendix B.

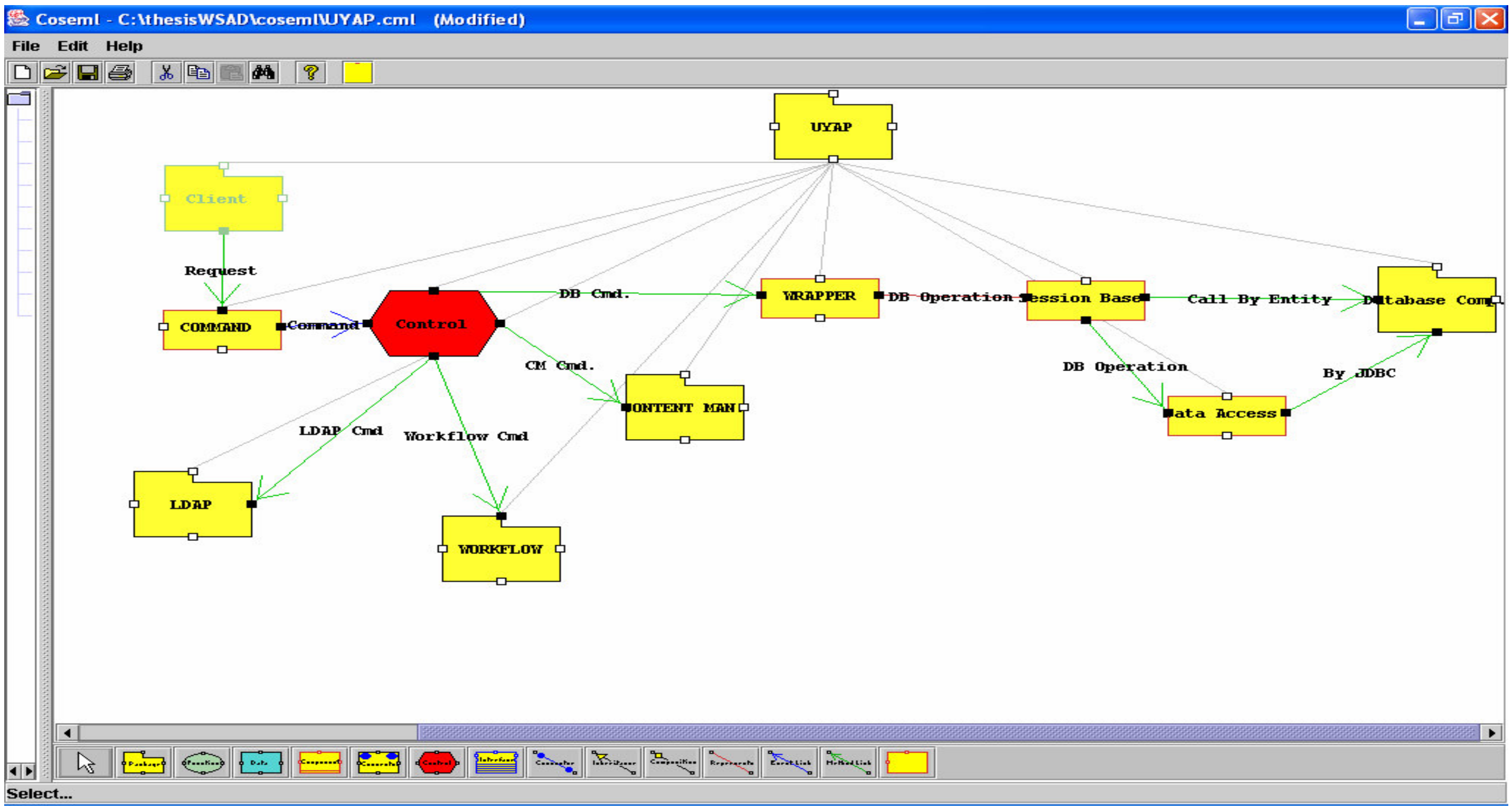


Figure 7. COSECASE screen for the example when patterns are in abstract level.

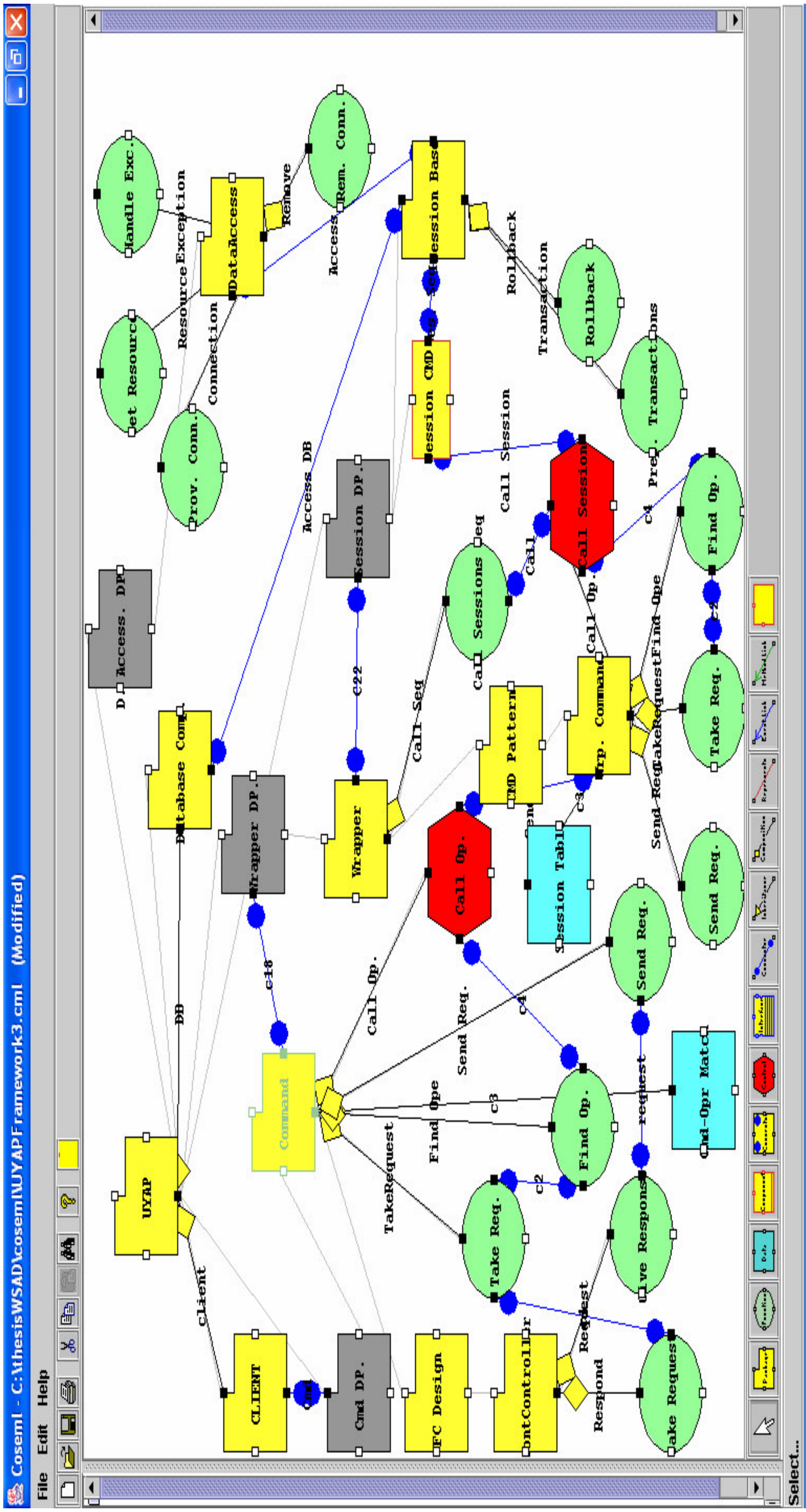


Figure 8. COSECASE screen for the example when patterns are in detailed mode.

CHAPTER 4

IMPROVEMENTS TO THE CASE TOOL

The work includes enhancements to the graphical editor COSECASE v1.0 that was implemented for aiding Component Oriented software development before [6]. Unfortunately it does not support the utilization of design patterns in either the abstract or physical levels of COSEML. Therefore the tool is upgraded to support these capabilities. Initial tool was developed using Borland JBuilder 3.0 that is a highly productive visual development tool for creating high-performance and platform-independent applications using the Java programming language. In this section the design overview of newly added capabilities are presented.

4.1. COSECASE v1.1

The initial tool was upgraded for this research using IBM Web Sphere Application Developer. During the upgrade development only core JDK and Swing classes were used, and the target JDK is Java version 1.2.

COSECASE enables software designers to use all COSEML symbols for any project. It only produces the structural views of target systems, and it is simply a graphical editor. Thus, it enables the user to hierarchically decompose a system's requirements, and to view relations among components graphically.

The hierarchical decomposition is in two levels: Abstract and component levels. COSECASE enables users to decompose a system's requirements into two levels; first, abstraction level decomposition is performed in a single tree, and next, appropriate components and their interfaces are included in a component forest. Trees in COSECASE are graphically balanced such that every node is centered according to its children.

COSECASE now enables using design patterns in both abstract and detailed modes. A brief user manual for using design patterns in COSECASE is presented in Appendix A.

By definition, a design pattern is an abstract entity. It can best be modeled as a collaborating set of objects (abstract components, in our case). However, practical development environments prefer to have implemented instantiations of design patterns, as adopted partial solutions in a particular domain. This research allows the representation of a design pattern as an abstract super-component as well as a physical super-component.

A design pattern may be instantiation into more than one super-component. Also once utilized a design pattern can be modified and enhanced at abstract or physical levels, the modified design patterns have new names and they will also retain the original design pattern if its origins will need to be viewed.

Initially, a design pattern is introduced as a set of structurally connected abstract components. Their operational connectors are introduced later, as modifications. Modifications may only involve connectors (operational) but a detailed enhancement may even introduce further components hence affecting the structural connections also.

4.2. Added Capabilities

COSESACE v1.0 has capabilities for designing a whole system by decomposition. The utilization of design patterns in both abstract and detailed mode support is added to the tool. After some enhancements COSECASE v1.1 is defined. Some of the newly added capabilities are:

- Creating new design pattern models and removing a defined pattern from the system.
- Selecting among existing design patterns.
- Viewing original details of a design pattern.
- Integrating a design pattern in a COSEML design.

- Diffusing a design pattern to a COSEML design in the form of a set of connected abstractions.

- Making modifications on the detail of a design pattern.

- Ability to re-form an abstraction corresponding to a design pattern that has been diffused.

4.2.1. Creating New Design Pattern Models and Removing a Defined Pattern from System

COSEML v1.1 enables users to create a new design pattern model to the system. User can define any existing design as a design pattern. The user given name and the path are saved by the tool. When the design pattern is first created this information is stored in the structure that defines the design pattern. When the design pattern is used for the first time in the detail mode, the system finds the structural elements of the design pattern by using this information. When user modifies some part of this design, the new design is stored in the design pattern structure. By this capability there exists no relation with the main design and the modified design of a design pattern. If user wants to make a permanent modification in design pattern, it must be done in the file that holds the main design of the design pattern. The modifications done in this file will not effect the design pattern samples and derivations used before because there is no relation between the main design and the used designs for the design patterns.

When it is believed that there is no need for a specific design pattern in the list of existing design patterns, user can remove it. This is implemented through removing this design pattern from the data structure that holds the existing design patterns and their design file's path. A brief user manual for creating and removing design patterns in COSECASE is presented in Appendix A.

4.2.2. Selecting Among Existing Design Patterns

COSECASE v1.1 enables users to work only with existing design patterns. When user wants to use a design pattern, system shows the defined design patterns for selecting among them. If user selects non of the existing design patterns, the system creates a design pattern symbol but does not give the ability to use this design pattern in the detailed mode. A brief user manual for selecting design patterns in COSECASE is provided in Appendix A.

4.2.3. Viewing Original Details of the Design Pattern

COSECASE v1.1 enables users to see the original details of the design pattern at any time. Each design pattern holds the original file and the path of this file in the structure that saves the design pattern. When this original design is desired to be viewed, a new COSEML frame is created and the original design pattern will be loaded into this frame. By this capability the user is enabled to detect the modifications done on the original detailed design of the design patterns.

