Planning and Analysis of Knowledge Intensive Enterprise Resource Planning Systems
A Case Study

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ABSTRACT

ERP software and applications have become basic requirement of almost every organization in order to compete with each other and in time constraint. In order to develop an efficient application, project planning and analysis play very important role in better understanding of the problem domain and to provide a risk free solution. There are many different approaches which software developers used to develop the systems. These traditional approaches have some drawbacks and constraints. Either these are ad-hoc basis or have some fixed patterns and rules. We discussed all these techniques and suggest that planning and analysis of ERP application during its development can be done by applying more appropriate knowledge engineering commonKADS model. CommonKADS is a structured approach, It comprises of different model suites. Thesis presents that by using commonKADS model for project planning and analysis, real problem domain and efficient solution can be identified. Also domain process is identified. Tasks related to each process in the domain are identified. Knowledge assets related to each task are identified. These features help in defining real knowledge specification. In this way, ERP applications can be made knowledge based. ERP systems were introduced to solve different organizational problems and provide integrated structure. Although ERP packages offer advantages to enterprises, they have not achieved many of their anticipated benefits. Autonomous and heterogeneous applications co-exist in companies with ERP systems and integration problem having not been addressed. This thesis seeks to make some suggestions to this area by studying and analyzing ERP problems, through mapping commonKADS methodology in a case study.

Thesis in start, presents an overview about ERP applications, Knowledge Engineering and commonKADS methodology. In the end, thesis presents our contribution a case study “online courses Registration Portal for BTH” which shows that planning and analysis of ERP applications by using commonKADS methodology helps in reaching knowledge based and more accurate solutions.

Keywords: Enterprise Resource Planning (ERP), Knowledge Engineering, CommonKADS, Knowledge Based System (KBS), Online Course Registration.
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CHAPTER 1: INTRODUCTION

This chapter provides a brief introduction to our research domain. It provides information about motivation, related work, aims & objectives, research methodology and main contribution.

1.1. Setting up the Scene:

There are number of organizations doing business around us. Due to successive competition amongst the organizations, they need to compete with each other and in time constraint. Nowadays use of technology has become an essential part of any organization. In order to manage their resources, organizations require a centralized system which includes various applications to perform different functions. Enterprise Resource Planning (ERP) Systems are widely used in almost every esteemed organization to handle the resources. Enterprise Resource (ERP) systems refer to a centralized system of various applications.

“ERP system integrates all the modules of the system with centralized administration into a unified system”[1].

“ERP systems integrate inventory data with financial, sales, and human resources data, allowing organizations to price their products, produce financial statements, and manage resources. An ERP system, as a software package, provides an information structure that is an isomorphic to the business processes of the entire organization”[2][7].

Our research mainly focuses on knowledge based ERP applications where human interacts with such a system and Knowledge Engineering practices for planning and analysis of such applications. We have given a case study “online courses Registration Portal for BTH” which shows that ERP application’s planning and analysis by using commonKADS methodology helps in reaching knowledge based ERP application and more accurate solutions

1.2. Related Work:

The field of knowledge engineering was established around 70’s and has from then on evolved to be used in many fields of which business administration is one. Knowledge engineering is good for finding bottlenecks and opportunities [3], e.g. how organizations develop, distribute and apply their knowledge resources. It is also a provider of methods to understand processes and structures used by knowledge workers. The main goal of knowledge engineering is to enable the possibility for building better knowledge systems [3].

“Knowledge Engineering commonKADS methodology favors a configurable and balanced project management approach which is more flexible than waterfall model and more controlled than rapid prototyping model”[5].

IBM has used commonKADS in development to increase software architecture reusability. Many banks and insurance companies in Netherlands have developed assessing loan and mortgage application with commonKADS. A well known application in UK i.e. credit card fraud detection program has used commonKADS for its development. CommonKADS also serves as a baseline for system development and research projects. Furthermore, the commonKADS are also used other than system development, such as knowledge management, requirements capture and business process analysis [5].
1.3. Online Course Registration:

The incredibly fast growth of the World Wide Web has established knowledge sharing infrastructure and knowledge itself and also determined as a key factor for production in any organization [4]. Management of courses is a common process for all the colleges, universities and training institutes [20]. It is also needed for distance learning and for web-based education programs which different universities offer.

1.2.2. Advantages for Online Course Registration Systems:

In old manual systems student face different problems. By adopting online course registration process universities facilitate both administration and students. Following are some advantages that can be achieved by adopting online course registration process:-

- Students living too far from the campus can register themselves online.
- No paper work.
- Improved student performance by putting level of previous knowledge.
- Compulsory prerequisite for specific courses.
- Less time consuming.
- Less work load for management.
- No biasness for international students.

Online registration systems are currently used by many universities i-e The University of Washington, Illinois State University, Manchester University and University of Birmingham etc [21, 22, 23].

1.4. Aims & Objectives:

The aim of this research is to define development of ERP applications where human interaction is involved using Knowledge Engineering practices. The main objectives of the study are listed below:-

i. Suggestions for planning and analysis of ERP applications during their development by using Knowledge engineering methodologies.

ii. To provide overview of the Knowledge Engineering methodology “CommonKADS”.

iii. To map knowledge based Courses Registration System using CommonKADS methodology, which will provide the counseling services.

1.5. Research Question

Our research question is based upon knowledge based ERP applications where human interact with such a system and Knowledge Engineering practices for planning and analysis of such applications.

i. Demonstration of Knowledge Engineering commonKADS methodology for knowledge intensive ERP systems applied in “Online Course Registration Portal for BTH”

The research question mentioned above is important enough to warrant a study because Courses Registration Process is a manual procedure at BTH. It is, therefore desirable, a generalized solution for the problem can be given and recommended.
1.6. Relation between Research Discipline and Application Area

ERP applications such as Customer Relationship Management and Decision Support System can be made knowledge based by using Knowledge Engineering practices. We have to plan and analyze problem domain during development of ERP application. These applications involve various knowledge intensive processes. As there is so much of information is handled by ERP applications, it is necessary to make them knowledge based and expert.

“Nowadays, one speak of smart products, knowledge-based services, intelligent systems, expert and knowledge systems, intelligent enterprise, smart homes, knowledge workers, knowledge-intensive and learning organizations, the knowledge Economy” [5].

Knowledge Engineering is a process of analyzing, eliciting, structuring, formalizing, and operationalizing of information and knowledge involved in knowledge intensive problem domains, for the development of knowledge based programs which can perform difficult tasks efficiently.

“Knowledge engineering (KE) provides the methods to obtain a thorough understanding of structures and processes used by the knowledge workers, even where much of their knowledge is asset – tacit leading to better information technology in support of knowledge work” [5].

Different software-development approaches can be used in development of ERP applications. We suggest that ERP applications can be made knowledge based by using commonKADS methodology. Planning and analysis of problems domain by using commonKADS can help in identifying real problem domain, actual process involved in domain, tasks and knowledge assets related to these tasks.

1.7. Research Methodology

The research will be based upon qualitative methodology because the knowledge is developed by using constructivist claims [6].

Literature review of the modern research will be carried out in this area of study. This literature review will help in great extent to know about aspects which come across while designing a framework for a knowledge based ERP system.

The problem will be evaluated and mapped with the CommonKADS methodology to apply knowledge engineering processes and methodology perspectives. CommonKADS methodology fill the need of structured methodology for KBS which constructing a set of engineering models built with organization and application in mind [18].

CommonKADS methodology will be applied in a case study “online courses registration portal for BTH” which will show that ERP application’s planning and analysis by using commonKADS methodology helps in reaching knowledge based and more accurate solutions.

Moreover, we will conduct some structured interviews with administration, teachers and students of BTH for our case study. This interviewing approach will provide us real world issues in understanding of online course registration system and will help in identifying problems associated with the existing system.

Conclusion and suggestions at the end of each chapter will be given. After completing research work we will give analysis related to our research work, conclusions drawn from our research work and future work.
1.8. Main Contribution

Our contribution towards this thesis is to suggest that planning and analysis of ERP applications during their development can be done by applying Knowledge Engineering CommonKADS Methodology. This will help us to reach knowledge based ERP application. We also suggest that consideration of Service Oriented Approach in each model of CommonKADS which are applied in planning and analysis of ERP application during development helps to reach efficient knowledge based system.

Our main contribution is to give a case study “Online Courses Registration Process”. In this case study we will plan and analyze our domain problem by applying CommonKADS model and show parts of organizational, task, agent, knowledge and communication model to support our suggestions.

We also plan to conduct many meetings, discussion sessions and interviews with administration, students and teachers (see appendix B) regarding domain of the case study. We found that Courses Registration Process at BTH includes selection, alteration and checking of pre-requisite / constraints / policies of the courses. These selection, alteration and checking of pre-requisite / constraint / policies of the courses are manual procedures at BTH. We will recommend an online knowledge based system namely “Courses Registration Portal” which will have ability to check pre-requisites of courses, constraint / policies. Also we will add a new knowledge based feature “student counseling” which will take various inputs from users such as field, complexity of courses, interest keywords and recommends courses to student. This feature is not normally found in traditional courses registration systems. Online registration systems are currently used by many universities [21, 22 and 23] but we will recommend these features on basis of current procedures and scenarios for course registration at BTH. We will plan and analyze our problem domain by applying CommonKADS methodology which will ease us to reach desired results. Also will consider “SOA entry points (see section 2.7.1)” while working on our Case Study. System will be flexible enough to be used in different universities.
CHAPTER 2: (ERP) APPLICATIONS AND SERVICE ORIENTED APPROACH

This chapter provides an overview about ERP systems. It also discusses evolution of ERP systems, features of ERP systems, drawbacks in ERP systems. Suggestions regarding planning and analysis of knowledge based ERP applications by knowledge engineering commonKADS are given where human interaction is involved with such a systems and role of ERP systems in education sector. The chapter mainly introduces different terminologies which will be detailed discussed in later chapters. A Service Oriented Approach for ERP systems is also discussed.

2.1. ERP Systems

A few years back organizations used different applications to automate their business processes. These applications were not developed in co-ordinate way but have evolved as a result of the latest technology innovation [9]. Many organizations have heterogeneous automated business applications. These applications cause various integration problems and not co-operate.

During the 1990s, Enterprise Resource Planning (ERP) systems were introduced as “integrated suites” that automate core corporate activities such as finance, human resources, manufacturing, supply and distribution [9]. These ERP applications provide the facility to share the common data within an organization. These applications minimize the integration problems and developers and DBAs work load.

2.2. Definition of ERP Systems

“Enterprise resource planning systems are configurable information systems packages that integrate information and information-based processes within and across functional areas in an organization. The current generation of ERP systems also provide reference models or process templates that claim to embody the current best business practices” [10].

ERP applications are standard software packages which are developed to meet the business requirements. Usually ERP information system packages are comprises upon management accounting, sales, inventory control, logistic, manufacturing and human resource management. These packages are used to provide management solution to the administration for different departments within an organization. These applications also provide the facility to share the common data within the organization. Through a central database all the modules in ERP application are closely integrated with each other [10]. In past two decades, special interest has been given to ERP solutions that improve business process [8].

2.3. Evolution of ERP Systems

ERP systems are the result of almost 40 years of continues improvements in the systems and gradual improvement of Information Technology. In 60’s [12], systems were developed for the inventory control and for the automation of the inventory in large organizations. The main focus of organizations was development of inventory systems. The most important (Inventory) system among them was Economic Order Quantity (EOQ) [12].

It can be assumed that the name ERP was derived from the term MRP (Martial Requirement Planning) and MRPII which stands for manufacturing resource planning [11]. Basically MRP was developed for the calculation of the material needed. It provide the more efficient and quick result for calculation of the material. MRPII was about sales planning and management and scheduling day to day works.
These systems were basically used for calculation of the material and scheduling management task. Soon companies realized that for maximum customer satisfaction and to increase profit portion they must automate their systems beside human resource, production and sales department enhancement. Computer integrated manufacturing (CIM) is regarded as next step, to embed technical functions of product development and production process in a comprehensive integration framework [11]. The concept of a totally integrated enterprise solution is now called ERP.

ERP systems provide administrations solution for Human resource management, financial, logistics, sales and manufacturing departments. Included parts, or modules, are closely integrated with each other through a central database [10].

![Figure 2.1: Evolution of ERP (taken from [10])](image)

### 2.4. Different Features of ERP Systems

ERP systems are used to integrate all the modules of any organization either business or education. All data is stored in a single database in a distributed environment. All the departments can access current and updated data from the database. It is a software architecture that facilitates the flow of information among all functions within an organization [13]. Any organization can customize this system according to its business processes. Almost every business requirements of any organization are handled in these systems. Some of the salient features of the ERP based product are as under:-

- Latest Technology
- Centralized administration
- Modular Approach
- Integrated Modules
- User friendly
- Graphical User Interface
- Robust
- Customization
- Secured
- Y2k bug complaint
- Online Help
- Efficient
- Portable
2.4.1. Drawbacks in ERP Systems

Although ERP systems were developed to integrate all the modules of an organization, yet integration is an important problem of ERP solutions. Although ERP packages were described and promoted as “integrated suites” [9], they face serious integration problems. These problems are faced as ERP packages are not designed to tie up other autonomous applications [9]. As a result a number of disparate applications co-exist with ERP systems in companies and ERP packages fail to provide an integrated IT infrastructure.

Following are major drawbacks in ERP systems:-

- Implementation complexity
- Integration Problems
- Customization Problems
- Over budget and late projects
- Organizational change and resistance to change
- Problem with business strategy and competitive advantage

2.5. Knowledge Based ERP Systems

All enterprise systems are related to data storage, retrieval and manipulation. This data can be used as information for different applications. These data and information can be well structured to be utilized efficiently by both the users and the system. When both data and information are structured and organized gives rise to a concept of knowledge. [5] We suggest that this knowledge can be utilized in better understanding of high quality services and can help in development of knowledge based ERP systems.

We also suggest for utilizing knowledge present in the organizations. It is really important to know about the business process involved in the organization. Based on discussion in sections 2.1, 2.2, 2.3 and 2.4 we have made some suggestions as follows:-

We suggest that understanding of the knowledge related to business process must be properly analyzed. Different departments of the organization play different roles. Various roles in each department can be identified and work flow related to these roles can be defined and mapped. Business process and role can be divided into sub processes and tasks. Knowledge can be identified which is involved in each and every process and sub process. This knowledge can be efficiently used to make Knowledge based ERP systems.

2.6. ERP systems in Education Sector

ERP systems can be utilized not only in business organizations but can also be utilized in education sectors. Many universities are customizing its modules according to their requirements. All departments of an educational organization such as Human resource management, accounts, marketing, and curriculum can be customized accordingly. It is important to note that ERP systems can provide improvement opportunities for business, engineering and computer science schools [13].

ERP based models helps management to integrate various administration applications and to manage them accordingly. It provides a centralized administration to maintain whole organization business process. We are providing the suggestions for efficient course registration system which will not only decrease the management burden for courses registration also it will provide ease for students to register subjects of interest without any wastage of time.
2.7. ERP: Service Oriented Engineering

Service oriented approach in software engineering is often related to service oriented architecture, where software deployed as a part of services. SOA is widely known, and can be fitted into many other kinds of software development methodologies such as Rational Unified Process or Extreme Programming [14]. SOA is a way of developing the applications in a way which can access the existing and future applications without any major development efforts [15].

