PROJECT MANAGEMENT SYSTEM FOR CONSTRUCTION BUSINESS

by

Mr. Thomas Andreasen Hoyer

A Final Report of the Three - Credit Course
CS 6998 System Development Project

Submitted in Partial Fulfillment
of the Requirements for the Degree of
Master of Science
in Computer Information Systems
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Project Title	Project Management System for Construction Business
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Academic Year	November 2000

The Graduate School of Assumption University has approved this final report of the three-credit course, CS 6998 System Development Project, submitted in partial fulfillment of the requirements for the degree of Master of Science in Computer Information Systems.

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ABSTRACT

The purpose of the project is to develop an Information System especially for the Project Management to support the management of resources in interfacing and interacting with internal and external entities such as executives, engineers, subcontractors, and clients. After performing an Information System Analysis the new system is required to have the following features in order to support the Project Management, and be a frame for collection of experiences;

(1) Resource Management System covering: Time Management, Quality Management, and Cost Management, Human resource Management.

(2) Standard Operating Procedures (SOP) for all Project Phases.

The information system design phase consist of three parts;

A Configuration phase where candidate solutions are identified, analyzed, and a target system that will be designed and implemented is recommended. The solution will take the form of a SAP/R3 software suite chosen because of a fast implementation and comprehensive functionality.

A Procurement phase where appropriate hardware and/or software products for the new system has been determined. The new system will run on Windows NT servers with Windows NT workstations supported by a INFORMIX database as well as Microsoft Internet Information Server.

A Design and Integration phase where technical design specifications that will guide the construction of the new system is developed, - this is in the form of database design, software structure charts and finally standards for the graphical user interfaces is created.

ACKNOWLEDGEMENTS

Several persons have made this System Development Project possible, and the writer would like to acknowledge their efforts and express gratitude for their contributions.

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I. INTRODUCTION

1.1 Background of the Project

The Danish Civil Engineering Company, Pihl & Son A/S, is about to introduce a new Information System to support the Project Management.

By interviewing various levels in the organization, covering from Executives, several project managers on national level as well as international level, to engineers, it has been stated that the biggest problem in the company is the project management.

The problems occur in the project management because each project is unique, and the most valuable asset in performing the project management is the project manager's experience.

But the company does not have a system for collecting and making these individual experiences collectively. Hence there are mistakes being repeated that are costly to the firm. Scenario 1 is a reference scenario that describes the current situation:

Scenario 1

(1) Split up in Divisions.

(2) Hierarchical.

(3) Centralized Decision Processes.

(4) Conservative Attitude.

This organizational state is not desirable, and will be changed in the same process as when implementing a new information system.

Many information system implementations fail because not enough attention is given to organizational changes compared to technological changes. Pihl & Son wish to keep the non-technical aspects in mind during the system development process; therefore the reference scenario and the desired scenario are drawn up.

1.2 Objectives of the Project

Pihl & Son A/S is about to introduce a new Information System, with the objectives to support the Project Management, and be a frame for a Collection of Experiences, and in relation to this transform the organization in the direction of a decentralized learning organization.

The new information system is desired to have the following features in order to support the Project Management, and be a frame for collection of experiences;

(1) Resource Management System covering:

  (a) Time Management.

  (b) Quality Management.

  (c) Cost Management.

  (d) Human resource Management.

(2) Standard Operating Procedures (SOP) for all Project Phases.

A new information system further has the objective to facilitate some organizational changes, under which Pihl & Son A/S can function more effective and efficient.

The second scenario describes the desired situation in which the new information system will be used optimally and most efficient.

Scenario 2

(1) Network.

(2) Flexibility.

(3) Change.

(4) Inspiring Management.

(5) Personal Growth.

(6) Reflecting.

(7) Team Learning.

(8) Knowledge Sharing.

(9) Collection of Experiences.

1.3 Scope of the Project

The Scope of the project is analyze the existing business System, and to develop a new Information System specially for the Project Management to support the management of resources in interfacing and interacting with internal and external entities such as executives, engineers, subcontractors, clients etc.

The scope of the project is further more to develop a datastore for collection of experiences and best practices for operating procedures and related activities.

1.4 Deliverables

The deliverables of the project is a system analysis and development. That is, a system analysis of the business functions of Pihl & Son A/S that a new information system must facilitate, and the development of a conceptual plan for a new information system to be implemented at Pihl & Son A/S, in order to improve the efficiency of the company. The project plan for the entire project is shown on the following page on Figure 1.1.

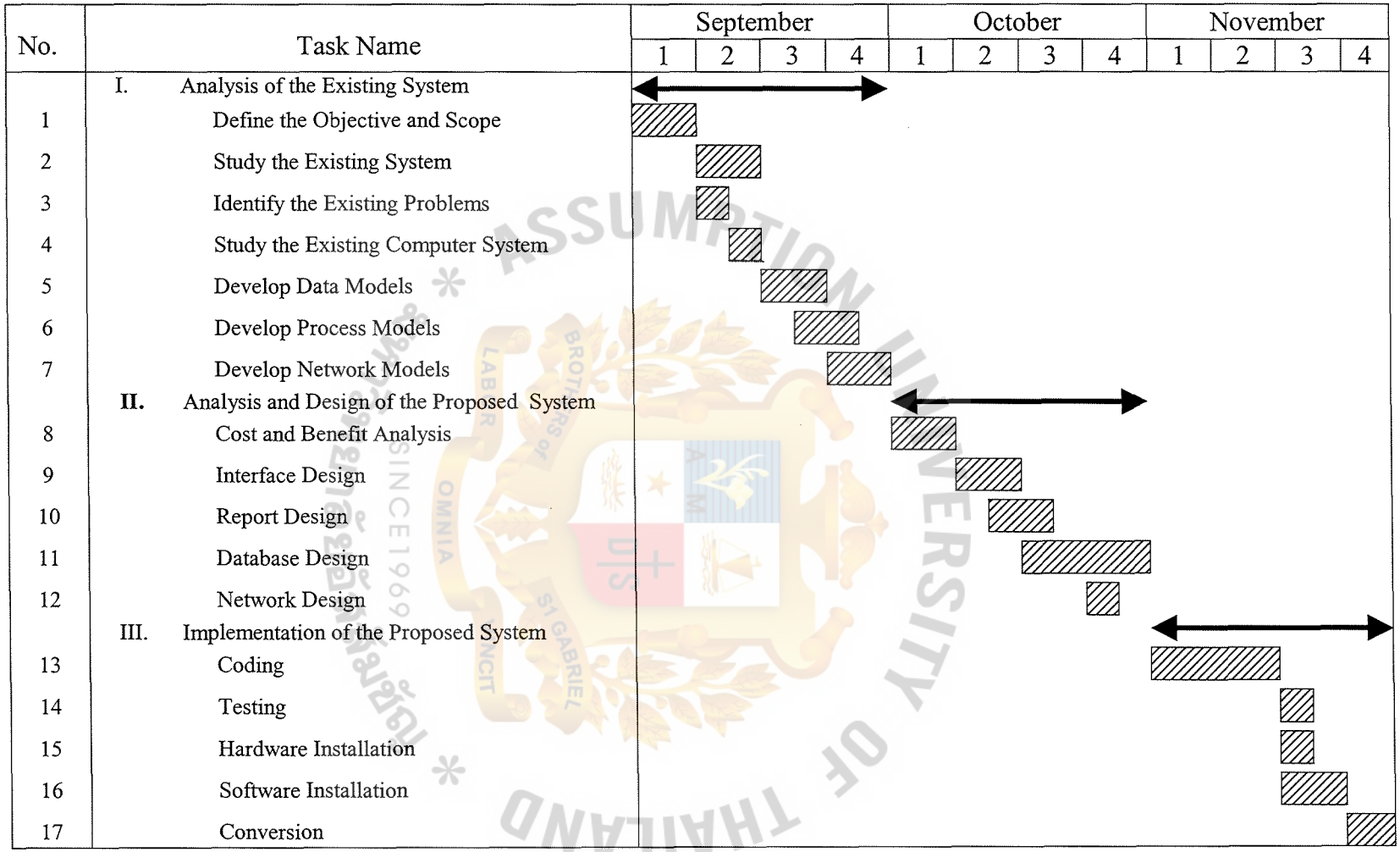

Figure 1.1. Project Plan of Project Management System.

II. EXISTING SYSTEM

The current system is studied first, because in order to go somewhere, we must know where we are standing. A system is defined as e set of interconnected components interacting to solve a specified problem. The existing system description in Pihl & Son is hence first a look at the pure business system, and then the existing information system.

First follows an introduction of Pihl & Son A/S, to establish the product the firm desires to output. After that the existing information system and the problems relating to it is described.

Then follows the analysis of the business system needs existing in Pihl & Son A/S that can output the desired product. The System is described through the construction of following models:

(1) Data Model.

(2) Process Model.

(3) Network Model.

All system models are created using the CASE tool 'Visible Analyst Version 7.1'

2.1 Background of the Organization

E. PIHL & SØN A.S., Denmark, established in 1887, is a limited liability company. Most often using the short name Pihl, the internationally operating company is a totally Danish owned and independent company.

Pihl's main office in Lyngby, Denmark, is the center of Pihl's worldwide activities. Today Pihl works in different countries covering the North Atlantic Area, Africa, Europe, the Middle and Far East and the Caribbean's. Pihl carries many of the

contracts out alone, but quite a few joint ventures are formed with other companies from around the world.

Furthermore, Pihl operates through subsidiaries in Iceland, Greenland, the Faroe Islands and Germany and through associated companies in Sweden and Lithuania, Pihl's annual turnover in the fiscal year 1998/99 amounts to 1,706 MDKK (230 mill USD).

55% of the annual turnover derives from work carried out abroad and thus 45 % from domestic activities. Pihl employs approximately 1000 engineers plus other administrative staff.

The types and scopes of projects, within civil engineering and building construction, undertaken by Pihl are numerous. Pihls main activities, in Denmark and abroad, cover a wide range of projects. Large infrastructure assignments such as harbors, bridges, tunnels roads and airports are major projects. Water supply and environmental engineering projects are of increasing importance.

Furthermore, power plants and industrial buildings are also a significant part of Pihl's core business. Similarly, building projects, office buildings and institutions together with rehabilitation of buildings and urban renewal projects have contributed to the expansion Pihl has enjoyed.

This expansion, supported by an effort within the Design-and Construct field of projects, includes an increasing portfolio of project management and turnkey projects. As a consequence Pihl is actively promoting the concept of Build-Operate-Transfer through the participation in the company BOT Management A/S.

A trimmed and alert organization, respecting its roots of handicraft by providing the highest standards of bricklaying, painting and carpentry, the Pihl of today is capable

of undertaking the most complex tasks through the use of skill and talent always available within the organization. Figure 2.1. shows the Organization Chart.

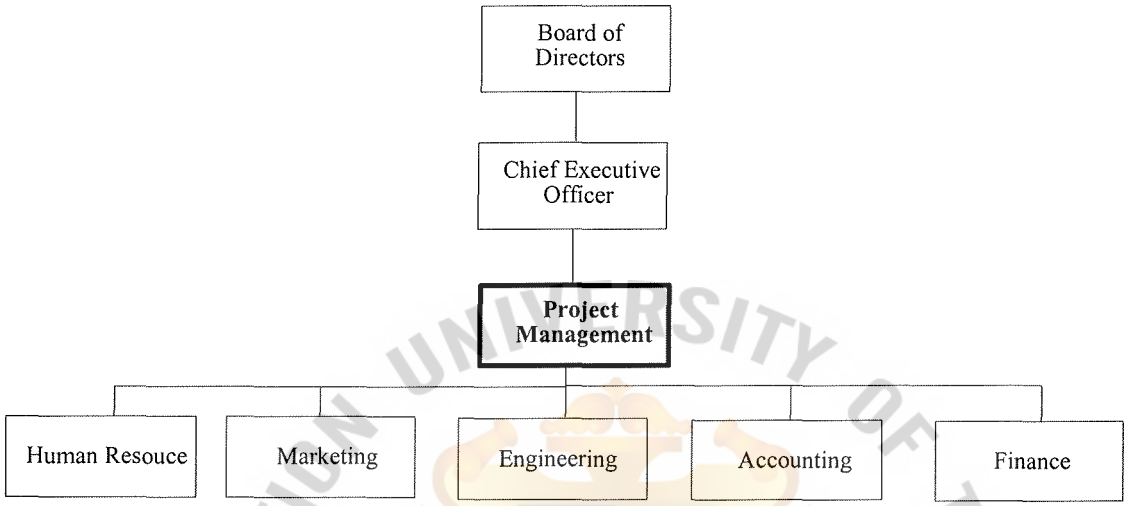

Figure 2.1. Organizational Chart for Pihl & Son A/S.

2.2 Existing Information System

Pihl & Son A/S has developed an Enterprise Application Architecture Strategy dictating standards for Network, Data and Interface describing the existing system.

Application architecture defines the technologies to be used by one or more information systems. Application architectures may be developed and enforced strategically, or they may tactically evolve on a project-by-project basis. (Laudon 1998)

There are four categories of technology:

(1) Network.

(2) Data.

(3) Interface.

(4) Process.

The enterprise application architecture strategy describes the existing information system in Pihl & Son A/S.

Network

The prevailing computing model is currently client/server wherein a network of clients, single-user computers, are connected to and inter-operate with servers, multiple-user computers that share their services. This is also called distributed computing.

Centralized computing, distributed presentation, distributed data, distributed data and logic, and Internet/intranet computing are flavors of client/server computing.

Client/server computing can be based on different network topologies including bus, ring, star, and hierarchical networks.

The Enterprise Application Architecture Strategy in Pihl & Son A/S dictates Windows NT servers with Windows NT workstations as well as Microsoft Internet Information Server.

Data

Data storage is typically implemented using distributed relational database technology that either partitions data to different servers or replicates data on multiple servers.

The Enterprise Application Architecture Strategy in Pihl & Son A/S dictates MS SQL servers RDBMS with 1000 GB arrayed capacity.

Interface

User interface options include batch, on-line, remote batch, keyless data entry (including optical character/mark and bar coding methods), pen input, graphical user interfaces, electronic messaging, electronic data interchange, and imaging.

System interfacing is typically implemented using middleware.

The Enterprise Application Architecture Strategy in Pihl & Son A/S dictates RANK XEROX Network Laser Flatbed all in one for all departments. Keyboard and mouse are the commonly used interfacing tools in Pihl & Son A/S.

Process

Processes are implemented using highly integrated tool kits called software development environments.

The process architecture is evolving on a project-by-project basis, based on the demand in Pihl & Son A/S to continually upgrade and apply state of the art application software. The chosen operating system in Pihl & Son is Windows NT, following the latest upgrades when maturity has reached. Pihl & Son A/S are using Microsoft Office Professional including MS Project.

The system configuration is shown on the following page on Figure 2.2.

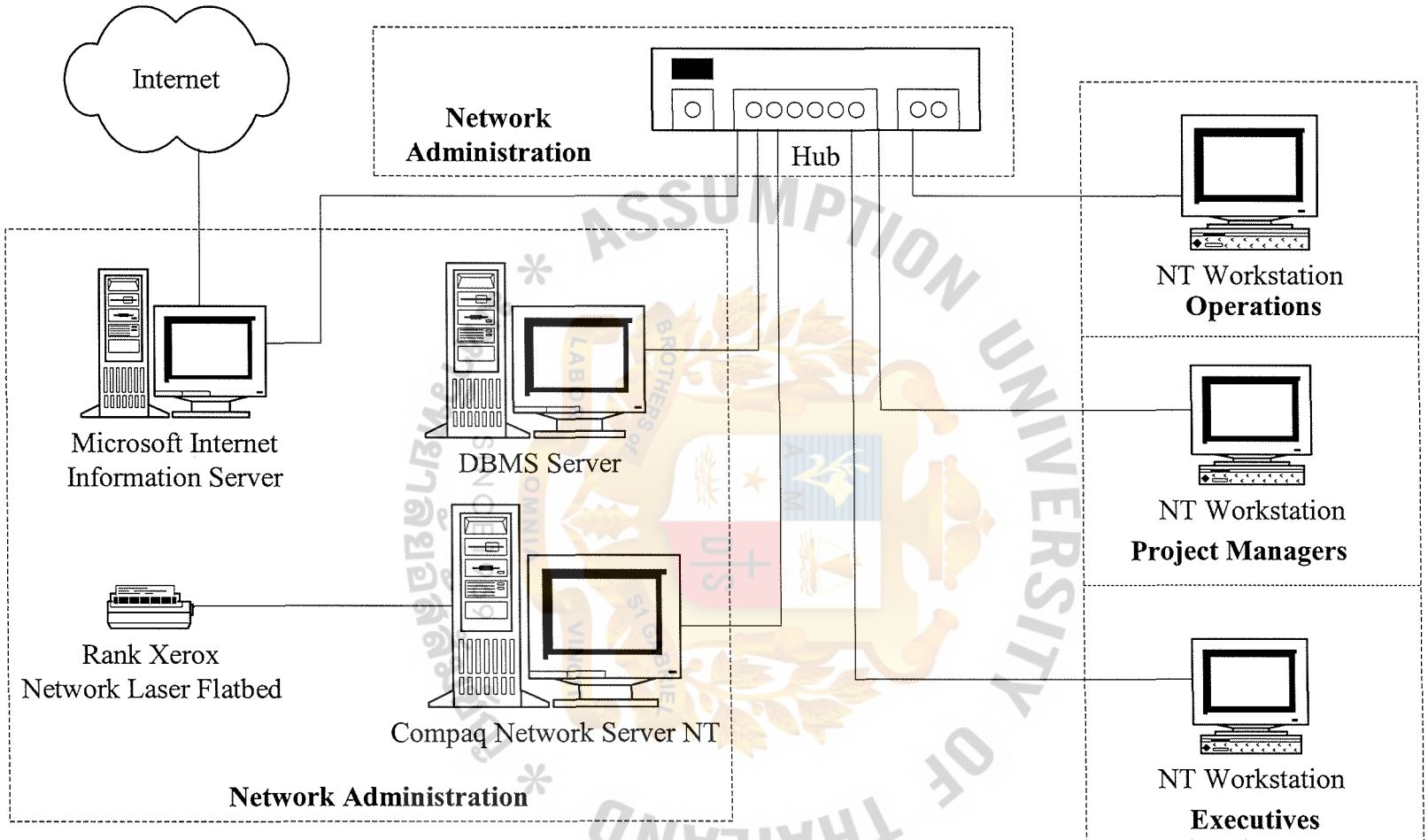

Figure 2.2. System Configuration for Pihl & Son A/S.

2.3 Problems/Opportunities/Directives

The problems that exist in Pihl & Son A/S, related to the existing information system are now systematically organized according the PIECES Problem-Solving Framework which covers:

(1) Performance.

(2) Information.

(3) Economics.

(4) Control.

(5) Efficiency.

(6) Service.

Each point focuses on problems, opportunities and directives.

Performance

(1) Problems; mistakes are repeated on an organizational level, because the existing information system does not facilitate storage of specific problem solving methods and solutions previously tried in Pihl & son A/S.

(2) Opportunities; guidelines for best practices for all steps in the project management can be provided in a new information system.

(3) Directives; operating procedures can be enforced through a new information system, in the sense that all formal project work is only possible by the use of the information system.

Information

(1) Problems; not all information is available to all employees, new employees does not have the knowledge of the more experienced project managers in Pihl & Son A/S, hence time is wasted to acquire this knowledge that already exits in the firm, but not collectively accessible.

(2) Opportunities; individual experiences can be made collective in a new information system, by building the information system with link to a knowledge warehouse that stores the solutions to problems occurring in the project work.

(3) Directives; a new information system can have rules for storing and retrieving experiences. A standardized format for entering information and where in the knowledge warehouse must be followed in order to reuse the stored experiences conveniently.

Economics

(1) Problems; cost are difficult to predict with the existing information system since each project is unique, and the existing information system does not store how costs previously have been estimated in a manner that are useful for reuse and trend spotting. This means that money are spend doing work that has already been done in the firm before, and even worse, -some of the wrong problem solving solution might be applied again.

(2) Opportunities; best practices for all steps in the project management can be used and continuously improved in a new information system. This means that mistakes and wrong approaches can gradually over time be memorized in a new information system and hence avoided repeated, leading to reduced costs.

(3) Directives; shareholders in today's diversified economic demand higher profit margin for their investments, requiring Pihl & Son A/S to take some action that will improve the economics of the firm and paying the shareholders higher dividends.

Control

(1) Problems; not all information are accessible for all employees, both because the existing information system does not allow, and are not compatible, for a free flow of information across departments and divisions. So internal competition, organizational barriers and an inflexible existing information system is a hindrance to effective problem solving in the firm.

(2) Opportunities; the experience of most experienced project managers can be made available to less experienced with a new information system also across departmental boarders.

(3) Directives; a new information system can require evaluation of project after it is finished, for improvement of operating procedures and troubleshoot any problems related to hindrance of free flow of information over departments and divisions.