4.2.4. Integrating a Design Pattern in a COSEML Model

Integrating a design pattern in a COSEML model can be done by the same way that the other objects are integrated. The only difference is the user is asked to choose one of the existing design patterns instead of component. The user has the option not to choose one of them. In that case design pattern is integrated but it can only be used in abstract mode. When a design pattern is integrated into a model, it is created under the object that the user has selected, and the system holds this design pattern as one of the children of the selected object. Since design patterns are abstract level objects, system ensures that they can only be created under a package. Since a design pattern has the ability of integration with other objects, a design pattern has four connection points (as far any COSEML object). User can make the connections of the design patterns with the other objects by using these connection points and by using as connectors . When a design pattern is integrated in a design, the tool automatically creates a new node to the tree that hierarchically displays the objects in the model. Design patterns are abstract designs that correspond to a solution of a subproblem in the main design. A design pattern can contain other abstractions such as packages, functions and etc. in its detailed design.

4.2.5. Diffusing a Design Pattern to a System Model

Design patterns can be used both in abstract and detail mode in COSECASE v1.1. To use it in the detailed mode the tool diffuses the structural design of the design pattern into the model. To achieve this, first the current detailed design of the design pattern is read from the structure that holds the design pattern. The detailed design of the design pattern is not read from the main file that holds the original structural design of the design pattern, because user could have made some modifications on the design pattern at the previous diffuse operation. This gives the ability to make modifications on a design pattern's detail again and again without affecting other designs using this design pattern and the original design that holds the detail design of the design pattern. Also later modifications in the original detail of the design pattern will not affect design pattern created before modification.

To diffuse the design pattern's current detail, the data structure that represents the design pattern in abstract mode is removed. If it is the first time the design pattern is being diffused, a special data structure which is derived from the package will be created instead of the design pattern structure. If it is not the first time the design pattern is diffused, this structure will not be created since it will be existing in the design pattern's current design. This special package will be created under the package that is the parent of the design pattern and all the connections to the design pattern will be connected to this structure.

The other objects that take place in the design pattern's current detail are read one by one and created within to the current design. COSECASE handles these creations as if a user is creating them. All the properties of these objects are also defined by the tool automatically by using the previous current design. After this operation user can use all these objects just like the other objects that were created by the user in the design. There is no difference in the usage of the automatically generated objects that represents the detailed design of a design pattern and any other object that are created by the user. The objects that are created automatically by the tool to represent the detail of the design patterns are also created under the tree structure that shows the hierarchical decomposition of the system. User can update, delete and perform any other operations on these objects. If required, connections of these objects with the other objects in the model can be made. If a new connection between the objects of the design pattern is made, the tool will define this connection as a new modification to the design pattern and will store it in the design pattern's current design. The diffusion operation is presented in the example presented in Appendix B.

4.2.6. Making Modifications on the Detail of a Design Pattern

User can make any modification in the detail of the design pattern. The properties of any object that is a part of the detail of the design pattern can be changed and this modification will be detected by the tool. Any modification done in the detail of the design pattern is updated in the data structure that holds the current (or modified) detail design of the design pattern.

If a link is created so that the objects that are in both sides of the link are members of the detail design of a design pattern, COSECASE 1.1 evaluates this link as a modification in the detail design of the design pattern. This link is a new member of the detail design of the design pattern and will not be shown when design pattern is used in abstract mode.

If a node object (such as interface, data, function and etc.) is created so that the parent of the object is a member of the detail of the design pattern, COSECASE evaluates this object as a modification in the detail design of the design pattern. This object will be presented as a new member of the detail design of the design pattern and will not be shown when design pattern is used in abstract phase.

4.2.7. Reforming Design Pattern Abstraction

Reforming design pattern abstraction is the reverse of the diffusing operation. By reforming design pattern abstraction and diffusing a design pattern to a COSEML design, user is enabled to use design patterns both in abstract and detail modes. Reforming a design pattern abstraction simply means, removing the elements of the design pattern from the model and inserting the design pattern abstraction instead. When the design pattern is desired to be reformed as abstraction, the tool first stores the current detail of the design pattern. To achieve this the specialized package that is created instead of the design pattern is used. This package holds the detail of the design pattern to be used when the design pattern will be diffused. COSECASE starts saving the design pattern under the root package and finds all the objects that are elements of the detail of the design pattern. All these properties of these elements are saved in the data structure that holds the detail design of the design pattern. Addition to these objects the connections that are created between the objects that come from the design pattern are stored in a data structure which will record the design pattern's current form. All these elements are removed from the main system's hierarchy tree. A design pattern is created at the place of the specialized package (in other words, the place that design pattern existed before diffusion). Also a new node is added to the hierarchy tree. The connections that are among the design pattern's detailed objects and the rest of the system, are connected to the newly created design pattern abstraction. Meanwhile the introduced connections internal to the design pattern are also saved for later access. This helps in finding the internal connection points in a future diffusion operation.

4.3. Design Overview

As described before, COSECASE is developed by using the Java programming language and core JDK and Swing classes helped in designing the user interface of the tool. Therefore it can be used and embedded in any tool that supports java with no or a very small modification.

4.3.1. Newly Added Classes

The class hierarchy of COSECASE v1.0 was described in thesis "A Graphical Editor For Component Oriented Modeling" by Aydin Kara [6].. There are newly added classes added to this hierarchy. The first class is OKDesignPattern class. This class has the same hierarchy with component and interfaces classes. It holds necessary information for design patterns. Related class structure is depicted in Figure 9.

OKDesignPatternPropertiesDialog is implemented in a similar fashion. This class enables user to enter the name and the properties of a design pattern just like AKComponentPropDialog and AKInterfacePropDialog would. These classes are used for describing the properties of components and interfaces. Like others OKDesignPatternPropDialog is inherited from JDilaog. To define design patterns and select or remove design patterns from the system two new graphical user interface

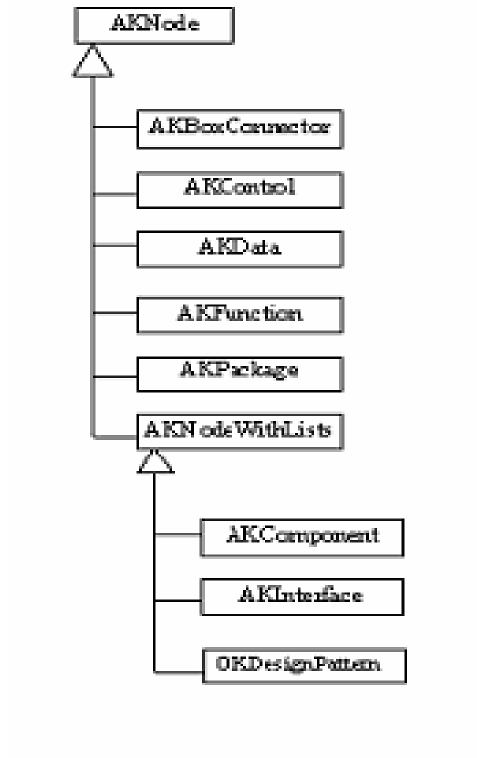


Figure 9. Class hierarchy for Design Patterns

elements were implemented. These are inherited from JDialog class like most other graphical user interfaces used in COSECASE v1.0. The new hierarchy for GUI classes in COSECASE is shown in Figure 10. The current design patterns defined to the system are saved in a file. Tool browses the structural design of design patterns by using this file as a pointer table. Each design pattern must have its structural design in a coseml file in the file system.

Since user is enabled to use design patterns both in abstract and detailed modes, a separator is needed to distinguish the design pattern when used in detailed mode. To achieve class is inherited from AKPackage class as shown in Figure 11. It is used to show the user which part of the design belongs to the detail of the design pattern.

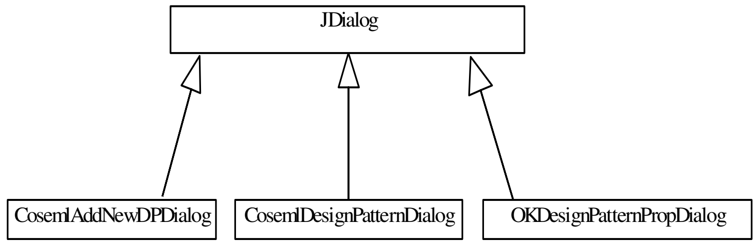


Figure 10. Class hierarchy of new dialog classes

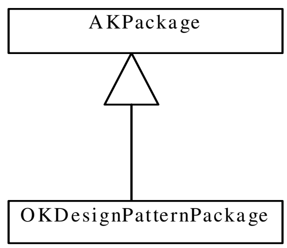


Figure 11. Class hierarchy of Design Pattern Package

4.3.2. Zoom Algorithms

The zoom algorithms are designed to graphically show the abstract and detailed modes of design patterns. To achieve this each design pattern is enabled to hold its own design. Thus the modifications in design patterns structure and links connected to this structure is saved in a specific data structure. This enables the user to modify the structural composition of the design pattern. The zoom in algorithm works when user wants to see design pattern in detail, zoom out works to show the abstract mode.

4.3.2.1. Zoom Out Algorithm

Zoom out algorithm works on the data structure that holds the design of the design pattern. It first finds the structural elements of design pattern in the design, and then saves the current status of these structures. By this approach a future zoom in operation can retrieve the last modified phase of the design pattern.

```
ZoomOut(Input: designPattern; Output: abstract phase of design pattern)
(Shows the abstract phase of design pattern)
begin
Create abstract design pattern
Current = root of design pattern
While design pattern has structural element
Begin
    Current = next structural element
    If current is node
    Begin
        While current has connected link
        Begin
            If link is not connected to the same design pattern
            begin
                Connect local part to the abstract design pattern
                Save connection information
            end
        end
    Read the properties of node and save to the design pattern
    End
    Else
        Read properties of link and save to the design pattern
End
Delete current from the main design
```

4.3.2.2. Zoom In Algorithm

Zoom in algorithm is the reverse of the zoom out algorithm. Zoom in algorithm works on the data structure that holds the design of the design pattern. It first reads the structural elements of the design pattern. Nodes are created in the order of read operation. At each create operation, external links are updated in the structure that holds the design pattern. When all the elements are created and updated the old abstract element for the design pattern is removed from the model.

```
ZoomIn(Input: designPattern; Output: detail of design pattern)
(Shows the detail of design pattern)
begin
Current = root of design pattern
While design pattern has structural element
Begin
    Read the next  structural element
    Current = next structural element
    Create a new structural element according to current
    Update properties of the new element according to current
    If current is node
    Begin
         While current has connected link
        Begin
            If link is not connected to the same design pattern
            Begin
                Remove the connection from the abstract design pattern
                Make Connections of  link to the new created structure
            end
        end

    End
End
Delete abstract design pattern from the main design
```

CHAPTER 5

CONCLUSIONS AND FUTURE WORK

In this chapter a brief conclusion is presented regarding the use of design patterns as super components in COSE. Next, the results of a comparison between COSEML and other popular CASE tools is interpreted. Finally, a section suggesting the directions for future work is presented.

5.1. Conclusions

The aim of this work is using design patterns in Component Oriented Software Engineering. To achieve this, a facility for using design patterns is added to the Component Oriented Software Development tool: COSECASE. Then the use of design patterns is discussed in details.

The first problem is the representation of a design patterns. A design pattern is represented as a special kind of package to indicate that it is an abstract structure. It was initially thought that only abstract level representation of a pattern would be adequate. After some experiments and observations, it was realized that abstract level demonstration will not be sufficient because of the detail in the structures and definitions of design patterns. Design patterns capture a good solution to a recurring problem in a theoretical and general way. But the practice (design and use of design patterns) can be different in some cases. Users of design patterns can design it in different ways according to the requirements and the framework used. Users usually specialize the generalized solution that design patterns provide while adapting them. However the concept of ‘generalized solutions’ of design patterns still exists. This brought the necessity of using design patterns in detailed mode. Therefore a new symbol and also a new representation are developed such that design patterns can be used both in abstract mode and in detailed mode. User is enabled to make modifications on a design pattern, defining a design pattern and removing a design pattern from the system.

After conducting some case studies, it was observed that design patterns could be used as super components in a component-based design. However this does not mean that all design patterns can be used as super components directly. To use a design pattern as a super component in the component-oriented design, this design pattern must be usable as a component by itself not as a part of a component. Also it must contain information about how to use; not how to code. It is observed that creational design patterns can not be used as super components but some structural and behavioural design patterns can be used as super components in component oriented development. Creational design patterns can be used in methods of a component but this is not in the concern area of this research. Structural and behavioural design patterns that are concerned with the objects can be used as super components.

