ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES
SCHOOL OF INFORMATION SCIENCE FOR AFRICA
(SISA)

DESIGNING NETWORKED INFORMATION SYSTEM FOR CONSTRUCTION COMPANIES USING AN OBJECT-ORIENTED APPROACH: A CASE STUDY OF SUR CONSTRUCTION S. CO.

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF MASTER OF SCIENCE IN INFORMATION SCIENCE

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Tesfaye Tafere Reda

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TESFAYE TAFERE

Name and Signature of Members of the Examining Board

Ato Getachew Birru, Chairman, Examining Board

Ato Tesfaye Biru, Advisor

Prof. I.K. Ravichandra Rao, External Examiner

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Abstracts

Most system development methods, at least in principle, have two important components, namely a modeling language and a process. The modeling languages are graphical notations for expressing designs and provides easy communication and documentation. The process of the method shows how to do the development process.

This thesis uses the Rumbough's OMT (Object Modeling Technique) for the process of the analysis and designing of information support system for SUR Construction S. Co. Equipped with this object oriented methods, the thesis focuses on identifying the requirement of the company, department by department. And then a special focus is given to the material resource of the company. It has been found that almost every department is concerned with the material resources, and as such it is a decisive object that determines the success or failure of the company. Therefore, the necessary information and operations concerned with this important material has to be identified and designed so that every department is provided with the kind of information the department requires for decisions making.

Many system development efforts are made with very little or no regard to the very important aspect of development process, namely, the documentation. Although system development efforts are made in SUR very recently it appears no sufficient documentation for the requirement analysis of the company has been made. As a result, each is an islands of desperate attempts, that failed to come up with a system that can provide an accurate, timely, and relevant information that the management of SUR needs for decision making and control of operation. This thesis uses the UML as ways of communicating and documenting the requirement analysis of the company.

Risk and uncertainty are fact of life. SUR are faced with a multitude of different risk and uncertainty issues. But the company approaches these unpredictable circumstances of business based on the whims and experiences that can be subject to variation and errors. Hence it is good to collect the experience of the domain experts of the company on the area and formalize and organize the decisions by clearly identifying the important variables both controllable and uncontrollable and describe them through a model. And use this model to forecast how each risk circumstance behaves, to make a better decision that otherwise would have been costly. To this end, this paper explores the potential of models in bidding for a new project with competitors.

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Chapter I

Introduction

1.1 General Background

Information is important almost in every corner of life in the information society. Organizations need to have a well-designed information system in order to have the necessary information they need to achieve their goals. Today most business firms insist that the analysis and designing of business information system contribute directly to the firms' strategic goals (Martin, 1995). The whole essence of having the best information system to a large extent must not only consider current information requirements but also future requirements. Such information system supported by latest Information and Communication Technology (ICT) would enable to easily react to the dynamically changing business environment and consequently would be highly beneficial.

1.1.1 SUR Construction Share Co.

SUR Construction Share Company is a profit making organization in the construction industry, with its head office located in Addis Ababa. It was established in 1984 (E.C.), with an initial capital of 200 million Birr with grade GC1 (See Appendix G for a minimum requirement of GC1 and BC1). It is engaged in the construction of roads, bridges, buildings, airfields, dams etc. It is organized into five functional departments, namely the Construction Department, The Planning and Programming Department, and The Purchase and Supply Department, The Human Resource and Development Department and The Finance Department.

It has currently ten active projects. Projects are where the construction activities for profit generation take place. These projects are located hundreds of kilometers away from the head office as indicated in the following table (Table 1.1). Each project has a project Engineer who is fully authorized to run and lead all of its operations. The relation between the head office and each project is based on the principles of a Matrix of Organization.

According to the 1991(EC) annual report of the Finance Department, the annual gross revenue of the company for the year 1991 (E.C.) is estimated at about 150 million Birr and the annual net profit is estimated at about Birr 2.5 million.

No.	Projects	Distance From Telephone lines in (KM)	Distance from the head office in KM
1	Road Projects		
	• Milla Road Project	60	521
	• Tekeze Humera Road project	80	1251
	• Alamata - Maichew Road project	25	660
2.	Buildings and Civil engineering		
	• Mekelle Business Collage	0	780
	• Monument Project	0	780
		0	

	• Almeda Low Cost Housing • Gondar Brewery Factory • Ethio Rental Office • Shire Military Comp	0 0 0	1020 843 783 1091
3.	Dams • Tis Abay Hydro Electric Power	20	690

Table 1. 1 Projects and their distance from the head office and from the nearby telephone lines

(Source: Contract documents for the respective projects)

1.1.2 Statement of the Problem

During the preliminary survey, which was made for the preparation of the research proposal for this work, it has been observed that SUR Construction S. Co. has a number of problems that need to be addressed.

a) In principle, accounts of projects are closed annually and centrally at the head office to determine the profit and loss status of each project, as well as the profit/loss status of the company as a whole. But annuals closing of accounts at head office are being delayed by some six to eight months. This is against the strict requirement by government authority to report income/loss of any enterprises with in three months from the date of the closing of the account in June 30 of the respective year. For example the following table (Table 2) shows how closing of account and preparation of financial statement have been

delayed in the last four years in the head office.