2.7.1. Basic Service oriented Architecture

The service oriented architecture defines the interaction between different software agents, which exchange the messages and information. Clients and service provider both work as agents in SOA. Clients which are actually software agents send a request and providers which are also software agents they provide the service [15]. SOA is relationship between Clients, Service providers and the Service discovery agency as shown in fig 2.3 [15]. Service discovery agency is where all the definitions are defined in it and it location information is stored in a repository such as UDDI [15].

![Basic service oriented Architecture](image)

**Figure 2.3: Basic service oriented Architecture**

IBM has introduced five SOA entry points are as follows [14]:-

i. **Flexibility**: The business application should be so flexible that it can be modified without any major development work. Application exposes business behavior as a service and also that business logic can be reuse which is also exposed as a service.

ii. **User’s connectivity**: All the users must be connected with the business application in such a way that they can access the application from anywhere and any time by using any intermediary service gateway. All the three people, information and process must be connected with a seamless flow of messages.

iii. **Client Interaction and collaboration services**: All the services must be presented to the clients through different ways either by World Wide Web or through PC or by using the cell phones. All these interaction and collaboration services increase the productivity of the persons if they have the proper information in time. Here all the information is in the context of business process.

iv. **SOA as Business process management**: Business process management is a pattern which is a combination of software capabilities and business expertise to get the improved business processes and for further innovations.

v. **Information as a service**: Information as a service offers information access to complex, heterogeneous data sources within your company as reusable services.

We have given detailed overview of ERP software and applications. It is now clear from the discussion that ERP applications automate parts of almost every business process. As we all know that every business process is to provide various services to clients, employees and administration, in order to handle workflow in the organization efficiently. It is therefore, we suggest that ERP systems should be developed by applying service oriented approach. So far we have talked about
the need of ERP system in a business process to automate it. We should also focus development of ERP application concerning user’s aspects which are part of any business process of the organization. It will affect overall performance of any organization. We propose that use of “SOA entry points [14]” of service oriented approach during all development phases of any ERP system must be considered to reach efficient ERP system. It is therefore, ERP application are directly associated with service oriented approach due to involvement of users in business process. It includes all users who provide service and who uses services. In the next chapter, we will discuss about knowledge Engineering and CommonKADS methodology.
CHAPTER 3: KNOWLEDGE ENGINEERING
“Introduction to CommonKADS Methodology”

This chapter provides an overview about Knowledge Engineering and its methodology CommonKADS. We will discuss some major concepts of Knowledge engineering which were built in this field in last decade. We will elaborate the process of KE and then roles of different knowledge engineers in the development of the knowledge system. We will also discuss traditional methodologies for software development with their limitations. Beside this we will discuss the model suite of CommonKADS methodology which we are going to use in our upcoming chapter 4. All the models are explained with reference to our case study which will help to understand our main contribution.

3.1. What is Knowledge Engineering?

Traditionally knowledge engineering is concerned with the development of those information systems in which knowledge and reason have pivotal role.

“Knowledge engineering is not some kind of “mining from the expert’s head,” but consists of constructing different aspect models of human knowledge.” [5]

It was assumed in past, Knowledge engineering is same as transferring knowledge from an expert to the knowledge base. This theory was often failed due to reason that experts are usually unaware of what technique they used to solve the problem [16]. That is why core parts of the knowledge are not accessible, need to be constructed and structured during the knowledge acquisition phase and also this has led to several frameworks. These frameworks are developed for the knowledge based systems with aim to realize problem-solving capabilities which can be verified by domain experts [16]. Nowadays knowledge engineering has become modeling activity which constructs a good description and a purposeful abstraction. Developers can focus upon certain aspects which are more important and ignore others. In knowledge modeling concentration is upon conceptual structure of the knowledge and programming details upon second priority [5]. Knowledge engineering is now performing as a key technology for knowledge society. Now knowledge has become key assets for any organization, this is the current and well organized knowledge which can make it possible for organizations to compete the world economy.

Knowledge management within an organization is impossible without advanced information and knowledge management system [5]. More efficient and accurate systems is one which have most updated information, advanced technology and have the ability to interconnect and interoperation between different information systems.

It is not an easy task to interconnect and interoperate with different information systems as much knowledge is required to resolve the different hurdles. Knowledge engineering has become a major technique for information integration [16].

Knowledge engineering has become the scientific discipline Following are few reasons which make knowledge engineering an important main stream technology [5]:-

i. Knowledge engineering provides opportunities and bottlenecks in how organizations develop, distribute and apply their knowledge resources, and provide a tool for knowledge management.

ii. Knowledge engineering provides detailed understanding about the structure, processes used by the knowledge workers, and provides opportunity for better integration of the information technology into knowledge work.
iii. Knowledge engineering helps to develop better knowledge systems, the systems which are easy to use, simpler to maintain and well structured.

3.1.1. Knowledge Engineering Process

Following processes are usually involved in knowledge engineering process [17].

i. **Scope of the System:** First we have to determine what kind of queries will be answered by the knowledge system. All the requirements must be analyzed. Scope of the system must be defined.

ii. **Ontology:** After defining the scope of the system a glossary of the terminologies or concepts must be created and then there must be a relationship between terms and the constraints of their usage. This is usually known as conceptual model.

iii. **Knowledge based construction:** After developing the conceptual model create the instances of the domain knowledge which create rules, constraints, facts and cases etc.

iv. **Validation:** All the operations must be validated against the scope of the system. If it satisfies system then release it, otherwise repeat from scope to validation steps.

v. **Refinement and maintenance:** This step is usually performed after the system delivery. As knowledge changes, system continues to evolve and from step scope to step validation is again performed.

3.1.2. Knowledge Process Roles

In knowledge engineering process, it is good to identify roles of humans. There are several different roles which humans play in knowledge engineering process. We shall only discuss here six roles out of others. These roles are not hard and fast for all the organizations but it can be changed according to the size and conditions of the organization. [5]

i. **Knowledge Specialist:** Knowledge specialist is a person who has the expertise in the field and having the complete knowledge of the domain. Some times, knowledge specialist known as the owner of the knowledge. All the system developers have to consult to her for any query regarding the domain. Knowledge specialist acts as knowledge provider.

ii. **Knowledge Analyst:** Analyst is a person who is responsible from the beginning to implementation of knowledge system. She has to analyze the standard knowledge intensive tasks by utilizing commonKADS methods and tools.

iii. **System Developer(s):** System developers are persons who have to shape the requirements into practical form. They must have basic knowledge of analysis and development of knowledge systems. In small organizations sometimes developers also perform as system analyst. Developers are responsible for development and design of the system.

iv. **Users:** These are direct or indirect knowledge users of knowledge systems. It is better to involve end user in the beginning. The design and interface must be user friendly.

v. **Project Manager:** Project manager is an incharge of the project. He is responsible for requirement monitoring, time scheduling, risk management, scope management, cost and budgeting of the project. A project manager must know how to get job from her team without annoying any person.

vi. **Knowledge Manager:** Knowledge manager is not directly involved in the knowledge system development. They formulate a knowledge strategy at business level and initiate development of the system and different knowledge distribution activities.
3.2. Software Development Approaches

Different methodologies are used to explore the essential features of a proposed system through practical experimentation before its actual implementation to make the correct design choices early in the process of software development.[24]

In order to explain why we use commonKADS methodology for mapping our case study here we discussed traditional approaches with their limitations.

3.2.1. Waterfall Methodology:

The Waterfall method is a standard software development model, as well as an instructional development model. It is linear and sequential, having distinct goals for each phase of development. The Waterfall model begins with the definition of objectives and ends with the development of a finished product (software or instruction) containing components designed to achieve each objective [24].

Limitations of Waterfall methodology:

As with a waterfall, after water has dropped over the edge of a precipice, it cannot turn back. Accordingly, once a particular development phase is complete, the development must proceed to the next phase. Momentum—in the form of substantial investment in the phase—prohibits significant revision. One of the benefits of this methodology is a high-quality end product; however, the drawbacks are the length of time it takes to develop the initial product, and the tremendous effort required to revise it [25].
3.2.2. Rapid Prototyping:

Rapid prototyping is an instructional design methodology in which designers work with clients to quickly build a series of prototypes for instruction in order to experiment with and evaluate a variety of instructional designs before committing to a single instructional approach for further development. [25]

Limitations of Rapid Prototyping:

Although rapid prototyping is more effective and efficient than waterfall hence it has following limitations [25]:-

- Informal Design Method
- Ad-hoc based
- It is slow and clumsy process
- Unable to represent real activities of design
- Bad solution

3.3. CommonKADS

CommonKADS is a structured approach for the knowledge and expertise representation in designing and developing systems of any enterprise [17, 18]. It comprises of different model suites [5] which are used as a convenient instrument to break down and structure the knowledge-engineering process. These model suites [5] act as means to carve up organizational task in pieces and also suggest selection of suitable pieces. CommonKADS provide a different modeling technique and introduce a new approach for knowledge based system development. It provides extensive facilities for domain knowledge modeling. That is why CommonKADS has become a good candidate for the de facto European standard and for referencing of the knowledge engineering methodologies and covers a wide range of knowledge based system development aspects [18].

This methodology was developed in European Esprit program in 1983 [5, 17, 18]. Now this methodology is widely used in Europe and US [17]. This methodology is used for knowledge based system (KBS). Specifically its problem solving behavior concretes organizational and application context. Different models capture different sources and organizational requirements that are used in development of the real applications. Knowledge based systems are collection of these models [17].

3.3.1. CommonKADS Principles

CommonKADS methodology is based upon few principles. These principles are extracted after several years of experiences. These principles are as follow [5].

Traditionally it was assumed that knowledge is “mining from the expert’s head”. CommonKADS introduce modeling technique which proves that this is totally wrong as experts are sometimes unable to describe how they solve some crucial part of any knowledge system. Modeling describes a good description of problem and accurately addresses all the aspects of the problems. Second main fault in traditional view was, expert knowledge is neither sufficient nor completely accessible.
The second principle of this methodology is to concentrate upon conceptual structure of the knowledge, all programming details leave for later. It prioritized activities. In commonKADS it is important to develop computational artifact but most important is the human side, what is the real world problem, what kind of problems end users face?

Knowledge level model help us to understand human problem-solving by knowledge typing. Knowledge engineering must develop well-structured, functional having some restrictions and a whole model knowledge which plays a specialized role in human problem solving.

“A knowledge project must be managed by learning from your experiences in a controlled spiral way”. CommonKADS provide a balanced and configurable management approach rather than traditional waterfall which is a very famous approach. Drawback with this approach is that it has some fixed rules and stages which has preplan format for information gathering from the users. Another approach rapid prototyping is commonly used in development of the knowledge systems. It is developed by learning at the spot and changes course whenever required. Problem with this approach is that it is ad-hoc typed, very difficult to predict and manage. Whereas commonKADS is configurable, balanced and more controlled than rapid prototyping. It is therefore, we adopt commonKADS methodology for our case study.

The commonKADS methodology consists upon five elements like any other software development approach and these elements are shown in the fig 3.1. These elements are known as methodological pyramid. [5]

![CommonKADS pyramid](taken from [5])

**3.3.2. CommonKADS Model Suite**

CommonKADS model suites are core of this methodology and are practical expression of knowledge engineering principles. These model suites address three basic and fundamental questions and these are Why, What and How [5, 18].

Why? Why a knowledge system is potential solution. What type of problems it solves, what benefits organization can have and what does it cost? It provides clear picture, for what this knowledge system is actually comprised of. What? It addresses that what type of knowledge is...
involved in problem domain and conceptual description of the knowledge is applied. Third group “How” explains, implementation of the knowledge into computer system, computational mechanisms and software architecture. Moreover all technical aspects are focused here.

Following [5] is the brief introduction of the model suite for CommonKADS methodology; we will discuss these models with reference to our case study. A detailed discussion is in chapter 4, where we mapped all the necessary models for our system.

- Organization Model.
- Task Model.
- Agent Model.
- Knowledge Model
- Communication model
- Design Model

![CommonKADS Model Suite](image)

Fig 3.2 CommonKADS model suite (taken from [5])

### 3.3.2.1. Organization Model

Organization model identify problems, opportunities and possible solutions for a knowledge system [5]. It provides analysis of organization that how the knowledge system affects organizational structure and establishes feasibility and bottlenecks. Organization model consist of five main components [5, 19]. These components are OM-1, OM-2, OM-3, OM-4 and OM-5.

#### 3.3.2.1. OM-1

It identifies problem and opportunities, features of organization, mission of the organization, strategy and external factors of the organization. This model also describes proposed solution to the problem.
3.3.2.1.2. OM-2

This model describes organization aspects. It is covers various components. These components are Structure, Process, People, Resources, Knowledge and Culture and Power. Structure refer to Organization chart, its departments etc. Process denotes different business processes. Peoples: this component indicates different staff members, stakeholders, decision-makers and users etc. Resources: What types of resources are utilized for the business process? For instance these may be information systems or equipments etc. Knowledge is a special technique or resource which is employed in the business. In our proposed system we are providing student counseling and application assessment for registration of courses on the basis of her previous academic record. All ethical and unwritten rules in the organization are described in culture and power.

3.3.2.1.3. OM-3

All business processes are further described in this model. It consists of different sub tasks and their ownership. In OM-3 we describe who will perform a particular task and where will be performed this particular task. The type of knowledge asset describes the significance of the task. Basically all main tasks are further subdivided into smaller tasks and are prioritize upon the significance basis.

3.3.2.1.4. OM-4

Knowledge assets of OM-2 are further described in the OM-4. It is basically an analysis. All those pieces of knowledge which are actively used by agents for a specific task or process are significant as an asset. It describes what is the knowledge asset, who posses that asset and where it will be used?

3.3.2.1.5. OM-5

All business and technical feasibilities are carried out in this organizational model. It represents a big picture of all benefits versus the cost and needed technologies for the solution of proposed project. OM-5 is basically a feasibility report of the projects.

3.3.2.2. Task Model

3.3.2.2.1. TM-1

It is the refinement of the data in OM-3. Basically it describes a goal oriented activity having some value to the organization. It handles inputs and delivers outputs in a structured and controlled way. It is performed by some responsible and accountable agent. Following are the components of the TM-1 [5].

i. Task: It is the task identifier and the task name.
ii. Organization: Where this knowledge asset is carried out in the organization.
iii. Goal and value: It describes purpose of the task.
iv. Dependency and Flow: Any input or output for a particular task. It can be denoted by data flow diagrams.
v. Timing and control: It describes frequency of the task.
vi. Agent: Agent is staff member who performs that particular task and responsible for carrying out the task.
vii. Knowledge and Competences: For successful completion of any task competences are needed. It is further described in TM-2.
viii. **Resources:** What, resources will be consumed by that particular knowledge asset. For example, staff time, system and equipment etc.

ix. **Quality and performance:** There must be a quality measure for the successful task execution. Through this quality measure we can judge quality of the task.

### 3.3.2.2.2. TM-2

TM-2 is more refined model of OM-4 knowledge asset. It concentrates in detail on bottlenecks and improvements relating to the specific area of knowledge.

Information can be obtained directly from staff by questioning to concerned persons. For example questions like this, how you perform this task? How long does it take to perform a task etc?