Incorporating design patterns in COSE has been a valuable experience. The case studies demonstrated the increased efficiency in reuse. It can be easily felt that bigger sub-problems are being solved faster in developing system models. The usage of the pure design pattern definition however had to be extended. The mere abstract definition of a pattern is a strong idea but our practice shows that in a development environment, some more concrete definition of a design pattern can be more effective. Even, implemented variations of a design pattern as its instantiations surfaced as a valid idea in especially a "built by integration' avenue to development. If this practice has a chance to be adopted by the industry, a widely appreciated interpretation of the concept (design pattern) may settle that suggests more concrete than abstract utilization of design patterns. Finally, it is observed to be a very effective enhancement, to provide design pattern incorporations into COSE.

Since design pattern concept is not a specialized concept for component-oriented development, the usage of design patterns in the other CASE tools and languages are studied. It is observed that design patterns are widely used in especially object oriented approach and other software engineering disciplines. This usage has not been specifically supported by the CASE tools for these approaches.

5.2. Future Work

The current version of COSECASE does not support error checking or syntax enforcement. For now, every symbol can be connected with any other symbol. Such abilities could be added to develop the application towards a more complete CASE tool. Design Patterns can be used both in abstraction and detailed mode. But automatically code generation for components (and also design patterns) is not available. The need of a component and design pattern catalog is clear. The ability of searching design patterns from the catalog and using them, and then automatically generating code could be added to the CASE tool.

Design patterns are used as super components in COSECASE. The mechanism created for design patterns can be utilized for other widely used designs. The ability to use abstraction for widely used designs, or some part of a big design can be added to COSECASE. This may mean selecting a section of an existing design and naming the selection as a new design pattern.

Inclusion of at least another view and consistency checking among the views can be done. COSECASE provides, for now, only the structural view using nodes and connectors. The nodes or alternatively, connectors in a model can be hidden to yield a single-concern view. Other views, like data or control, can be added. The abstract part of the model includes data, function and control concepts. Different views only displaying related abstract components will yield a hierarchically organized data view, function view and a network of multi-tasking control structures. Connectors are an important concept in Component Oriented modeling. COSEML includes primitives to represent them as only graphical links or more detailed specifications of a connection. Therefore, two different detail level views for “connectors” are possible to implement.

An existing component framework, such as Enterprise JavaBeans (EJB), can be integrated with COSECASE so that an implementation could be generated, especially for specific domains. A help facility is also missing. A complete and user-friendly help option could be added after the completion of the syntax enforcement and error checking facilities.

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APPENDIX A

A BRIEF USER MANUAL FOR USING DESIGN PATTERNS IN COSECASE

A manual for using COSECASE was incorporated in thesis “A Graphical Editor For Component Oriented Modeling ” by Aydin Kara [6]. Only new added capabilities are explained here. The new added capabilities are defining and removing design patterns into and from the system and using them in abstract and detailed mode. These capabilities are described by figures and examples in the subsequent subsections. The main window and all other capabilities in COSECASE version 1.0 are kept. Besides, new buttons for adding/removing design patterns and using design patterns in the main window are added.

A.1. Design Pattern Dialog

The design pattern dialog box of the improved tool contains four buttons. OK, Cancel, Add New Pattern and Remove From View As shown in Figure A.1. The dialog can be activated by using the Design Pattern button in main window. Each added design pattern is shown to the user through this dialog box. The design pattern that user wants to use is selected using this dialog box. Add New Pattern button activates Add New Design Pattern dialog and enables user to add a new design pattern to the system. Remove From View button removes the selected design pattern from the system. To remove a design pattern from the system the steps shown in Figure A.6. should be followed.

Figure A.1. Design Pattern Dialog Box

A.1.1. Add New Design Pattern Dialog

Add New Design Pattern Dialog, shown in Figure A.2., is activated when Add New Pattern button in the Design Pattern dialog is pressed. Dialog contains choose file, OK and Cancel buttons. Choose File button activates Choose Design Pattern File Dialog shown in Figure A.3.. This dialog is used to choose the COSEML file that contains the structure design of the design pattern. User must choose a file and give a name to the design pattern to add it to the system. In case of the absance of one of these the tool will generate the corresponding error messages shown in Figure A.4.. To define a design pattern user must enter a name and choose a file. After this operation if user presses OK button the new created design pattern will be added to the system and after this it will be shown in Design Pattern dialog as shown with all steps in Figure A.5..

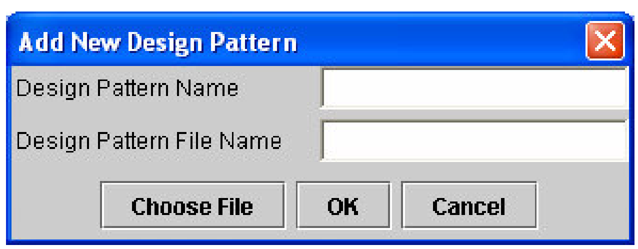


Figure A.2. Add New Design Pattern Dialog Box

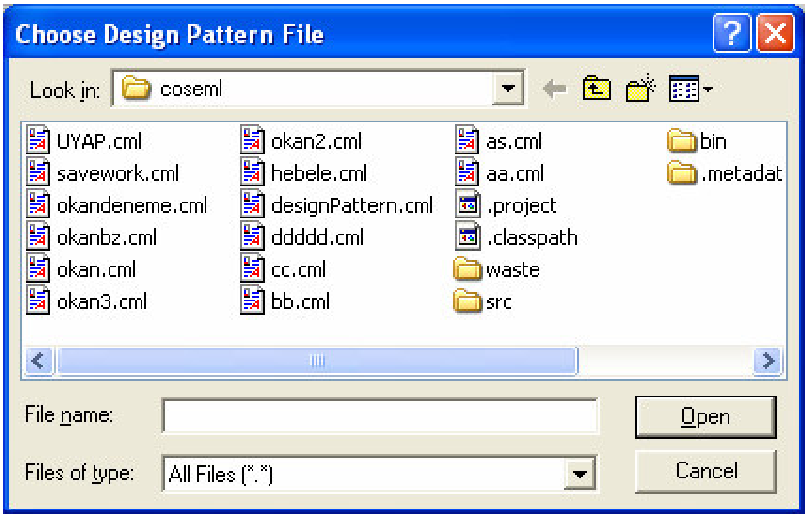


Figure A.3. Choose Design Pattern File Dialog

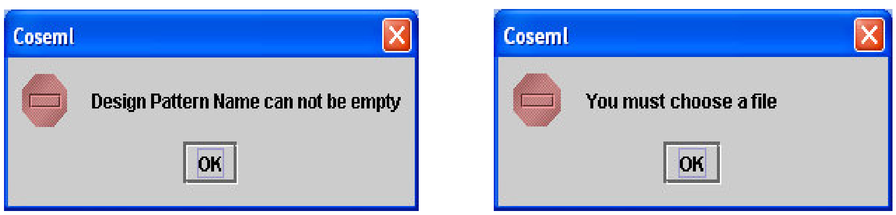
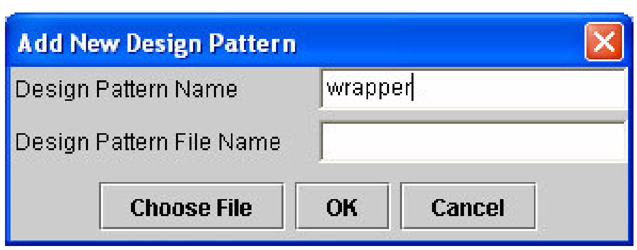
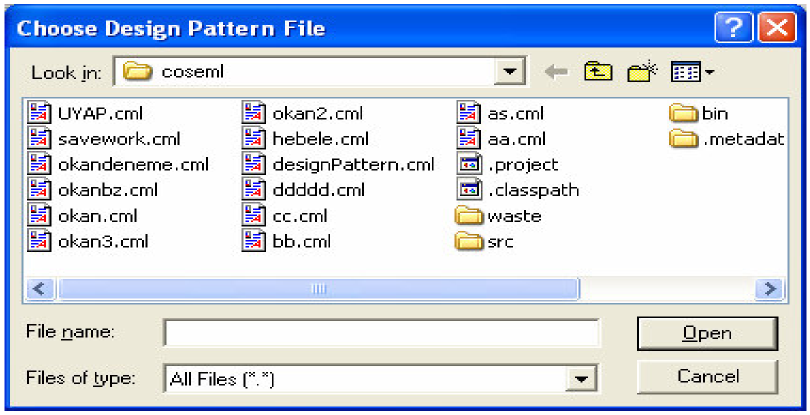


Figure A.4. Error Dialogs For Add New Design Pattern Dialog

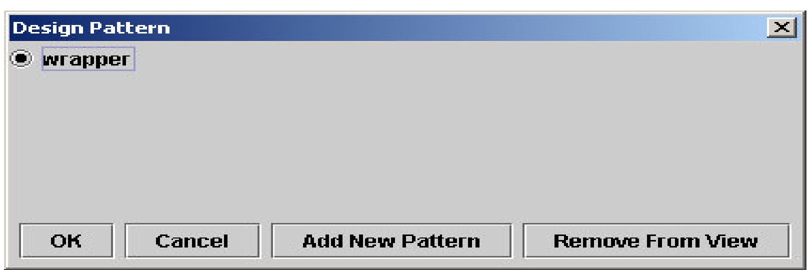


STEP 1. User Enters A Design Pattern Name



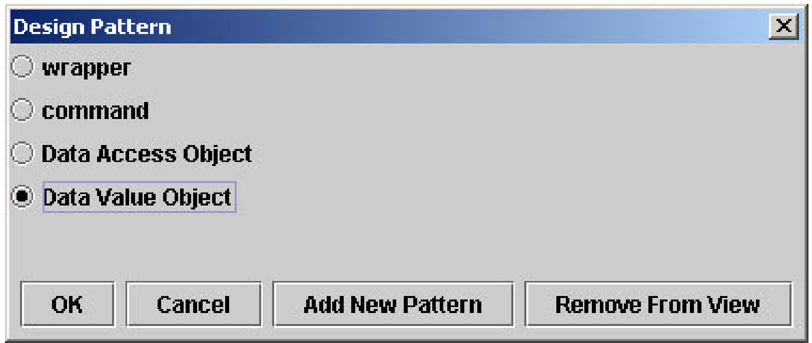
STEP 2. User Chooses A Coseml File For Design Pattern

STEP 3. User Presses OK Button

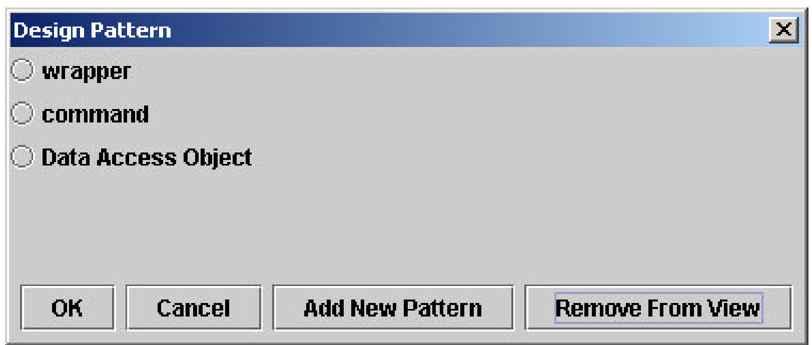


STEP 4. System Adds Design Pattern to System For Future Use

Figure A.5. Steps For Adding a Design Pattern to System



STEP 1. User Selects the Design Pattern To Remove



STEP 2. User Presses Remove From View Button

Figure A.6. Steps For Removing a Design Pattern from System

A.2. The New Symbols and Usage of Them

To use Design Patterns in COSECASE two new symbols added to the system. The first one is for Design Patterns. This symbol represents the design pattern in the detailed mode and it can be only created under a package. This symbol is also added to the symbol menu found in the bottom of the COSECASE main window. The other symbol is the Design Pattern Package symbol. This symbol is not added to the symbol menu because it is generated automatically when needed.

A.2.1. Design Pattern Symbol and Its Attributes

Since one of our aim is using design patterns in component system designs, there must be a unique and standard symbol for design patterns. To achieve this the design pattern symbol shown in Figure A.7. is used. The similarity of this figure with other COSEML symbols is clear. This figure represents the abstract mode of the design patterns. It has four options as shown in Figure A.8.. These options are delete, Properties, Open Specification and Zoom In. Delete operation deletes the design pattern from the model. The properties attributes enables the properties dialog. Open Specification shows user the detail of the design pattern in an another COSEML window. Zoom In is used to use the detail of the design pattern instead of the abstract mode.