Efficiency

(1) Problems; planning activities are carried out slow by less experienced, because the most valuable asset in carrying out project planning is experience (stated by various project managers in the firm.)

(2) Opportunities; work can be done faster, with less mistakes, and profits can be increased with a new information system that supports the project management with standard operating procedures and a knowledge warehouse.

(3) Directives; guidelines for operating procedures can be given in a new information system. This means that uniform work procedures are enforced, making staffing and swapping employees from project to project easy.

Hence the organization will be better able to take on new projects with this increased flexibility.

Service

(1) Problems; current incompatible system is servicing users to slow because there is not enough flexibility and free flow of information in the firm. And the existing information system in Pihl & Son provides insufficient information for efficient problem solving.

(2) Opportunities; a new information system can be faster and easier to use in the problem solving and project planing phases, by providing standard operating procedures with links to a knowledge warehouse.

(3) Directives; a new information system can have fixed steps for all activities in the project phases to be followed by all project managers in any project.

2.4 Data Models

The analysis of the business system existing in Pihl & Son A/S that outputs the desired product is first focused on the data that must be used in the firm. The data modeling consists of:

(1) A Context Data Model.

(2) A Key-Based Data Model.

(3) A Fully Attributed Model.

The data modeling is a technique for organizing the documenting the data that must be stored in a database. The most popular logical data modeling techniques involve drawing entity relationship diagrams. An entity is the basic construct of data modeling. Entities are described by attributes that holds data about entity instances. (Loomis 1989)

A logical data model is developed in the following stages:

Entities are discovered and defined

(1) A context data model is built, seen on Figure A.1. A context data model contains only fundamental entities and relationships. This is the only model in which non-specific relationships are shown.

(2) A key-based data model is built, seen on Figure A.2. The key-based model eliminates non-specific relationships and adds associative entities. All entities in the model are given keys.

(3) A fully attributed model is built, seen on Figure A.3. This model shows all the attributes to be stored in the system.

(4) A fully described model is built. Each attribute is defined in the Data dictionary, in Appendix C, and described in terms of properties such as domain and security.

2.5 Process Model

The Process Model consists of:

(1) Decomposition Diagram.

(2) Context Diagram for Process model.

(3) Event Diagrams.

(4) System Diagram.

Process Modeling is a technique for organizing and documenting the process requirements and design for a business system.

Process modeling can be divided into;

(1) Creating a context diagram that shows how the system interfaces to other systems, the business, and external organization. The context diagram is seen on Figure A.4.

(2) Drawing a decomposition diagram that shows the functional decomposition of a system into processes and subprocesses. It is a planning tool for subsequent data flow diagrams. The decomposition diagram is seen on Figure A.5.

(3) Creating an Event Diagram that shows its interaction with external entities, data stores. The Event Diagram is seen on Figures A.6 to A.9.

(4) Combining the event diagrams into a System Diagram. The System Diagram is seen on Figure A.10.

Context, FDD, Event Diagram, System Diagram are seen in Appendix A.

Data Dictionary for the Process Model is seen in the Appendix D.

2.6 Network Model

The network modeling is a technique for documenting the geographic structure of a system. While it was created in response to computer networks, it is equally applicable and important for describing business networks.

The network modeling consists of:

A Location Connectivity Diagram (LCD), which is a logical network modeling tool that depicts the geography of a business network in terms of its user, data, process and interface locations and the necessary communications lines that must exist between those locations. LCD is seen on Figure A.11. in Appendix A.

Data Dictionary for Network Model is seen in Appendix E.

2.7 Synchronization of Systems Model

Synchronization of Systems Models consists of;

(1) Data-to-Process-CRUD matrix.

(2) Data-to-Location- CRUD matrix.

(3) Process-to-Location-Association matrix.

System models must be synchronized for consistency and completeness. With respect to network models, they must be synchronized with both data and process models to determine which data and processes are essential to each geographic location. CRUD matrices and association matrices are tables that conveniently document these requirements and synchronize the data, process, and network models. (Whitten & Bentley 1998)

(1) Data-to-Process-CRUD matrix; The Matrix provides a simple quality check that is simpler to read than either the data or process models. The Data-to-Process-CRUD matrix is seen in Table A.1.

(2) Data-to-Location-CRUD matrix; is a table in which the rows indicate entities (and possible attributes); the columns indicate locations; and the cells (the intersection of rows and columns) document level of access where C = Create, R = Read or use, U = Update or modify, and D = Delete or deactivate. The Data-to-Location-CRUD matrix is seen in Table A.2.

(3) Process-to-Location-Association Matrix; is a table in which the rows indicate processes (event or elementary processes); the columns indicate locations; and the cells document which processes must be performed at which locations. The Process-to-Location-Association Matrix is seen in Table A.3.

Synchronization of Systems Model is seen in Appendix A.

III. PROPOSED SYSTEM

3.1 Business Requirements for New System

The new system must have the following features in order to support the Project Management, and be a frame for collection of experiences:

(1) Resource Management System covering:

(a) Time Management.

(b) Quality Management.

(c) Cost Management.

(d) Human resource Management.

(e) Standard Operating Procedures (SOP) for all Project Phases.

(2) Best Practices for solving ad hoc problems encountered in the Project Work and planning. Links in the Information System to a large database containing experiences about above requirements.

The Project aims to develop an Information System specially for the Project Management to support the management of resources in interfacing and interacting with internal and external entities such as executives, engineers, subcontractors, and clients. The aim is further more to develop a Knowledge Warehouse for collection of experiences and best practices for operating procedures and related activities.

3.2 Systems Design

Systems design is the evaluation of alternative solutions and the specification of a detailed computer-based solution. It is also called physical design.

The information system design work consist of three phases:

(1) Configuration phase; identify candidate solutions, analyze those candidate solutions, and recommend a target system that will be designed and implemented.

(2) Procurement phase; selecting appropriate hardware and/or software products for the new system.

(3) Design and Integration phase; developing technical design specifications that will guide the construction of the new system.

3.3 Configuration Phase

Configuration phase identify candidate solutions, analyze those candidate solutions, and recommend a target system that will be designed and implemented. The Configuration phase covers:

(1) Naral description of candidate solutions.

(2) Feasibility analysis of candidate solutions.

(3) Candidate Matrix.

The outcome of the configuration phase is a system proposal intended for system owners or a steering committee who will make the final decision.

3.3.1 Naral Description of Candidate Solutions

With the enterprise application architecture in mind several possible solutions for a new information system have come up for consideration. First intuitive solution is to program the system in a programming language like Visual Basic, ensuring compatibility with the MS professional software suite. Secondly comes the idea of purchasing a finished software solution from an established vendor.

For the construction business two information systems vendors are prevailing; Lotus Notes, respectively SAP. So the final choice of candidate solution comes down to 3 different solutions:

(1) A solution build up in Visual Basic around the MS Office Professional.

(2) A package solution with Lotus Notes.

(3) A package solution with SAP.

All the 3 candidate solutions fulfill the previously stated business requirements in managing the critical resources; time, money, quality and manpower. Further more they all support the project work and management with Standard Operating Procedures (SOP) providing input frames for all work.

The framework contains linkages to the Best Practices in the Organization and to an extensive database for all the experiences that the organization generated and generates.

The 3 candidate solutions are merely software solutions since a well functioning computer network already exists in the organization.

The 3 candidate solutions differ in the following ways:

Candidate 1

Candidate solution 1 is build up around the MS Professional Office combined with MS Project and MS exchange for the resource management. The experience database is MS SQL server. The GUI's, as well as the frames for the project work and management, are custom-made with Visual Basic 6.0. This solution is relatively cheap since MS licenses are already obtained.

Candidate 2

Candidate solution 2 is based on Lotus Notes systems to cover all aspects of the information system. The experience database is MS SQL server. This solution is expensive but very compatible and flexible.

Candidate 3

Candidate solution 2 is based on SAP/R3 systems to cover all aspects of the information system. Implementation of SAP/R3 requires that the database system used is INFORMIX. INFORMIX is expensive but reliable. This solution is expensive but very compatible and flexible and further more fast to implement with use of the Accelerated SAP methodology.

The three candidate solution are mapped up against each other in the Candidate Matrix in Table 3.1, for getting a overview in respect to portion of system computerized, benefits, etc.

Table 3.1. Candidate Matrix.

Items	Candidate 1	Candidate 2	Candidate 3
Portion Of System Computerized	Resource Management System, Standard Operating Procedures With Best Practices And Linkages To Experience Database	Same As Candidate 1	Same As Candidate 1
Benefits	Cheaper Than 2 And 3	Good Vendor Support Agreement	Same As Candidate 2
Servers And Workstations	Technical Architecture Dictates Windows NT Servers with Windows NT Workstations	Same As Candidate 1	Same As Candidate 1
Software Tools Needed	MS Visual Basic 6.0, And MS Access For Designing Experience Database With GUI	Custom Solution	Same As Candidate 2
Application Software	MS Professional With MS Project And AUTOCAD	Lotus Notes	SAP/R3
Method Of data processing	Client/Server	Same As Candidate 1	Same As Candidate 1
Output Devices And Implications	Technical Architecture Dictates Rank Xerox Network Laser Flatbed all-in-one for all Departments	Same As Candidate 1	Same As Candidate 1
Input Devices And Implication	Keyboard And Mouse	Same As Candidate 1	Same As Candidate 1
Storage Devices And Implications	MS SQL Servers DBMS With 1000 GB Arrayed Capacity	Same As Candidate 1	INFORMIX database is required.

3.3.2 Feasibility Analysis of Candidate Solutions

Feasibility is defined as the measure of how beneficial or practical the development of an information system will be to an organization. Feasibility analysis is the process by which feasibility is measured.

For each candidate solution the Feasibility analysis is carried out in the following contexts;

(1) Technical feasibility.
   (a) Technology.
   (b) Expertise.
(2) Operational feasibility.
   (a) Functionality.
   (b) Political.
(3) Economic feasibility.
   (a) Cost to develop.
   (b) Payback period.
   (c) Net Present Value.
   (d) Return On Investment.
(4) Schedule feasibility.
   (a) The speed and accuracy with which the project is implemented.

Economic feasibility analyses are conducted on Microsoft Excel spreadsheets seen on the Tables B.1 to B.7. All tables are seen in Appendix B. All 4 feasibility context aspects are shown in the scoring matrix against the existing system in Table 3.2.

The feasibility study is the comparison of development cost respectively benefits derived from the solution, and is then compared to the existing system.

The payback periods are shown on Figures B.1 to B.4.

Comments on the Economic Feasibility Analysis

Regarding the benefits from the new system, the benefits are categorized into;

(1) Tangible benefits.

(2) Intangible benefits.

Tangible Benefits

(a) Reduced errors in project work. Each error is estimated to be committed in average to 10.000 DKK once a week on an organizational level. Approximately 520.000 DKK/year.

(b) Faster project work;_Projects are estimated to be completed 10% faster, hence increasing throughput and total sales 10%, and profits are 5% of sales (current sales about 1 billion Kr.). Approximately 5.000.000 DKK/year.

(c) Faster and production of bids for tenders; Proposals estimated to be completed 50% faster, present average proposal cost is 1 million Kr. (With one proposal a month). Approximately 6.000.000 DKK/year.

Total tangible benefits; 11.520.000 DKK/year.

DKK is abbreviation for Danish Krone, 1 US$ = 8 DKK.

Intangible Benefits

(a) A new employee reaches higher productivity at a shorter time.

(b) Valuable knowledge of retired employees are kept in the organization.

(c) Higher employee satisfaction.

(d) Level of knowledge sharing and proactive vision attracts best potential employees from academic environments.

(e) Creating a better cooperation with customers and suppliers.

Table 3.2. Scoring Matrix.

Feasibility Criteria	Weight	Candidate 1	Candidate 2	Candidate 3
Technical – technology – expertise	10%	Custom-made software can be made exactly as desired Extra VISUAL BASIC programmers must be hired Score: 95	Package solutions are very compatible LOTUS NOTES consultants must be hired Score: 90	Package solutions are very compatible SAP/R3 consultants must be hired Score: 90
Operational – functionality – political	40%	The system requires training, and will improve most work procedures The system is backed up by management Score: 75	The system requires training, and will improve most work procedures The system is backed up by management and welcomed by most users Score: 85	The system requires training, and will improve all work procedures The system is backed up by management and welcomed by all users Score: 95
Economic –cost to develop –payback period –NPV –return on invest.	10%	647.500 DKK 6 Months. 56.159.382 DKK 8673% Score: 87	2.597.500 DKK 9 Months. 54.200.674 DKK 2087% Score: 21	3.607.500 DKK 10 Months. 53.186.254 DKK 1477% Score:15
Schedule	40%	About 6 months Score: 45	Less than 4 months Score: 75	Less than 3 months Score: 95
Ranking	100	67	75	86

As seen from the Scoring matrix the SAP/R3 System will be chosen as the enterprise software suite as well as for the foundation of a Knowledge Warehouse for collection of experiences from Project Managers - collection of unstructured knowledge for decision making.

A Knowledge Warehouse must include the following functionality:

(a) Web check-in, authoring and editing. All users can check in information via the browser interface. Those responsible for web content can edit text and set links within the browser interface as well.

(b) A Document Modeling Workbench providing pre-configured models for various types of documents and information structures, to guarantee consistency between all types of information.

(c) A Performance Assessment Workbench providing a highly flexible, all-purpose testing environment. It must include tools for creating, delivering, and accessing tests on-line, ranging from simple self-tests to sophisticated certification scenarios.

(d) Integration with Document Management System of Product Lifecycle Management makes it possible to attach information objects to business objects along the product lifecycle. For example, any product document can be linked to the document master.

(e) Connection to business workflows automatically trigger events when information objects are created or changed. For example, when a content developer changes a document, the approval or copy-editing process can be automatically started. (Patterson 1998)

3.4 Procurement Phase

Procurement phase is about selecting appropriate hardware and/or software products for the new system.

This section covers describes the application architecture for the target system.

The deliverable of the procurement phase is the contract order that would be sent to the winning vendor. In addition a set of integration requirements is created for ensuring that the vendors products will work in harmony with other product systems.

Application Architecture for Target System

Application architecture defines the technologies to be used by one or more information systems.

There are four categories of technology:

(a) Network.

(b) Data.

(c) Interface.

(d) Process.

The proposed system is fully compatible with the existing enterprise architecture, since we are merely talking about a software solution. In order to optimize the system an upgrade from Windows NT 4.0 to Windows 2000 is recommended.

A new Information System including a knowledge management system must provide a Web-enabled information-gathering environment, rich content, and powerful tools to create a network of information resources for transferring knowledge and enhancing employee performance. This Knowledge Management System helps Pihl & Son A/S manage all types of unstructured information, and deliver that information to those Project Managers who need it.

The new Information System including a knowledge management system provides a solid foundation for Pihl & Son A/S business intelligence requirements. Decision-support and analysis solutions, such as Strategic Enterprise Management, complete the picture to provide an industry-wide, strategic business perspective.

Because the Knowledge Warehouse is integrated with the Enterprise Information System, it supports the access of the full range of role-specific and general information Project Managers need to do their jobs. This information may include context-sensitive

help from within business transactions, links to related materials or external sources, links to relevant courses or documents, and access to portals, people, and projects.

3.5 Design and Integration Phase

The Design and Integration phase is about developing the technical design specifications that will guide the construction of the new system.

The Design and Integration phase covers the following items;

(1) Physical DFD for target system.

(2) Database design for target system.

(3) Knowledge Management Mapping.

(4) Structure chart (software design).

(5) Input & output user interfaces.

The output of the design and integration phase is the technical design statement. This output will guide the system builders as the project moves on to construction.

3.5.1 Physical DFD for Target System

Physical data flow diagrams model an information system's application architectures and processes. Because they show the planned implementation of all processes, data stores, and data flows, they serve as a general system design or blueprint for subsequent detailed design, prototyping and construction. (Elliason 1998)

Physical data flow diagrams are constructed from;

(1) Logical data model.

(2) Logical process model.

(3) Logical network model.

Physical Data Flow diagrams consist of;

(1) Data Distribution DFD:

How will data stores on the logical DFD's be physically stored and how will they be implemented. The Data Distribution DFD is seen on Figure B.5.

(2) Network Topology DFD:

Allocates processors and devices to network and establishes:

(a) The connectivity between the clients and servers.

(b) Where users will interact with the processors.

The Network Topology DFD is seen on Figure B.6.

(3) Process Distribution DFD, or physical DFD design unit for an event: The logical event diagrams must be assigned to processors and partitioned accordingly so that each physical DFD corresponds to a design unit for a given business event. The physical DFD design unit for an event is seen on Figures B.7. to B.8.

Network Topology DFD, Data Distribution DFD and physical DFD design unit for an event are seen in Appendix B.

3.5.2 Database Design for Target System

Database design is the process of translating logical data models into physical database schemas. The Database Schema is the physical model or blueprint for a database, based on the chosen database technology.

The starting point is the fully attributed and normalized entity relation diagram (ERD). The rules for transforming a logical data model into a physical database schema are as follows:

(1) Each entity becomes a table.

(2) Each attribute becomes a field.

(3) Each primary and secondary key becomes an index into the table.

(4) Each foreign key implements a possible relationship between instances of the table.

The database Model suggested is relational because of the flexibility and scalability of the model. Pihl & Son A/S is expecting the database to grow rapidly with the addition of more and more experiences and knowledge. (Date 1995)

The Logical data Model in Normalized form, showing the addition of the Recipe and Experience, comprising the enhanced system, is seen on Figure B.9. in Appendix B.

3.5.3 Knowledge Management Map

A Knowledge Management Information System supports the development and transfer of knowledge within the organization. It also provides an environment for making the most of all the knowledge assets. (Andersen 1994)

The Knowledge Warehouse supports knowledge development and transfer by providing:

(1) A single repository that eliminates redundancy, simplifies maintenance, and provides worldwide distributed access.

(2) A suite of tools that facilitate authoring, production, translation, distribution, delivery, and retrieval.

(3) Optional reusable content, which can greatly speed up information development and delivery.

When trying to map the organizations Knowledge, it must be done in following steps;

(1) Knowledge Development depicted in Table 3.3.

(2) Knowledge Transfer depicted in Table 3.4

(3) Knowledge Content depicted in Table 3.5.

Knowledge Development

Table 3.3. Knowledge Development.

Planning	Design	Authoring	Production	Translation
Needs Analysis Information Landscape Planning Curriculum Planning Documentation Planning Translation Planning Deployment Planning	General Information Design Documentation Design Training Material Design Quality Management	Knowledge Capture and Evaluation Information Structuring Writing and Content Assembly Indexing Attribute Definition Quality Management	Production Planning Conversion to Distributable Media Archiving Quality Management	Translation Management Localization Management Quality Management

Planning is essential for any information project. Unless projects are based on a comprehensive needs analysis and carefully defined priorities, they can easily slip out of control. During the Design phase, the product's appearance and interface is defined, as well as strategies for navigation, searches, and error recovery.

To facilitate the Authoring phase, Drag & Drop must be provided for structuring of existing materials, editing capabilities in native applications such as Word and PowerPoint, and simulation tools for developing system demonstrations and interactive exercises. The authoring tools also must provide hyper-link management for creating links within various types of content. In the Production phase, the tools should automatically convert documents to the appropriate presentation format - for example, Word documents are converted to HTML and PowerPoint files to GIF. Print support must be available for creating handouts, documents, and manuals. In the Translation

phase, tracking different versions and translation workflow is essential. The Knowledge Warehouse must track the status of translations and makes it possible for translators to work in the native application. In addition, the tools must provide check-out functionality to facilitate working with external translation agencies.

Knowledge Transfer

Table 3.4. Knowledge Transfer.

Distribution	Delivery & Execution	Retrieval	Feedback	Controlling
Online Distribution Offline Distribution Customized Distribution	Training Presentation Training Administration Assessment Tracking	Keyword, Index & Full-Text Search Context-based Search Information Filtering Assistants & Agents	Feedback Capture Usefulness Rating Trend Capture Feedback Incorporation	Cost Controlling

Once the materials have been developed, managing the various stages of knowledge transfer becomes a central concern.

In the Distribution stage, the tools in the Knowledge Warehouse provide for the instant, worldwide replication of information. No presentation tool should be required; all courses and documentation must be displayed in a standard Web browser. Because content structure can be represented by any number of logical information objects that are related to a single physical object in the System, it is possible to display only the specific content that matches a user's language, version, industry, or other characteristic.

In the Delivery and Execution phase, the assessment and tracking tools must help ensure that learning goals are met and that individual users can track their progress.

In addition, integration with the HR Personnel Development component makes that information available to those who monitor employee qualifications, while integration with the HR Training and Event Management component automates training administration.

Information is only as good as the user's ability to find it. For that reason, the Knowledge Warehouse must include full-text and keyword searching. In addition, authors can greatly assist their users in finding related information by linking between training materials, and documentation.

To achieve and maintain a high level of usability requires the efficient incorporation of feedback during the Feedback Management phase.