### 3.3.2.3. Agent Model

According to [5], agent model describes agent descriptions. It elaborates which knowledge task is being performed by a particular agent. It is graphical representation of the tasks carried out by different agents. Through this model we can understand which agent is involved in a particular knowledge task.

i. **Name:** Name of the agent.

ii. **Organization:** Agent’s position in the organization.

iii. **Involved In:** Upon which task working currently, all the tasks list in TM-1

iv. **Communicates with:** It refers to the other agents.

v. **Knowledge:** Which knowledge is possessed by the agent from TM-2?

vi. **Other Competences:** it deals with present and required competences of the agent

vii. **Responsibilities and constraints:** What type of responsibilities agent has and what are constraints of the agent?

### 3.3.2.4. OTA-1 Model

OTA-1 is another important model. It is not directly involved in knowledge system development. It used in managerial decision making about any change, improvement in organization, change in the task or change of an agent for a task.

i. **Impacts and changes in Organization:** Impact and change in organization describe what kind of impacts and changes considered system solution brings with respect to the organization.

ii. **Task/agent specific impacts and changes:** Task / agent specific impacts and changes describe which impact and changes proposed knowledge system brings with respect to individual task and the agents.

iii. **Attitudes and commitments:** It is also considered that how individuals react to the suggested changes.

iv. **Proposed actions:** What are recommended changes, with respect to the organization, as well as individual tasks, staff and system? This is part of the impact and improvement decision document and directly subjected to managerial commitment and decision making.

### 3.3.2.5. Knowledge Model

“Knowledge model is itself a tool that helps us to clarifying structure of a knowledge intensive information processing task”. [5]

A knowledge model has three parts. Each part is called knowledge category. These parts are as under.
i. **Domain Knowledge:** All domain specific information provided in this category. For example in our proposed system all terminologies relating to education systems and all definitions are discussed in this part.

![Diagram of Student and Student Class](image)

**Fig 3.3** Student and student class

ii. **Inference Knowledge:** It describes lowest level of functional decomposition.

iii. **Task Knowledge:** Task knowledge describes reasoning/goal for knowledge category and explains strategy to realize that goal.

Modeling is a constructive activity; there exists no single correct solution and not one optimal path to it. Each activity is carried out with the help of one or more techniques and can be supported through a number of guidelines. The process of knowledge model construction is decomposed in three stages these are as under.

i. **Knowledge Identification:** All information sources that are useful for knowledge modeling are identified. Task knowledge and domain knowledge are surveyed. If OM and TM description are completed then it can be done in short time.

ii. **Knowledge Specification:** Tasks decomposition and main domain information types are provided by knowledge engineers.

iii. **Knowledge Refinement:** Knowledge model is validated as much possible to complete the knowledge base. A paper simulation is gathered during knowledge identification. This simulation results that either this knowledge model can generate problem solution or not, which is required. If validation is positive then further steps are done.

### 3.3.2.6 Communication Model

The communication model, according to [5] specifies information exchange between different agents. Any action performed by an agent may cause result in the form of information that may be used by any other agent. It must provide reasoning to the users. This communicative act is called *transaction*.

Communication model perform in three layers from global to detailed specifications. These layers are as under:-

#### 3.3.2.6.1 Communication Plan

This is entry point for communication analysis. This plan gives overview of all required exchanges. When two agents successfully complete their tasks they want to exchange their information. This plan provides full top level dialogue corresponding to share top task.

#### 3.3.2.6.2 Individual Transactions

In second layer of the communication plan we have an agent to agent dialogue in terms of transactions. We define specifications of transaction in second layer. Following are elements those specify individual transactions known as CM-1.
i. **Transaction Name**: Each information object has a name which must be understandable to user.

ii. **Information object**: Indicate information object, and between which two tasks it is to be transmitted.

iii. **Agents involved**: Indicate both sending and receiving agents.

iv. **Constraints**: Specify requirements and conditions.

v. **Information exchange specifications**: Transaction may have its own structure which it contains. This will be explained in CM-2.

### 3.3.2.6.3. Information Exchange Specifications:

This is third layer of the communication model. It contains lowest level details of information and known as CM-2. It includes the following details:-

i. **Transaction**: Name of information exchange specification.

ii. **Agents involved**: Information items sending and receiving agent information.

iii. **Information Items**: Transmitted information items list.

iv. **Message specification**: All details of the messages that make up the transaction. These details might be communication type, content and reference etc.

v. **Control over messages**: Control over messages within the transaction can be given.

### 3.3.2.7. Design Model

“Design model describes the structure of the software system that needs to be constructed in terms of the subsystems, software modules, computational mechanisms, and representational constructs required to implement the knowledge and communication models”[5].

**Design Processes**: Usually design process is consisted upon four steps which are as under:-

#### 3.3.2.7.1. System Architecture

In this step we specify general architecture of the system. This step is further divided into three sub steps.

- Decomposition of system into subsystems.
- Overall control.
- Decomposition of subsystems into software modules.

#### 3.3.2.7.2. Implementation Platform

Implementation platform is basically choice of the software. Worksheet DM-2 provides a checklist for software selection. Following are the components of worksheet.

i. **Software Package**: Name of the software package.

ii. **Potential Hardware**: Hardware platforms the package runs on.

iii. **Target Hardware**: Platform the software actually runs.

iv. **Visualization Library**: Library available, facilities for views.

v. **Language Typing**: Either OO or strong versus weak typing.

vi. **Knowledge Representation**: Declarative or procedural.

vii. **Interaction Protocol**: ODBC, CORBA etc.

viii. **Control Flow**: Message passing protocol.

ix. **CommonKADS Support**: Implemented CommonKADS architecture.
3.3.2.7.3. Specification of Architectural Component

Architectural components are defined in more detailed in third step of the design model. In this step interfaces between subsystem and/or system modules is defined. A worksheet DM-3 provides a checklist for the decisions that needed to be taken during architecture specification. Worksheet is comprises upon the following items.

i. Controller: Mechanisms for event handling internal and external.
ii. Task: Initialization method.
iii. Task Method: Either the task method is declarative or procedural.
iv. Inference: Internal state variable and when they will be reset.
v. Inference Method: These are the mapping algorithm.
vi. Dynamic Role: Data types of roles.
vii. Static Role: Define access operation.
viii. Knowledge Base: All the rules regarding access and modification etc.
ix. Views: Standard graphical interface or some special facilities required.

3.3.2.7.4. Application within the Architecture

The design needs to be completed by specifying application-specific parts within the architecture. We can distinguish two steps in this process. Map analysis information on architecture specified in the previous step. Add additional details needed for application design.

3.3.2.7.4.1. Map Analysis Information

Knowledge model analysis information can be mapped easily onto architecture components for creating a number of architecture component instances (Task, inferences, etc). This mapping process can be done manually or through some automatic tool. By utilizing tool, chances of errors can be minimized and that is why it is preferred to use any automatic tool.

3.3.2.7.4.2. Design Specific Details

In case of real-time system, designer should become familiar with specialized literature on this subject. A work sheet DM-4 is a checklist for application-design decision. This checklist contains following elements:-

i. Task Method: Formalize method control structure in control language provided by the architecture.
iii. Inference Method: Specify a method for each inference.
iv. Dynamic Role: For each role chose a data type.
v. Views: There must be a choice of view. It is also guided by general user-interface design principles.

We have discussed about knowledge Engineering and CommonKADS methodology. Knowledge Engineering is very important to extract, analyze, structuralize and operationalize knowledge present in business process of any organization [5]. We can say
that each knowledge asset associate to business process provides some kind of services. We suggest that consideration of SOA “entry points[14]” in each applied model of CommonKADS methodology in planning and analysis of ERP applications during their development can help to reach efficient knowledge based ERP system. It is therefore, we propose operational knowledge present in ERP applications which are related to specific business process in any organization can be divided into different knowledge services. We have given detailed overview about Knowledge Engineering and CommonKADS methodology. In the next chapter, we will give a case study “Online Courses Registration Process to support our given suggestions.
CHAPTER 4: OUR CONTRIBUTION
“Online Course Registration Portal for BTH”

This chapter provides a case study “Online Course Registration Portal for BTH. The domain concerns the online Courses Registration Process in which courses are registered for the students in the respective LP/Semester. We have used knowledge engineering methodology “CommonKADS Analysis Model” in order to analyze, evaluate and map the case. Knowledge intensive tasks we have mainly focused concern with the “Student Counseling” for selection of courses of interest and “Assessment Criteria” for checking pre-requisites, constraints and policies. We have shown parts of the organization, task, agent, knowledge and communication model for this application domain.

4.1. Application Domain

4.1.1. Course Registration Process

In order to understand our domain Course Registration Process at BTH, we had many meetings, discussion sessions and interviews with administration, students and teachers (see appendix B). Courses Registration Process at BTH includes selection, alteration and checking of pre-requisite / constraints / policies of the courses. These selection, alteration and checking of pre-requisite / constraint / policies of the courses are manual procedures. First, student has to select courses on a paper application form which contains personal information and a course list. Then student meet programme manager with the signed application form and transcripts. The programme manager has responsibility to check pre-requisites, constraints-policies of the selected courses. Programme manager checks that student fulfills the assessment criteria and registers courses in a Database System which maintains student’s registration information.

Assessment and registration takes too much time. During registration process students have to wait for the turn. Programme Manager un-availability can also create problems. If the student could not meet programme manager and mean while registrations period gets over, student may have to drop LP / Semester. BTH as an esteemed organization will definitely be interested to address the problem i.e Registration Process.

4.1.2. Proposed Solution

The problem domain identified and discussed above encouraged us to do this research. Our contribution is to analyze and map the problem area using CommonKADS Methodology (see appendix A). The system will facilitate students, teachers, administration and BTH. Our proposed solution is as under:

i. Online Course Registration Portal for BTH.
ii. Student Login Password to access the System (for BTH students only).
iii. The system will be a centralized system for all the departments / programs.
iv. Input to the system is data about a particular application: data about courses and students.
v. The system output would be a decision for students to confirm the assessed courses by the system.
vi. There can be introduced an knowledge based system which can help new coming students at BTH. The system will ask students about their interests, skills, expertise, future aims, and other details regarding their academics. The system will then recommend courses of their interest and suggest difficulty level of courses.
4.2. BTH Organization Analysis

4.2.1. OM-1: Problems, Solutions, and Context

In OM-1, we have identified and listed perceived problems during our analysis about Courses Registration Process at BTH. There are two main problems i.e. course registration process is a manual procedure at BTH and application assessment takes too much time. We find that these problems are inter related to each other. For instance solving first problem will also solve other problem automatically. We have also characterized organizational context based on these problems which clearly sets our mission to automate the Registration Process in terms of transparency of procedures by taking opinion of the actors i.e student, teacher and administration. Our strategy is to facilitate students, teachers and administration. A proposed solution “Online Courses Registration Portal” to the problem is also listed. In short, we can say OM-1 clearly specify about what should be done in order to solve the problem (see appendix A: table A.1).

4.2.2. New System’s Focus Area in BTH

In OM-2, we have mentioned area which new system will focus in organizational structure of BTH (figure 4.1). The steps which Registration Process involves are shown in figure 4.2. People who act and communicate with the system are programme manager, student, database administrator and system owner. Already existing resources at BTH related to registration process are student record, courses offered, courses description and rights of registered students. Knowledge associated to the process, people and resources is identified which is “Student Counseling” and “Assessment Criteria”. Student counseling assesses student interests and helps them to choose courses of their interest. Assessment Criteria uses knowledge for assessing student application for course registration, e.g. checking pre requisite, constraints/policies. Trends which BTH follows related to registration process are mentioned as culture and power i.e. limit of students in a course, limit of registered courses in a semester. The important feature of OM-2 is structure of the BTH is shown in a graphical way which gives instant understanding of the problem. People, resources and knowledge associated with the registration process clear the picture of the domain and problems solution. Appendix A: table A.2 lists all the features mentioned above of new system focused area.

4.2.2.1. BTH Department’s Structure

Our system at the moment targets only school of Engineering and departments under this school. The person involved in courses registration of all departments is programme manager. Various departments of BTH under school of Engineering are shown in the figure below which clearly specify the focus area of the new system:-

![Figure 4.1: Organization Structure](image-url)
4.2.2.2. Process

Figure 4.2 shows a brief graphical description of the Courses Registration Process. Student gives user name and password in order to enter the online registration portal. Then student select courses from the course list and this process is named as Application/Course List. As student finishes up the selection procedure, system assesses the selected courses for pre-requisites and constraints/policies. Student confirms the registration after assessment of the selected courses. Primary and secondary processes are shown in figure:-

a. Primary Process

```
Sign In/Out

Application/Course List

Registration

Confirmation

Application Assessment
```

b. Secondary Process

```
: Application/Course List

Student Counseling

Courses Selection/Alteration

Database of courses/student Record

: Application Assessment

Constraints/Policies

Checking Pre-requisite

Database of courses/student Record
```

Figure 4.2: Primary & Secondary Process
4.2.3. Main tasks in the Registration Process

We have discussed about the primary and secondary process involved in the Registration Process. Each process performs some tasks. Registration process is also composed of various important tasks. Each task performs special roles and provides services. There are three tasks listed, but only two of them are knowledge intensive, namely “Application/Course List” and “Application Assessment”. These tasks are performed by different actors and in their relevant department. The significance of each task is also indicated. Description of the process in terms of the tasks and their main characteristics is as under:

<table>
<thead>
<tr>
<th>No (identifier)</th>
<th>Task (Task name)</th>
<th>Performed by (agent)</th>
<th>Where? (location)</th>
<th>Knowledge asset</th>
<th>Knowledge Intensive?</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Application/ Course List</td>
<td>Student /System</td>
<td>Relevant Department</td>
<td>Student Counseling</td>
<td>Yes</td>
<td>5</td>
</tr>
<tr>
<td>2.</td>
<td>Application Assessment</td>
<td>Programme Manager</td>
<td>Relevant Department</td>
<td>Assessment Criteria</td>
<td>Yes</td>
<td>5</td>
</tr>
<tr>
<td>3.</td>
<td>Registration Confirmation</td>
<td>Programme Manager</td>
<td>Relevant Department</td>
<td>-</td>
<td>No</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 4.1: Worksheet OM-3 (Process break down into tasks)

4.2.4. Knowledge Assets in the Registration process

We already have mentioned that there are two main knowledge intensive tasks. These tasks possess two main knowledge assets named as “Student Counseling” and “Assessment Criteria”. Knowledge assets are used in their respective tasks. Knowledge assets involved should be of right form, at right place, in right time and of right quality. These are the bottlenecks which should have been considered while specifying knowledge. See appendix A: (table A.9. and A.10.) which shows how these bottlenecks for each knowledge assets are identified. Description of the Knowledge components with their major characteristics is given below:

<table>
<thead>
<tr>
<th>Organization Model</th>
<th>Knowledge Assets Worksheet OM-4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge Asset (see OM-3)</td>
<td>Possessed by Agent (see OM-3)</td>
</tr>
<tr>
<td>Student Counseling</td>
<td>System</td>
</tr>
<tr>
<td>Assessment Criteria</td>
<td>Programme Manager</td>
</tr>
</tbody>
</table>

Table 4.2: Worksheet OM-4 (Knowledge assets used in tasks)

4.2.5. Feasibility of Courses Registration Portal:

We have discussed and analyzed problems in the Registration Process at BTH. Analysis related to BTH structure, main registration process, actors, existing resources, tasks involved in the process, knowledge intensive tasks and knowledge assets present in knowledge intensive tasks is done methodically. Now, we describe feasibility of the online course registration portal for BTH which will be, according to us, a potential solution for the perceived problems. When we discuss business feasibility, cost is the major factor which comes into play. In business feasibility, we have mentioned various aspects like our new system will be a centralized system, time will be saved, remotely access and Risks. Our system will be technically feasible, because assessment of
the problem is studied in detail and judged to be a feasible portal in all aspect for the management, teachers, students and BTH prospective. It is therefore, project feasibility has reached. After doing project feasibility analysis we are now able to propose some actions and features related to the new system such as focus, target solution, results and benefit. Feasibility analysis is given in appendix A: table A.5.