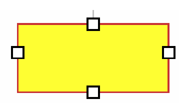


Figure A.7. The COSEML Figure Represents Abstract Mode of a Design Pattern

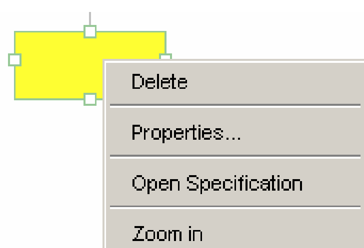


Figure A.8. Attributes of a Design Pattern

A.2.1.1. Design Pattern Properties Dialog

Design Pattern properties dialog shown in Figure A.9. is activated when the "properties" item on the submenu is pressed. It has two attributes "Design Pattern Name" and Text Area. Design Pattern Name is used to give a specific name to the Design Pattern in the model. The text area is used to enter the important and necessary expressions.

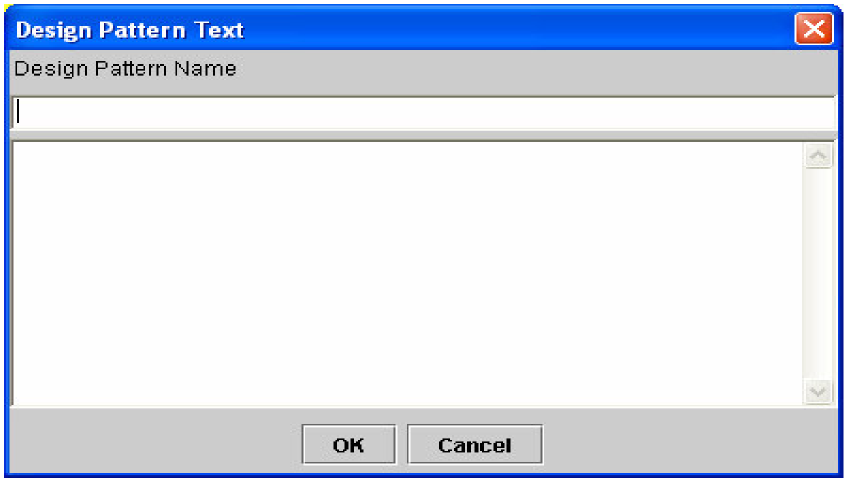


Figure A.9. Design Pattern Properties Dialog

A.2.2. Design Pattern Package Symbol and Its Attributes

The Design Pattern Package Symbol is shown in Figure A.10. It is similar to a regular package symbol but differs in some ways. It is not used by the user directly. It is generated when a design pattern's zoom in function is activated. Users are enabled to use design patterns in both abstract and detailed modes. In abstract level, a design pattern is represented by the design pattern symbol. But in detail use of design patterns the need to distinguish the design pattern structure and other structures in the model has occurred. To achieve this distinction, the Design Pattern Package Symbol is created. This symbol has all the properties that a regular package has. All the design patterns structure are created under this package and the user can clearly see which part of the design originates from design patterns. Since one of our aim is to use design patterns both in abstract and detailed mode there must be a way to return from detailed modes to abstract mode. This special package handles this issue. The zoom out option shown in Figure A.11. realize this requirement. When zoom out property is activated the design pattern package and other structures that are created under this package are all removed and the abstraction is created again. The "zoom in" and "zoom out " capabilities enable the user to switch between the abstract and detailed modes of a design pattern at any time during development. Other capabilities of design pattern package are "delete" and "properties". These are derived from the normal package defined in COSECASE v1.0 and they are the same.

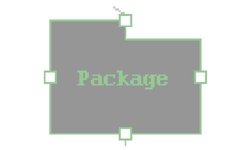


Figure A.10. COSEML Figure Represents Design Pattern Package (when design pattern is used in detailed mode)

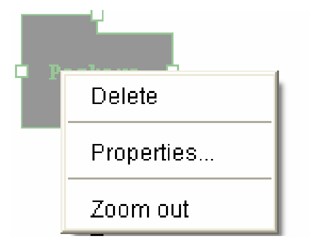


Figure A.11. Action options on a Design Pattern Package

APPENDIX B

CONSTRUCTION STEPS OF A SAMPLE MODEL

A COSEML model for the beginning of the J2EE framework development is shown in Figure 8. To construct the model, the user starts with creating design patterns which will be used. First front controller design pattern is created and defined as the framework to the system. Front Controller is a design pattern which is used to abstract a generic servlet mechanism which is responsible for taking requests from clients and sending these request to the server side by parameters. Therefore it has two functions : Give respond and take request.

Building the J2EE framework model continuous in a similar fashion: new design patterns are included and then their details are modified. The enhancement includes forming of connectors also.

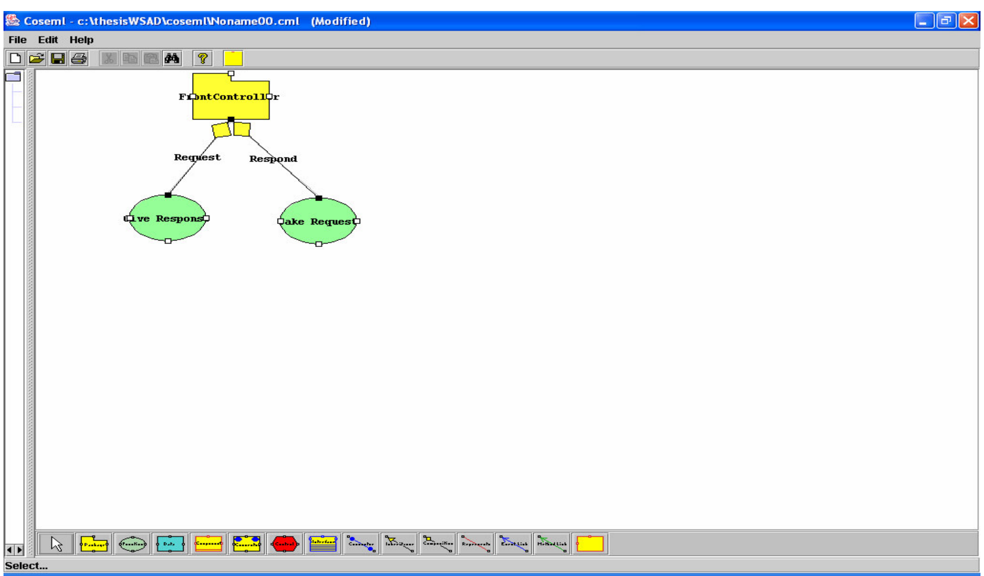


Figure B.1. Detail of Front Controller Design Pattern

Figure B.2. Add New Design Pattern for Front Controller Design Pattern

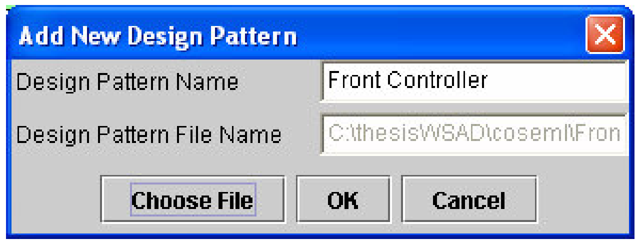


Figure B.3. Defining Name and Path for Design Pattern

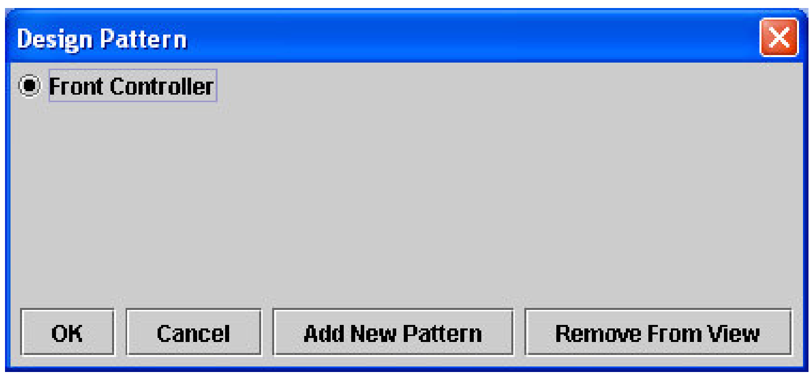


Figure B.4. Existing Design Patterns List After Front Controller Design Pattern is Added

By the same approach all other design patterns are created and defined to the system. Command design pattern is responsible for taking the request from client side and then decides the external system that must be interacted and sends the request to this external system. There is a file which holds the commands, the external system and operation which will run on this external system. Since it is responsible for taking request from client, front controller design pattern is used in command design pattern. The following figures illustrate the introduction of new patterns and then, their modification in the effort to build the J2EE framework.

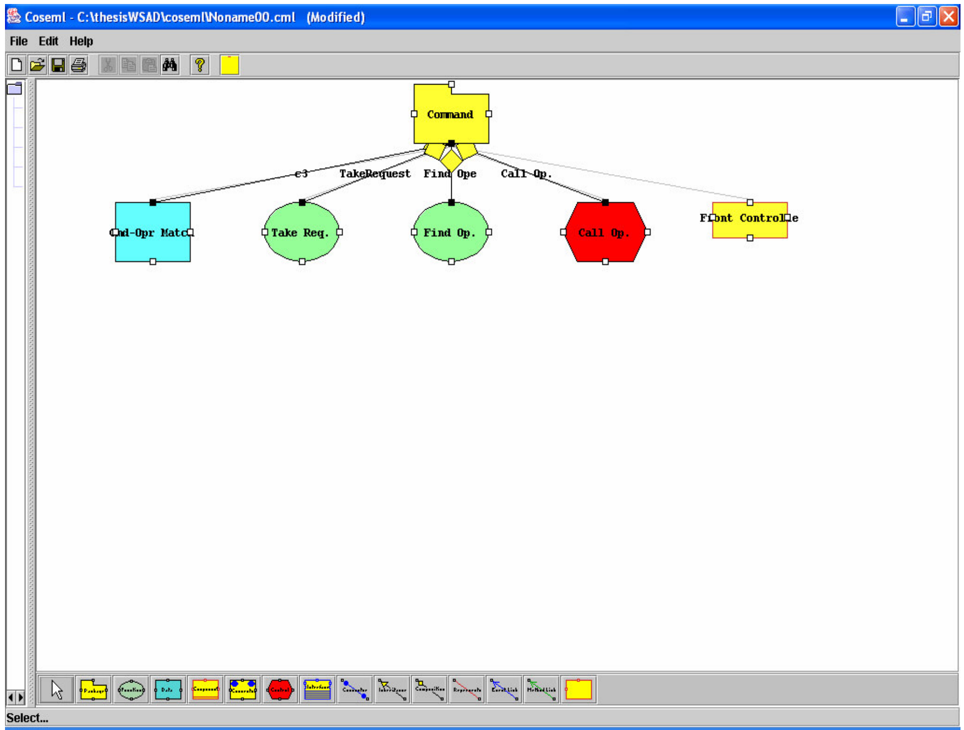


Figure B.5. Detail of the Command Design Pattern

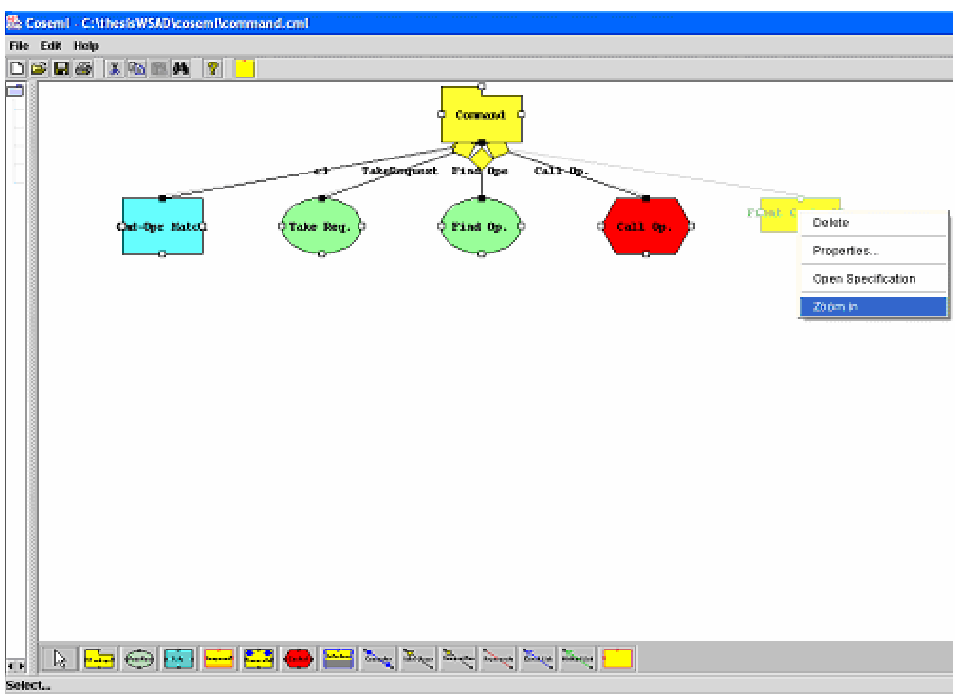


Figure B.6. Command Pattern After Front Controller Design Pattern is Created

If the command design pattern would not be used, all 6 elements shown in the above screen figures would have to be created and connected individually.