The Knowledge Warehouse provides the means to incorporate both factual corrections of content as well as trends in the overall strategy and design.

Finally, integration with Controlling will make it possible to analyze project costs and to incorporate that information into future planning for resource requirements and for scheduling.

Knowledge Content

Table 3.5. Knowledge Content.

Business Knowledge	Product Knowledge	Training Material	Documentation
Data/Process Models Implementation Models Information Query Solutions Business Knowledge	Brochures Product Information Kits Basis Knowledge Application Knowledge	Core Training Industry-Specific Training Material Role-Based Training Team Training Training System Data Simulation Data Standards	Conceptual Documentation How-to Information Field-Level Help Glossary Release Notes Standards

To facilitate the exchange of knowledge in general and to optimize the implementation and use of the System specifically, the following types of content must be continually extended:

(1) Business knowledge, which includes data, process, and implementation models that can be used as a basis for shaping models. By making information queries into a Solutions database, a pool of information can be accessed and contributed to, and grows with the experience. And by accessing materials that provide specific business knowledge, Pihl & Son can gain the perspective that puts information into the necessary business context.

(2) Product Knowledge for matching business needs to functionality include Fact Sheets, which provide product overviews, White Papers, which include technical details. In addition, booklets must provide detailed functional information about how particular technical topics affect business processes.

(3) Training Material that provides for the specialized needs of the construction industry. For flexible and independent learning, self-study options must be offered in various delivery formats. These materials must include the Basis Knowledge Products to extend the knowledge of technical training courses, and a series of Computer Based Training courses for as-needed access to end-user training.

(4) Documentation, which provides both the conceptual information needed to customize the System and procedural information to use as the basis of end-user materials. In addition, context-sensitive help must always be at the user's fingertips. A glossary that defines unfamiliar terms should be available as well. Because consistency is a key usability factor in

documentation, the Knowledge Warehouse should contain the supporting tools used for the quality control of materials.

3.5.4 Structure Chart (Software Design)

In designing the software for the information system to be implemented two following steps are taken;

(1) Modular design; the decomposition of a program into modules. A module is a group of executable instructions with a point of entry and a single point of exit.

(2) Packaging is the assembly of data, process, interface and geography design specification for each module.

The primary tool used in structured design is the structure chart.

Structure charts are used to graphically depict a modular design of a program, and are constructed on the basis of DATA FLOW DIAGRAMS. (Whitten & Bentley 1998)

There are two approaches:

(1) Transform analysis; is an examination of the DFD to divide the processes into those that perform input and editing, those that do processing or data transformation, and those that do output.

(2) Transaction analysis; is the examination of the DFD to identify processes that represent transaction centers, - a process that does not do actual transformation on the incoming data.

The two measures of quality of structure charts are coupling and cohesion. A sample Structure Chart is seen on Figure B.10. in Appendix B.

3.5.5 Input & Output User Interfaces

The steps in designing and prototyping a user interface includes;

(1) Charting the dialogue.

(2) Prototyping the dialogue and user interface.

(3) Obtaining user feedback.

Input Design

Business Transactions creates data, -keypoints regarding Input design includes;

(1) Data capture is the identification of new data to be inputted.

(2) A Source document is a paper form used to record data that will eventually be inputted to a computer.

(3) Data entry is the process of translating the source document into a machine-readable format.

(4) Data input is the actual entry of data in a machine-readable format into the computer.

Most new applications developed uses Graphical User Interfaces, as seen on Figure B.11. Inputs must be designed simple to reduce the possibility of faulty inputs, see Figure B.12.

Output Design

Outputs consist of external and internal outputs.

The following general principles are important for output design:

(1) Computer outputs should be simple to read and interpret.

(2) The timing of computer outputs are important.

(3) The distribution of computer outputs must be sufficient to assist in all relevant system users.

(4) The computer outputs must be acceptable to the system users who will receive them.

The design and prototyping involve the following steps:

(1) Identify system outputs.

(2) Select output medium and format.

(3) Prototype the output for systems users. Example is seen on Figure B.13.

Switch Board, Input/ Output screens for the Project Management are seen in Appendix B.

3.6 Security and Control

Pihl & Son A/S is using Microsoft Windows NT network operating system which has built-in comprehensive security features. A single log on to the Windows NT-based domain allows user access to resources anywhere in the corporate network. The system provides tools for security policy and account management, and the Windows NT domain model is flexible and can support a wide range of network configurations.

Windows NT 5.0, that Pihl & Son will upgrade to, extend these features to provide support for Internet-aware enterprise networks and the distributed services included in the operating system.

The primary goal of the Security is to provide a single point of administration for Windows NT-based system security.

To provide comprehensive security administration and information, configuration and analysis all of the following features must be possible:

(1) Account Policies – set access policy, including domain or local password policies, domain or local account lockout policy.

(2) Local Policies – configure local audit policy, user rights assignment, and various security options such as control of floppy disk, CD-ROM, and so forth.

(3) Restricted Groups – assign group memberships for built-in groups such as Administrators, Server Operators, Backup Operators, Power Users, and so forth.

(4) System Services – configure security for the different services installed on a system, including network transport services such as TCP/IP, NetBIOS, File Sharing, Printing, and so forth.

(5) File/Folder Sharing – This sub-area allows to configure settings for Windows NT File Server (NTFS) and Redirector service. These include options to turn off anonymous access and to enable packet signatures and security when accessing various network file shares.

(6) System Registry – to set the security on system registry keys.

(7) System Store – set the security for local system file volumes and directory trees.

(8) Directory Security –to manage the security on objects residing in the Windows NT 5.0 Active Directory.

Windows NT Distributed Security Services has features to simplify domain administration, improve performance, and integrate Internet security technology based on public-key cryptography, including:

(1) Integration with the Windows NT Server Directory Service (the Active Directory) to provide scalable, flexible account management for large domains, with fine-grain access control and delegation of administration.

(2) Kerberos Version 5 authentication protocol, a mature Internet security standard, is implemented as the default protocol for network authentication and provides a foundation for authentication interoperability.

(3) Strong authentication using public-key certificates, secure channels based on Secure Sockets Layer version 3.0, and CryptoAPI version 2.0 deliver industry-standard protocols for data integrity and privacy across public networks.

To protect the Information System against virus following will be implemented:

(1) VirusScan for Windows NT.

Employs advanced technologies to detect and remove memory, boot, multi-partite, stealth and polymorphic viruses.

(2) InterScan E-Mail VirusWall for NT.

Is a real time virus scanner that scans incoming email and attachments for possible virus infection. It also scans incoming FTP and WWW transfers and is designed to check compressed and encoded formats such as MIME, Zip, and UUencode. Built in proxy servers compatible with existing LAN firewall.

Reliability and Fault Tolerance

Pihl & Son A/S relies on Windows NT to provide reliability and fault tolerance.

The system ensures high availability of information and services in three ways: by uniformly handling hardware and software system faults, protecting user programs from each other as well as the system, and providing data and system recovery mechanisms. Windows NT Server has the ability to tolerate faults while still maintaining the availability of the system, applications, network resources, and data.

Windows NT Server includes the following reliability and fault tolerance capabilities:

(1) Error handling and protected subsystems.

(2) Recoverable file system.

(3) Automatic restart.

(4) Tape backup support.

(5) Uninterruptible power supply (UPS) support.

(6) Disk mirroring.

(7) Disk duplexing.

(8) Disk striping with parity (RAID 5).

IV. PROJECT IMPLEMENTATION

4.1 Overview of Project Implementation

Systems implementation is the construction of the new system and the delivery of that system into production. Systems implementation contains following phases:

(1) Identification of main objects.

(2) Construction.

(3) Delivery.

(4) Testing.

4.2 Identification of Main Objects

Object-Oriented-Analysis (OOA) techniques are used to;

(1) Study existing objects to see if they can be reused or adapted for new uses.

(2) Define new or modified objects that will be combined with existing objects into a useful business computing application.

OOA uses primarily Object Modeling; -a technique for identifying objects within the systems environment and the relationships among those objects.

Definitions:

Objects; -something that is or capable of being seen, touched or otherwise sensed, and about which users store data and associate behavior.

Attributes; -the data that represent characteristics of interest about an object.

Behavior; -those things that an object can do and that correspond to functions that act on the objects attributes.

Main Objects in the System, their Attributes and Behavior are shown in Table 4.1 on next page.

Table 4.1. Main Objects in the System; Attributes and Behavior.

Objects	Attributes	Behavior
Project	Project name Location Date	Is worked on Progressing Stops
Engineer	Social security number Name Address	Works on project Promoted Fired
Subcontractor	Category Company name Address	Supports project Canceled Creates delays
Budget	Type Budget number	Limits expenses Is kept/exceeded
Experience	Type Date Experience number	Created Updated Read
Recipe	Activity Procedure Step	Followed Created Updated
Client	Project Name Date	Makes payments Orders a project Default payments
Executive	Position Rank	Approves project Cancels project
Material supplier	Type Project Company name Address	Supplies on time Faulty deliveries Creates delays Requires payments
Information system	Functions Specification	Increases productivity Breaks down

4.3 Construction

The purpose of the construction phase is two fold:

(1) To build and test a functional system that fulfills business and design requirements, and

(2) To implement the interfaces between the new system and existing production systems.

The construction phase consists of two activities:

(1) Build and test new INFORMIX database.

(2) Install and test SAP/R3 software package.

4.4 Delivery

The delivery phase consists of the following activities:

(1) Conducting a system test.

(2) Preparing a systems conversion plan.

(3) Installing INFORMIX database.

(4) Training project managers

(5) Converting from old to new system.

Pihl & Son A/S will convert to the new system in the following pattern:

(1) Parallel conversion; both the old and new system are operated for a period of some time to ensure that all major problems in the new system are solved before the old system is discarded.

(2) Location conversion; the SAP/R3 system will be used at several geographical locations, therefore it will be converted to the head office first, then following approval, farmed to other sites.

4.5 Testing

The systems acceptance test is the final opportunity for project managers, management, engineers and information systems operations management to accept or reject the system. (Whitten & Bentley 1998)

A systems acceptance test is a final system test performed by the project managers using real data over an extended period of time. It is an extensive test that addresses three levels of acceptance:

(1) Verification testing; runs the data in a simulated environment using simulation data.

(1) Verification testing; runs the data in a simulated environment using simulation data.

(2) Validation testing; runs the system in a live environment using real data, -a beta test.

(3) Audit testing; certifies that the system is free of errors and ready to be placed into operation.

V. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The Project Management is to be supported by a new Information System, because each project is unique, and the most valuable asset in performing the project management is the project manager's experience. So the company has initiated an Information System Analysis and Development for collecting and making these individual experiences collective experiences.

After performing an Information System Analysis the new system is required to have the following features in order to support the Project Management, and be a frame for collection of experiences;

(1) Resource Management System covering:

(a) Time Management.

(b) Quality Management.

(c) Cost Management.

(d) Human resource Management.

(2) Standard Operating Procedures (SOP) for all Project Phases.

The information system development the design specifications have been determined.

From the Configuration phase candidate solutions have been identified, candidate solutions analyzed, and a target system that will be designed and implemented has been recommend. The solution is SAP/R3 software suite chosen because of a fast implementation and comprehensive functionality.

From the Procurement phase appropriate hardware and/or software products for the new system has been determined, in the sense that an enterprise application

architecture strategy already exists. The new system will run on Windows NT servers with Windows NT workstations supported by a MS SQL server as well as Microsoft Internet Information.

From the Design and Integration phase technical design specifications that will guide the construction of the new system that has been developed, in the form of database design, software structure charts and graphical user interfaces has been created.

Table 5.1. The Degree of Achievement of the Proposed System.

Process	Existing System	Proposed System
Reduced errors in Projects	Once a week	0.1 error pr. week
Faster Project work	100 days	90 days
Faster Bid for tender	30 days	14 days

Now the system is ready for implementation, continual enhancement -and system support will be required.

5.2 Recommendations

It is recommended that a SAP/R3 System will be chosen as the enterprise software suite, as well as the foundation of a Knowledge Warehouse for collection of experiences from Project Managers,- unstructured knowledge for decision making. Therefore the database system must be changed to INFORMIX.

Otherwise the proposed system is fully compatible with the existing enterprise architecture, and in order to optimize the system, it is recommended that Pihl & Son

upgrade their Windows NT 4.0 to Windows NT 5.0 (or Window 2000) network servers with Windows NT workstations as well as Microsoft Internet Information Server.

Pihl & Son A/S must keep in mind that many Information System Implementation Projects fail due to a lack of resources in spending on training end-users.

Therefore it is recommended that extensive training is arranged for all project managers including training Material providing for the specialized needs of the construction industry, as well as a series of Computer Based Training courses for as-needed access to end-user training.

For flexible and independent learning, self-study options must also be offered in various delivery formats, such as e-learning, CD-ROMs, Intranet, etc.

APPENDIX A

EXISTING SYSTEM MODELS

Table A.1. Data-to-Process CRUD-Matrix.

Enitity-Attribute	Project Scheduling	Subcontractor Interfacing	Quality Assurance	Material Controling	Budgetting	Expences	Accounting	Engineers Management	Site Management
Project	CRUD	R	R	R	R	R	R	R	R
-Project Number	CRUD	R	R	R	R	R	R	R	R
-Project Name	CRUD	R	R	R	R	R	R	R	R
-Location	CRUD	R	R	R	R	R	R	R	R
-Date	CRUD	R	R	R	R	R	R	R	R
Project Manager	R								CRUD
-Project Manager No	R								R
-Managed Projects	R								
Engineer	CRUD							RU	CRUD
-Engineer Number	CRUD							RU	R
-Engineering Field	CRUD							RU	R
Subcontractor	R	CRUD	RU	CRUD		CRU			R
-Subcontractor No.	R	CRUD	R	R		RU			R
-Category	R	CRUD	RU	RU		RU			R
-Company Name	R	CRUD	R	R		RU			R
-Address	R	CRUD	R	R		RU			R
Budget									R
-Budget Number									R
-Type									R
-Date									R
Receipe	CRUD								CR
-Receipe Number	CR								CR
-Activity	CRUD								CR
-Procedure	CRUD								
-Step	CRUD								
Experience	CRU	CRU	CRU	CRU	CRU	CRU	CRU	CRU	CRU
-Experience Number	CRU	CRU	CRU	CRU	CRU	CRU	CRU	CRU	CRU
-Type	CRU	CRU	CRU	CRU	CRU	CRU	CRU	CRU	CRU
-Date	CR	CR	CR	CR	CR	CR	CR	CR	CR

C=create R=read U=Update D=delete

Table A.2. Data-To-Location CRUD-Matrix.

Enitity-Attribute	Project Managers, Head Office	Executives, Head Office	Project Managers, Construction Site	Engineering Department	Subcontractors	Material Suppliers	Clients
Project	ALL	ALL	INDV	INDV	INDV	INDV	INDV
-Project Number	CRUD	R	R	R	R	R	X
-Project Name	CRUD	R	R	R	R	R	R
-Location	CRUD	R	R	R	R	R	R
-Date	CRUD	R	R	R	R	R	R
Project Manager	SS	ALL	SS	INDV	INDV	INDV	R
-Project Manager Number	R	R	R	R	X	X	X
-Managed Projects	R	R	R	R	X	X	R
Engineer	INDV	ALL	INDV	SS	INDV	X	X
-Engineer Number	R	R	R	CRUD	X	X	X
-Engineering Field	R	R	R	CRU	R	X	X
Subcontractor	INDV	ALL	INDV	R	SS	SS	X
-Subcontractor Number	R	R	R	R	X	X	X
-Category	R	R	R	RU	X	X	X
-Company Name	R	R	R	RU	R	R	X
-Address	R	R	R	RU	R	R	X
Budget	INDV	ALL	INDV	INDV	X	X	X
-Budget Number	CRUD	R	R	R	X	X	X
-Type	CRUD	R	R	R	X	X	X
-Date	CRUD	R	R	R	X	X	X
Receipe	ALL	ALL	ALL	ALL	X	X	X
-Receipe Number	CRU	R	RU	CRU	X	X	X
-Activity	CRU	R	RU	CRU	X	X	X
-Procedure	CRU	R	RU	CRU	X	X	X
-Step	CRU	R	RU	CRU	X	X	X
Experience	ALL	ALL	ALL	CRU	X	X	X
-Experience Number	CRU	R	CRU	CRU	X	X	X
-Type	CRU	R	CRU	CRU	X	X	X
-Date	CRU	R	CRU	CRU	X	X	X

INDV=individual ALL=all SS=subset X=no access C=create R=read U=update D=delete

Table A.3. Process-to-Location Association-Matrix.

Process/ Location	Project Managers, Head Office	Executives, Head Office	Project Managers, Construction Site	Engineering Department	Subcontractors	Material Suppliers	Clients
Project Scheduling	X	X	X	X			X
Subcontractor Interfacing	X		X	X	X	X	
Quality Assurance	X		X	X			
Material Controling	X		X	X			
Budgetting	X	X	X	X			
Expences	X	X	X	X			
Accounting	X	X	X				
Engineers Management	X		X	X			
Site Management	X		X	X			

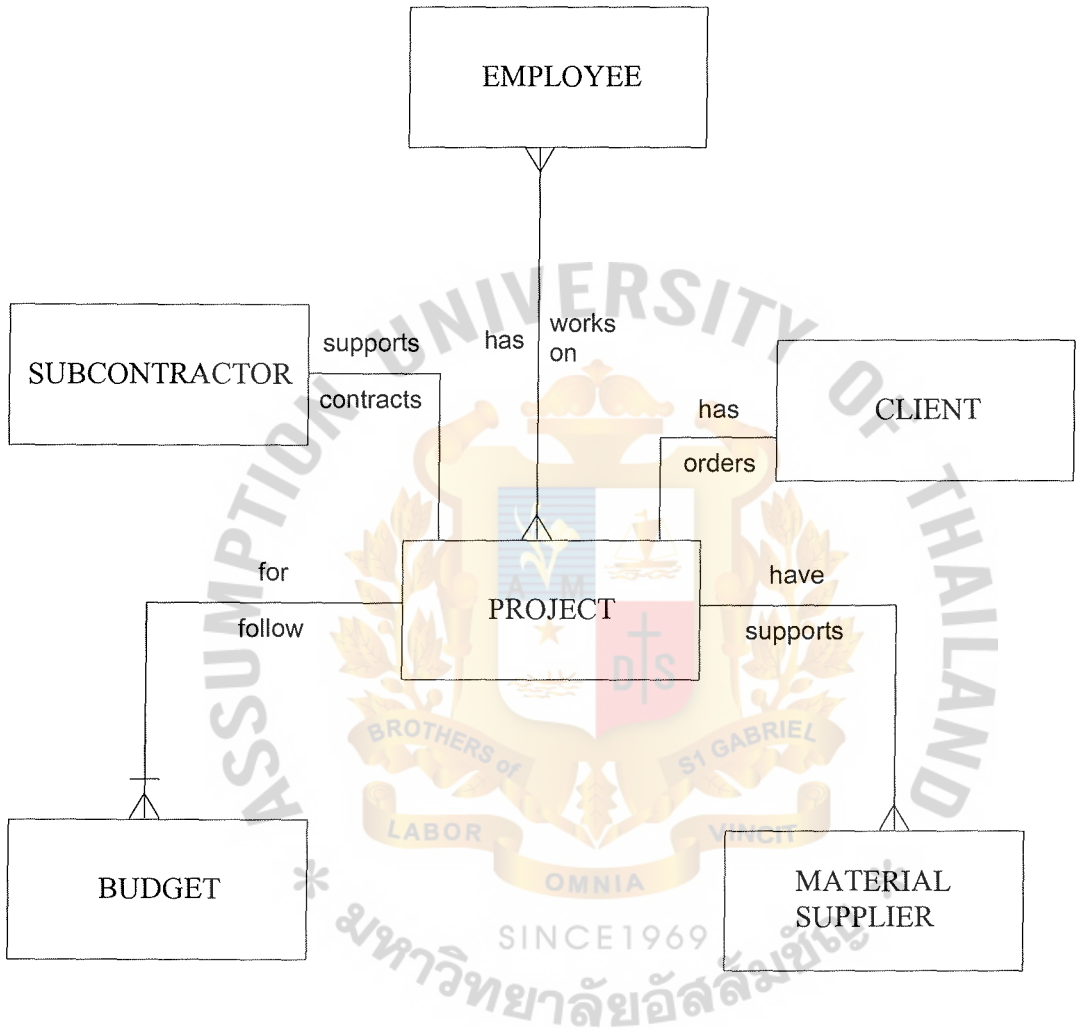

Figure A.1. Context Data Model.