4.3. Course Registration Task Analysis Model

As a result of doing organization analysis of registration process at BTH, we identified tasks for each process and knowledge assets related to these tasks. Task model focuses on two aspects of each task. The first is regarding analysis of each task and named as TM-1 and second is to take a closer look at the knowledge involved in each task and named as TM-2. We shall now give analysis related to tasks involved in courses registration which will help us in setting up clear direction and picture about our domain “Courses Registration Portal”.

4.3.1. TM-1: Task Analysis

We have identified two main knowledge intensive tasks in the registration process and one simple task in the organization analysis of courses registration process. Now, we shall give detailed analysis of each task which will help us in understanding of the various aspects involved in each task with the help of TM worksheets. TM-1 task description has specific goal to achieve and has certain values. It also has information about objects handled which is very much important for knowledge specification such as input, output and internal objects. Task model shows the dependency, flow and time control in the form of a diagram which completely explains the behavior of task. It also mentions what agents are involved in performing this task and knowledge asset involved in this task. It also gives details about resources involved and system availability information.

4.3.1.1. First Task Analysis: Application/Course List

Application/Course List task is responsible for selection/alteration of courses and student counseling for recommendation of courses. Student can also use self counseling facility by having access to course descriptor. Selected courses, course list, course description, and student counselor are object handled in this task. Agents involved in carrying out this task are students, system and database resources. Knowledge asset involved in this task is “student counseling”. Our focus is on quality of this task which should be 100%. Data and flow for this task in the course registration process domain is shown in figure 4.3 and 4.4. Task “Sign In/Out” is an input task and task “Application Assessment” is an output task. Refined description of the knowledge intensive task “Application / Course List” within the target process is given in appendix A: table A.6.

4.3.1.2. Second Task Analysis: Application Assessment

Application Assessment is a key task for online courses registration portal for BTH. It is really important that there should be transparency in the procedures of Courses Registration Process. It deals with the checking pre-requisites and constraints / policies of the courses. Selected courses as input object, validated courses as output object, constraints/policies and pre-requisite as internal objects are the objects handled in this task. Programme manager, existing database and system are the agents involved in this task. Knowledge asset involved in this task is named as “Assessment Criteria”. This task communicates with the existing database resources such as student record, courses offered and courses description. Application Assessment task will play a centralized role in proposed solution. It is therefore, quality of this task should be 100%. Data and flow for this task in the course registration process domain is shown in figure 4.3 and 4.4. Task
“Application/Course list” is an input task and task “Registration Confirmation” is an output task. Refined description of the knowledge intensive task “Application Assessment” within the target process is given in appendix A: table A.7.

4.3.1.3. Third Task Analysis: Registration Confirmation

Registration Confirmation is not a knowledge intensive task but has its own importance and significance. As a result of assessment of the courses done by the system, student confirms the registration of the courses, means student is sure about courses that he is going to study in the semester. Validated courses as input objects and Courses Registered as output object are the objects handled in this task. There are no internal objects for this task. Student and system are involved in this task execution as agents. As we have already mention that this task is not a knowledge intensive task, so there is no knowledge asset involved in this task. Data and flow for this task in the course registration process domain is shown in figure 4.3 and 4.4. Task “Application Assessment” is an input task and task “Sign Out” is an output task. Refined description of the knowledge intensive task “Application Assessment” within the target process is given in appendix A: table A.8.

4.3.1.4. Data Flow/Control Diagram and State Diagram

In task analysis we put light on the details of each task. Task analysis table gives both internal information and external information related to the task. Internal information is related to the dependency, flow and object handled by the task. External information is related to quality, service provided by the task, goal of the task, and constraints. Figure 4.3 describes the data flow and control in the courses registration process. Registration process is a simple process in which student gives user name and password to sign in the registration portal. Only students of BTH are authorized to have access of this portal. After signing in, students of different departments have access to the course list of respective departments. From this course list student may select courses for registration which belong to “Courses/Selection” task. Description of the courses can be viewed by following the link of course name in the course list. In this way students can self counsel themselves. If students want that system to counsel and recommend courses related to their field, interests and complexity of courses, there is another sub task related to course selection task named as “Student Counseling” has been mentioned which apply knowledge asset “Counseling Criteria”. It is an important task for the new students coming to BTH. They can fill a form related to their skills, field and course difficulty level and ask the system to counsel them about their interests. There is another important task named as “Application Course-list” in which system assesses selected courses for pre-requisites and constraints/policies. After assessment student confirms the registration. Figure 4.3 and 4.4 briefly shows the states of the registration process below:-

![State Diagram](image)

**Figure 4.3: State Diagram**
4.3.2. Knowledge Assets in the Tasks

We have discussed detailed analysis of the each task of registration process. Now, we take a closer look on the knowledge assets involved in each task in the form of nature of knowledge, form of knowledge and availability of knowledge. Knowledge has its own structure, meaning and information associated with it. There are two important knowledge assets named as “Student Counseling” and “Assessment Criteria”. Knowledge assets are used in their respective tasks.

4.3.2.1. First Knowledge Asset: Student Counseling

Student counseling is used as a knowledge asset in the task Application/Course List. We have characterized this knowledge base task in terms of its nature form and availability of the knowledge. The nature of the knowledge asset is formal, rigorous, experienced based, hard to verify, tacit and hard to transfer. The bottleneck which we identified it is hard to verify and uncertain. Specification of the knowledge asset for a task, and possible bottlenecks and areas for improvement are listed in appendix A: table A.9.

4.3.2.2. Second Knowledge Asset: Assessment Criteria

Assessment Criteria is used as a knowledge asset in the task Application/Course List. It acts a key knowledge asset for our proposed solution “online course registration portal”. The nature of this knowledge asset is formal, rigorous, quantitative, highly specialized, hard to verify and hard to
transfer. The only bottleneck which we identified is hard to verify. Specification of the knowledge employed for a task, and possible bottlenecks and areas for improvement are listed in appendix A: table A.10.

4.4. Agents /Actors Involved in Registration Process Analysis

In agent model, we have analyzed Courses Registration Process by keeping focus on the actors associated with the new proposed solution. There is no new information is given here, instead we are looking the system as perspective of the agents involved.

4.4.1. Agent: System

They are three agents involved i.e. system, students and programme manager in the Registration Process. Different actors communicate with existing database and each other. For instance student communicates with the system. He selects courses, sees description of the courses, can use counseling function which recommends courses related to student’s interest and is involved in almost every process of registering the courses.

On the other hand, system communicates with the resources such as existing information systems and databases which maintain student record and knowledge data involved in the Registration Process. Further registration portal provides different services to the user such as counseling for selecting courses, assessment of the selected courses and confirmation of the courses.

Due to presence of online course registration portal, Programme Manager role will most probably reduce. Programme Manager has full access to the Registration Portal. He verifies course transcripts of the international students or exchange students about which BTH do not have courses record of previous study of these students. In the courses registration portal, it will be a constraint for every student to attach their previous academic transcript. New system plays an efficient role in the registration process. Therefore, we discuss System specification according to the CommonKADS agent model is given in appendix A: table A.11.

4.5. Organization, Task and Agent Combined Analysis

We have done detailed analysis in terms of BTH organizational perspective on which our study domain mainly focuses. We have identified actual tasks, knowledge intensive tasks and knowledge assets related to these tasks involved in the actual Courses Registration Process. Our main agent is our Knowledge based System in online courses registration portal. Now, we will summarize all the detailed description about organization, task and agent analysis in work sheet OTA-1.

4.5.1. Summary of Organizational Changes, Improvement, and Actions

In OTA-1, we give the summary of the changes, improvements and actions to be taken place in the Registration Process at BTH. New system will affect over all performance of the Registration Process in a remarkable way. It will be not wrong to mention here that OTA-1 gives final feasibility analysis of our new system for courses registration. Impacts and changes regarding BTH course registration process are very much significant. Students, teachers, administration will be facilitated with remote access of the system which will save time. Student will register courses online and programme manager duty will be eased by new registration system. Impacts and changes in aspect of an agent are also mentioned in OTA-1. A centralized system will be recommended which will do student counseling and application assessment. In OTA-1, we have mentioned commitments that should be given significance such as transparency of procedures and bringing effective change within organization. In order to bring effective change within the
organization we should have focused on successive interviewing with the students and administration. Also we have proposed that system should be flexible enough to adapt to these changes. Various changes, impacts, improvements, commitments, proposed actions in organization and task-agent perspectives are given in appendix A: table A.12.

4.6. Risk Analysis by CommonKADS Cycles Model

We, now focus on the factors which can influence on our proposed system. Risk analysis has its significance according to project planning and project management aspects. Risk analysis provides quality assurance in project planning and analysis. Risk analysis through CommonKADS cycle model provides stability to the system. It consists of four phases i.e. review, risk, plan and monitor. Review phase lists the scenarios leading to the risk phase. Plan phase makes assumptions from Risk analysis. Monitor closely observes assumptions made in the planning phase. We have identified three main risks in “online courses registration portal” which are as follows:-

i. Domain Expert i-e programme manager might not available to provide information about the problem domain.

ii. The organization may not be interested to implement such kind of system.

iii. Who will pay for the system which will have been developed?

iv. Programme Manager might think this system as a threat to his job and would not help him to perform his tasks.

These risks are monitored closely through the CommonKADS cycles in appendix A: tables A.13, A.14 and A.15.

4.7. Risk Assessment in Terms of Project Management

After careful assessment of risks we can make counter measures for eliminating these risks. Major risks are finding sponsorship for project and threat to Programme manager job. For risk of finding sponsorship for the project, we have proposed that system should be made flexible enough so that it can be used in any universities for registration process. For risk of threat to programme manager job, we have proposed to meet with programme manager and ensure him that this would ease his work. Another risk is unavailability of programme manager. If this situation is created, then there is a possibility of time lapse of registration period. Many students might have to drop their study period or semester which will definitely be an issue. This risk will be removed by our existing new system. Likelihood of occurrence for each risk is mentioned. Likelihood of first three risks mentioned in section 4.6 is high and for fourth risk likelihood is low. Severity of effect on project of each risk is also mentioned. Severity of effect of first three risks mentioned in section 4.6 is high and for fourth risk severity of effect is low. Appendix A: table A.16 lists all the factors effecting current registration system and can have effect on our proposed system.
4.8. Knowledge Analysis of Courses Registration Portal

4.8.1. Knowledge Identification

4.8.1.1. Domain Formalization

We had many meetings and discussion sessions with the staff associated with registration process to know about different aspects of Courses Registration Process. Staff responded to our queries sincerely and provided us with detailed information about present procedures involved in student’s courses registration (see appendix B). Overview about the course registration process is given below:-

Courses Registration Process at BTH includes selection, alteration and checking of pre-requisite / constraints / policies of the courses. These selection, alteration and checking of pre-requisite / constraints / policies of the courses are manual procedures. First, student has to select courses on a paper application form which contains personal information and a course list. Then student meet the programme manager with signed application form and transcripts. The programme manager has responsibility to check the pre-requisites, constraints, policies of the selected courses. Programme manager checks that student fulfills the assessment criteria and registers courses in a Database System which maintains student’s registration information. We also, had many discussion sessions with our fellow students at BTH. Demands from all the actors including students, teachers, staff and management are more. Actors gave us suggestions to improve the registration system. They emphasized of definite need of an online web based courses registration portal at BTH. The feed back and appreciation given by actors encouraged us to great extent. States involved in the registration process are shown in the figure 4.5 below:-

![Diagram of Registration Process]

**Figure 4.5:** States involved in Registration Process
4.8.1.2. List of Potential Components

There are many potential aspects regarding registration process at BTH which are our main sources of information. These sources act as useful resources for our proposed system “Online Course Registration Portal at BTH”. Some potential components related to registration process are listed below:

i. Existing database for the students and registration is the key resource for our proposed system. This also simplifies the realization of the connection between knowledge tasks “Application Assessment” with the existing student and registration database.

ii. Another key resource for our proposed system is an existing database related to the courses and courses description. This will help in realization of the connection between the knowledge tasks “Student counseling” with the courses database.

4.8.2. Knowledge Specification

4.8.2.1. Domain Schema

Students and Courses: In the domain “Courses Registration Process”, we find two central objects namely student and course. The relation between these central objects acts as base for domain specification in terms of standard data-modeling techniques. Both can be specified through a concept or class with a collection of attributes. The value types of these attributes can be pre-defined. But value types of these attributes can also be user-defined. This is illustrated in the figure. 4.6. The figure shows two central domain concepts with their attributes. The relation “Select Course” between two central domain concepts i.e “student” and “course” is also shown. The relation also has an attribute named “selected-course”.

![Diagram](image-url)

Figure 4.6: Domain Schema
4.8.2.2. Domain Schema Representation

We give specification of central objects i.e “student” and “course” in terms of concept representing their attributes in the domain schema. Binary relation “select-course” between concepts “student” and “course” is also given which has an attribute. One student may select up to six courses per semester which is represented in the form of “Cardinality” for student and course. Figure 4.7 represents the domain schema below:-

CONCEPT student;
DESCRIPTION:
“Students of BTH who register courses for studies”;
ATTRIBUTES:
user-name: STRING;
password: STRING;
END CONCEPT student;

CONCEPT course;
DESCRIPTION:
“Courses offered at BTH for different programs departments”;
ATTRIBUTES:
course-code: STRING;
course-name: STRING;
responsible: STRING;
course-description: STRING;
pre-requisite: STRING;
field: STRING;
complexity: STRING;
interest-keywords: STRING;
END CONCEPT course;

BINARY-RELATION select-course;
DESCRIPTION:
“Student select course for registration”; 
ARGUMENT-1: student;
CARDINALITY: 1
ARGUMENT-2: course;
CARDINALITY: 0-6
ATTRIBUTES:
selected-course: string;
END BINARY-RELATION select-course;

Figure 4.7: Specification of domain objects in terms of concepts with their attributes and relation between them. Relation represents description, arguments and attribute.

4.8.2.3. Domain Knowledge Specification

In our detailed organizational analysis about courses registration process at BTH, we firstly defined actual Courses Registration Process. After defining registration process, we identified tasks which registration process involves. There we mentioned three tasks in analyzing registration process (see table 4.3). Out of these three tasks, we have given knowledge specification for the two main tasks. These main tasks are listed below:-

i. Application/Course List
ii. Application Assessment
There are two parts of specification of each task. First part comprises of “task definition” and other part comprises of “task method”. We have given task specification for each task which is involved in registration process separately with its task definition and method. Task definition specifies domain name, task goal and input / output task roles. Whereas specification of task method gives task name from which it is realized. Task method also lists further tasks and inferences to which it is decomposed. Task method further represents intermediate roles and control structures. Now, we shall step forward in order to give specification of each task in terms of task definition and method.

4.8.2.3.1. Task Application/Course List

As we can see in figure 4.8 “application-courselist” on top level. This main task is further divided into one functional task “select-drop” and one knowledge intensive task namely “student-counseling” (see table 4.3). Each task performs specific role which is done through task method. Task methods are further decomposed at lowest level to inferences. Figure 4.8 gives the graphical representation of this task below:-

![Figure 4.8: Task and task methods in the Application/Course List domain. The task methods are decomposed into inferences at the lowest level.](image)

Now we, discuss the specification of application-courselist task in terms of task definition and task method.