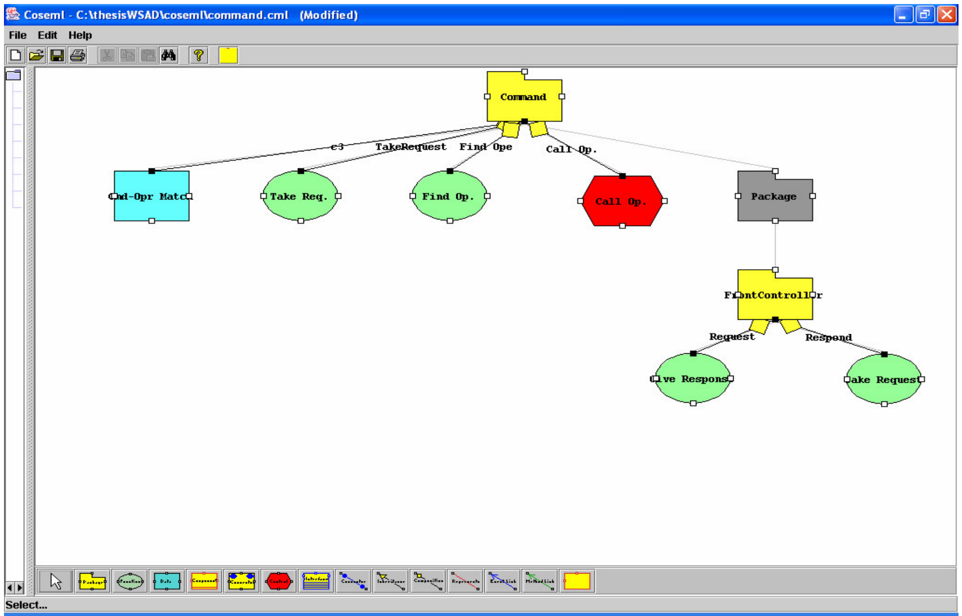


Figure B.7. Command Pattern After Front Controller Design Pattern is Diffused

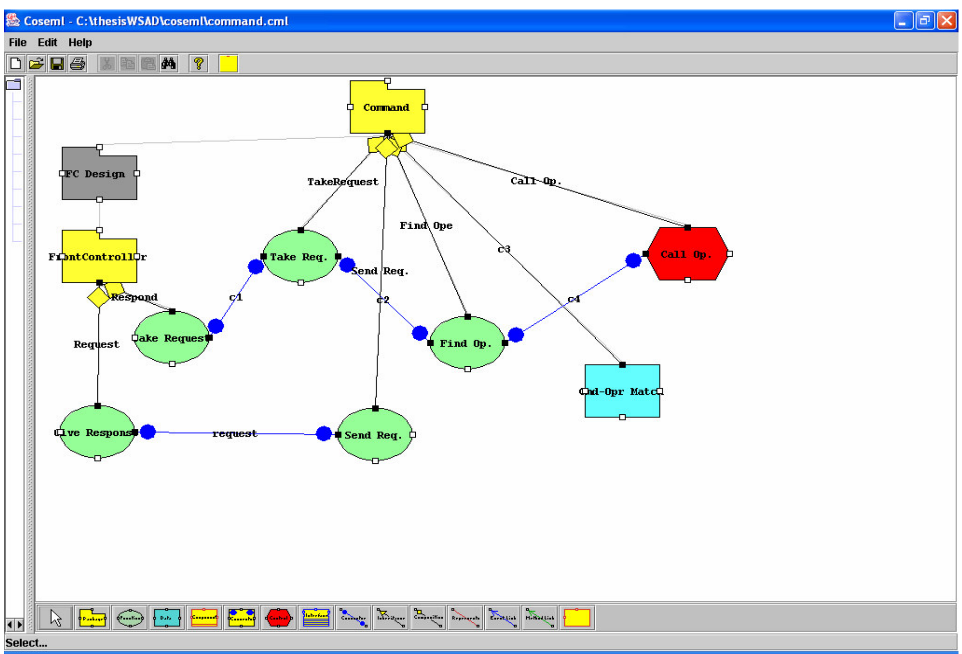


Figure B.8. Command Design Pattern After the Necessary Connections Created

The wrapper design pattern is the pattern that is the first leg for database operations in the framework. This design pattern is an EJB design pattern that decides which session base class or classes will be activated and in which order these will be activated. Since there is a decide activity by using a file, command design pattern is used in the design phase of wrapper design pattern.

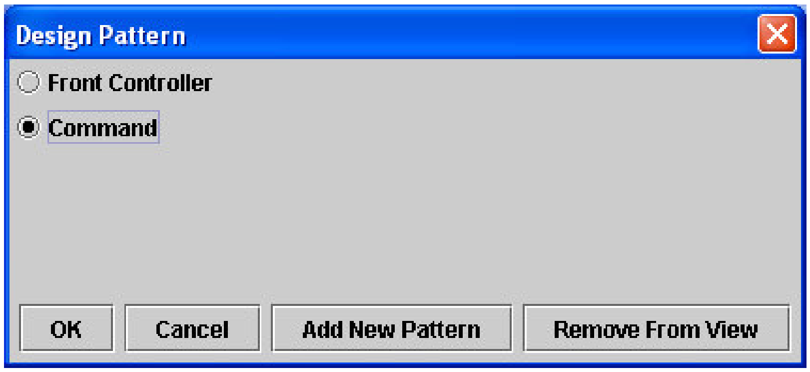


Figure B.9. Existing Design Patterns List After Command Design Pattern is Added

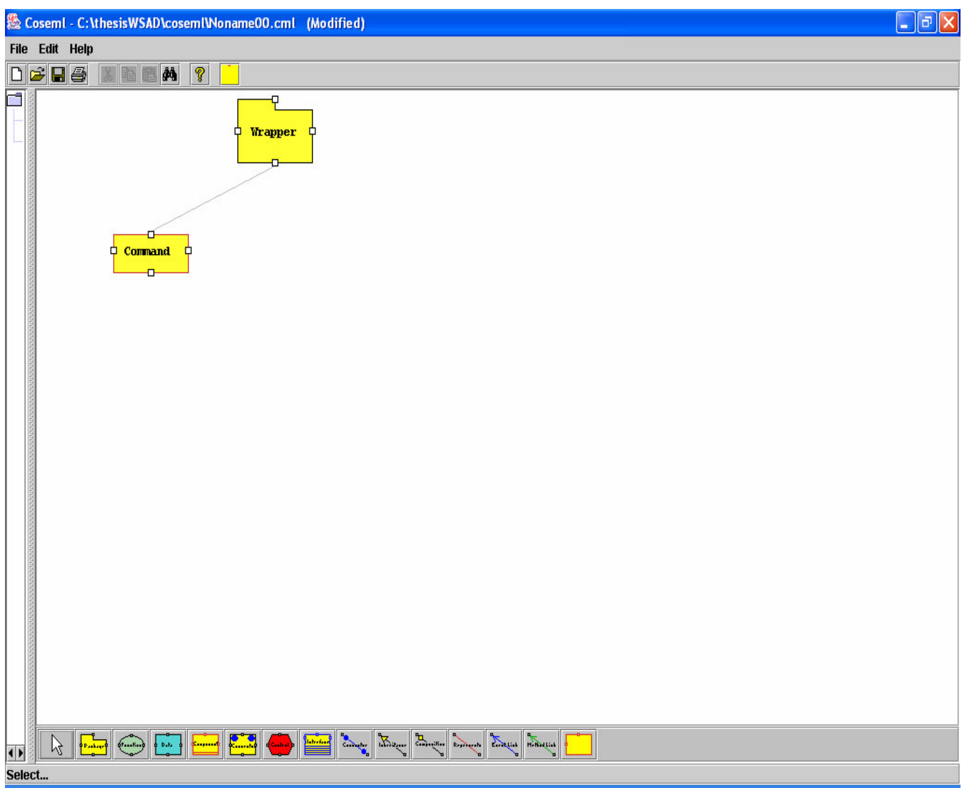


Figure B.10. Wrapper Design Pattern After Command Design Pattern is Created

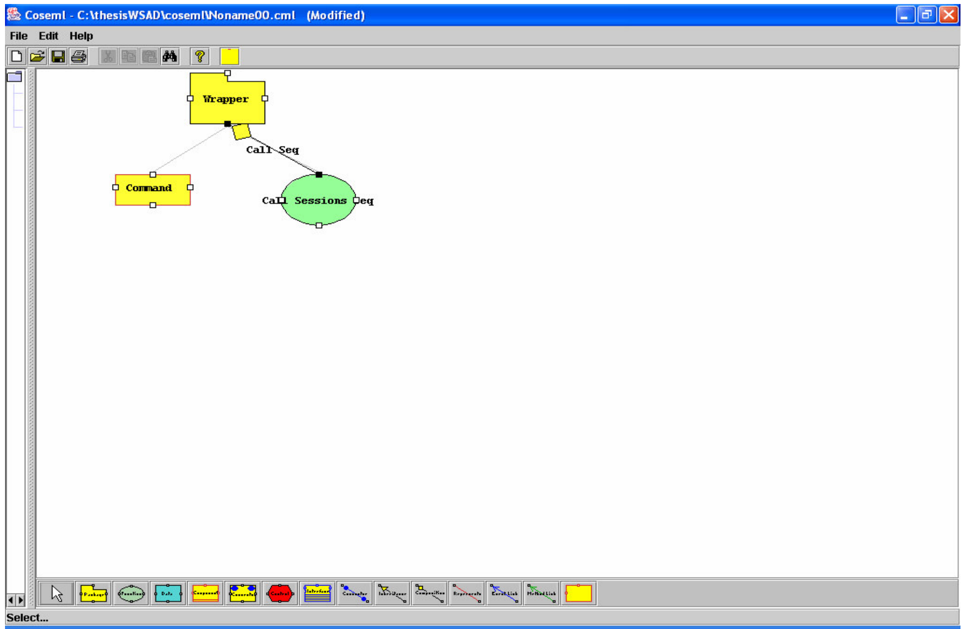


Figure B.11. Wrapper Pattern After Call Sessions Sequentially Function is Created