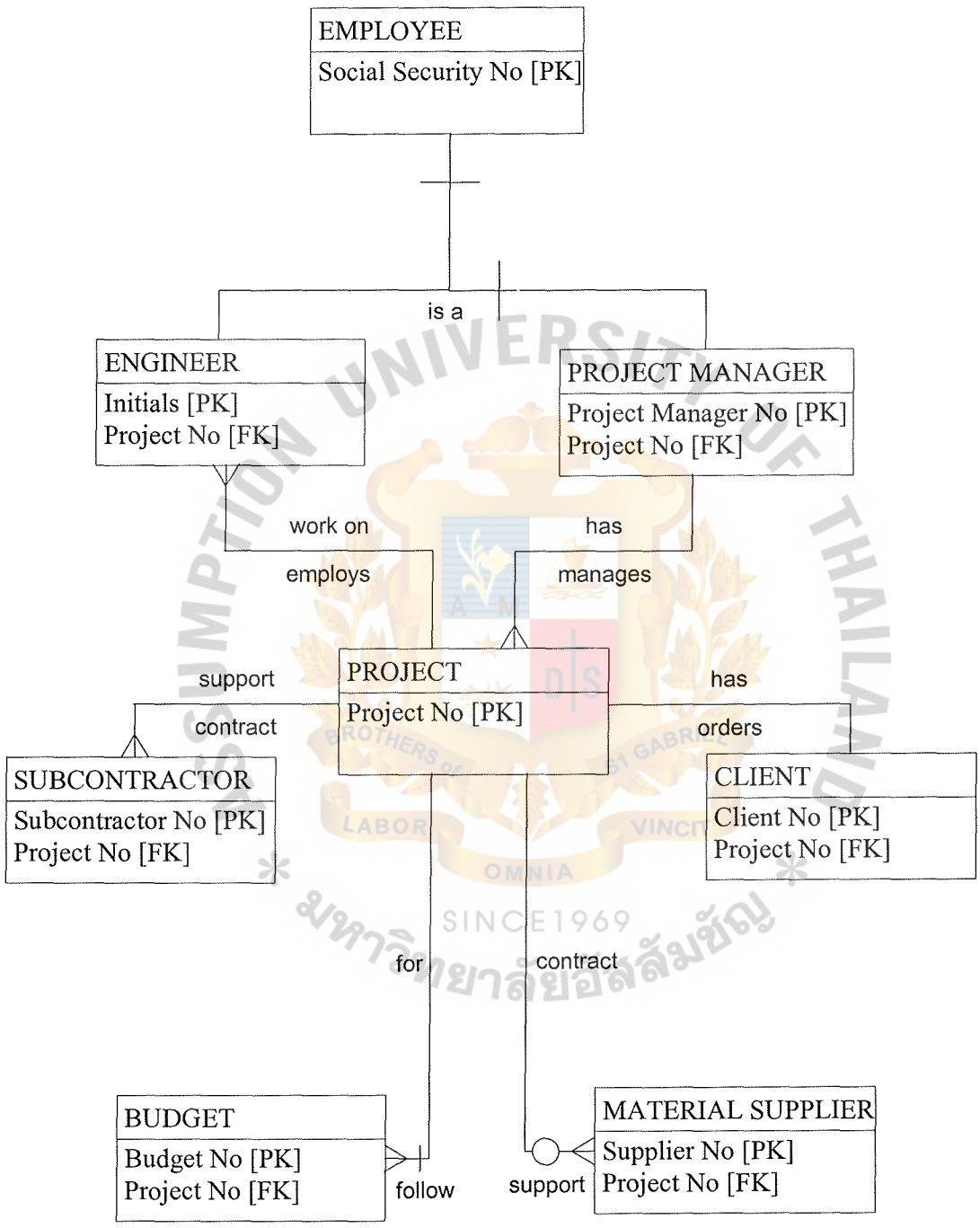

Figure A.2. Key-Based Data Model.

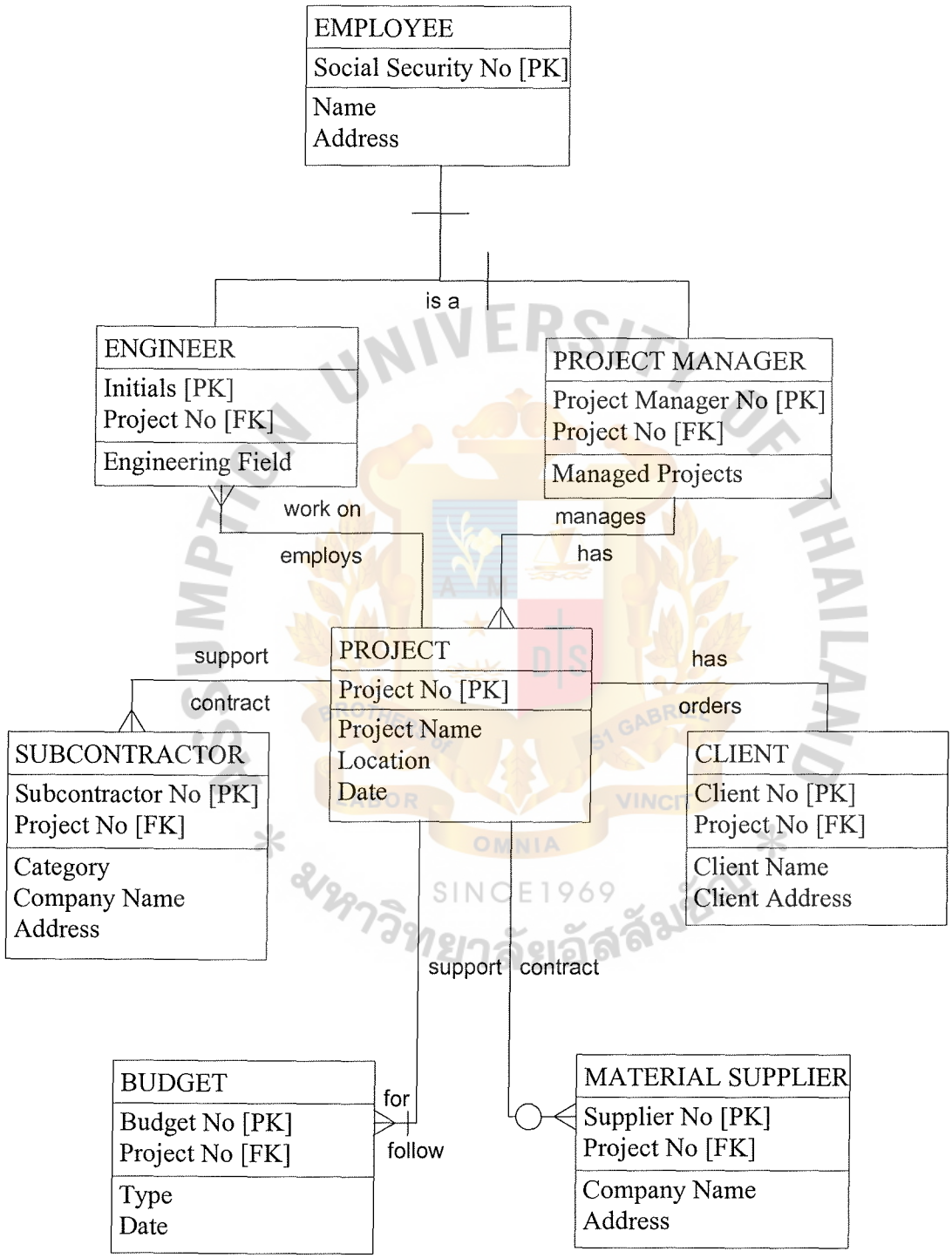

Figure A.3. Full-Attribute Data Model.

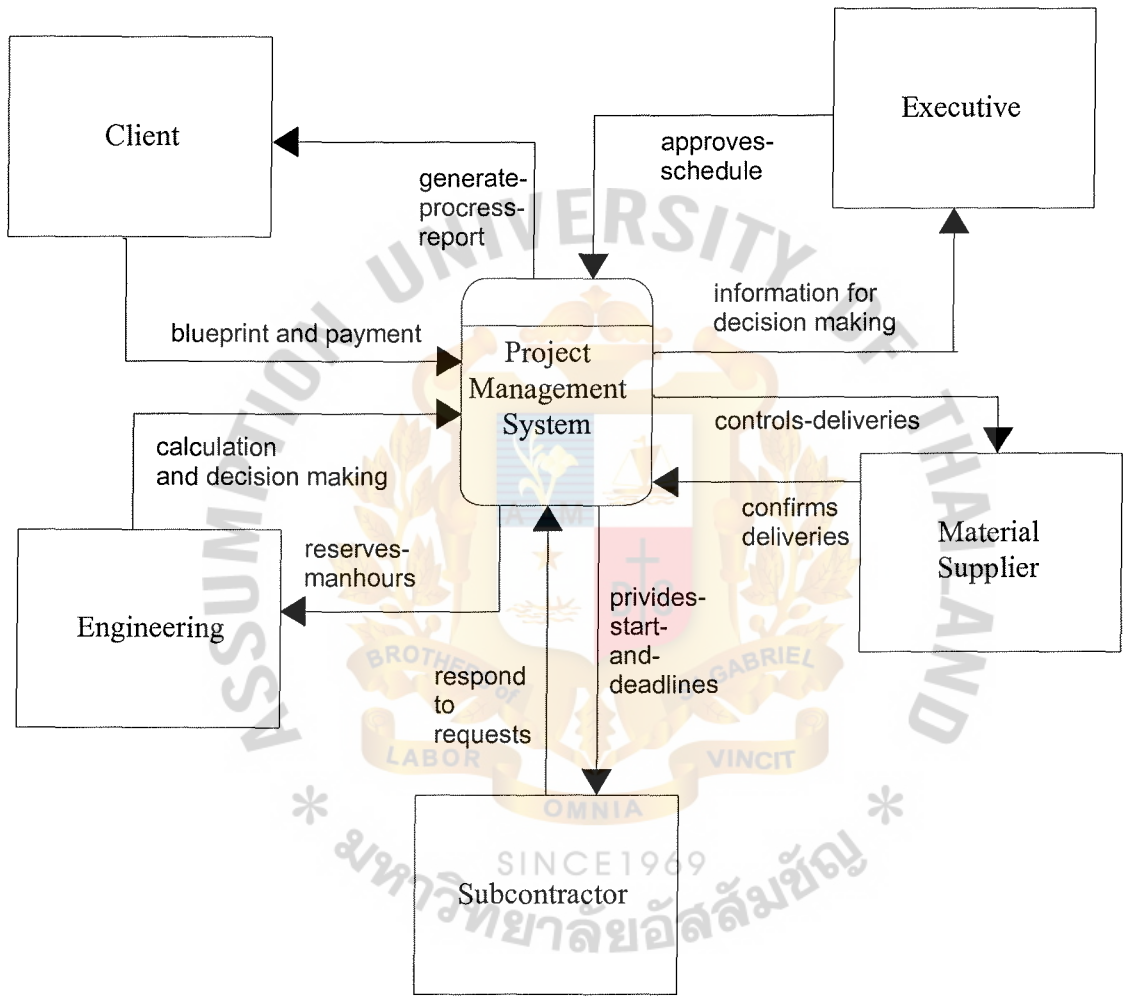

Figure A.4. Context Diagram for Process Model.

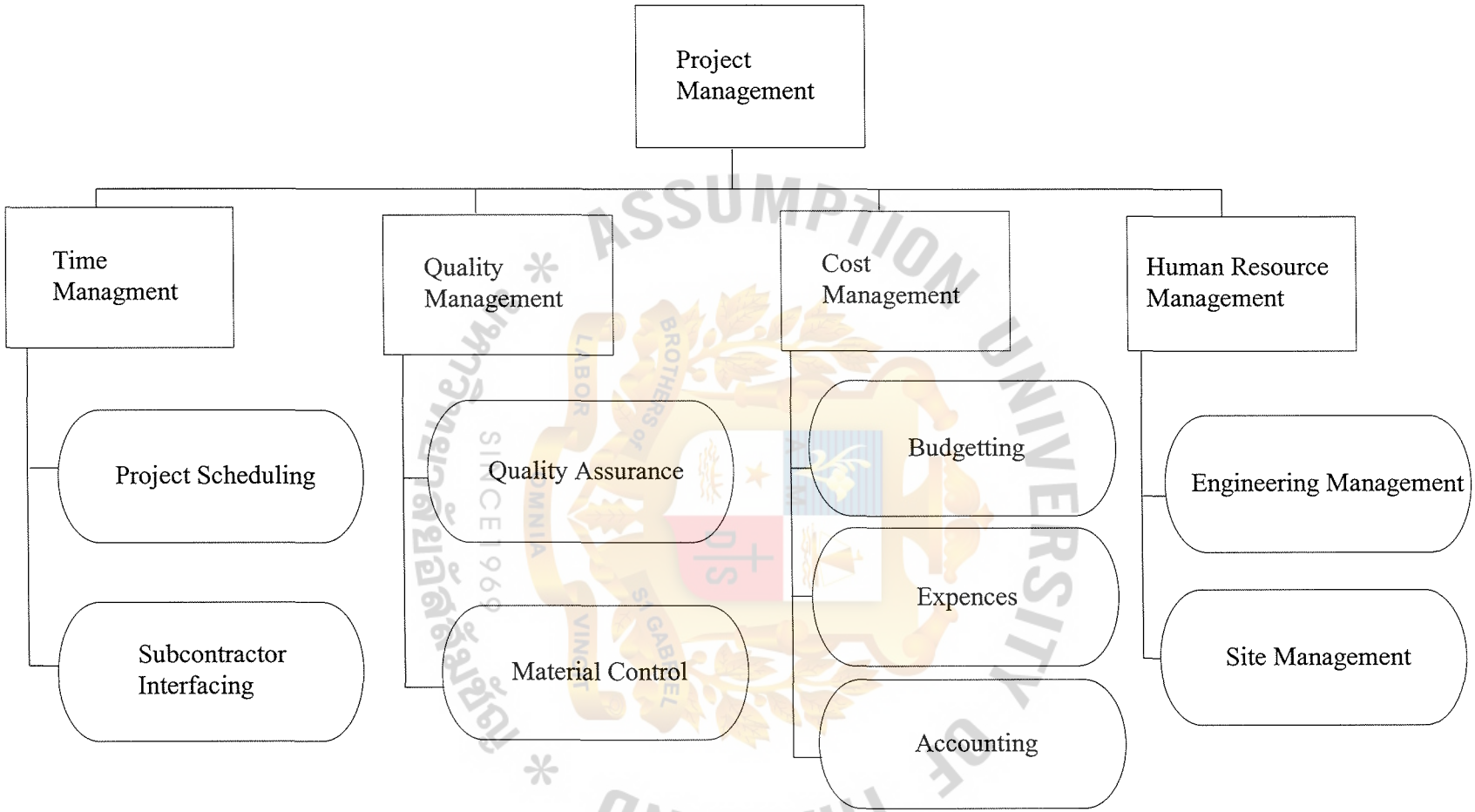

Figure A.5. Decomposition Diagram.

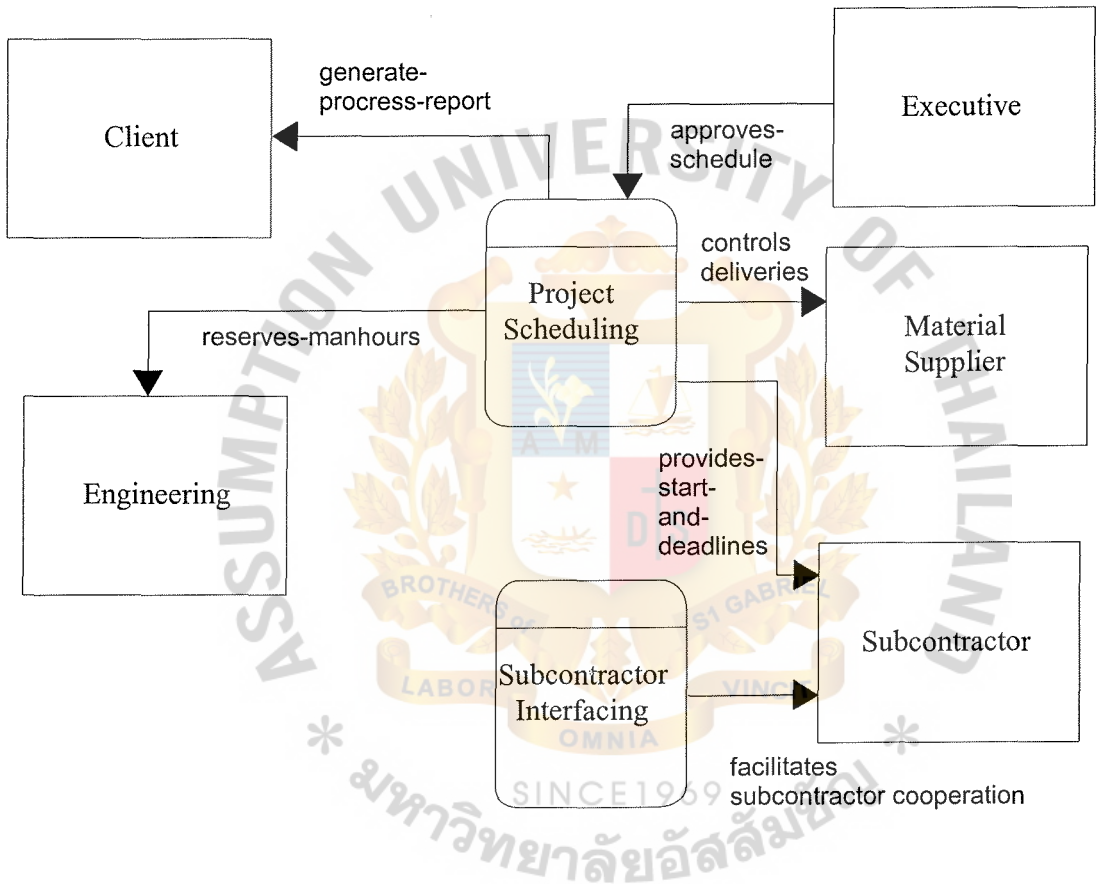

Figure A.6. Event Diagram, 1 of 4.

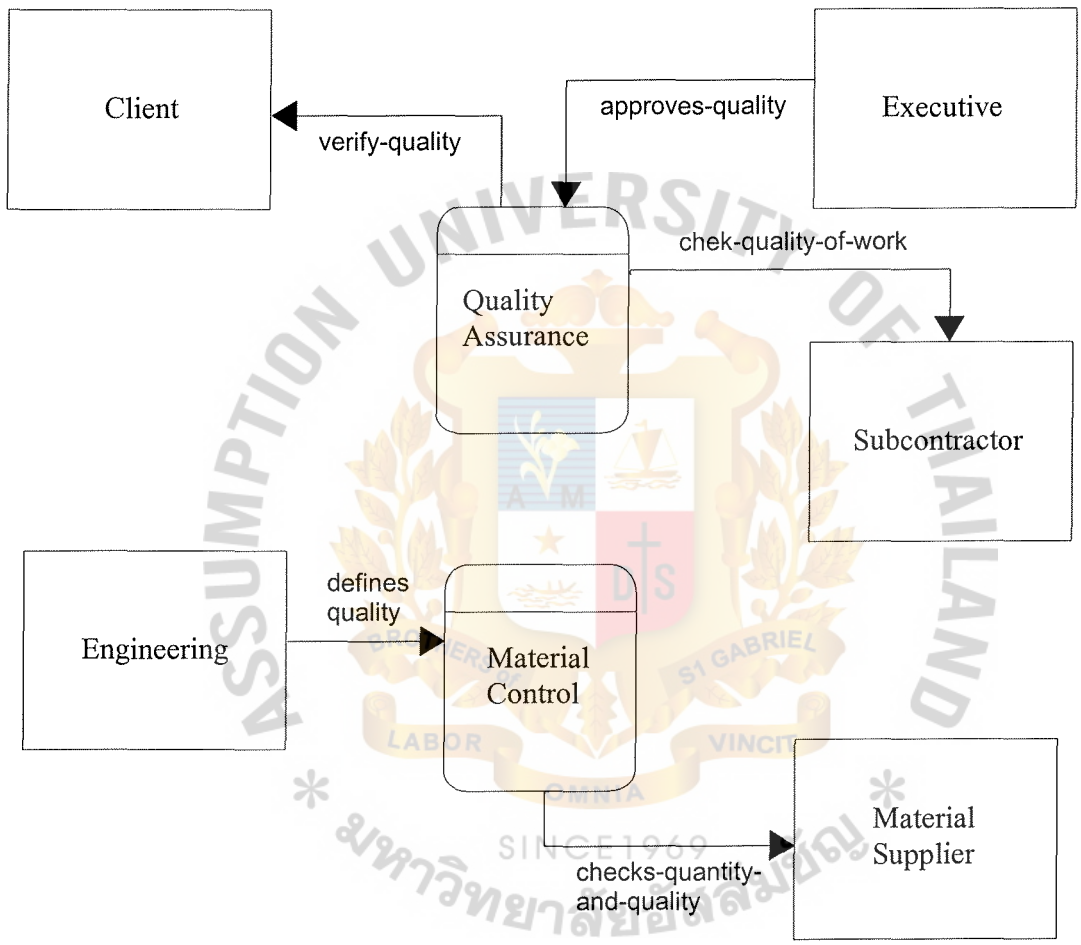

Figure A.7. Event Diagram, 2 of 4.