**Task definition** specifies main goal of application-courselist which is to select/alter courses. Another goal which task definition specifies is to provide student counseling. An optional domain name select-alter-course-counseling is assigned to it. Input and output roles are listed in task definition. There is no input specified to this task because in this task student has access to a list of courses from which he has to select courses. The output of this task is the selected courses which student selects from the course list.
**Task method** application-courselist-method realizes from task application-courselist. It is decomposed into two sub tasks. One of which is functional task namely “select-drop” and other task is knowledge intensive namely “student-counseling”. We shall focus on the control structure description in specification task method. Logic for application-courselist task is simple as this task is used for selection of courses from course list until student finishes selecting courses. If student want to take advice of system to help him in selection of courses, student may call student counseling module. Specification of application-courselist task is given in figure 4.9 below:-

**TASK application-courselist;**  
**DOMAIN NAME:** select-alter-course-counseling;  
**GOAL:**  
“Selection or alteration of the courses, Student Counseling”;  
**ROLES:**  
**INPUT:**  
none: “there is no input to this task”;
**OUTPUT:**  
selected-courses: “Selected courses from the course list”;  
**END TASK application-courselist;**

**TASK METHOD application-courselist-method;**  
**REALIZES:** application-courselist;  
**DECOMPOSITION:**  
**TASKS:** select-drop, student-counseling;  
**INFERENCE:** Finish, field, complexity, interest, common, select, drop;  
**ROLES:**  
**INTERMEDIATE:**  
courses-list: “list of the courses offered in a semester”;  
result-counseling: “list of recommended courses by the system to choose in a semester”;  
click-button-counseling:
**CONTROL STRUCTURE:**  
IF click-button-counseling = = TRUE THEN  
student-counseling (result-counseling);
ELSE IF click-button-selection = = TRUE THEN  
DO  
select-drop (course-list -> selected-courses);
WHILE  
finish (selected-courses);  
END DO WHILE
END IF  
**END TASK METHOD application-courselist-method;**

**Figure 4.9:** Specification of task “application-courselist. Task is divided in to two sub tasks namely “select-drop” and knowledge intensive task “student-counseling”.

4.8.2.3.1.1. Sub Task Select-Drop

**Task definition** specified goal is selection and alteration of courses and optional domain name select-alter-course is assigned to it. Input to this task is “course-list” in which students select courses from a course list and output to this task is “selected-courses”.

**Task method** select-drop-method realizes from task select-drop. It is decomposed into three inferences finish, select, drop. Logic specification in control structure of task select-drop is simple as it selects courses from course list and places them in selected courses list until finishes selecting course. If student wants to drop a course from selected course list, select-drop method removes course from the selected course list and updates it until finish updating and gives outcome selected courses. Specification of select-drop task is given in figure 4.10 below:-
Figure 4.10: Specification of task “select-drop. Task role is to select courses into selected course list and to drop courses from selected course list and updates it.

4.8.2.3.1.2. Sub Knowledge Intensive Task Student-Counseling:

Task definition: specified goal is student counseling and optional domain name student-counseling-course is assigned to it. A question arises in one’s mind that how system will provide student counseling for the selection of courses. For the solution we have proposed that system will take some information from students such as their study programme, interests and complexity of courses in an electronic form and will search for the best suitable courses from the course list as desired by student. Various inputs are given to this task by student namely “choose-field”, “interest” and “complexity courses” and output to this task is “recommended-courses” by the system.

Task method: student-counseling-method realizes from task student-counseling. It involves inferences named as field, complexity, interest, common and finish. Now we shall discuss about the control structure specification for this task. Logic for this task is simple and knowledge based. Control structure first maintains a list of courses “list-field-courses” related to student’s field. Then control structure maintains a list of courses “list-complexity-courses” related to course’s complexity which are selected from list-field-courses. Also control structure maintains a list of
courses “list-interest-courses” related to student’s interest which are also selected from list-field-courses. From the lists “list-field-courses” and “list-complexity-courses”, control structure select common course between these two lists and maintain another list named as “common-list”. In counseling criteria if we get six courses or more than six courses in “common-list”, then system recommends only first six courses to student in list of “recommended-courses” because there is a limit of choosing maximum six courses in a semester and job is finished here. Still if “common-list” has less number of courses than limit of courses per semester, then system selects remaining courses from “list-complexity-courses” and adds up with “common-list” courses to the list of “recommended-courses” and recommends them. Specification of student-counseling task is given in figure 4.11 below:-

**TASK student-counseling;**

**DOMAIN NAME:** student-counseling-courses;

**GOAL:** “Counseling students for the selection of courses in aspect of their interest, skills and field”;

**ROLES:**

**INPUT:**
- choose-field: “student choose a field of his own choice”;
- complexity-courses: “Easy, hard, medium”;
- interest-keywords: “Student enter interest in the form keywords”;

**OUTPUT:**
- recommended-courses: “System recommends courses to select”;

**END TASK student-counseling;**

**TASK METHOD student-counseling-method;**

**REALIZES:** student-counseling;

**DECOMPOSITION:**

**INFERERENCE:** field, complexity, interest, common, finish;

**ROLES:**

**INTERMEDIATE:**
- recommended-courses-counter: “counter for recommended courses initially zero”;
- max-courses-limit-semester: “maximum number of courses per semester which a student can select”;
- list-complexity-courses: “maintain a list of courses from list-field-courses regarding user given complexity”;
- list-interest-courses: “maintain a list of courses from list-field-courses regarding user given interest”;
- common-list: “list common courses from list-complexity-courses + list-interest-courses”;
- select-required-courses: “select courses from common list according to maximum course limit per semester”;
- select-remaining-courses-from-list-complexity-courses: “Add courses to recommended courses list until it equals to maximum No. of courses per semester limit”;
- add-to-recommended-courses: “Add courses to list of recommended courses”;

**CONTROL STRUCTURE:**
- field (choose-field -> list-field-courses);
- complexity (complexity-courses -> list-complexity-courses);
- interest (interest-keywords -> list-interest-courses);
- common (common-list)

**COUNSELING CRITERIA:**

**IF** (No.-of-common-list-courses \( \geq \) max-courses-limit-semester) **THEN**
- add-to-recommended-courses : = select-required-courses;
- finish (add-to-recommended-courses -> recommended-courses);

**ENDIF**
IF (add-to-recommended-courses ≠ select-required-courses) THEN
    add-to-recommended-courses := select-remaining-courses-from-list-complexity-courses;
    finish (add-to-recommended-courses -> recommended-courses);
END IF
END TASK METHOD student-counseling -method;

Figure 4.11: Specification of task “student-counseling. Task role is to recommend students courses regarding input given in the form field, complexity and interest given.

4.8.2.3.2. Task Application Assessment: In figure 4.12 “application-assessment” is on top level. This task involves knowledge asset named as “Assessment Criteria” (see table 4.3). Assessment Criteria involves two knowledge intensive tasks namely “check-prerequisite” and “constraints-policies”. Each task performs specific role which is done through task method. Task methods are further decomposed at lowest level to inferences. Figure 4.12 gives the graphical representation of this task below:

Figure 4.12: Task and task methods in the Application Assessment domain. The task methods are decomposed into inferences at the lowest level.

We shall now discuss the specification of application-assessment task in terms of task definition and task method.

Task definition: specifies main goal of application-assessment which is to do assessment of pre-requisite, constraints/policies and transparency of procedures”. An optional domain name
assessment-course-registration-application is assigned to it. Input and output roles are listed in task definition. Input to this task is selected-courses which student selects from the course list. These courses are then assessed by the system with the help of application-assessment task. The output of this task is the validated courses after assessment.

**Task method:** application-assessment- method realizes from task application-assessment. It is decomposed into two knowledge intensive sub tasks namely “check-prerequisite” and “constraints-policies”. Now, we shall discuss control structure specification. Control structure first checks selected courses for constraints/policies. Then it verifies pre-requisites of selected courses from the student record. In control structure specification task constraints-policies is called before the task check-prerequisite because selected courses may change due to application of any constraint. This helps in improving system performance. Result of both the tasks should be OKAY in order to get validated courses and moving to confirmation task. Specification of application-assessment task is given in figure 4.13 below:-

**TASK application-assessment;**

**DOMAIN NAME:** assessment-course-registration-application;

**GOAL:**

“Assessment of pre-requisite, constraints and policies, transparency of procedures”;

**ROLES:**

**INPUT:**

selected-courses: “Data about selected courses”;

**OUTPUT:**

validated-courses: “Decision about selected courses”;

**END TASK application-assessment;**

**TASK METHOD application-assessment-method;**

**REALIZES:** application-assessment;

**DECOMPOSITION:**

TASKS: constraints-policies, check-prerequisite;

**INFERENCe:** decision;

**ROLES:**

**INTERMEDIATE:**

result-prerequisite: “okay / not okay”;  
result-constraints-policies: “okay / not okay”;  
evaluation-result: “Result of the assessment of pre-requisite, constraints and policies”;

**CONTROL STRUCTURE:**

**DO**

constraints-policies (selected-courses -> result-constraints-policies);  
check-prerequisite (selected-courses -> result-prerequisite);

**IF** result-constraints-policies AND result-prerequisite = = OKAY **THEN**

evaluation-result : = OKAY;

**END IF**

**WHILE**

decision (evaluation-result -> validated-courses);

**END DO WHILE**

**END TASK METHOD application-assessment-method;**

**Figure 4.13:** Specification of task “application-assessment. Task role is to do assessment of courses selected in terms of pre-requisites and constraints/policies.

**4.8.2.3.2.1. Sub Task Constraints-Policies:**

**Task definition:** specified goal is to check constraints-policies of selected courses and optional domain name “check-constraints-policies” is assigned to it. Selected courses are given as input to
this task for verification of any constraints / policies. Output to this task is “result-constraint-policies” which gives result of constraints / policies checking. (See figure 4.1)

**TASK constraints-policies;**
- **DOMAIN NAME:** check-constraints-policies;
- **GOAL:**
  “Checks whether selected courses meet the constraints and policies requirements”;
- **ROLES:**
  - **INPUT:**
    selected-courses: “Data about selected courses”;
  - **OUTPUT:**
    result-constraints-policies: “okay”;

**END TASK constraints-policies;**

**TASK METHOD constraints-policies-method;**
- **REALIZES:** constraints-policies;
- **DECOMPOSITION:**
  - **INFORMATION:** decision, verify-max, verify-mandatory, constraint-message;
- **ROLES:**
  - **INTERMEDIATE:**
    verify-max-courses: “Limit of selecting maximum No. courses per semester is verified”;
    verify-mandatory-courses: “Verifies whether student has selected mandatory course or not. If system does not selects mandatory courses, then system matches whether student has “stared” mandatory courses in student Ladok transcripts. If student have “stared” mandatory courses in their record, then system moves forward otherwise show a constraint message to select that mandatory course”;
    result-verify-max-courses: “Yes or No”;
    result-verify-mandatory-courses: “Yes or No”;
    result-verify-attached-student-previous-study-transcript: “Yes or No”;
    message: “Message relevant to the constraint”;

**CONTROL STRUCTURE:**

DO
  verify-mandatory (selected-courses -> verify-mandatory-courses);
  verify-max (selected-courses -> verify-max-courses);
  verify-attached-student-previous-study-transcript (result-verify-attached-student-previous-study-transcript);
  IF result-verify-max-courses OR result-verify-mandatory-courses OR result-verify-attached-student-previous-study-transcript = = NO THEN
    constraint-message (message);
  ELSE
    result-constraint-policies := OKAY;
  END IF
END DO WHILE

**END TASK METHOD constraints-policies-method;**

**Figure 4.14:** Specification of task “constraints-policies”. Task role is to verify various constraints and policies regarding courses registration Process.

**Task method:** constraint-policies-method realizes from task constraint-policies. It is decomposed into four inferences decision, verify-max, verify-mandatory, and constraint-message. Control structure specification for the task check-constraints-policies verifies for three major constraints which we have considered for Courses Registration Portal. First selected courses are verified for mandatory courses. If student selects mandatory courses, then verification result of mandatory
courses is YES. But if student does not select any mandatory course in a semester, then system checks whether mandatory courses are present in BTH student’s portal. If mandatory courses are present in student’s portal, then result of mandatory courses verification for selected courses is YES, otherwise a constraint message appears on the screen (please select mandatory courses). Secondly selected courses are verified for maximum number of courses per semester. If a student selects more than three courses per LP (study period), a constraint message appears on the screen (please do not select more than three courses per LP). Else result for checking maximum number of selected courses is YES. In last, system verifies a constraint that student must attach their previous study transcripts. If student has already attached previous study transcript, then attached transcript verification is YES, otherwise a constraint message appears on the screen (please attach your previous study transcript). After verification result of all the constraints is OKAY, control structure stops checking for constraints and policies. There can be verified more constraints and new policies in this check-constraints-policies task. In this way be flexible enough to adapt to new policies and constraints. We therefore, have achieved another mission by making system flexible (see table 4.1). Specification of check-constraints-policies task is given in figure 4.13.

4.8.2.3.2.2. Sub Task Check-Prerequisite

**Task definition** specified goal is to check pre-requisite of selected courses in the student record and optional domain name “check-course-prerequisite” is assigned to it. Selected courses are given as input to this task for the assessment of pre-requisite. Output to this task is “result-prerequisite” which gives result of pre-requisite checking.

**Task method** check-prerequisite-method realizes from task check-prerequisite. It is decomposed into three inferences namely decision, match and send-email-message. Control structure specification for the task check-prerequisite checks whether selected courses have some pre-requisite courses. If selected courses have some pre-requisite courses, then these courses are matched with BTH official courses transcript which are marked as star (stared courses are those courses which have been passed). As there are coming number of international and exchange students study at BTH beside local students. It is therefore, impossible for making database regarding previous studies record of every student. If match result is OKAY, it means selected courses meet the pre-requisite requirement meaning that student’s BTH transcript has pre-requisite courses. Instead if match result is not OKAY meaning that student’s BTH transcript do not has pre-requisite courses. But it is a possibility that international students may have studied the pre-requisite courses in their previous studies. By keeping in mind this probability, system will mark the pre-requisite result OKAY, but at the same time will send an email message with an attachment of student previous study transcript to the Programme Manager. Programme manager then checks pre-requisite by verifying from student’s previous study transcripts and after verification programme manager registers them in Student Portal. Also another email notification (“pre-requisite courses do not match with passed or stared courses in BTH official transcript) is send to student which lists those selected courses which do not meet pre-requisite requirement. In this way, we have solved our main problem of checking pre-requisites of selected courses which is a manual procedure at BTH (see table 4.1). Our mission to bring transparency of procedures will be also met by this task (also see table 4.1). By this email notification service students will hesitate to select courses for which they are sure do not meet pre-requisite requirement. But still if someone gives wrong information, it will be verified. It is, therefore, this system will definitely provide transparency in procedures. Specification of check-prerequisite task is given in figure 4.15.
**TASK check-prerequisite;**

**DOMAIN NAME:** check-course-prerequisite;

**GOAL:**
“Checks whether selected courses has prerequisites and then match them with student transcripts”; 

**ROLES:**

**INPUT:**
selected-courses: “Data about selected courses”;

**OUTPUT:**
result-prerequisite: “okay”;

END TASK check-prerequisite;

**TASK METHOD check-prerequisite-method;**

**REALIZES:** check-prerequisite;

**DECOMPOSITION:**

**INFORMATION:** decision, match, send-email-message;

**ROLES:**

**INTERMEDIATE:**
match-transcript: “Selected courses have prerequisite, then prerequisite courses are matched with student transcripts”; 
prerequisite-courses: “Prerequisites of selected courses”
course-has-prerequisite: “Yes or No”; 
email-message: “A message generated by the system to both programme manager of relevant department and students.”;

**CONTRO$\$L STRUCTURE:**
IF course-has-prerequisite = = Yes THEN 
REPEAT 
match (prerequisite-courses -> matched-transcript);
UNTIL 
decision (result-prerequisite);
IF result-prerequisite = = NOT OKAY THEN 
result-prerequisite : = OKAY;
decision (result-prerequisite);
send-email-message (email-message );
END IF 
ELSE course-has-prerequisite = = No THEN 
result-prerequisite : = OKAY;
decision (result-prerequisite);
END IF 

END TASK METHOD check-prerequisite-method;

**Figure 4.15:** Specification of task “check-prerequisite”. Task role is to match pre-requisite of selected courses with student’s transcript.