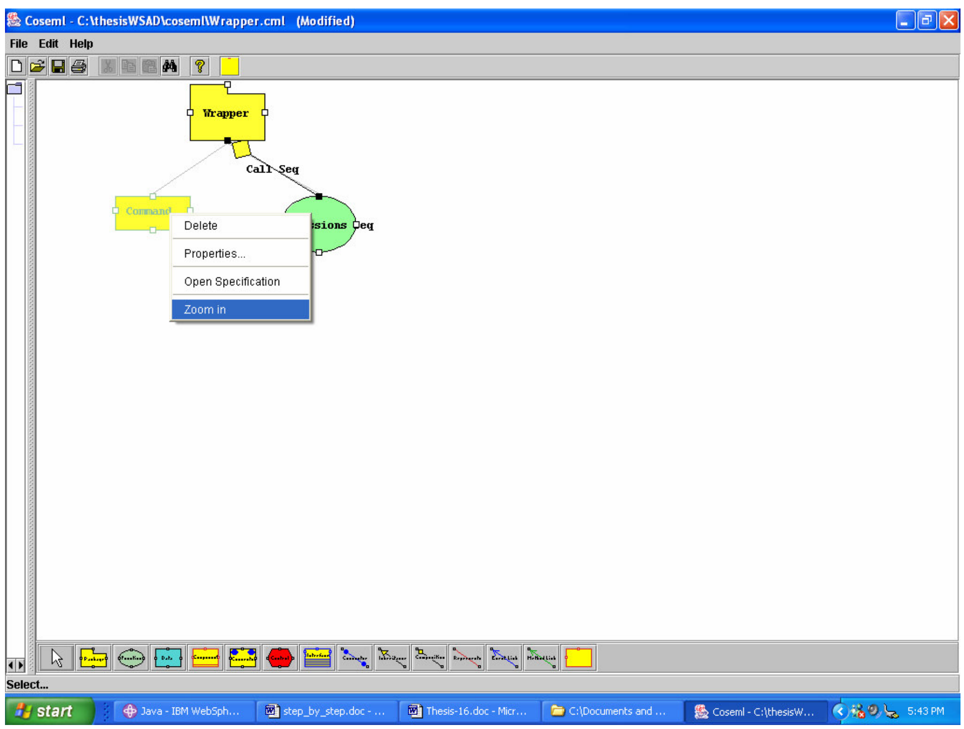


Figure B.12. Wrapper Pattern Before Command Pattern is Diffused

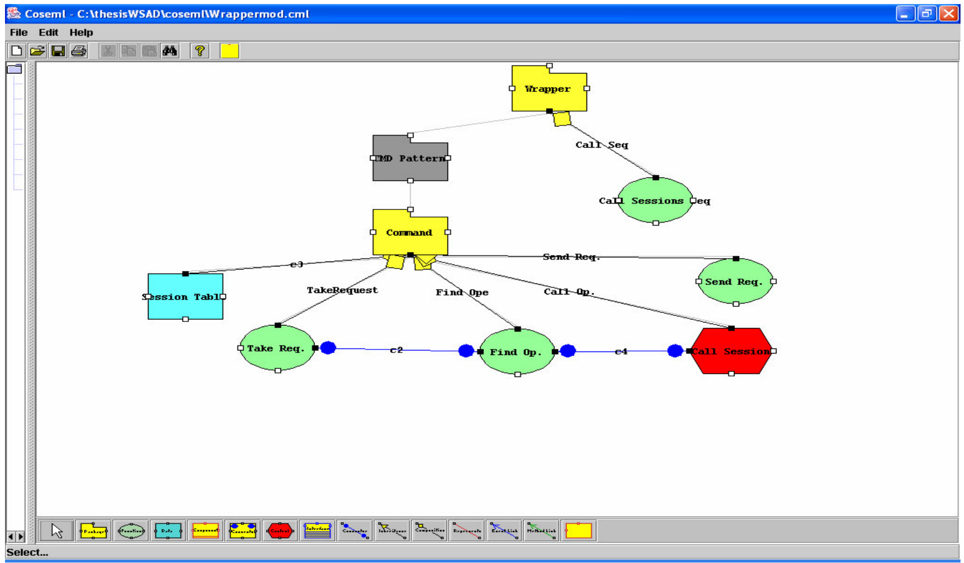


Figure B.13. Wrapper Pattern After Command Pattern is Diffused

Session Base design patterns use session beans or in other words session beans inherit session base design patterns. Session base design patterns handles all the responsibilities for transaction and rollback operation. It also decides how to connect to database, by using entity beans or Data Access Object Design patterns. Since again there exist a decide activity by using a file, command design pattern is again used in the design phase of session base design pattern.

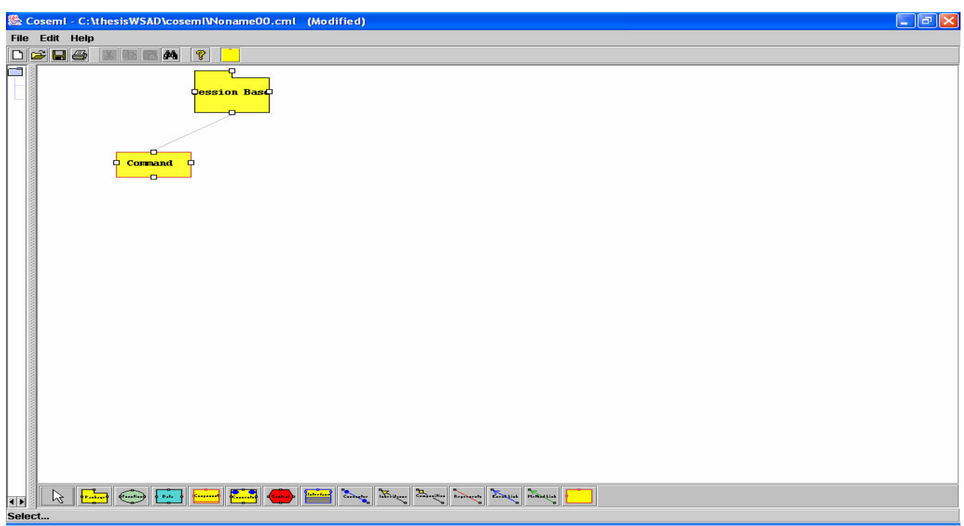


Figure B.14. Session Base Pattern After Command Design Pattern is Created

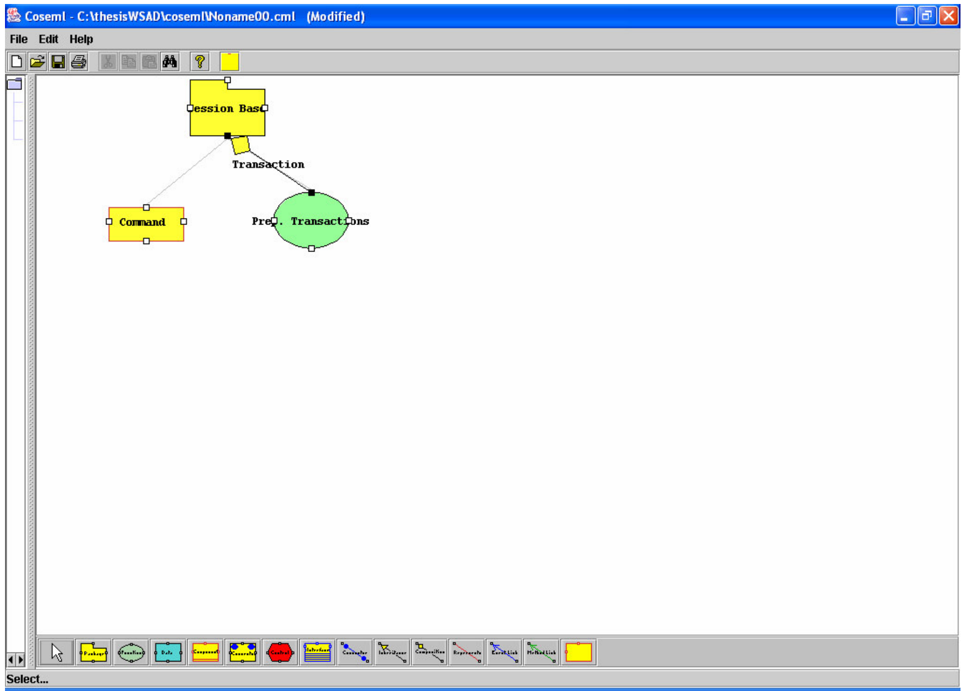


Figure B.15. Session Base Pattern After Prepare Transactions Function is Created

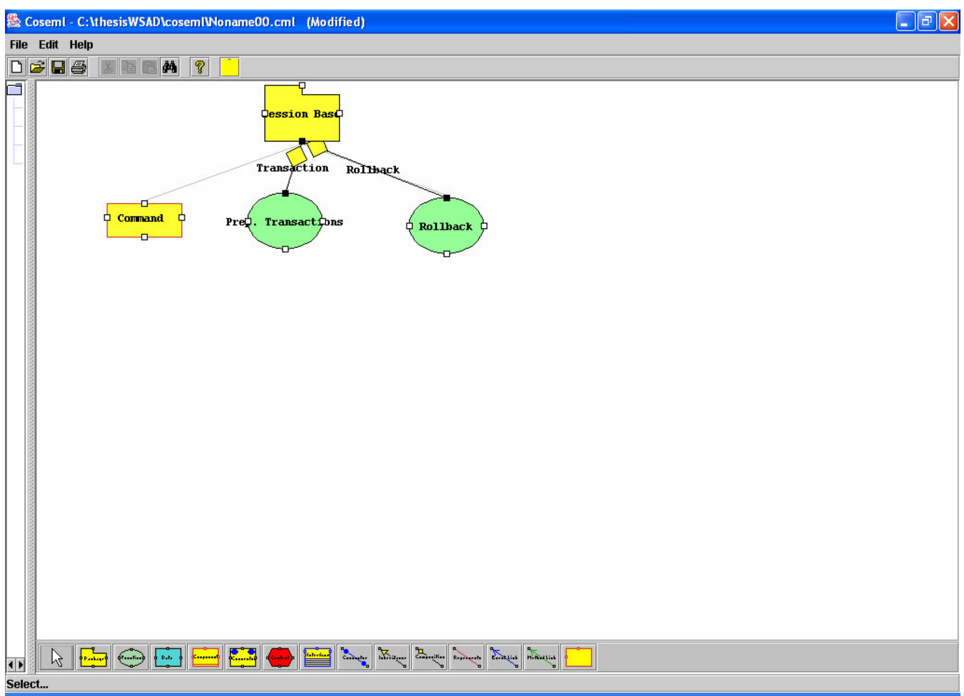


Figure B.16. Session Base Pattern After Rollback Function is Created

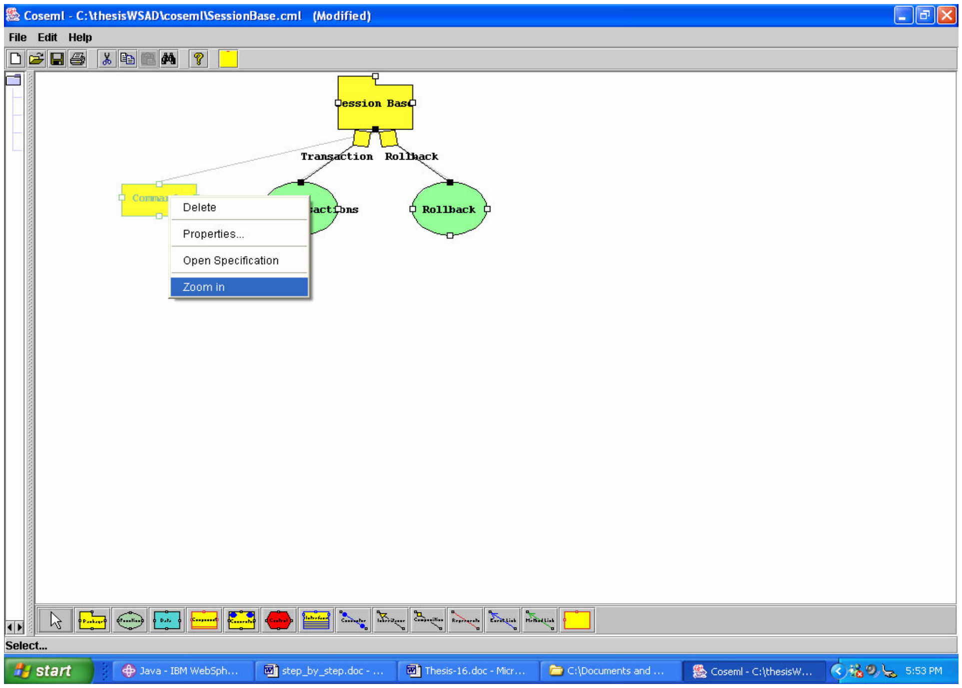


Figure B.17. Session Base Pattern Before Command Design Pattern is Diffused

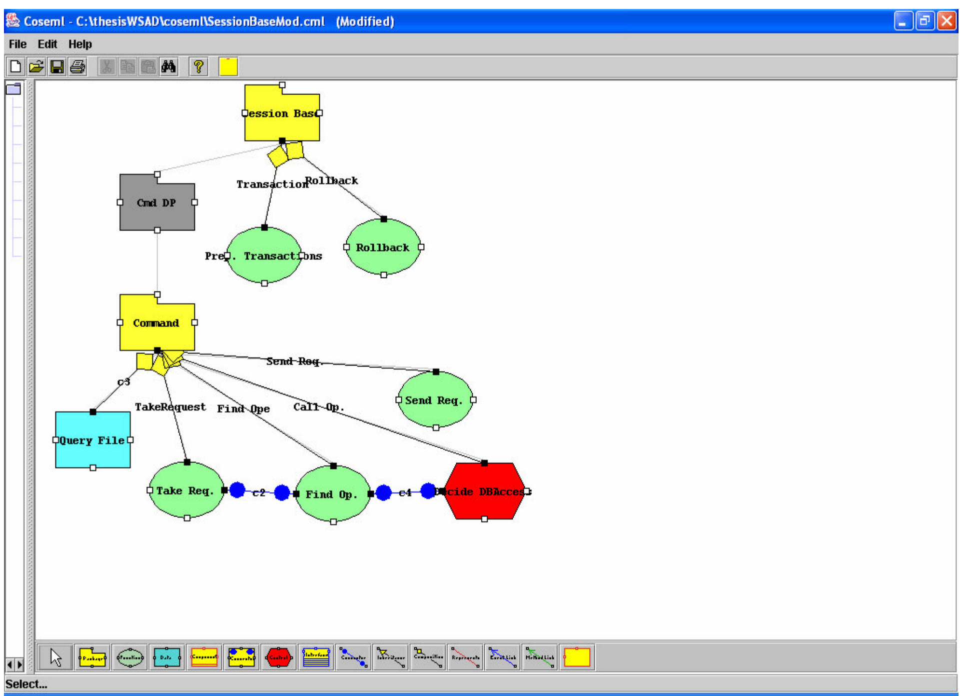


Figure B.18. Session Base Pattern After Command Design Pattern is Diffused

The data access object design pattern handles all the JDBC (Java Database Connection) requirements such as providing a connection and resources from the pool, removing connections and handling exceptions. The queries that will run is decided by the DAO using the command. A file is used to hold the relation between the command and queries.