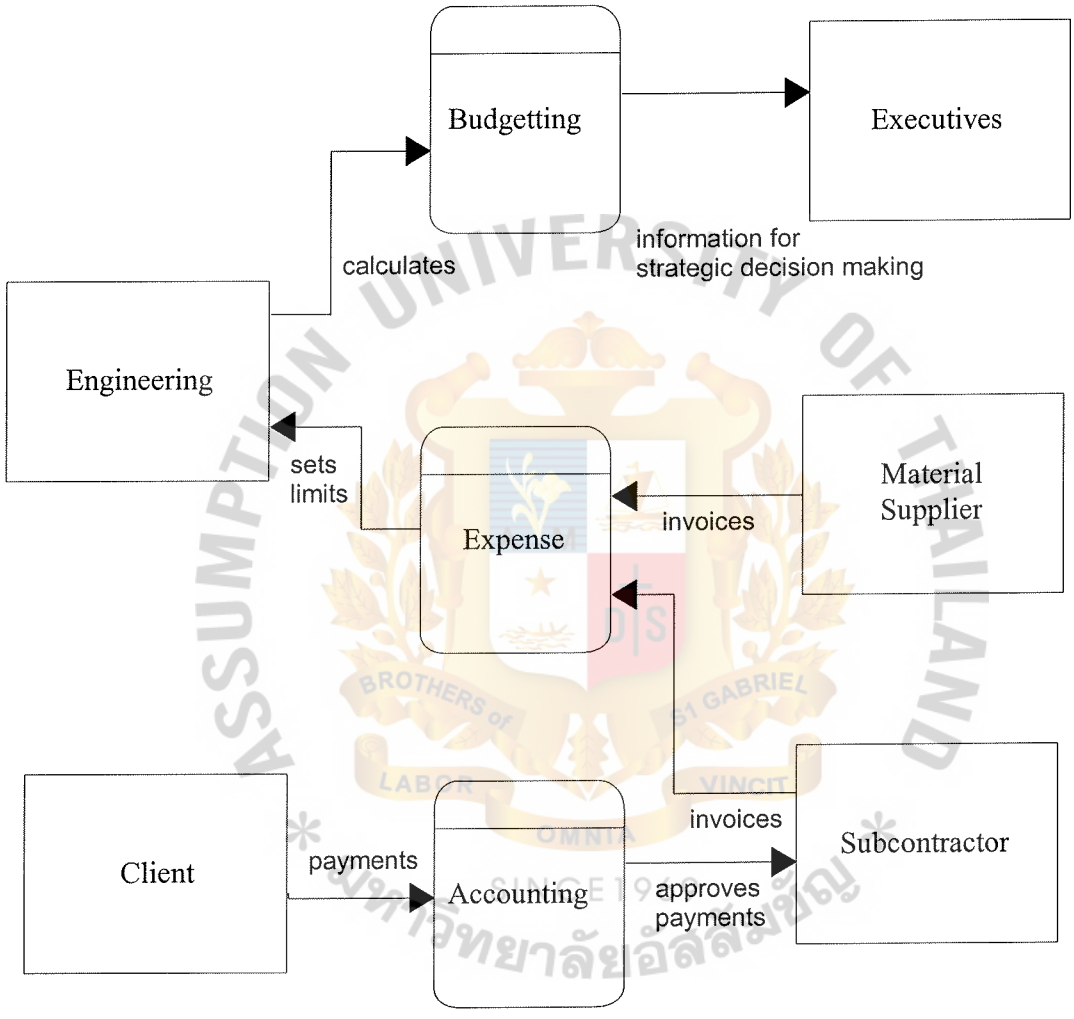

Figure A.8. Event Diagram, 3 of 4.

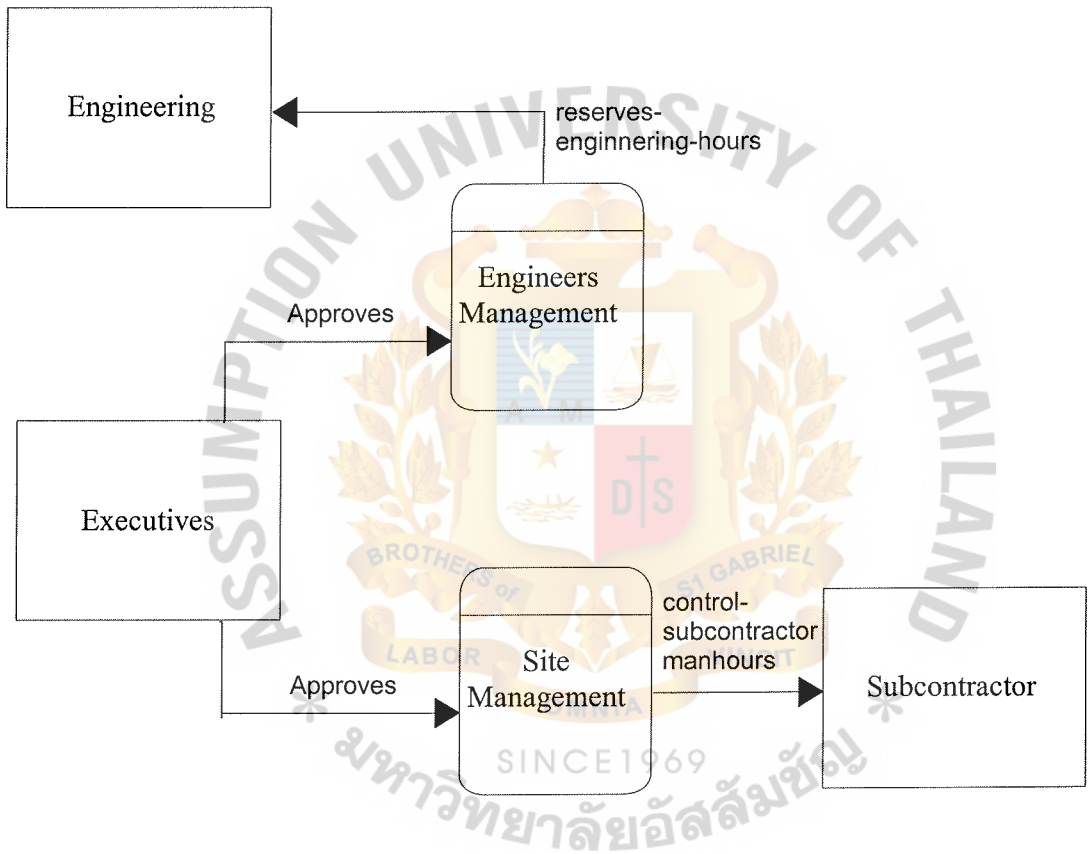

Figure A.9. Event Diagram, 4 of 4.

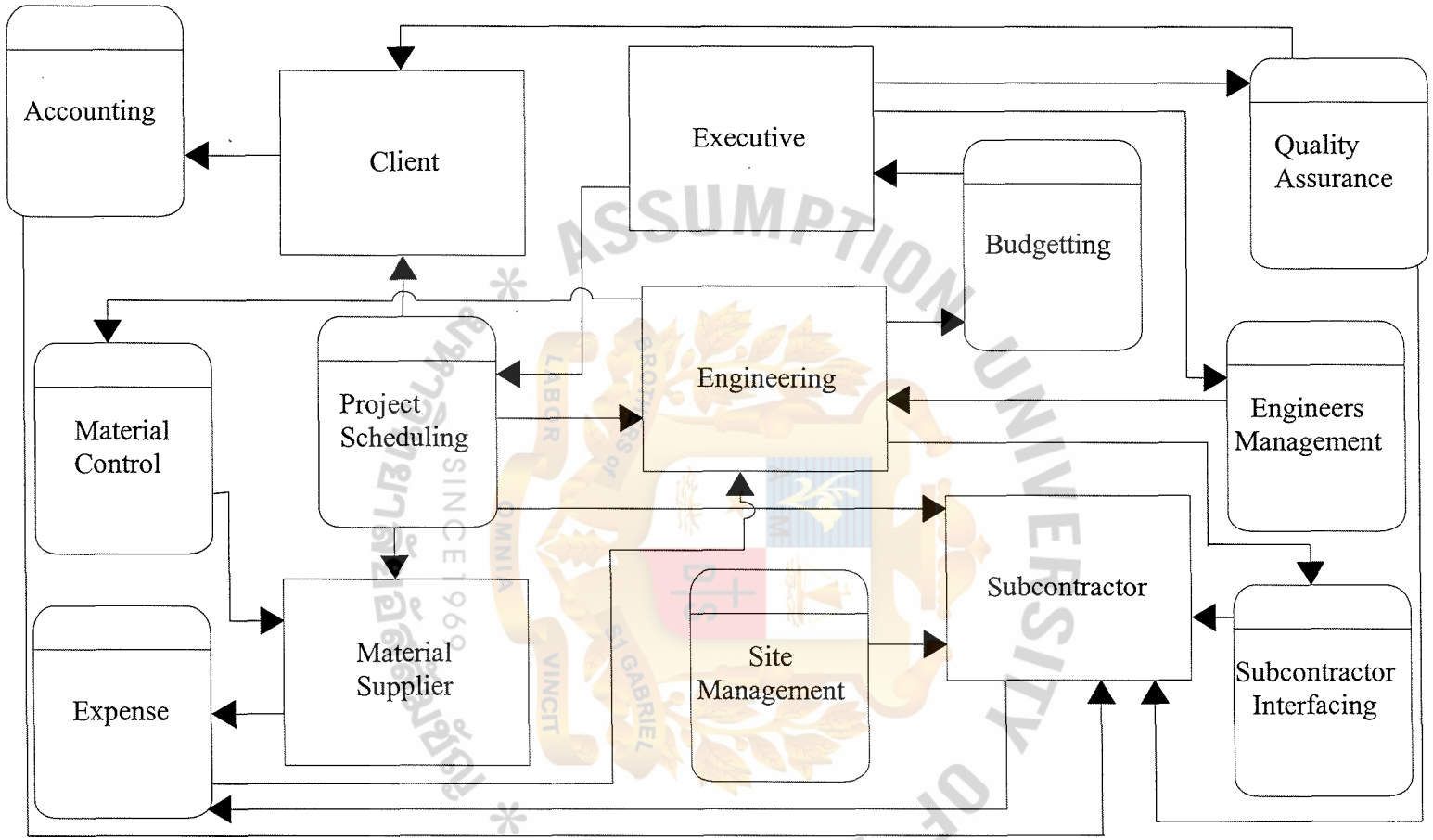

Figure A.10. System Diagram.

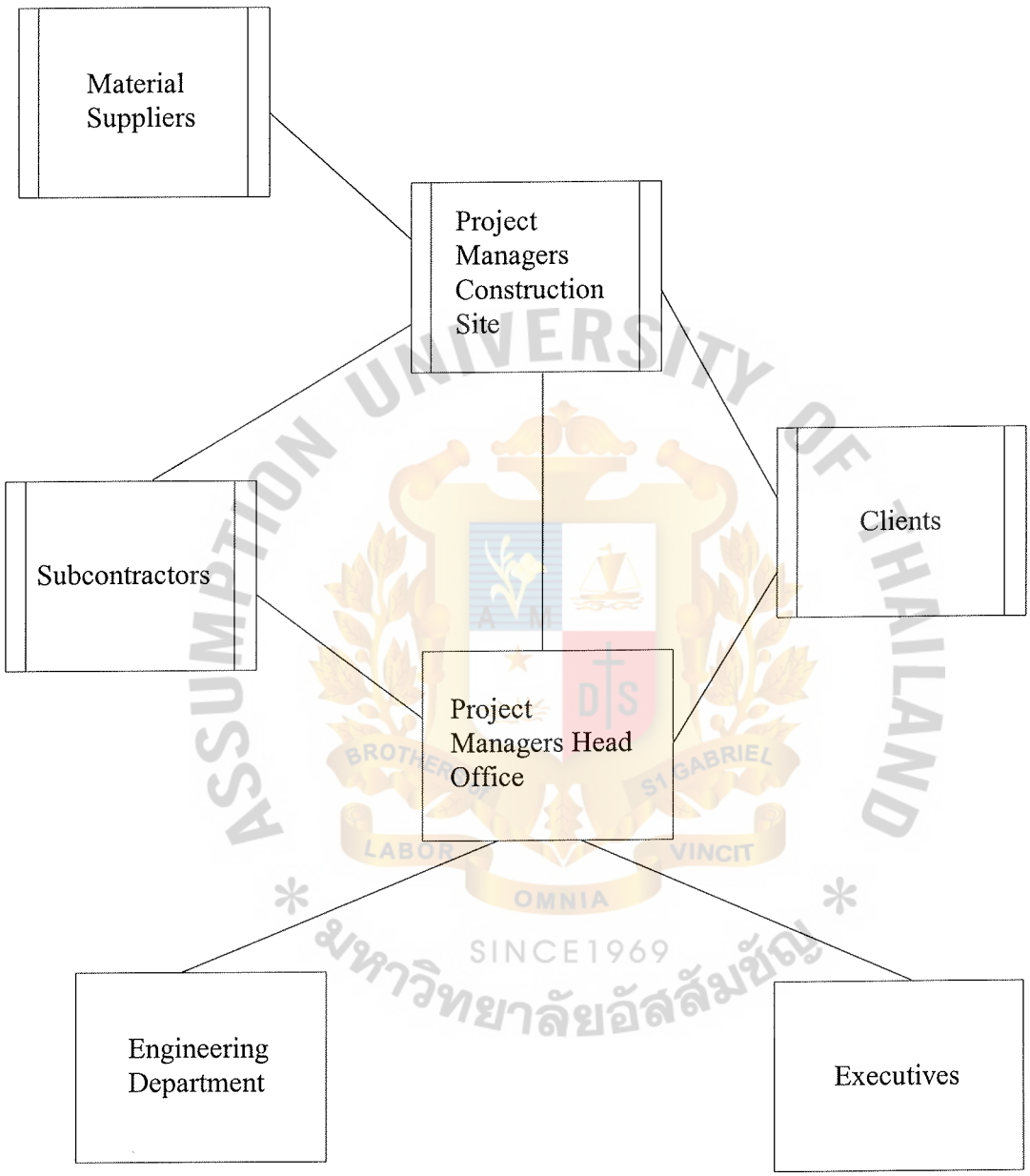

Figure A.11. Location Connectivity Diagram.

APPENDIX B

PROPOSED SYSTEM MODELS

Table B.1. Payback Analysis for Existing System, DKK.

Cost Items	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Operation and Maintenance cost	50,250	55,000	60,000	65,000	70,000	75,000	80,000
Discout factors for 10%	1.000	0.909	0.826	0.751	0.683	0.621	0.564
Time-adjusted-costs	50,250	49,995	49,560	48,815	47,810	46,575	45,120
Cumulative time-adjusted-cost	50,250	100,245	149,805	198,620	246,430	293,005	338,125
Benefits derived from operation of new system		-	-	-	-	-	-
Discout factors for 10%	1.000	0.909	0.826	0.751	0.683	0.621	0.564
Time-adjusted-benefits		-	-	-	-	-	-
Cumulative time-adjusted-benefits		-	-	-	-	-	-
Cumulative lifetime time-adjusted-costs +benefits	- 50,250	- 100,245	- 149,805	- 198,620	- 246,430	- 293,005	- 338,125

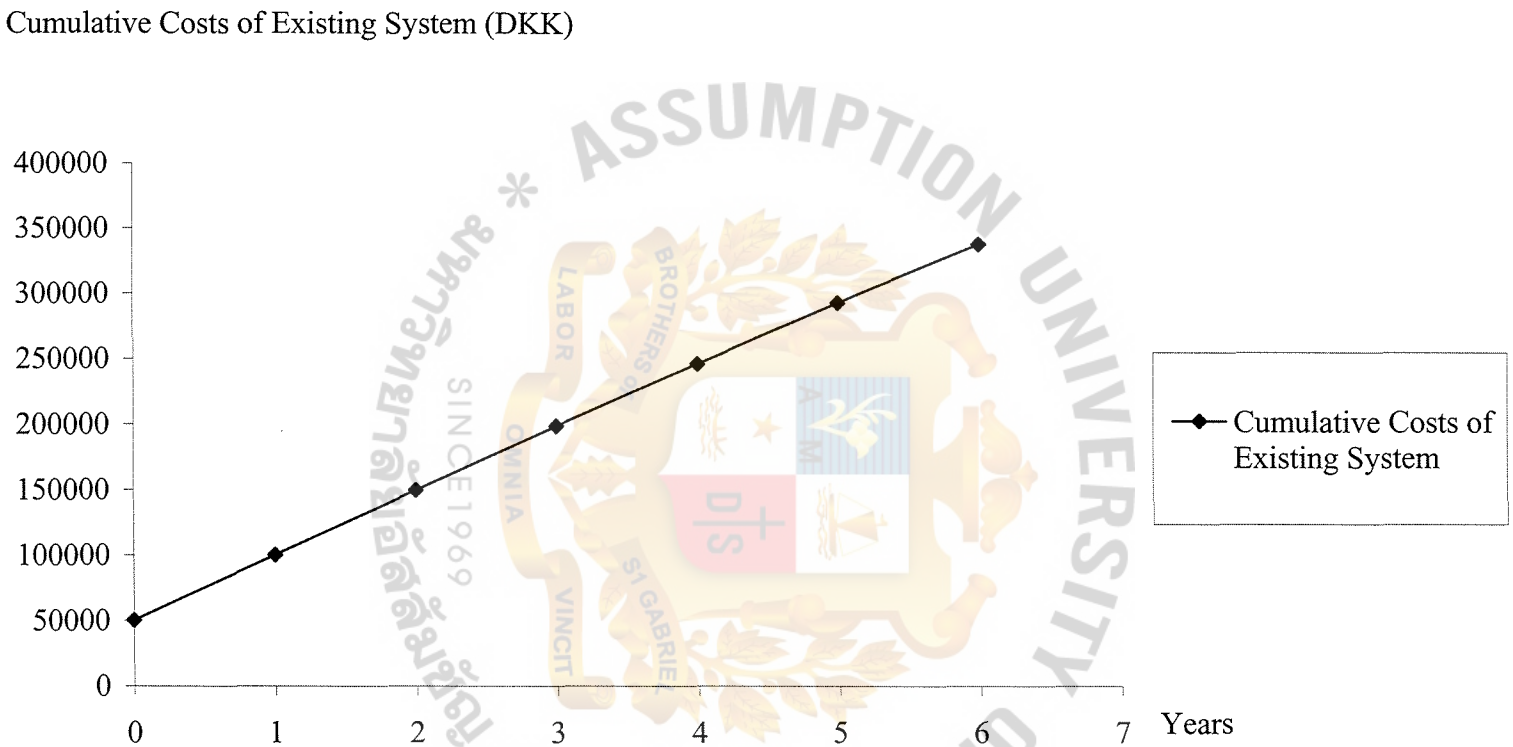

Figure B.1. Payback Analysis for Existing System.

Table B.2. Development Cost for Candidate Solution 1.

Cost Item	Description	Amount	Unit Price (DKK /hrs.)	Price (DKK)
1. Development Cost	1.1 Personnel Cost:			
	Systems Analyst (400 hours/ea)	1	300	120,000
	Programmer (500 hours/ea)	1	250	125,000
	Database specialist (50 hours/ea)	1	300	15,000
	System Librarian (250 hours/ea)	1	150	37,500
	Subtotal 1:			297,500
	1.2 Expenses: Training	100	1500	150,000
	Subtotal 2:			150,000
	1.3 New Software:			
	DBMS server software	2	25000	50,000
	DBMS client software	100	1500	150,000
	Subtotal 3:			200,000
	Total Development Costs			647,500
2. Projected Annual Operating Costs	2.1 Personnel Cost:			
	Programmer (125 hours/ea)	1	250	31,250
	System Librarian (100 hours/ea)	1	150	15,000
	Subtotal 1:			46,250
	2.2 Maintenance: Server DBMS software	2	2000	4,000
	Subtotal 2:			4,000
	Total Operating costs			50,250

Table B.3. Payback Analysis for Candidate Solution 1, DKK.