**4.9. Communication Analysis between Agents**

We have already identified, analyzed and discussed in detail about the agents involved in the Courses Registration Domain. In the domain, we find two central agents namely “student” and “Knowledge Based System (i.e. Online Course Registration Portal)”. These agents communicate during all states involved in registration process of the courses.

We have specified two main knowledge assets named as “Student Counseling” and “Assessment Criteria” which we identified from registration process. We shall only analyze communication between agents involved in main knowledge intensive tasks (see table 4.4). Communication analysis between agents is quiet simple for this application.
4.9.1. Communication Aspects in Application Assessment

In figure 4.16, main states involved in this task are shown. Student selects courses from the given course list and orders assessment. Meanwhile system waits for selected courses to be received. As system received selected courses, transaction ORDER ASSESSMENT becomes activated. Knowledge system applies assessment criteria on the selected courses and communicates with the student in terms of messages appearing on the screen. Student responds to these queries. Knowledge system also obtains and compares information with database. As assessment transaction is carried out completely, decision assessment is reported out.

**Figure 4.16**: State diagram showing communication plan for assessment task

In transaction ORDER ASSESSMENT, Knowledge system verifies whether selected courses meet required assessment criteria for pre-requisite checking of courses and other constraints / policies. Three transactions are overall represented in figure 4.16.

i. Order Assessment
ii. Obtain DATA
iii. Report Decision

The detailed description of these transactions can be analyzed through CommonKADS worksheet CM-1. These transactions are listed in table 4.3 and 4.4 below:

<table>
<thead>
<tr>
<th>Communication Model</th>
<th>Transaction Description Worksheet CM-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRANSACTION</td>
<td>ORDER ASSESSMENT</td>
</tr>
<tr>
<td>INFORMATION OBJECT</td>
<td>Selected Courses</td>
</tr>
<tr>
<td>AGENTS INVOLVED</td>
<td>Student + knowledge system</td>
</tr>
<tr>
<td>COMMUNICATION PLAN</td>
<td>See figure 4.15 (transaction becomes active as ordered assessment)</td>
</tr>
<tr>
<td>CONSTRAINTS</td>
<td>Student must give some input to activate this transaction.</td>
</tr>
<tr>
<td>INFORMATION EXCHANGE SPECIFICATION</td>
<td>This transaction is of ORDER type.</td>
</tr>
</tbody>
</table>

**Table 4.3**: Work sheet CM-1(Transaction Order)
**Table 4.4: Work sheet CM-1(Transaction Obtain)**

<table>
<thead>
<tr>
<th>Communication Model</th>
<th>Transaction Description Worksheet CM-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRANSACTION</td>
<td>OBTAIN DATA (selected courses)</td>
</tr>
<tr>
<td>INFORMATION OBJECT</td>
<td>Selected courses, Student database, course list</td>
</tr>
<tr>
<td>AGENTS INVOLVED</td>
<td>Knowledge System + database</td>
</tr>
<tr>
<td>COMMUNICATION PLAN</td>
<td>See figure 4.15</td>
</tr>
<tr>
<td>CONSTRAINTS</td>
<td>Transparency of procedures, constraint messages</td>
</tr>
<tr>
<td>INFORMATION EXCHANGE</td>
<td>This transaction is of ASK – REPLY type.</td>
</tr>
<tr>
<td>SPECIFICATION</td>
<td></td>
</tr>
</tbody>
</table>

### 4.9.2. Communication Aspects in Student Counseling

If student wants to do counseling related to selection of courses, therefore he has to give inputs which best suits him according to his interests, field and complexity level of courses and orders counseling. Figure 4.17 shows main states involved in this task below:-

![Diagram](image-url)

**Figure 4.17: State diagram showing communication plan for counseling task**

As system receives various inputs from the user and order counseling, transaction ORDER COUNSELING becomes activated. Knowledge system obtains given inputs from student and applies knowledge counseling criteria for given inputs. At the same time system communicates with the database in order to obtain and match information. In last transaction state, knowledge system reports counseling’s results in the form of recommended courses.

In transaction ORDER COUNSELING, knowledge system task is to give appropriate results related to various interests of the students. Communication plan for this transaction is very much similar to transaction ORDER ASSESSMENT and represents overall three transactions involved in student counseling in figure 4.17.

i. Order Assessment
ii. Obtain DATA
iii. Report Decision
The detailed description of these transactions can be analyzed through CommonKADS worksheet CM-1. These transactions are listed in table 4.5 and 4.6 below:-

<table>
<thead>
<tr>
<th>Communication Model</th>
<th>Transaction Description Worksheet CM-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRANSACTION</td>
<td>ORDER COUNSELING</td>
</tr>
<tr>
<td>INFORMATION OBJECT</td>
<td>Inputs Given</td>
</tr>
<tr>
<td>AGENTS INVOLVED</td>
<td>Student + knowledge system</td>
</tr>
<tr>
<td>COMMUNICATION PLAN</td>
<td>See figure 4.16 (transaction becomes active as ordered counseling)</td>
</tr>
<tr>
<td>CONSTRAINTS</td>
<td>Constraint messages.</td>
</tr>
<tr>
<td>INFORMATION EXCHANGE</td>
<td>This transaction is of ORDER type.</td>
</tr>
<tr>
<td>SPECIFICATION</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.5: Work sheet CM-1(Transaction Order)

<table>
<thead>
<tr>
<th>Communication Model</th>
<th>Transaction Description Worksheet CM-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRANSACTION</td>
<td>OBTAIN DATA (Inputs Given)</td>
</tr>
<tr>
<td>INFORMATION OBJECT</td>
<td>Input Given, Recommended courses</td>
</tr>
<tr>
<td>AGENTS INVOLVED</td>
<td>Knowledge System + database, student</td>
</tr>
<tr>
<td>COMMUNICATION PLAN</td>
<td>See figure 4.15</td>
</tr>
<tr>
<td>CONSTRAINTS</td>
<td>System should recommend some courses to student.</td>
</tr>
<tr>
<td>INFORMATION EXCHANGE</td>
<td>This transaction is of ASK – REPLY type.</td>
</tr>
<tr>
<td>SPECIFICATION</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.6: Work sheet CM-1(Transaction Obtain)

Communications in form of data, information and knowledge is spreaded all over the Internet and World Wide Web. Various businesses are based upon internet and online applications. Million of users and organization are involved in data, information and knowledge exchange over the internet. [5] We have discussed and mapped communication aspects between agents in our case study. It is therefore, we suggest ERP applications can be developed by keeping in mind communication aspects among agents, as user play a vital role in using, interacting and communicating with software. We also suggest that service oriented approach should also be considered in this communication level. Although we have previously suggested that “SOA entry points [14]” should be considered in each step of planning and analysis of ERP applications during its development by using KE commonKADS model. But we suggest that at communication level, SOA must be given even more preference. At this level communication aspects between agents and knowledge services can be used to produce efficient knowledge based ERP application. In next chapter, we will give analysis related to our research work, conclusions drawn from our research work and future work.
CHAPTER 5: CONCLUSION AND FUTURE WORK

This chapter provides conclusion to our research done in thesis work. Also this chapter presents future work which can be done to implement our case study “Online Course Registration Portal for BTH”.

5.1. Research Work Analysis

In this thesis, we have researched that how can knowledge Engineering CommonKADS methodology be more specific in planning and analysis of ERP application during their development, which is our research question as well. We have done detailed literature study and given an overview about ERP applications, Knowledge Engineering and commonKADS methodology. Also to further support our research question we have considered a real life case study “Online course Registration Portal for BTH” which is our main contribution towards this thesis.

We have discussed those parts of knowledge in giving overview about ERP systems, Knowledge Engineering and CommonKADS methodology which are related to our research question and domain. We have analyzed that ERP applications automate parts of almost every business process. We have mentioned that business process is to provide various services to clients, employees and administration, in order to handle workflow in the organization efficiently. We have suggested that ERP systems should be developed by applying service oriented approach to produce efficient ERP systems. We have mentioned that ERP application are directly associated with service oriented approach due to involvement of users in business process.

We find knowledge engineering is very important to extract, analyze, structuralize and operationalize knowledge present in business process of any organization. It is therefore, we suggest that by applying knowledge engineering CommonKADS methodology in planning and analysis of ERP applications during their development can help to reach efficient knowledge based ERP system. We have proposed operational knowledge present in ERP applications which are related to specific business process in any organization can be divided into different knowledge services.

Based upon these literature studies and suggestions, we have given a case study “Online Course Registration Portal at BTH” to future support of our research.

In our case study, we have done planning and analysis about our domain “Courses Registration” by using commonKADS methodology. Our mission was to do case analysis, finding out actual problem and domain, defining process related to domain, identifying mains tasks and subtask involved in domain process, identifying knowledge intensive tasks, knowledge assets involved in these tasks, specifying knowledge and giving knowledge bases solution to real problem by using CommonKADS methodology. We have shown parts of the organization, task, agent, knowledge and communication model for this application domain.

- CommonKADS organization model helped us in identifying main problems i.e Selection, alteration and checking of pre-requisite / constraint / policies of the courses are manual procedures at BTH related to domain “Courses Registration” and time taking. A solution is proposed to automate the registration system. Graphical representation of process involved in domain is given. Main tasks are identified named as Application / Course list” and “Application Assessment”. Two knowledge assets i.e “student counseling” and “Assessment Criteria” related to these tasks are identified. Feasibility about the project is determined.
- CommonKADS task model has given detailed analysis of each task in terms of task goal/value, input/output tasks, objects handled, data flow diagrams, knowledge assets and resources involved. Similarly agent model has given detailed analysis of main agent involved registration process.
- Risk Assessment is done in order to remove risks in planning and designing phases by using commonKADS life cycle model which improves quality of the software.
- As commonKADS models provide detailed analysis of any organization. Any model of commonKADS can be utilized for further development of software of that particular organization. These models are reusable. It is there for commonKADS not only minimize work load of software developers but also save time and resources of the organization.
- Knowledge model gives each knowledge intensive task specification in detail and flow diagrams. In the domain “Course Registration” we have introduced knowledge based task “student counseling” which takes information from user like field, interests and complexity of courses. After student order for counseling, system recommends some courses to students. We have also introduced a service like system generates messages automatically to both students and programme manager in their email accounts, if required. It is therefore, planning and analysis through commonKADS methodology helped us to introduce these new features which are not often found in related works about “Course Registration Domain.” Common features in related works regarding course registration domain are selection/alteration of courses and checking pre-requisites and constraints/policies. CommonKADS also helped us in defining these features efficiently.
- CommonKADS communication model gives us communication analysis between different agents involved in course registration domain.
- Application of CommonKADS methodology for planning and analysis of knowledge Intensive Enterprise Resource Planning systems.
- This thesis provides an idea how ERP systems can be knowledge intensive.

5.1.1. Case Study Analysis

In our case study “Courses Registration Portal at BTH”, we have proposed, specified and given solutions for online courses registration process at BTH related to current difficulties and scenarios associated with this domain. These solutions are analyzed below:

- Only authorized students can access system for security reasons.
- Student select, drops courses from a course list, can follow up links giving courses description, and can see senior student’s opinion.
- Checking pre-requisite of courses and various constraints / policies is done by system which uses knowledge intensive assessment criteria for pre-requisite’s and constraints / policies checking. Services like sending emails messages to students and administration are introduced. System verifies constraints/policies such as mandatory courses must be selected, students must attach previous study transcripts, maximum number of courses in a learning period and other policies. System is made flexible to adapt to impacts and changes in organization rules and policies.
- We have introduced another feature “student counseling” which is not normally used by traditional Course Registration Systems. In this feature students give various inputs such as their field, complexity of courses, and interests-keywords. System applies counseling criteria and recommends courses to students.
- We suggest here that another new feature can be introduced namely “opinion of old students for taking courses” which is not normally used by traditional Course Registration System and is our own idea. Student’s opinions should be maintained in a list. In this feature students who have studied a specific course will be able to fill an electronic form which will base upon various questions regarding particular course. There is a possibility that senior students do not bother to fill this form. For this purpose, we can add a
constraint in our “constrain-polices” task that student must fill opinion form for the courses they have passed or marked star in student portal. It will be system responsibility to verify whether student has filled opinion form for stared courses in student portal. If system finds that a student have not filled opinion form for a particular course, it will send automated generated message “student must fill opinion form”. This feature will help in great extent to all new coming students and those students who are confused to select a course.

5.1.2. Future Work related to Case Study

Future work which can be done related to our case study and the domain “Course Registration Process” are as follows:-

- Applying CommonKADS methodology in terms of organization, task, agent, risk, communication, knowledge model and knowledge specification for our newly introduced feature “opinion of old students for taking courses”.
- Development of a prototype interfaces and to implement main knowledge based tasks of the system. This will also help in verification of knowledge specification tasks.
- Design and implementation of “Online Course Registration Portal” should be carried out, so that BTH students can have benefit from such a system. Our study will serve as a resource in development of the system.
- Development of knowledge Intensive ERP systems for any organization which leads to Intelligent ERP systems.

5.2. Conclusion

Use of commonKADS methodology in project planning and analysis helps to identify real problem domain and sufficient solution. Also domain process is identified. Tasks related to each process in the domain are identified. Knowledge assets related to each task are identified. These features help in defining real knowledge specification for the knowledge based system. It is therefore we suggest, ERP applications planning and analysis by using commonKADS methodology can help in analyzing knowledge involved in applications and can be made knowledge based. It was assumed that commonKADS methodology is only used for the knowledge based systems (KBS). It is not out of place to mention here that we provide an idea for planning and analysis through commonKADS methodology of knowledge intensive enterprise resource planning (ERP) systems. This thesis point out the drawbacks of existing techniques and methodologies which are used for development of the ERP systems.

This research work is done in terms of literature studies, research questions, research discipline, application domain and case study. On the basis of this research, we suggest that knowledge Engineering CommonKADS methodology will be more specific in planning and analysis of ERP application during their development.
CHAPTER 6: REFERENCES

This chapter gives references about the research material which we have studied used during this research thesis. These references are very much important to mention.