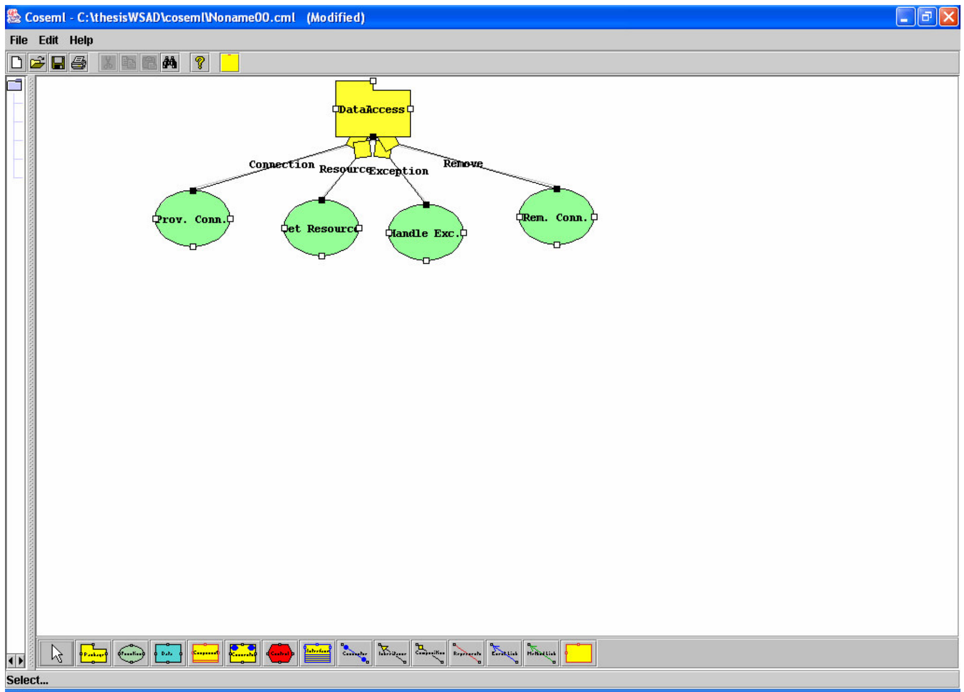


Figure B.19. Detail of Data Access Design Pattern

Since the necessary design patterns are defined to the system, framework design can be done easily. First a package is inserted which describes the framework. And then a package is inserted which describes the client operations and classes. Since command design pattern will be used to make operations between the client and server sides, this design pattern is added to the framework. The necessary relations to use command design pattern are introduced in the detail mode of the super component. External systems are defined by creating packages and necessary links are created to these packages.