Cost Items		Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Development Cost		647,500						
Operation and Maintenance cost	50,250		55,000	60,000	65,000	70,000	75,000	80,000
Discout factors for 10%		1.000	0.909	0.826	0.751	0.683	0.621	0.564
Time-adjusted-costs			49,995	49,560	48,815	47,810	46,575	45,120
Cumulative time-adjusted-cost		647,500	697,495	747,055	795,870	843,680	890,255	935,375
Benefit derived by operation of new system			11,520,000	12,000,000	13,000,000	14,000,000	15,000,000	16,000,000
Discout factors for 10%		1.000	0.909	0.826	0.751	0.683	0.621	0.564
Time-adjusted-benefits			10,471,680	9,912,000	9,763,000	9,562,000	9,315,000	9,024,000
Cumulative time-adjusted-benefits			9,518,757	19,430,757	29,193,757	38,755,757	48,070,757	57,094,757
Cumulative lifetime adjusted-costs+benefits		- 647,500	8,821,262	18,683,702	28,397,887	37,912,077	47,180,502	56,159,382

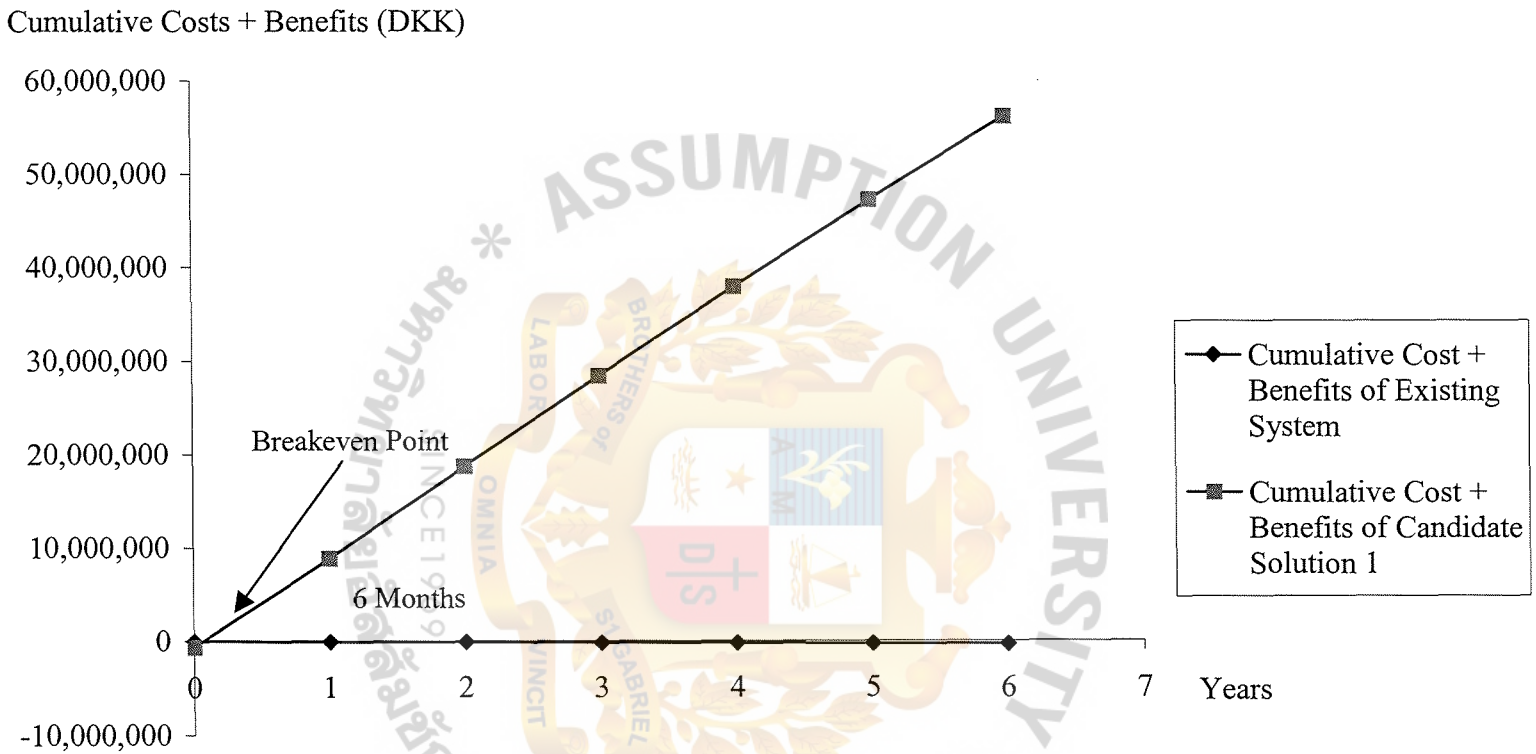

Figure B.2. Payback Analysis for Candidate Soloution 1.

Table B.4. Development Cost for Candidate Solution 2.

Cost Item	Description	Amount	Unit (DKK /hrs.)	Price (DKK)
1. Development Cost	1.1 Personnel Cost:			
	Systems Analyst (300 hours/ea)	1	300	90,000
	Programmer (100 hours/ea)	1	250	25,000
	Database specialist (50 hours/ea)	1	300	15,000
	System Librarian (250 hours/ea)	1	150	37,500
	Subtotal 1:			167,500
	1.2 Expenses:			
	Training	100	1500	150,000
	Subtotal 2:			150,000
	1.3 New Software:			
	Lotus Notes			2,080,000
	DBMS server software	2	25000	50,000
	DBMS client software	100	1500	150,000
	Subtotal 3:			2,280,000
	Total Development Costs			2,597,500
2. Projected Annual Operating Costs	2.1 Personnel Cost:			
	Programmer (100 hours/ea)	1	250	25,000
	System Librarian (100 hours/ea)	1	150	15,000
	Subtotal 1:			40,000
	2.2 Maintenance:			
	Lotus Notes Software		8000	8000
	Server DBMS software	2	2000	4,000
	Subtotal 2:			12,000
	Total Operating costs			52,000

Table B.5. Payback Analysis for Candidate Solution 2, DKK.

Cost Items	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Development Cost	2,597,500						
Operation and Maintenance 52,000		57,000	62,000	67,000	72,000	77,000	82,000
Discout factors for 10%	1.000	0.909	0.826	0.751	0.683	0.621	0.564
Time-adjusted-costs		51,813	51,212	50,317	49,176	47,817	46,248
Cumulative time-adjusted-cost	2,597,500	2,649,313	2,700,525	2,750,842	2,800,018	2,847,835	2,894,083
Benefit from operation of new system		11,520,000	12,000,000	13,000,000	14,000,000	15,000,000	16,000,000
Discout factors for 10%	1.000	0.909	0.826	0.751	0.683	0.621	0.564
Time-adjusted-benefits		10,471,680	9,912,000	9,763,000	9,562,000	9,315,000	9,024,000
Cumulative time-adjusted-benefits		9,518,757	19,430,757	29,193,757	38,755,757	48,070,757	57,094,757
Cumulative life adjusted-costs+benefits	- 2,597,500	6,869,444	16,730,232	26,442,915	35,955,739	45,222,922	54,200,674

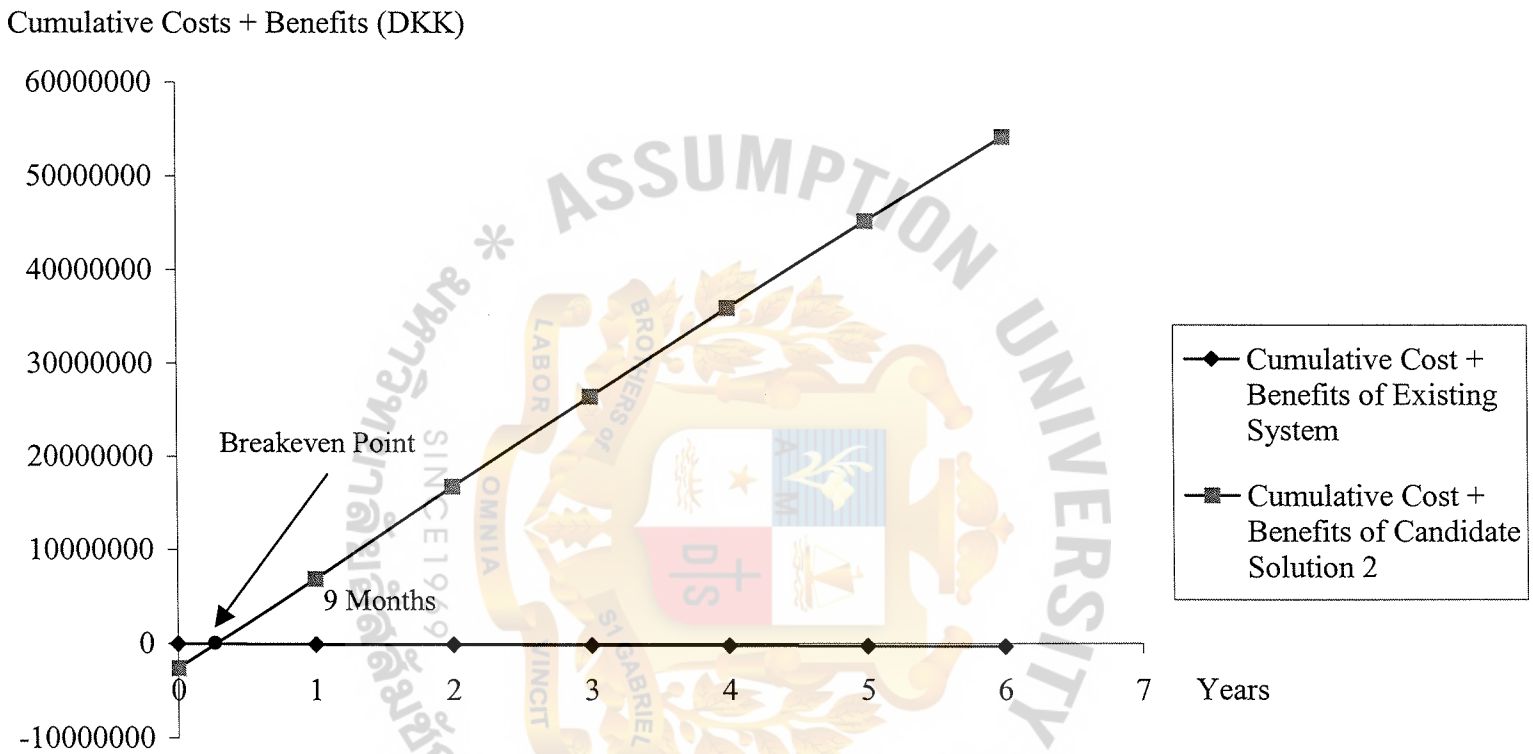

Figure B.3. Payback Analysis for Candidate Solution 2.

Table B.6. Development Cost for Candidate Solution 3.

Cost Item	Description	Amount	Unit (DKK /hrs.)	Price (DKK)
1. Development Cost	1.1 Personnel Cost:			
	Systems Analyst (300 hours/ea)	1	300	90,000
	Programmer (100 hours/ea)	1	250	25,000
	Database specialist (50 hours/ea)	1	300	15,000
	System Librarian (250 hours/ea)	1	150	37,500
	Subtotal 1:			167,500
	1.2 Expenses:			
	Training	100	1500	150,000
	Subtotal 2:			150,000
	1.3 New Software:			
	SAP/R3			2,090,000
	INFORMIX			1,000,000
	DBMS client software	100	2000	200,000
	Subtotal 3:			3,290,000
	Total Development Costs			3,607,500
2. Projected Annual Operating Costs	2.1 Personnel Cost:			
	Programmer (100 hours/ea)	1	250	25,000
	System Librarian (100 hours/ea)	1	150	15,000
	Subtotal 1:			40,000
	2.2 Maintenance:			
	SAP/R3	1	7000	7000
	Server DBMS software	1	4000	4,000
	Subtotal 2:			11,000
	Total Operating costs			51,000

Table B.7. Payback Analysis for Candidate Solution 3, DKK.

Cost Items	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Development Cost	3,607,500						
Operation and Maintenance 51,000		52,000	57,000	72,000	77,000	82,000	87,000
Discout factors for 10%	1.000	0.909	0.826	0.751	0.683	0.621	0.564
Time-adjusted-costs		47,268	47,082	54,072	52,591	50,922	49,068
Cumulative time-adjusted-cost	3,607,500	3,654,768	3,701,850	3,755,922	3,808,513	3,859,435	3,908,503
Benefit from operation of new system		11,520,000	12,000,000	13,000,000	14,000,000	15,000,000	16,000,000
Discout factors for 10%	1.000	0.909	0.826	0.751	0.683	0.621	0.564
Time-adjusted-benefits		10,471,680	9,912,000	9,763,000	9,562,000	9,315,000	9,024,000
Cumulative time-adjusted-benefits		9,518,757	19,430,757	29,193,757	38,755,757	48,070,757	57,094,757
Cumulative life adjusted-cost+benefit	-3,607,500	5,863,989	15,728,907	25,437,835	34,947,244	44,211,322	53,186,254

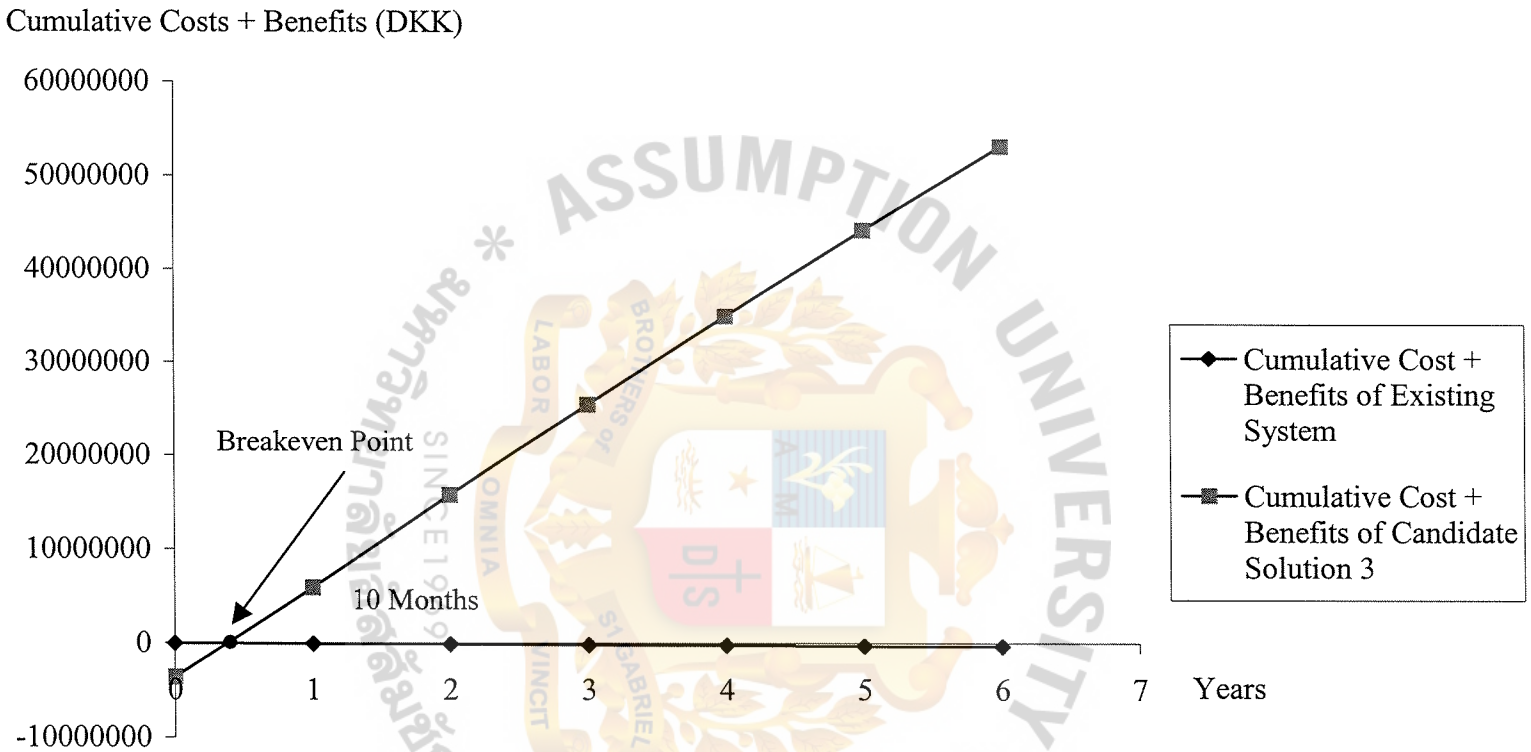

Figure B.4. Payback Analysis for Canidate Solution 3.

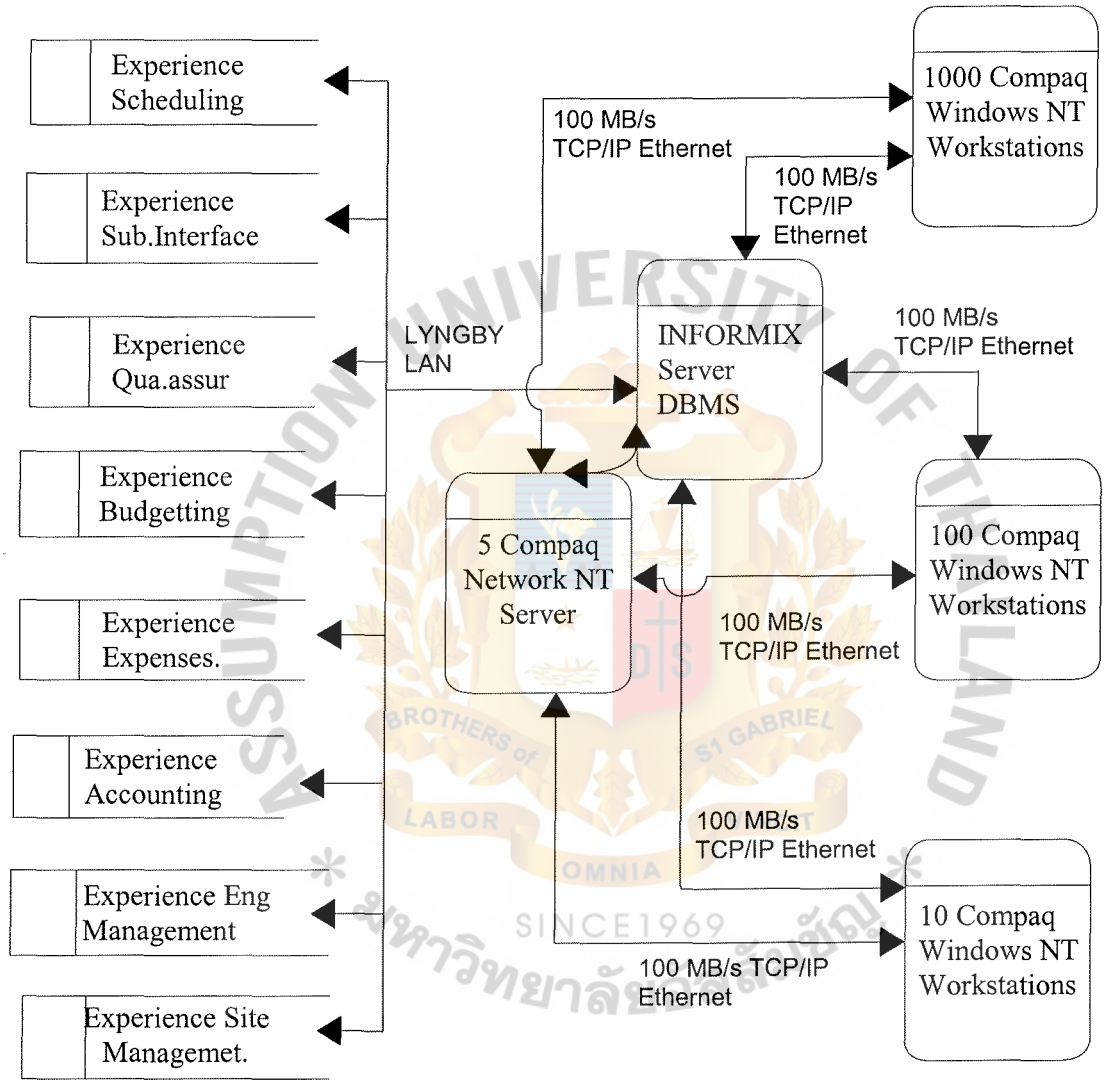

Figure B.5. Data Distribution Data Flow Diagram.