[8] Jorge Cardoso, Robert P. Bostrom and Amit Sheth, “Workflow Management Systems and ERP Systems: Differences, Commonalities, and Applications”, LSDIS Lab, Computer Science Department, University of Georgia, USA


[21] Illinois State University (http://www.ilstu.edu/) last visited 2007/12/10

[22] University of Manchester (http://www.manchester.ac.uk/) Last visited 2007/12/10

[23] University of Birmingham (http://www.bham.ac.uk/) Last visited 2007/12/10


CHAPTER 7: APPENDICES

This chapter provides various Appendices which gives information about thesis related work. This information is useful and very much important as far as our research and case study “online course registration portal for BTH” point of view.

Appendix A

Complete Organization, Task and Agent Analysis for Courses Registration Process at BTH (Using CommonKADS)

A.1.1. BTH Organization Analysis

In order to understand our domain Course Registration Process at BTH, we had many meetings, discussion sessions and interviews with administration, students and teachers (see appendix B).

A.1.1.1. OM-1: Problems, Solutions, and Context

OM-1 clearly specify about what should be done in order to solve the problem as in given table below:

<table>
<thead>
<tr>
<th>Organization Model</th>
<th>Problems and Opportunities Worksheet OM – 1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Problems and Opportunities</strong></td>
<td>Courses Registration Process at BTH includes selection, alteration and checking of pre-requisite / constraints / policies of the courses. These selection, alteration and checking of pre-requisite / constraint / policies of the courses are manual procedures. Applications Assessment for Registration takes too much time for the students and the administration.</td>
</tr>
<tr>
<td><strong>Organizational Context</strong></td>
<td><strong>Mission:</strong> Automating Registration Process Transparency of procedure System should be made flexible <strong>External Actors:</strong> BTH Registration Policies Administration Opinion Student’s Opinion Teacher’s Opinion <strong>Strategy:</strong> Facilitate Students, Teachers and Administration</td>
</tr>
<tr>
<td><strong>Solutions</strong></td>
<td>An online <strong>Web Based System</strong> for courses registration.</td>
</tr>
</tbody>
</table>

*Table A.1: Worksheet OM-1 (Problems, context and possible solution)*
A.1.1.2. New System Focus Area in BTH

In OM-2, we have mentioned area which new system will focus in organizational structure of BTH.

<table>
<thead>
<tr>
<th>Organization Model</th>
<th>Variant Aspects Worksheet OM-2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Structure</strong></td>
<td>See figure 1.1</td>
</tr>
<tr>
<td><strong>Process</strong></td>
<td>Online Course Registration / alteration Process: See figure 4.2</td>
</tr>
<tr>
<td><strong>People</strong></td>
<td>Programme Manager, Students, System Owner, Database Administrator, Databases of courses and student record.</td>
</tr>
</tbody>
</table>
| **Resources**      | 1. **Existing Information systems / Database**: It include  
|                    |   - Student Record  
|                    |   - Courses Offered  
|                    |   - Courses Description  
|                    | 2. **Rights**  
|                    | Only authorized user will have access to the system. |
| **Knowledge**      | **Student Counseling**: Asses student interests and helps them to choose courses of their interest.  
|                    | **Assessment Criteria**: Knowledge for assessing student application for course registration, e.g. checking pre requisite, Constraints/Policies (Max & Minimum No. of Courses etc.) |
| **Culture and Power** | 1. There is a specified limit on number of student who can register in a course.  
|                    | 2. There is a specified range of selecting maximum and minimum number of courses in a LP or a semester. |

*Table A.2: Worksheet OM-2 (Various aspects of Courses Registration Process)*
A.1.1.3. Main tasks in the Registration Process:

Description of the process in terms of the tasks and their main characteristics is as under:

<table>
<thead>
<tr>
<th>Organization Model</th>
<th>Process Breakdown Worksheet OM-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>No (identifier)</td>
<td>Task (Task name)</td>
</tr>
<tr>
<td>1.</td>
<td>Application/ Course List</td>
</tr>
<tr>
<td>2.</td>
<td>Application Assessment</td>
</tr>
<tr>
<td>3.</td>
<td>Registration Confirmation</td>
</tr>
</tbody>
</table>

Table A.3: Worksheet OM-3 (Process break down into tasks)

A.1.1.4. Knowledge Assets in the Registration process:

Description of the Knowledge components with their major characteristics is given below:

<table>
<thead>
<tr>
<th>Organization Model</th>
<th>Knowledge Assets Worksheet OM-4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge Asset (see OM-3)</td>
<td>Possessed by Agent (see OM-3)</td>
</tr>
<tr>
<td>Student Counseling</td>
<td>System</td>
</tr>
<tr>
<td>Assessment Criteria</td>
<td>Programme Manager</td>
</tr>
</tbody>
</table>

Table A.4: Worksheet OM-4 (Knowledge assets used in tasks)
### A.1.1.5. Feasibility of Courses Registration Portal:

|--------------------|-------------------------------------------------------------|
| **Business Feasibility** | 1. **Centralized System:** An online web based system will be a centralized system for use in all the departments.  
2. **Time Saving:** Programme Manager being a responsible person will have a productive time to address the departmental issues rather being involved in a clerical job.  
3. **Remote Access:** Students will be facilitated with an online web based system to register their courses remotely.  
4. **No organization change required.**  
5. **Risks and Uncertainties:**  
   - BTH might not be interested for the development work. Risk is only can be eliminated if authorities at BTH agree for sponsoring the project.  
   - **If circumstances inside or outside the organization change:** we believe that system will be flexible enough to adapt to changes easily. |
| **Technical Feasibility** | 1. An online web based Course Registration System.  
2. Student Login Password to access the Registration System for BTH students only.  
3. The system will be a centralized system for all the departments.  
4. Students of the respective departments will have access to the courses List for the respective LP/Semester  
5. Courses List should be made as links for each course. By following these links students will be able to see the course details. This will help to choose the courses of their own choice. |
| **Project Feasibility** | 1. BTH as an esteemed organization will definitely be interested to address the problem i.e Registration Process. We assume here that funds will be available at the BTH disposal to sponsor the project development.  
2. Programme Manager and teachers will be benefitted for the smooth functionality of the university.  
3. Students will be facilitated with an online web based system to register their courses remotely. |
| **Proposed Actions** | 1. **Focus:** Automating Registration Process, Transparency of Procedures.  
2. **Target solution:** An online **Web Based System** for courses registration.  
3. **Expected results and benefits:** will give rise to smooth functioning for Registration Process. It will facilitate students, teachers and administration.  
4. **If circumstances inside or outside the organization change:** we believe that system will be flexible enough to adapt to changes easily. |

*Table A.5: Worksheet OM-5 (Feasibility study of the proposed solution)*
A.1.2. Course Registration Task Analysis Model

A.1.2.1. TM-1: Task Analysis

A.1.2.1.1. First Task Analysis: Application/Course List

Refined description of the knowledge intensive task “Application / Course List” within the target process is given below:-

<table>
<thead>
<tr>
<th>Task Model</th>
<th>Task Analysis Worksheet TM-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task</td>
<td>cf. OM-3: Task identifier (No.) and Task name:</td>
</tr>
<tr>
<td></td>
<td>1. Application/Course List</td>
</tr>
<tr>
<td>Organization</td>
<td>cf. OM-2: Relevant Department</td>
</tr>
<tr>
<td>Goal and Value</td>
<td>Goal: Student Counseling, Selection /alteration of courses</td>
</tr>
<tr>
<td></td>
<td>Value:</td>
</tr>
<tr>
<td></td>
<td>1. Students make selection/alteration of courses. (mandatory courses or courses of their own choice)</td>
</tr>
<tr>
<td></td>
<td>2. Students have access to courses descriptor. In this way they can counsel themselves.</td>
</tr>
<tr>
<td></td>
<td>3. Students can take help from knowledge system to council them to take courses of their own choice.</td>
</tr>
<tr>
<td>Dependency and Flow</td>
<td><strong>Input Tasks:</strong> Sign In/Out</td>
</tr>
<tr>
<td></td>
<td><strong>Output Tasks:</strong> Application Assessment</td>
</tr>
<tr>
<td>Objects handled</td>
<td>Input objects:</td>
</tr>
<tr>
<td></td>
<td>Output objects: Selected Courses</td>
</tr>
<tr>
<td></td>
<td>Internal objects: Course List, Courses Description, Student Counselor</td>
</tr>
<tr>
<td>Time and Control</td>
<td><strong>Frequency:</strong> Each time when user register course this task is carried.</td>
</tr>
<tr>
<td></td>
<td><strong>Duration:</strong> Course Registration Period</td>
</tr>
<tr>
<td></td>
<td><strong>Control:</strong> See fig: A.1 &amp; A.2</td>
</tr>
<tr>
<td></td>
<td><strong>Constraints &amp; Conditions:</strong> No constraints &amp; conditions apply on this task.</td>
</tr>
<tr>
<td>Agents</td>
<td>OM-2: People, System Resources:</td>
</tr>
<tr>
<td></td>
<td>Students, Existing information System/Database</td>
</tr>
<tr>
<td></td>
<td>OM-3: Performed-by:</td>
</tr>
<tr>
<td></td>
<td>Students/System</td>
</tr>
<tr>
<td>Knowledge and Competence</td>
<td>cf. OM-4: Knowledge Asset:</td>
</tr>
<tr>
<td>Resources</td>
<td>Student Counseling</td>
</tr>
<tr>
<td></td>
<td>Detailing of OM-2:</td>
</tr>
<tr>
<td></td>
<td><strong>Existing Information systems / Database:</strong> It include</td>
</tr>
<tr>
<td></td>
<td>● Courses Offered</td>
</tr>
<tr>
<td></td>
<td>● Courses Description</td>
</tr>
<tr>
<td>Quality and Performance</td>
<td><strong>Measures:</strong> System availability should be 100%. Updated Database.</td>
</tr>
</tbody>
</table>

| Table A.6: Worksheet TM-1: First analysis of application/course-list task. |
### A.1.2.1.2. Second Task Analysis: Application Assessment

Refined description of the knowledge intensive task “Application Assessment” within the target process is given below:-

<table>
<thead>
<tr>
<th>Task Model</th>
<th>Task Analysis Worksheet TM-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task</td>
<td>cf. OM-3: Task identifier (No.) and Task name: 2. Application Assessment</td>
</tr>
<tr>
<td>Organization</td>
<td>cf. OM-2: Relevant Department</td>
</tr>
<tr>
<td>Goal and Value</td>
<td>Goal: Constraint/Policies, Checking Pre-requisite, Transparency of procedures. Value: 1. System checks Constrains (Max &amp; Min No. of Courses) and Polices (new and existing policies) 2. System checks Pre-requisites for the courses using Existing Database (student record &amp; course offered).</td>
</tr>
<tr>
<td>Dependency and Flow</td>
<td>Input Tasks: Application/Course List Output Tasks: Registration Confirmation</td>
</tr>
<tr>
<td>Objects handled</td>
<td>Input objects: Selected Courses Output objects: Validated Courses Internal objects: Constraints/Policies, Pre-requisite</td>
</tr>
<tr>
<td>Time and Control</td>
<td>Frequency: Each time when user register course this task is carried. Duration: Course Registration Period Control: See fig: A.1 &amp; A.2 Constraints &amp; Conditions: Constrains (Max &amp; Min No. of Courses) and Polices (new and existing policies), Checking pre-requisites of the courses.</td>
</tr>
<tr>
<td>Agents</td>
<td>OM-2: People, System Resources: Programme Manager, Existing information System/Database OM-3: Performed-by: In the new situation this task is performed by the System. (Previously performed by Programme Manager)</td>
</tr>
<tr>
<td>Knowledge and Competence</td>
<td>cf. OM-4: Knowledge Asset: Assessment Criteria</td>
</tr>
</tbody>
</table>
| Resources | Detailing of OM-2: Existing Information systems / Database: It include  
- Student Record  
- Courses Offered  
- Courses Description |
| Quality and Performance | Measures: System availability should be 100%. Updated Database. |

Table A.7: Worksheet TM-1: First analysis of the application-assessment task.
A.1.2.1.3. Third Task Analysis: Registration Confirmation

Refined description of the knowledge intensive task “Application Assessment” within the target process is given below:

<table>
<thead>
<tr>
<th>Task Model</th>
<th>Task Analysis Worksheet TM-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task</td>
<td>cf. OM-3: Task identifier (No.) and Task name:</td>
</tr>
<tr>
<td></td>
<td>1. Registration Confirmation</td>
</tr>
<tr>
<td>Organization</td>
<td>cf. OM-2: Relevant Department</td>
</tr>
<tr>
<td>Goal and Value</td>
<td>Goal: Registration Confirmation.</td>
</tr>
<tr>
<td></td>
<td>Value:</td>
</tr>
<tr>
<td></td>
<td>1. Student confirm registration</td>
</tr>
<tr>
<td>Dependency and Flow</td>
<td>Input Tasks: Application Assessment</td>
</tr>
<tr>
<td></td>
<td>Output Tasks: Sign Out, Application / Course List</td>
</tr>
<tr>
<td>Objects handled</td>
<td>Input objects: Validated Courses</td>
</tr>
<tr>
<td></td>
<td>Output objects: Courses Registered</td>
</tr>
<tr>
<td></td>
<td>Internal objects: -</td>
</tr>
<tr>
<td>Time and Control</td>
<td>Frequency: Each time when user register course this task is carried.</td>
</tr>
<tr>
<td></td>
<td>Duration: Course Registration Period</td>
</tr>
<tr>
<td></td>
<td>Control: See fig: A.1 &amp; A.2</td>
</tr>
<tr>
<td></td>
<td>Constraints &amp; Conditions: -</td>
</tr>
<tr>
<td>Agents</td>
<td>OM-2: People, System Resources:</td>
</tr>
<tr>
<td></td>
<td>Programme Manager</td>
</tr>
<tr>
<td></td>
<td>OM-3: Performed-by:</td>
</tr>
<tr>
<td></td>
<td>In the new situation this task will be performed by the Students (Previously performed by Programme Manager)</td>
</tr>
<tr>
<td>Knowledge and Competence</td>
<td>cf. OM-4: Knowledge Asset:</td>
</tr>
<tr>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Resources</td>
<td>Detailing of OM-2:</td>
</tr>
<tr>
<td></td>
<td>Student will confirm registration of the courses.</td>
</tr>
<tr>
<td>Quality and Performance</td>
<td>Measures: System availability should be 100%.</td>
</tr>
</tbody>
</table>

Table A.8: Worksheet TM-1: First analysis of registration-confirmation task.
A.1.2.1.4. Data Flow/Control Diagram and State Diagram

Figure A.1 and A.2 briefly shows the states of the registration process below:-

![Data Flow and Control Diagram](image)

**Figure A.1: Data Flow and Control Diagram**

![State Diagram](image)

**Figure A.2: State Diagram**
A.1.2.2. TM-2: Knowledge Assets in the Tasks

A.1.2.2.1. First Knowledge Asset: Student Counseling

Specification of the knowledge asset for a task, and possible bottlenecks and areas for improvement are listed below:

<table>
<thead>
<tr>
<th>Task Model</th>
<th>Knowledge Item Worksheet TM-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Student Counseling</td>
</tr>
<tr>
<td>Possessed by</td>
<td>System</td>
</tr>
<tr>
<td>Used in</td>
<td>2. Application/Course List</td>
</tr>
<tr>
<td>Domain</td>
<td>Student Course registration at University</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nature of the knowledge</th>
<th>Bottleneck/to be improved</th>
</tr>
</thead>
<tbody>
<tr>
<td>formal, rigorous</td>
<td>X</td>
</tr>
<tr>
<td>empirical, quantitative</td>
<td></td>
</tr>
<tr>
<td>heuristic, rules of thumb</td>
<td></td>
</tr>
<tr>
<td>highly specialized, don specific</td>
<td></td>
</tr>
<tr>
<td>experience-based</td>
<td>X</td>
</tr>
<tr>
<td>action-based</td>
<td></td>
</tr>
<tr>
<td>Incomplete</td>
<td>X</td>
</tr>
<tr>
<td>uncertain, may be incorrect</td>
<td>X X</td>
</tr>
<tr>
<td>quickly changing</td>
<td></td>
</tr>
<tr>
<td>hard to verify</td>
<td>X</td>
</tr>
<tr>
<td>tacit, hard to transfer</td>
<td>X</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Form of the knowledge</th>
<th>Bottleneck/to be improved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mind</td>
<td></td>
</tr>
<tr>
<td>Paper</td>
<td></td>
</tr>
<tr>
<td>Electronic</td>
<td>X</td>
</tr>
<tr>
<td>Action skill</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Availability of knowledge</th>
<th>Bottleneck/to be improved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limitations in time</td>
<td></td>
</tr>
<tr>
<td>Limitations in space</td>
<td></td>
</tr>
<tr>
<td>Limitations in access</td>
<td>X</td>
</tr>
<tr>
<td>Limitations in quality</td>
<td></td>
</tr>
<tr>
<td>Limitations in form</td>
<td></td>
</tr>
</tbody>
</table>

**Table A.9:** Worksheet TM-2: Knowledge asset “Student counseling” bottlenecks
A.1.2.2.2. Second Knowledge Asset: Assessment Criteria

Specification of the knowledge employed for a task, and possible bottlenecks and areas for improvement

<table>
<thead>
<tr>
<th>Task Model</th>
<th>Knowledge Item Worksheet TM-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Assessment Criteria</td>
</tr>
<tr>
<td>Possessed by</td>
<td>System</td>
</tr>
<tr>
<td>Used in Domain</td>
<td>2. Application Assessment Courses Registration process at BTH.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nature of the knowledge</th>
<th>Bottleneck/to be improved</th>
</tr>
</thead>
<tbody>
<tr>
<td>formal, rigorous</td>
<td>X</td>
</tr>
<tr>
<td>empirical, quantitative</td>
<td>X</td>
</tr>
<tr>
<td>heuristic, rules of thumb</td>
<td></td>
</tr>
<tr>
<td>highly specialized, don specific</td>
<td>X</td>
</tr>
<tr>
<td>experience-based</td>
<td></td>
</tr>
<tr>
<td>action-based</td>
<td></td>
</tr>
<tr>
<td>Incomplete</td>
<td></td>
</tr>
<tr>
<td>uncertain, may be incorrect</td>
<td></td>
</tr>
<tr>
<td>quickly changing</td>
<td></td>
</tr>
<tr>
<td>hard to verify</td>
<td>X</td>
</tr>
<tr>
<td>tacit, hard to transfer</td>
<td>X</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Form of the knowledge</th>
<th>Bottleneck/to be improved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mind</td>
<td></td>
</tr>
<tr>
<td>Paper</td>
<td></td>
</tr>
<tr>
<td>Electronic</td>
<td>X</td>
</tr>
<tr>
<td>Action skill</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Availability of knowledge</th>
<th>Bottleneck/to be improved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limitations in time</td>
<td></td>
</tr>
<tr>
<td>Limitations in space</td>
<td></td>
</tr>
<tr>
<td>Limitations in access</td>
<td>X</td>
</tr>
<tr>
<td>Limitations in quality</td>
<td></td>
</tr>
<tr>
<td>Limitations in form</td>
<td></td>
</tr>
</tbody>
</table>

Table A.10: Worksheet TM-2: Knowledge asset “Assessment Criteria” bottlenecks
A.1.3. Agents / Actors Involved in Registration Process Analysis

A.1.3.1. Agent: System

Specification according to the CommonKADS agent model is given below:-

<table>
<thead>
<tr>
<th>Agent Model</th>
<th>Agent Worksheet AM-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>System, student, programme manager</td>
</tr>
<tr>
<td>Organization</td>
<td>Relevant Department</td>
</tr>
<tr>
<td>Involved in</td>
<td>Application/Course List</td>
</tr>
<tr>
<td></td>
<td>Application Assessment</td>
</tr>
<tr>
<td></td>
<td>Registration Confirmation</td>
</tr>
<tr>
<td>Communicates with</td>
<td>Existing Information systems / Database: It include</td>
</tr>
<tr>
<td></td>
<td>● Student Record</td>
</tr>
<tr>
<td></td>
<td>● Courses Offered</td>
</tr>
<tr>
<td></td>
<td>● Courses Description</td>
</tr>
<tr>
<td>Knowledge</td>
<td>Student Counseling, Assessment Criteria</td>
</tr>
<tr>
<td>Other competencies</td>
<td>List of other required or present competences of the agent</td>
</tr>
<tr>
<td>Responsibilities and</td>
<td>1. Help student to choose courses which are of their own interest.</td>
</tr>
<tr>
<td>Constraints</td>
<td>2. Registered them in the courses</td>
</tr>
<tr>
<td></td>
<td>3. System checks Constrains (Max &amp; Min No. of Courses) and Policies (new and existing policies)</td>
</tr>
<tr>
<td></td>
<td>4. System checks Pre-requisites for the courses using Existing Database (student record &amp; course offered).</td>
</tr>
</tbody>
</table>

Table A.11: Worksheet AM-1: System
A.1.4. Organization, Task and Agent Combined Analysis

A.1.4.1. Summary of Organizational Changes, Improvement, and Actions

Various changes, impacts and improvements, commitments and proposed actions in organization, task and agent perspective are given below:

<table>
<thead>
<tr>
<th>Organization-Task-Agent Models</th>
<th>Checklist for Impact and Improvement Decision Document Worksheet OTA-1</th>
</tr>
</thead>
</table>
| Impacts and Changes Organization | 1. An online web based system.  
2. System helps students to choose courses of their own interest.  
3. System registers them in the courses.  
4. **Time Saving:** Programme Manager being a responsible person will have a productive time to address the departmental issues rather being involved in a clerical job.  
5. **Remote Access:** Students will be facilitated with an online web based system to register their courses remotely. |
| Task/Agent-Specific Impacts and Changes | 1. **Centralized System:** An online web based system will be a centralized system for use in all the departments.  
2. System helps students to choose courses of their own interest related with the task i.e. **1. Student Counseling.**  
3. System is intelligent enough to check constraints which are related with the task i.e. **2. Application Assessment.** |
| Attitudes and Commitments | 1. Transparency of procedures  
2. The idea is to bring effective change within the organization.  
3. Analyzing changes through successive interviewing agents and stakeholders. |
| Proposed Actions | 1. Successive interviewing with the agents and the stake holders about the changes and proposed for further work.  
2. System must be flexible to accept new policies regarding registration. |

**Table A.12: Worksheet OTA-1** (Summary of organization, task, and agent analysis)
A.1.5. Risk Analysis by CommonKADS Cycles Model

We have identified three risks in “online courses registration portal”. These risks are monitored closely through the CommonKADS cycles in tables 4.13, 4.14 and 4.15 shown below:

### A.1.5.1. Cycle-0

<table>
<thead>
<tr>
<th>Monitor</th>
<th>Review</th>
</tr>
</thead>
<tbody>
<tr>
<td>- It has been observed that assumptions made are correct and relevant to the system to some extent.</td>
<td>- Course registration process at BTH is a manual process. Student has to meet the programme manager in order to get register in the course.</td>
</tr>
<tr>
<td>- An online <strong>Web Based Knowledge System</strong> for courses registration will overcome this problem.</td>
<td>- Application/Course List and Application Assessment are two knowledge intensive tasks, which are identified.</td>
</tr>
<tr>
<td>- BTH may not be interested to implement this system.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Plan</th>
<th>Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>- We make assumption about the problem domain and the knowledge intensive tasks and areas.</td>
<td>- Domain Expert i-e programme manager might not available to provide information about the problem domain.</td>
</tr>
</tbody>
</table>

Table A.13: Risk-1

### A.1.5.2. Cycle-1

<table>
<thead>
<tr>
<th>Monitor</th>
<th>Review</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Proposed system should be flexible so that many other universities may use this for their courses registration process.</td>
<td>- While concentrating on the assumption and finding the stake holders it has been observed that organization may not be interested to implement such kind of system.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Plan</th>
<th>Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>- The system must be made flexible so that many other universities/institutes can be able to use this for course registration.</td>
<td>- The organization may not be interested to implement such kind of system.</td>
</tr>
<tr>
<td></td>
<td>- Who will pay for the system which will have been developed?</td>
</tr>
</tbody>
</table>

Table A.14: Risk-2
A.1.5.3. Cycle-2

**Monitor**

- Programme manager looks satisfied with the discussion.

**Review**

- While discussing the system with the owner and other stakeholders, it looks that programme manager is not satisfied with the system.

**Plan**

- A detail meeting with the programme manager ensuring him that this would help him to perform his tasks.

**Risk**

- Programme Manager might think this system as a threat to his job and would not help him to perform his tasks.

**Table A.15: Risk-3**

A.1.6. Risk Assessment in Terms of Project Management

Table 4.16 lists all the factors effecting current registration system and can have effect on our proposed system.

<table>
<thead>
<tr>
<th>Project Management</th>
<th>Risk Assessment Worksheet PM-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>RISK</td>
<td>AFFECTED QUALITY FEATURE</td>
</tr>
<tr>
<td>Domain Expert has no time</td>
<td>Quality of System</td>
</tr>
<tr>
<td>Programme Manager might think threat to his job</td>
<td>Quality of System</td>
</tr>
<tr>
<td>Who will pay for it?</td>
<td>-</td>
</tr>
<tr>
<td>Identifying Stake Holders</td>
<td>Quality of System</td>
</tr>
</tbody>
</table>

**Table A.16: Risk Assessment of Courses Registration Portal**
Appendix B

Research Interviews and Questionnaire

In order to obtain information, requirement gathering and opinion of administration, various students and teachers regarding our domain “Courses Registration Process”, existing systems, difficulties and hurdles in current courses registration system, we have conducted structured interviews. The sole purpose of these interviews was to get administration’s and student’s opinions about existing and our purposed system for courses registration at BTH.

To get the feed back we have developed a questionnaire (Questionnaire B.1.3 & B.1.4) and target specific administration officers for interviews.

B.1.1. Interview Guide

i. **Course registration responsibility**: Who is responsible for course registration?

ii. **Registration Procedure**: What is the course registration procedure?

iii. **Criteria for prerequisites of a subject**: If there is any prerequisite for a particular course, what is the criteria for evaluating of the prerequisite. Who is responsible for evaluating and granting the permission for registration?

iv. **Policies for subject registration**: A brief description of BTH policies for maximum subject registration in a learning period.

v. **Single subject course registration**: What is the procedure for single course registration?

vi. **Time required for registration**: How much time required for course registration process?

vii. **Issues in existing system**: Do you feel any discomfort within current system?

viii. **Suggestions for betterment**: Do you have any suggestions for the betterment of the current system?

B.1.2. Results and Suggestions

On the basis of our conducted interviews with administration and students we get the following views and suggestions. This is actually a summary of our interviews. We are writing just a few points. Actually these are the problems faced by the administration and students.

i. **Work load**: Students registration is a hectic process in the current scenario. It creates sometimes burden for program managers and help desk staff to manage large number of students in start of every learning period.

ii. **Time consuming**: It takes lots of time for every student to register courses. In order to register a course having pre-requisites, it is necessary for student to meet program manager. If a student is living far from university, he must visit university for course registration.

iii. **Contingent on Human being**: Program manager is an only person who can register a course. In the absence of programme manager students have to wait. Sometimes permission of course responsible is compulsory. Students first take permission of that course from course responsible and then get a signed copy from program manager and then submit that copy to student help desk for registration of that particular course. This all takes a lot of time and moreover absence of any person. Such lapses can cause penalty for one to two days, sometimes one week or more.

iv. **Paper work**: In current scenario students take a printed form from help desk. After filling the form they submit it to the program manager for approval. After getting approved and
signed, they submit it to the student help desk. Heading B.1.5. show Manual Course Registration form at BTH.

v. **It must be automated**: Most of the students suggest that, course registration process should be automated, so that students would have been able to register courses remotely. There should have been a system from where students can choose courses of their interest and register them.

B.1.3. Questionnaire for Administration

- Q. What is the procedure for course registration for new comer and existing students?
- Q. Who is responsible for the course registration?
- Q. What are the criteria for course prerequisite?
- Q. How many courses can be registered in a Learning period?
- Q. What is the procedure for single subject course registration?
- Q. How much time required for course registration?
- Q. Do you feel any discomfort/ problem in the existing system?
- Q. Suggestions for the betterment of the system.

B.1.4. Questionnaire for Students

- Q. What is your Program?
- Q. Do you know how to register a course?
- Q. How you come to know to register a course?
- Q. How much time does it take to register a course?
- Q. Are you satisfied with the existing system?
- Q. Do you have any suggestions for course registration process?
### B.1.5. Paper form for Courses Registration

- **Full name:**
- **Swedish personal number:**
- **E-mail:**
- **Telephone:**
- **Started studies:**
- **Date and Signature:**

#### Time Table

<table>
<thead>
<tr>
<th>Time</th>
<th>Name</th>
<th>Code</th>
<th>Pre-req</th>
<th>Apply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring</td>
<td>24. Agent Systems</td>
<td>DV2401</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25. Verification and Validation</td>
<td>PA2405</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>26. Optimization Techniques</td>
<td>DV2414</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>27. Software Security</td>
<td>DV2409</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>28. Computer Security</td>
<td>DV2413</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>29. Introduction to Simulation</td>
<td>ET1218</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>30. Applied Network Management</td>
<td>ET1324</td>
<td>NM</td>
<td></td>
</tr>
<tr>
<td></td>
<td>31. Web Technologies and Applications</td>
<td>DV1311</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>32. Strategic Management of Change</td>
<td>FE1315</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>33. Advanced Topic in Software Engineering</td>
<td>PA2401</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>34. Wireless Personal Area Networks</td>
<td>ET1325</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>12. Master Thesis in Computer Science</td>
<td>DV2403</td>
<td>45</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time</th>
<th>Name</th>
<th>Code</th>
<th>Pre-req</th>
<th>Apply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring</td>
<td>35. Multiprocessor Systems</td>
<td>DV2407</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>36. Server Architectures</td>
<td>DV2407</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>37. Complex Analysis and Transforms</td>
<td>MA1305</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>38. Intelligent Decision Support Systems</td>
<td>DV2408</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>39. Statistical Methods</td>
<td>MS1104</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>40. Software Metrics</td>
<td>PA1303</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>41. Network Security</td>
<td>ET1318</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>42. Advanced Topic in Computer Science</td>
<td>DV2402</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>43. Research Methodology</td>
<td>PA2404</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>44. Usability from an industrial perspective</td>
<td>DV1301</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>45. Innovative Interfaces</td>
<td>AB1304</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTE:** If you have selected courses for this LP previously, revised selection has to be mentioned!

Choose two courses per study period for full-time studies. A maximum of three courses is allowed but highly not recommended!

Check prerequisites for the individual courses and be prepared to show transcripts.

Courses are filled by first-come first-served philosophy and some courses may get full!

Courses are closed for registration two weeks after starting date.

---

Approved
Registered

---

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