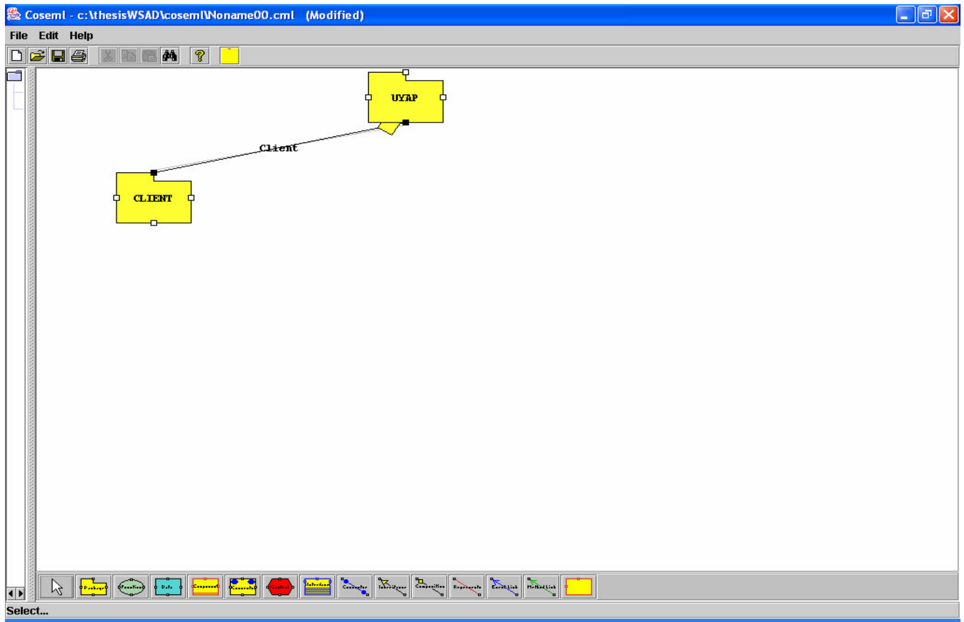


Figure B.20. Design of Example After Client Package Created

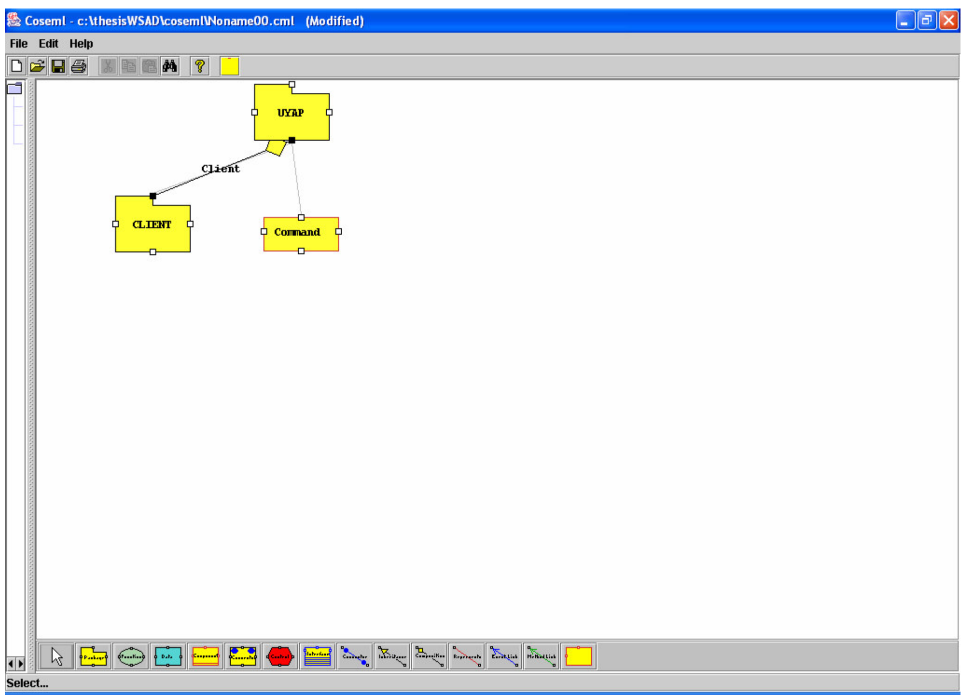


Figure B.21. Design of Example After Command Pattern Created

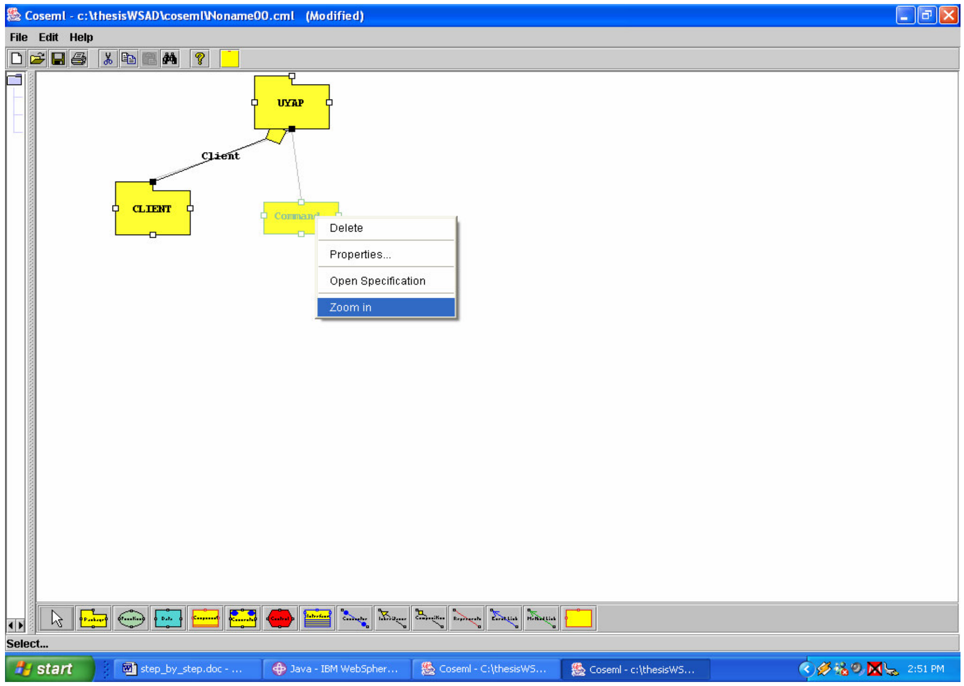


Figure B.22. Design of Example Before Command Pattern Diffused

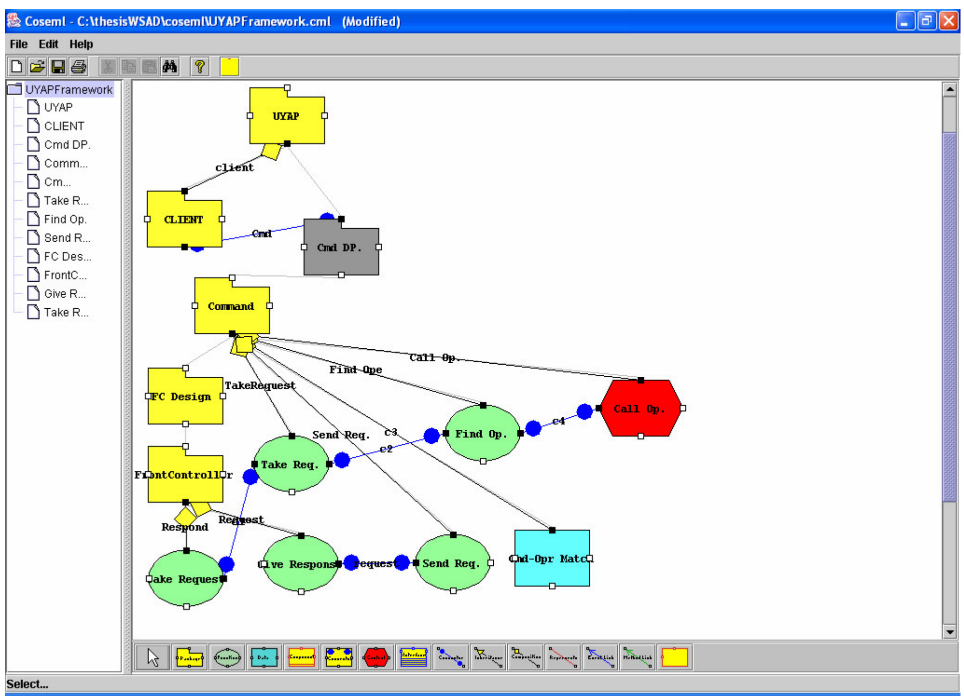


Figure B.23. Design of Example Before Command Pattern Diffused

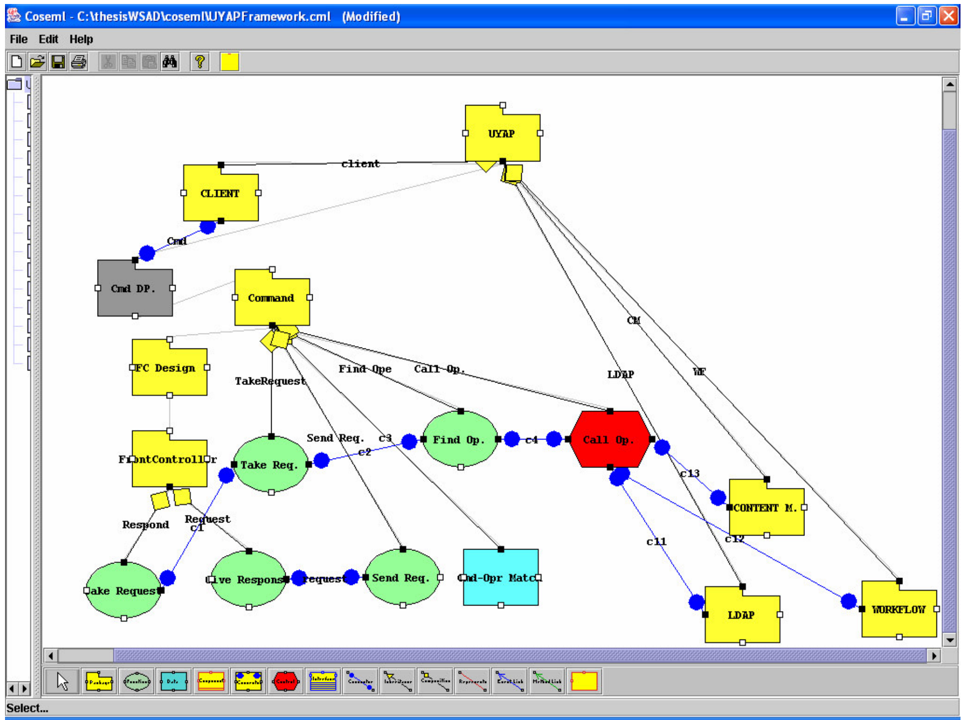


Figure B.24. Design of Example After Connections with External Systems Done

After external systems are created, the wrapper design pattern is added to the framework in case us database operations will be used. After the wrapper design pattern is added, the session base design pattern and data access object design pattern are added. Finally a package that represents the database is created.

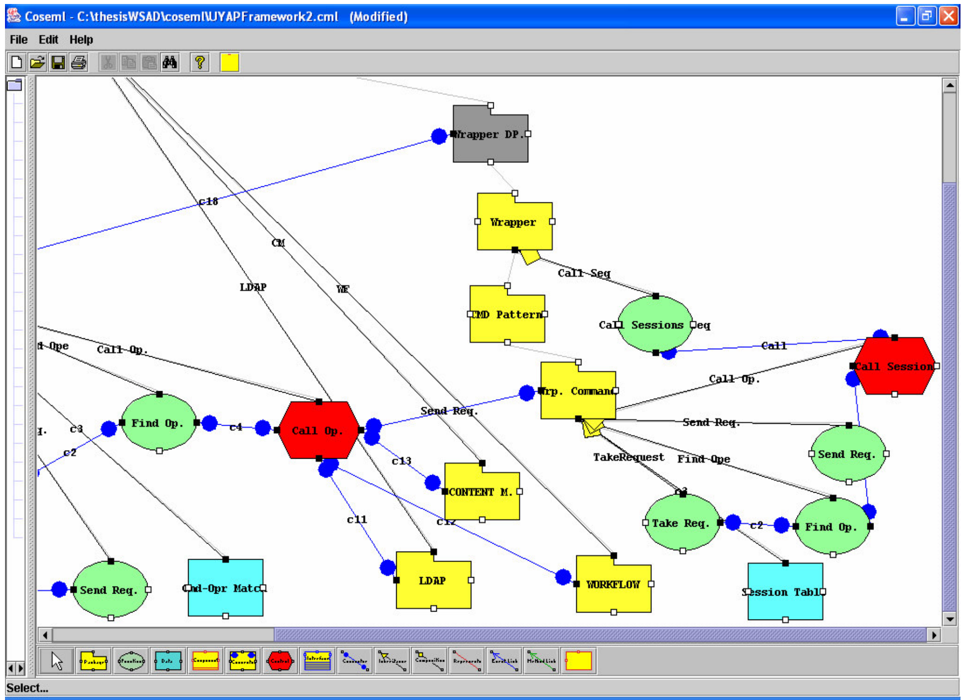


Figure B.25. Design of Example After Wrapper Design Pattern Created and Diffused

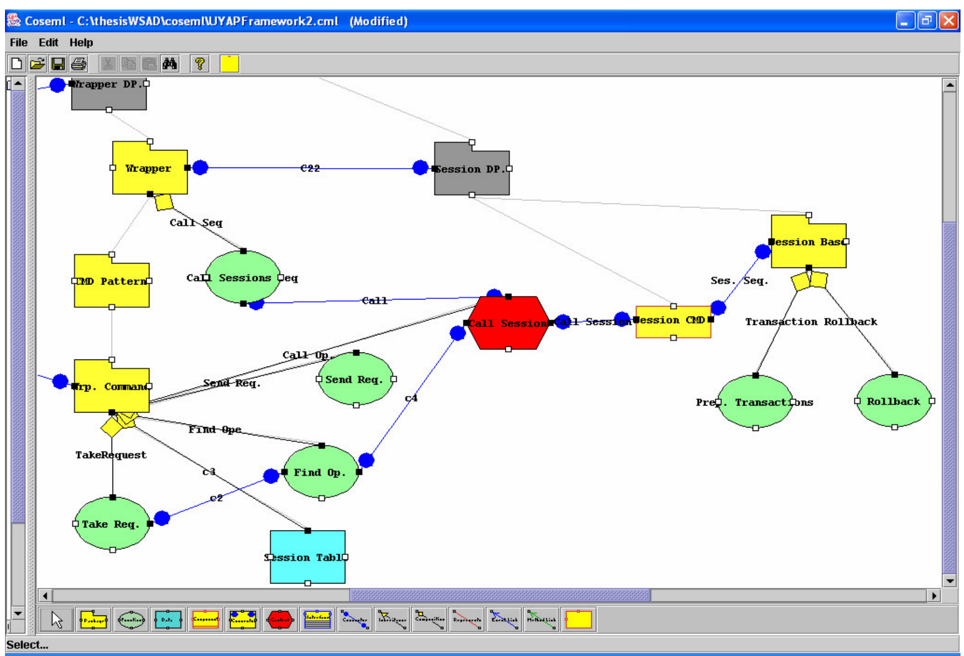


Figure B.26. Design of Example After Session Base Created and Diffused

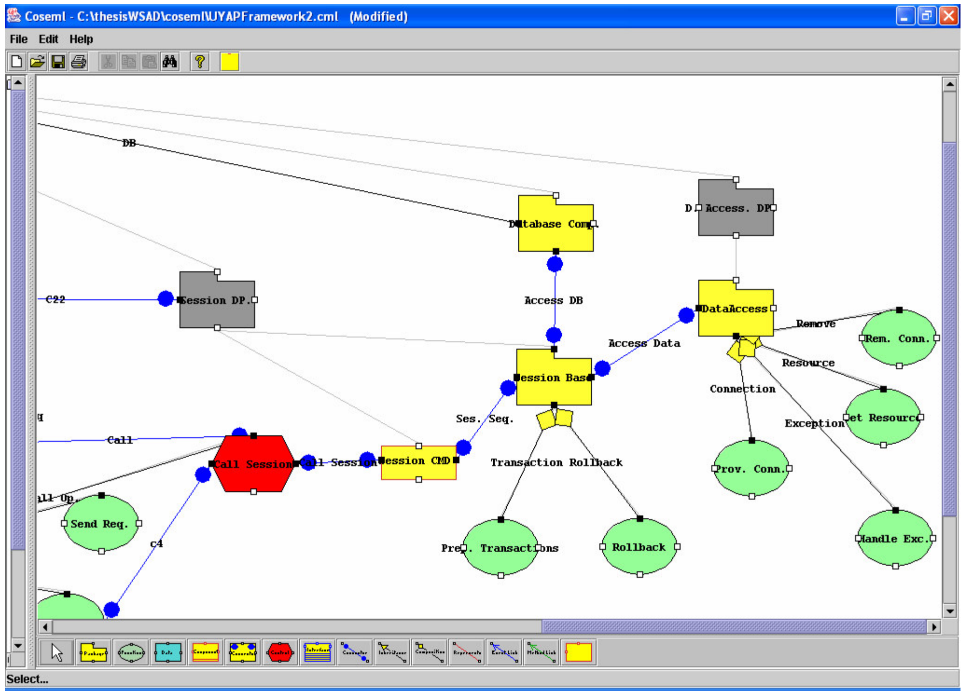


Figure B.27. Design of Example After Data Access Pattern Created and Diffused

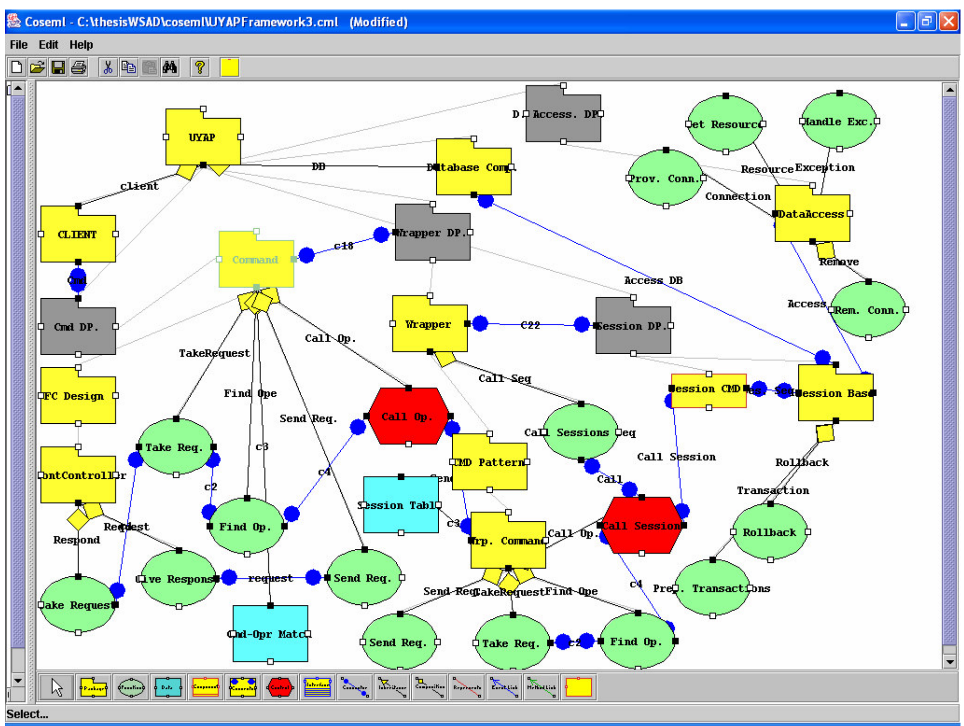


Figure B.28. Design of Example After All Connections Created

If the capability of using design patterns was not added to the COSECASE, then these detailed designs of design patterns had to be created at each use. The final design would be the same except for the packages that represent the design pattern's detailed design. These design patterns are modified in some way to make them appropriate and specific to this design. For example the original design of the command design pattern does not have an extra file to find the appropriate external system or wrapper component. For each operation a new class inherited from the base command class would be implemented. But in this design instead of all of these classes, a generic class that conducts the same operation by using a file and a parameter set. Therefore the original detailed design of the command design pattern is modified. The same approach is repeated for the data access object design pattern. Instead of implementing a different class that is inherited from data access design pattern, a hash map file that contains the queries and relations of these queries with commands and parameters of these commands is used. Data access design pattern is modified to achieve these modifications.