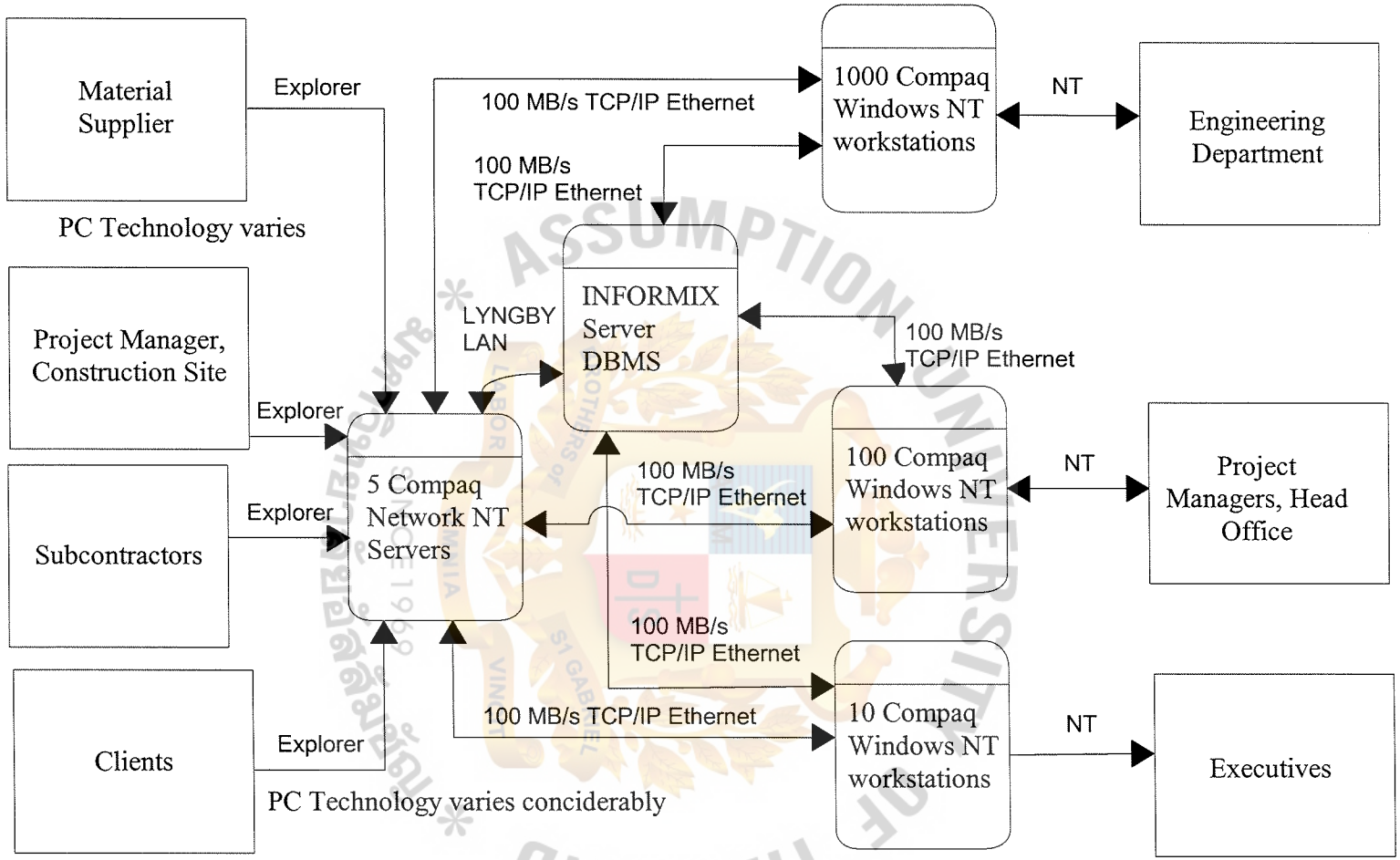

Figure B.6. Network Topology Data Flow Diagram.

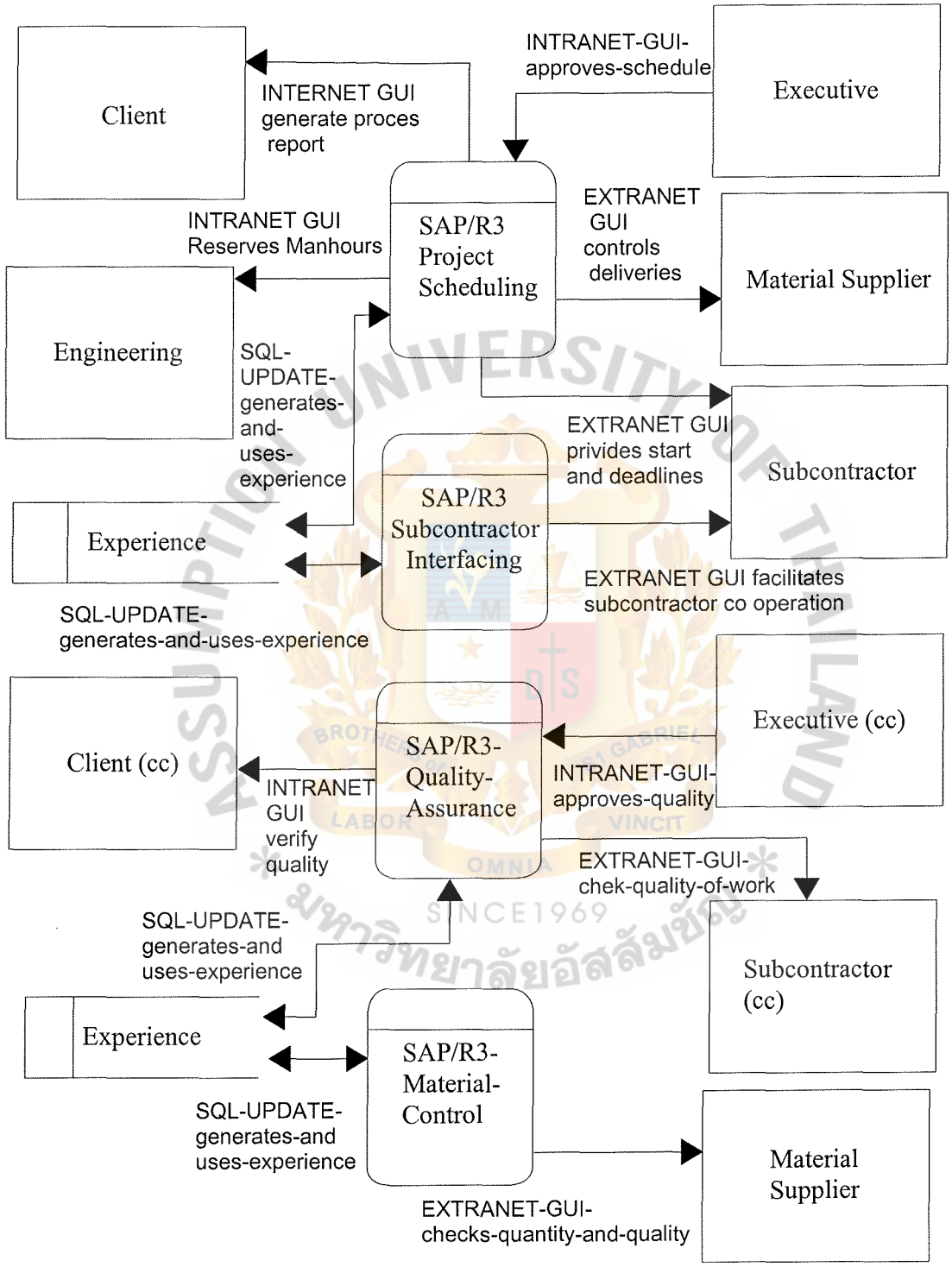

Figure B.7. Physical DFD Design Unit for an Event, 1 of 2.

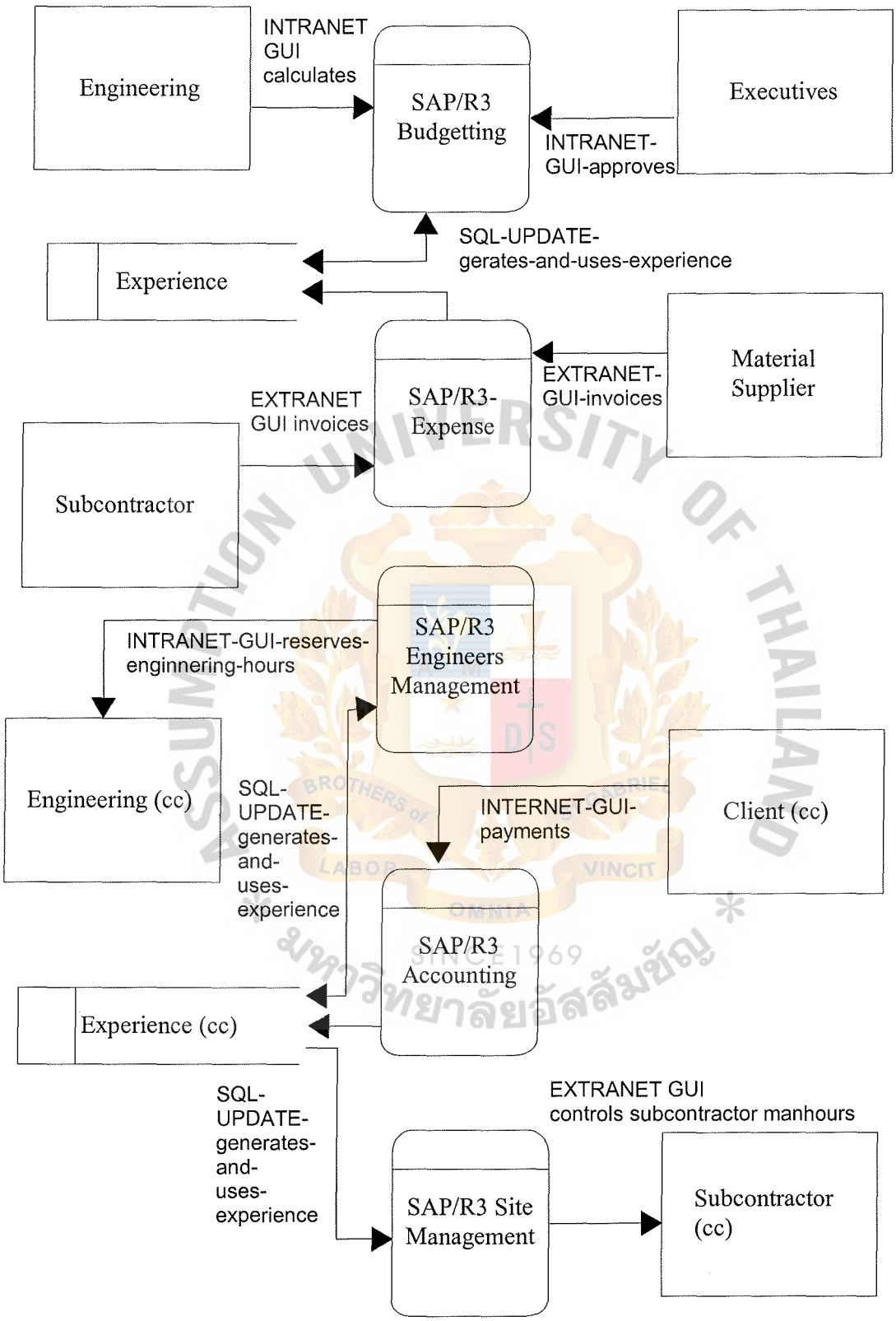

Figure B.8. Physical DFD Design Unit for an Event 2 of 2.

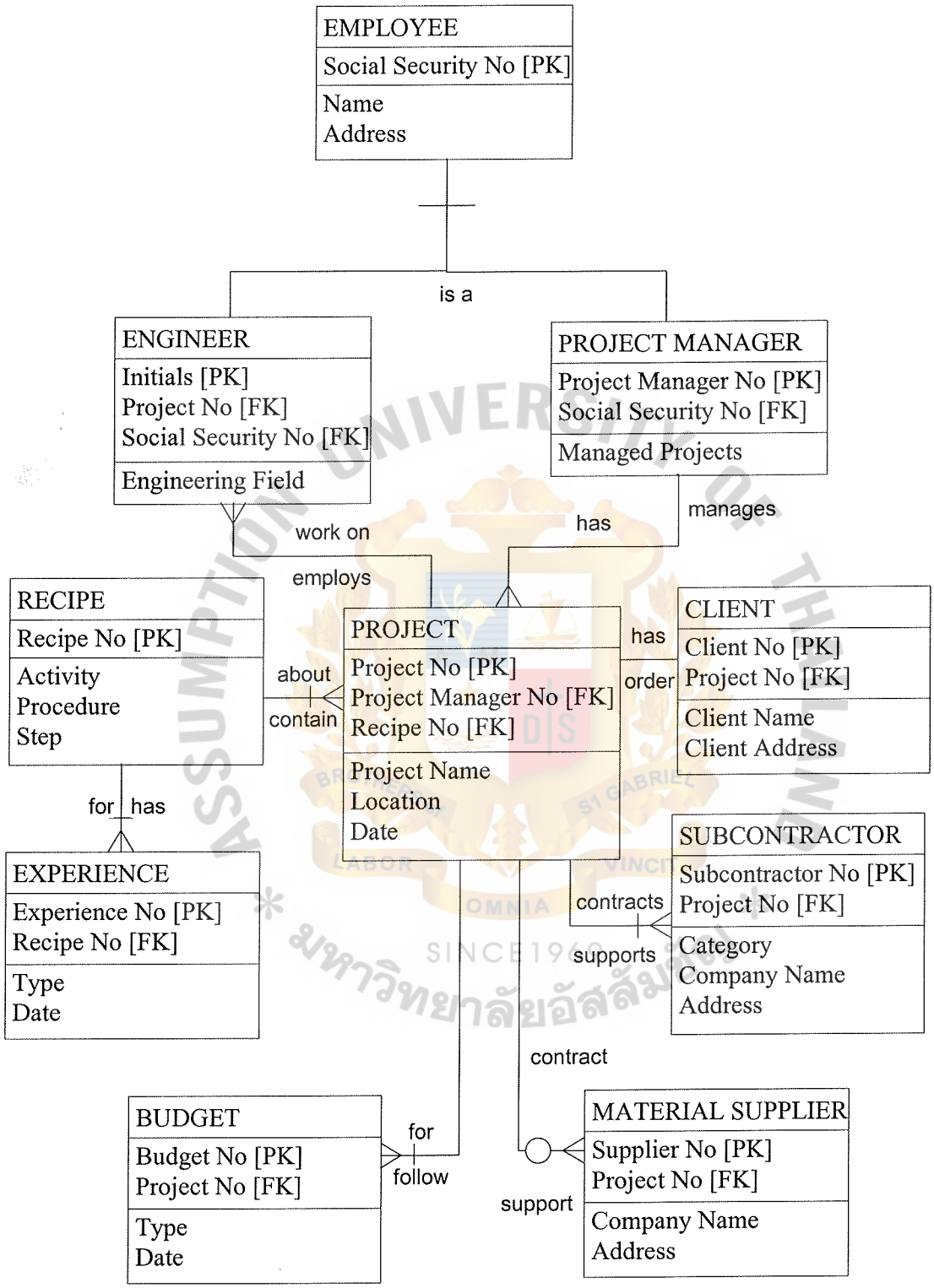

Figure B.9. Logical Data Model in Normalized Form.

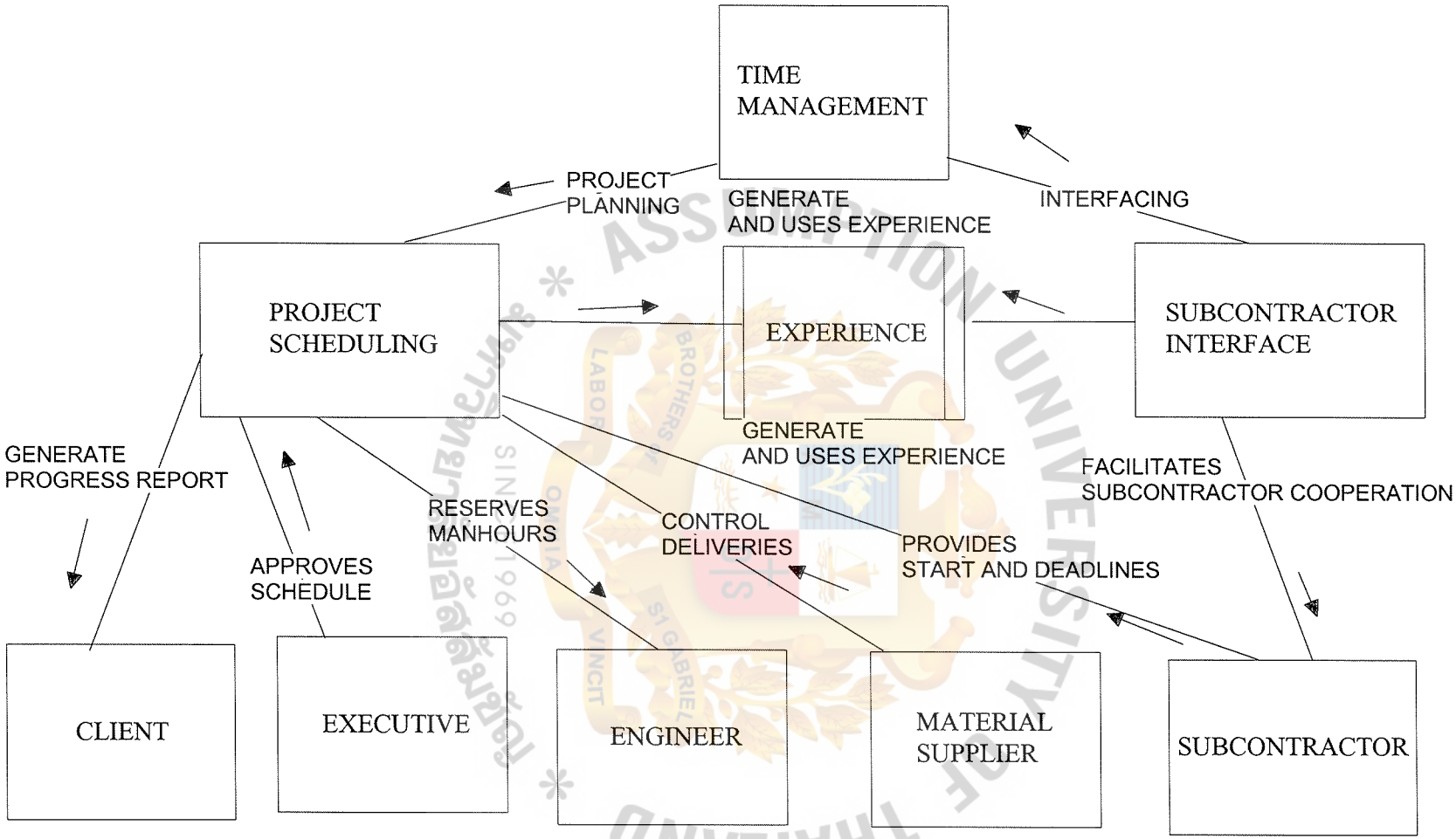

Figure B.10. Sample Structure Chart.

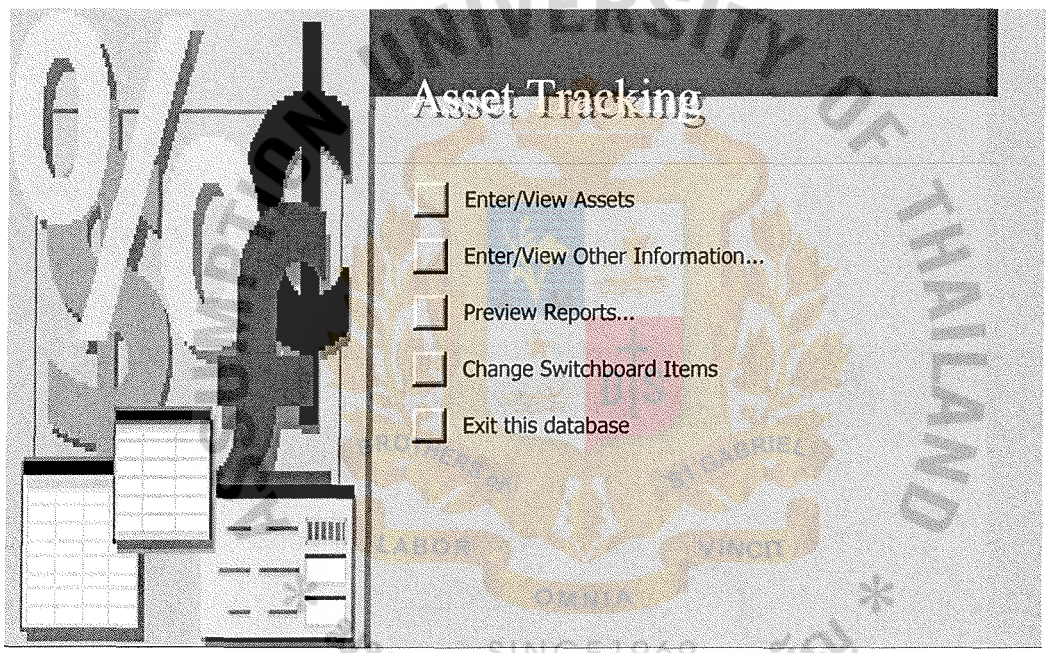

Figure B.11. Switch Board.

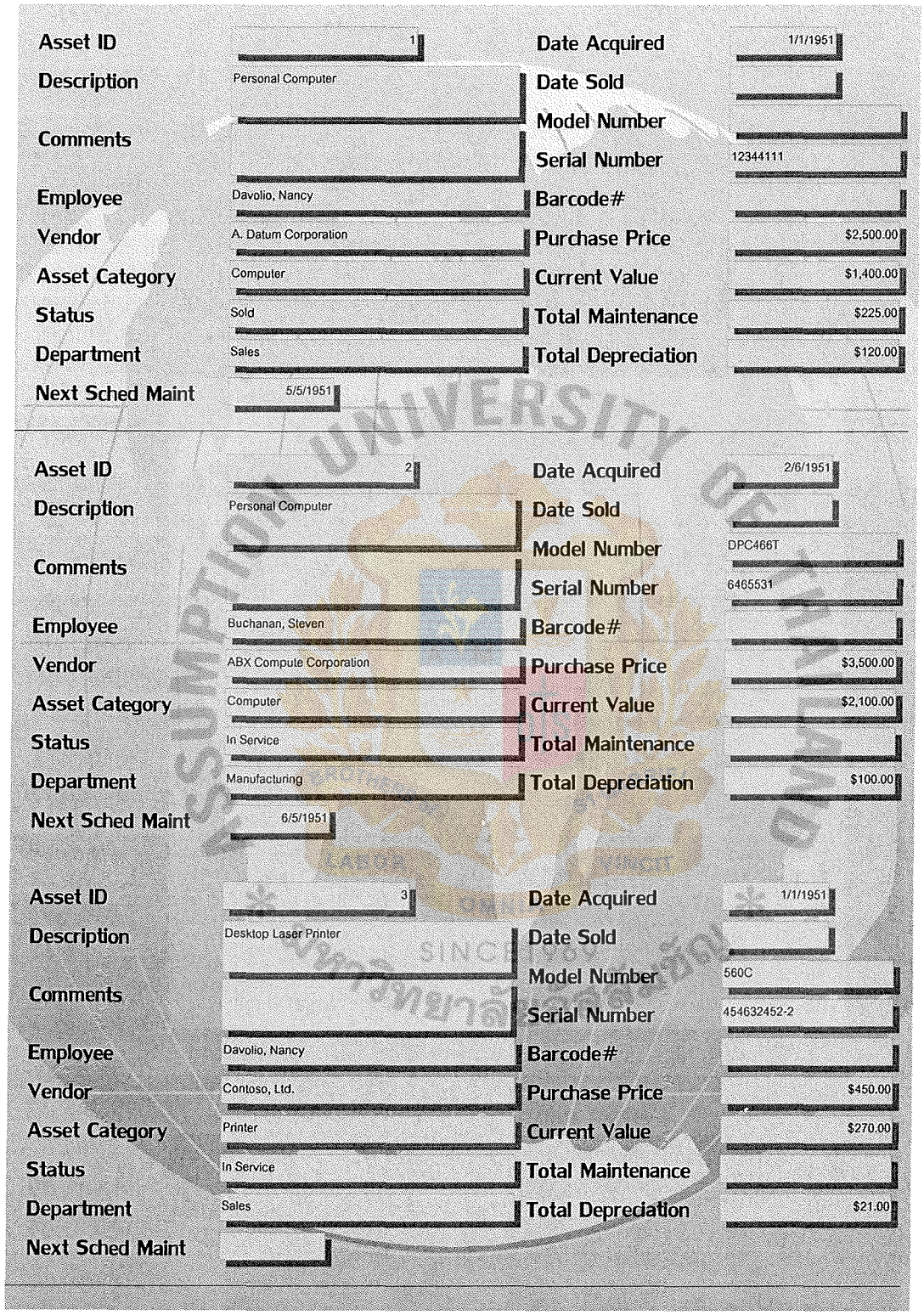

Figure B.12. Input Screen.

Assets by Date Acquired

Acquired	ID	Asset Description	Serial Number	Status	Purchase Price	Current Value
1/ 1/94	3	Desktop Laser Printer	454632452-2	In Service	$450.00	$270.00
1/ 1/94	1	Personal Computer	12344111	Sold	$2,500.00	$1,400.00
6/ 2/94	2	Personal Computer	6465531	In Service	$3,500.00	$2,100.00
2/ 3/94	5	Executive Desk	33222-AB45	In Service	$1,060.00	$450.00
1/ 4/94	4	Desktop Laser Printer	4556544-9	In Service	$1,500.00	$600.00
			Grand Total		$9,010.00	$4,820.0

Figure B.13. Output Screen.

APPENDIX C

DATA DICTIONARY FOR DATA MODEL

DATA DICTIONARY FOR DATA MODEL

Employee Entity

Description: Employee in the Pihl & Son A/S

Composition: Social Security Number : Integer 4

Name : VarChar

Primary Key:

Index Name: Generated by VAW

Column(s): Social Security Number [ASC]

Location: ProjectManagement

Attached relationships on ProjectManagement:

is a MIN: 0 MAX: 1

Engineer is a MIN: 0 MAX: 1

Project Manager ISA

Attached relationships on ISA:

is a MIN: 0 MAX: 1

Engineer is a MIN: 0 MAX: 1

Project Manager

Date Last Altered: 7/11/99 Date Created: 7/11/99

Budget Entity

Description: Expense, Income, Planned and Actual Budget

Composition: Budget Number : Integer 4

Type : VarChar

Date : DateTime

Primary Key:

Index Name: Generated by VAW

Column(s): Budget Number [ASC]

Foreign Key(s):

Project 'follow'

On Delete Restrict

On Update Restrict

On Insert of Child Row Restrict

Location: ProjectManagement

Attached relationships on ProjectManagement:

for MIN: 1 MAX: 1

Project ISA

Attached relationships on ISA:

for MIN: 1 MAX: 1

Project

Date Last Altered: 7/11/99 Date Created: 7/11/99

Experience Entity

Description: Experience generated in previous project

Composition: Experience Number : Integer 4

Type : VarChar

Date : DateTime

Primary Key:

Index Name: Generated by VAW
Column(s): Experience Number [ASC]
Foreign Key(s):
Receipe 'contain'
On Delete Restrict
On Update Restrict
On Insert of Child Row Restrict
Location: ProjectManagement
Attached relationships on ProjectManagement:
about MIN: 1 MAX: 1
Receipe ISA
Attached relationships on ISA:
about MIN: 1 MAX: 1
Receipe
Date Last Altered: 7/11/99 Date Created: 7/11/99

Subcontractor Entity
Description: Supplier of work, material or machinery
Composition: Subcontractor Number : Integer 4
Category : VarChar
Company Name : VarChar
Address : VarChar
Primary Key:
Index Name: Generated by VAW
Column(s): Subcontractor Number [ASC]
Foreign Key(s):
Project 'contract'
On Delete Restrict
On Update Restrict
On Insert of Child Row Restrict
Location: ProjectManagement
Attached relationships on ProjectManagement:
support MIN: 1 MAX: 1
Project ISA
Attached relationships on ISA:
support MIN: 1 MAX: 1
Project
Date Last Altered: 7/11/99 Date Created: 7/11/99

Engineer Entity
Description: Employed with Engineer status
Composition: Engineer Number : Integer 4
Engineering Field : VarChar
Primary Key:
Index Name: Generated by VAW
Column(s): Engineer Number [ASC]
Foreign Key(s):
Employee 'is a'
On Delete Restrict

On Update Restrict
On Insert of Child Row Restrict
Project 'employ'
On Delete Restrict
On Update Restrict
On Insert of Child Row Restrict

Location: ProjectManagement

Attached relationships on ProjectManagement:

[is a]		MIN: 1 MAX: 1
Employee	work on	MIN: 1 MAX: 1
Project	ISA	

Attached relationships on ISA:

[is a]		MIN: 1 MAX: 1
Employee	work on	MIN: 1 MAX: 1
Project		

Date Last Altered: 7/11/99 Date Created: 7/11/99

Project Manager Entity

Description: Employee with Project Manager Status

Composition: Project Manager Number : Integer 4
Managed Project : Integer 4

Primary Key:
Index Name: Generated by VAW
Column(s): Project Manager Number [ASC]

Foreign Key(s):
Employee 'is a'
On Delete Restrict
On Update Restrict
On Insert of Child Row Restrict
Project 'is manged by'
On Delete Restrict
On Update Restrict
On Insert of Child Row Restrict

Location: ProjectManagement

Attached relationships on ProjectManagement:

[is a]		MIN: 1 MAX: 1
Employee	manage	MIN: 1 MAX: 1
Project	ISA	

Attached relationships on ISA:

[is a]		MIN: 1 MAX: 1
Employee	manage	MIN: 1 MAX: 1
Project		

Date Last Altered: 7/11/99 Date Created: 7/11/99

Receipe Entity

Description: Detailed work and operating procedure

Composition: Receipt Number : Integer 4
Activity : VarChar
Procedure : VarChar

Task : VarChar
Primary Key:
Index Name: Generated by VAW
Column(s): Receipt Number [ASC]
Foreign Key(s):
Project 'has'
On Delete Restrict
On Update Restrict
On Insert of Child Row Restrict
Location: ProjectManagement
Attached relationships on ProjectManagement:

for		MIN: 1 MAX: 1
Project	contain	MIN: 0 MAX: many
Experience	ISA	

Attached relationships on ISA:

for		MIN: 1 MAX: 1
Project	contain	MIN: 0 MAX: many
Experience		

Date Last Altered: 7/11/99 Date Created: 7/11/99

Project Entity
Description: Any potential project causing activity in Pihl & Son A/S
Composition: Project Number : Integer 4
Project Name : VarChar
Location : VarChar
Date : DateTime
Primary Key:
Index Name: Generated by VAW
Column(s): Project Number [ASC]
Location: ProjectManagement
Attached relationships on ProjectManagement:

employ		MIN: 0 MAX: many
Engineer is manged by		MIN: 0 MAX: many
Project Manager contract		MIN: 0 MAX: many
Subcontractor follow		MIN: 0 MAX: many
Budget has		MIN: 0 MAX: many
Receipe	ISA	

Attached relationships on ISA:

employ		MIN: 0 MAX: many
Engineer is manged by		MIN: 0 MAX: many
Project Manager follow		MIN: 0 MAX: many
Budget contract		MIN: 0 MAX: many
Subcontractor has		MIN: 0 MAX: many
Receipe		

Date Last Altered: 7/11/99 Date Created: 7/11/99

---

employ Relationship
Attached Entities:
Project

employ MIN: 0 MAX: many
Engineer [work on] MIN: 1 MAX: 1
Location: ProjectManagement ISA
Date Last Altered: 7/11/99 Date Created: 7/11/99

---

about Relationship
Attached Entities:
Experience
about MIN: 1 MAX: 1
Receipe [contain] MIN: 0 MAX: many
Location:
ProjectManagement ISA
Date Last Altered: 7/11/99 Date Created: 7/11/99

---

for Relationship
Attached Entities:
Budget
for MIN: 1 MAX: 1
Project [follow] MIN: 0 MAX: many
Location:
ProjectManagement ISA
Date Last Altered: 7/11/99 Date Created: 7/11/99

---

contain Relationship
Attached Entities:
Receipe
contain MIN: 0 MAX: many
Experience [about] MIN: 1 MAX: 1
Location:
ProjectManagement ISA
Date Last Altered: 7/11/99 Date Created: 7/11/99

---

contract Relationship
Attached Entities:
Project
contract MIN: 0 MAX: many
Subcontractor [support] MIN: 1 MAX: 1
Location:
ProjectManagement ISA
Date Last Altered: 7/11/99 Date Created: 7/11/99

---

is manged by Relationship
Attached Entities:
Project
is manged by MIN: 0 MAX: many
Project Manager [manage] MIN: 1 MAX: 1
Location: ProjectManagement ISA
Date Last Altered: 7/11/99 Date Created: 7/11/99

---

manage Relationship

Attached Entities:

Project Manager

manage MIN: 1 MAX: 1

Project [is manged by] MIN: 0 MAX: many

Location: ProjectManagement ISA

Date Last Altered: 7/11/99 Date Created: 7/11/99

---

has Relationship

Attached Entities:

Project

has MIN: 0 MAX: many

Receipe [for] MIN: 1 MAX: 1

Location: ProjectManagement ISA

Date Last Altered: 7/11/99 Date Created: 7/11/99

---

is a Relationship

Attached Entities:

Employee

is a MIN: 0 MAX: 1

Engineer [is a] MIN: 1 MAX: 1

Location: ProjectManagement ISA

Date Last Altered: 7/11/99 Date Created: 7/11/99

---

follow Relationship

Attached Entities:

Project

follow MIN: 0 MAX: many

Budget [for] MIN: 1 MAX: 1

Location: ProjectManagement ISA

Date Last Altered: 7/11/99 Date Created: 7/11/99

---

support Relationship

Attached Entities:

Subcontractor

support MIN: 1 MAX: 1

Project [contract] MIN: 0 MAX: many

Location: ProjectManagement ISA

Date Last Altered: 7/11/99 Date Created: 7/11/99

---

work on Relationship

Attached Entities:

Engineer

work on MIN: 1 MAX: 1

Project [employ] MIN: 0 MAX: many

Location: ProjectManagement ISA

Date Last Altered: 7/11/99 Date Created: 7/11/99

APPENDIX D

DATA DICTIONARY FOR PROCESS MODEL

DATA DICTIONARY FOR PROCESS MODEL

Project Scheduling Process

Process #: 1

Location: context for process (0)

Date Last Altered: 12/12/99 Date Created: 12/12/99

Subcontractor Source/Sink

Location: event-quality (0)
Event-cost (0)
Event-Human-Resource (0)

Input Flows: control-subcontractor-man-hours

Date Last Altered: 12/12/99 Date Created: 12/12/99

Executive Source/Sink

Location: context for process (0)
Event-quality (0)

Date Last Altered: 12/12/99 Date Created: 12/12/99

Client Source/Sink

Location: context for process (0)
Event-quality (0)
Event-cost (0)

Date Last Altered: 12/12/99 Date Created: 12/12/99

Material Supplier Source/Sink

Location: context for process (0)
Event-cost (0)

Date Last Altered: 12/12/99 Date Created: 12/12/99

Engineering Source/Sink

Location: context for process (0)
Event-cost (0)
event-Human-Resource (0)

Input Flows: reserves-engineering-hours

Date Last Altered: 12/12/99 Date Created: 12/12/99

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approves-schedule Data Flow

Date Last Altered: 12/12/99 Date Created: 12/12/99

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provides-start-and-deadlines Data Flow

Date Last Altered: 12/12/99 Date Created: 12/12/99

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controls-deliveries Data Flow

Date Last Altered: 12/12/99 Date Created: 12/12/99

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reserves-man-hours Data Flow

Date Last Altered: 12/12/99 Date Created: 12/12/99

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generate-progress-report Data Flow
Date Last Altered: 12/12/99 Date Created: 12/12/99

Material Control Process
Process #: 2
Location: event-quality (0)
Date Last Altered: 12/12/99 Date Created: 12/12/99

Quality Assurance Process
Process #: 1
Location: event-quality (0)
Date Last Altered: 12/12/99 Date Created: 12/12/99

Material Supplier Source/Sink
Location: context for process (0)
Event-cost (0)
Date Last Altered: 12/12/99 Date Created: 12/12/99

Client Source/Sink
Location: context for process (0)
Event-quality (0)
Event-cost (0)
Date Last Altered: 12/12/99 Date Created: 12/12/99

Executive Source/Sink
Location: context for process (0)
Event-quality (0)
Date Last Altered: 12/12/99 Date Created: 12/12/99

Subcontractor Source/Sink
Location: event-quality (0)
Event-cost (0)
Event-Human-Resource (0)
Input Flows: control-subcontractor-man-hours
Date Last Altered: 12/12/99 Date Created: 12/12/99

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approves-quality Data Flow
Date Last Altered: 12/12/99 Date Created: 12/12/99

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check-quality-of-work Data Flow
Date Last Altered: 12/12/99 Date Created: 12/12/99

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checks-quantity-and-quality Data Flow
Date Last Altered: 12/12/99 Date Created: 12/12/99

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verify-quality Data Flow
Date Last Altered: 12/12/99 Date Created: 12/12/99

Accounting Process
Process #: 3
Location: event-cost (0)
Date Last Altered: 13/12/99 Date Created: 13/12/99

Expense Process
Process #: 2
Location: event-cost (0)
Date Last Altered: 13/12/99 Date Created: 13/12/99

Budgeting Process
Process #: 1
Location: event-cost (0)
Date Last Altered: 13/12/99 Date Created: 13/12/99

Executives Source/Sink
Location: event-cost (0)
Event-Human-Resource (0)
Output Flows: approves
Date Last Altered: 13/12/99 Date Created: 13/12/99

Client Source/Sink
Location: context for process (0)
Event-quality (0)
Event-cost (0)
Date Last Altered: 12/12/99 Date Created: 12/12/99

Engineering Source/Sink
Location: context for process (0)
Event-cost (0)
Event-Human-Resource (0)
Input Flows: reserves-engineering-hours
Date Last Altered: 12/12/99 Date Created: 12/12/99

Subcontractor Source/Sink
Location: Event-quality (0)
event-cost (0)
event-Human-Resource (0)
Input Flows: control-subcontractor-man-hours
Date Last Altered: 12/12/99 Date Created: 12/12/99

Material Supplier Source/Sink
Location: context for process (0)
event-cost (0)
Date Last Altered: 12/12/99 Date Created: 12/12/9-9
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invoices Data Flow

Date Last Altered: 13/12/99 Date Created: 13/12/99

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calculates Data Flow

Date Last Altered: 13/12/99 Date Created: 13/12/99

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approves Data Flow

Location: event-Human-Resource (0)

Source: Executives (Source/Sink)

Dest: Engineers Management (Process)

Source: Executives (Source/Sink)

Dest: Site Management (Process)

Date Last Altered: 13/12/99 Date created: 13/12/99

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payments Data Flow

Date Last Altered: 13/12/99 Date created: 13/12/99

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invoices Data Flow

Date Last Altered: 13/12/99 Date created: 13/12/99

Engineers Management Process

Process #: 1

Location: event-Human-Resource (0)

Input Flows: approves

Output Flows: reserves-engineering-hours

Date Last Altered: 13/12/99 Date Created: 13/12/99

Site Management Process

Process #: 2

Location: Event-Human-Resource (0)

Input Flows: approves

Output Flows: control-subcontractor-man-hours

Date Last Altered: 13/12/99 Date Created: 13/12/99

Subcontractor Source/Sink

Location: event-quality (0)

Event-cost (0)

Event-Human-Resource (0)

Input Flows: control-subcontractor-man-hours

Date Last Altered: 12/12/99 Date Created: 12/12/99

Executives Source/Sink

Location: event-cost (0)

Event-Human-Resource (0)

Output Flows: approves

Date Last Altered: 13/12/99 Date Created: 13/12/99

Engineering Source/Sink

Location: context for process (0)

Event-cost (0)

Event-Human-Resource (0)
Input Flows: reserves-engineering-hours
Date Last Altered: 12/12/99 Date Created: 12/12/99

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control-subcontractor-man-hours Data Flow
Location: event-Human-Resource (0)
Source: Site Management (Process)
Dest: Subcontractor (Source/Sink)
Date Last Altered: 13/12/99 Date Created: 13/12/99

reserves-engineering-hours Data Flow
Location:
Event-Human-Resource (0)
Source: Engineers Management (Process)
Dest: Engineering (Source/Sink)
Date Last Altered: 13/12/99 Date Created: 13/12/99

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approves Data Flow
Location: Event-Human-Resource (0)
Source: Executives (Source/Sink)
Dest: Engineers Management (Process)
Source: Executives (Source/Sink)
Dest: Site Management (Process)
Date Last Altered: 13/12/99 Date Created: 13/12/99

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approves Data Flow
Date Last Altered: 13/12/99 Date Created: 13/12/99

APPENDIX E

DATA DICTIONARY FOR NETWORK MODEL

DATA DICTIONARY FOR NETWORK MODEL

Engineering Department Module
Location: A8 LCD
Calls: Project Managers Head Office (Module)
Date Last Altered: 11/9/00 Date created: 11/9/00

Executives Module
Location: A8 LCD
Called by: Project Managers Head Office (Module)
Date Last Altered: 11/9/00 Date created: 11/9/00

Project Managers Head Office Module
Location: A8 LCD
Called by: Subcontractors (Library Module)
Calls: Project Managers Construction Site (Library Module)
Called by: Clients (Library Module)
Calls: Executives (Module)
Called by: Engineering Department (Module)
Date Last Altered: 11/9/00 Date created: 11/9/00

Clients Library Module
Location: A8 LCD
Called by: Project Managers Construction Site (Library Module)
Calls: Project Managers Head Office (Module)
Date Last Altered: 11/9/00 Date created: 11/9/00

Material Suppliers Library Module
Location: A8 LCD
Calls: Project Managers Construction Site (Library Module)
Date Last Altered: 11/9/00 Date created: 11/9/00

Project Managers Construction Site Library Module
Location: A8 LCD
Called by: Material Suppliers (Library Module)
Called by: Subcontractors (Library Module)
Called by: Project Managers Head Office (Module)
Calls: Clients (Library Module)
Date Last Altered: 11/9/00 Date created: 11/9/00

Subcontractors Library Module
Location: A8 LCD
Calls: Project Managers Construction Site (Library Module)
Calls: Project Managers Head Office (Module)
Date Last Altered: 11/9/00 Date created: 11/9/00

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