No.	Period during which accounts should be closed. (E.C)	Period during which accounts were closed. (E.C)	Time Elapsed (months)
1.	Sene 30, 1988	Miazia 15/1989	10
2.	Sene 30, 1989	Tir 30/1990	7
3.	Sene 30, 1990	Tahsas 30/1991	6
4.	Sene 30, 1991	Tahsas 30/1992	6

Source: annual performance report and annual Plan of the respective year of SUR

Table 1.2 Delay in closing of accounts for the head office of SUR

b) The Finance Department head reported that there is a delay to prepare payment certificates to client due to lack of compilation of timely accurate and complete information. This payment certificate is a financial document prepared by projects to request interim or partial collection from clients for the amount of work accomplished based on the agreement made on the contractual document. According to the Finance Department head of the company, although projects should send payment certificate to the head office, every month except for the mobilization period of new projects which is almost always 45 days from the date of commencement of the project, it usually takes some three months. This has a direct repercussion on the delay of collection from clients and in the depletion of the working capital of the company. In 1989 (E.C.), company records show that the company was forced to finance its cash shortages by borrowing 1

million Birr from Commercial Bank of Ethiopia (CBE) while, at the same time, the company had a total of 2 million Birr collection overdue. Since most clients of projects happens to be government institutes, the company requires the timely notification of the collection before the closing of the budget year. Otherwise, budget for these government bodies is released very lately in the budget year.

c) There are cases when tender documents are prepared based on inaccurate and outdated material prices or wrong specifications while the company bids for a new project. Once the client (owner of the project) awards the new project to the company through the contract agreement on each price and specification, a request for amendments is not acceptable and leads to continuous disagreements between the company and the client.

Basically it is the Planning and Contract Administration Department that compiles the necessary information for the bidding of a new project. But this department depends totally on the Purchase and Supply Department for current prices of materials. Normally it takes from three to eight days to compile current and latest prices from past transactions. According to my observation this delay is totally unacceptable by the Planning and Contract Administration Department and usually the Planning and Contract Administration Department urges the Purchase and Supply Department to provide the price information within three days at the latest. The Purchase and Supply Department head stated that the department has no alternative than going through all the purchase order pads to find for the latest price of the material.

Head of the Purchase and Supply Department of the company stated the following case as a good example of the danger of using wrong price or specification while bidding for a new project. While biding for Mekelle Business Collage project, the contract document states that the price of one lock is 330.00 Birr and the project has 512 pieces of locks. But the actual specification is not any kind but an ASSA brand lock, the unit price of which is 680 Birr / lock. This wrong price and specification cost the company about 350 Birr per door lock, which totals to Birr 109,200.00 for all door locks. This seems rather a hypothetical but it has happened and it is a real account of the company. In fact, this according to him is only one case out of the many that the company suffers due to wrong construction material specification and price. The Head further stated that the way current prices are collected itself is prone to errors and takes time for its compilation.

d) The head office, which is far away from the projects, is responsible for allocating and reallocating all sort of resources to projects. Heavy and light equipment and machinery are in most cases obtained from other organizations on lease basis, which requires a close control and supervision whether each machinery are optimally being used or not. Construction materials, which are not needed by one project, may be badly required by another projects. Highly paid personnel are needed in a single project for a limited period of time. Thus multiple project management and mobilization of resources requires a continuos communication between head office and the projects.

The gross effect of all of these problems is that, employees benefit schemes which totally

depends on project success or failure may always be suspended and this in tern may result in employees dissatisfaction and high turnover. Flowers and Charless in Pigors and Myers (1981) stated that most employees remain in an organization largely due to their financial needs. Conversely this means that delay in the employees' benefit forces employees to look for other similar organization that can pay better. Although the exact causes of the prevailing high turnover that exist in SUR is not formally studied, the 1991 (E.C.) annual report indicated that the number of released employee in 1991 (E.C.) totals 60 employees. On the other hand the company (SUR) has recruited 72 employees during the same year.

The above discussion indicates that the multitude of problems faced by SUR construction S. Co. is that department heads and project engineers do lack accurate, complete and timely information to make decisions on their day to day activities. As whitten et al (1989, pp. 142 - 143) stated, lack of relevant information concerning the decision or current situation, luck of timely information, information that is not in a form useful to management and inaccurate information are situations that triggers the need for improvement of the information system.

According to my observation, the company's management, understanding all the problems encountered, wants to have an information system that can curve the problems partially or fully. Since 1989 (E.C), the company tried to buy a numbers of computers and the employees of the company have been trained in general application software such as word and Excel. Now the number of personal computers has reached 29. Currently the

company is using MS project software, to prepare work schedule of projects for tendering purpose. It has been reported by one office engineer, users of the software, that the software makes a wrong assumption that percent of work completed is based on the dollar amount of the resource used. The physical volume of work done measure in the respective unit of measure of the activity is not taken in to consideration. Furthermore the software has very little use for other departments other than that of the Planning and Contract Administration Department, Construction Department and the project engineers, because the software ignores the dynamic nature of the projects and focuses on the static nature. For example, while scheduling resources to projects, the software only assumes that all resources are readily available at the project site, in reality however this is not the case. This should not lead to a conclusion that project management software such as the MS project is totally worthless. In fact project management software like the Ms project has a good facility in scheduling projects activities together with the resources need to accomplish these activity. It is also possible to work with multiple projects in several ways using project management software such as the Ms Project Version 4 (Microsoft Project User Guide, PP. 129). For a better solution, the software should be used in combination with software that takes the real needs and requirements of each user over a period of time across projects.

Very recently, it seems that the company has observed the fact that buying of computers alone addressed little if not, non-of the problem the company faces. As a result the company has called for external software developers to undertake for the software development activity. After selecting and awarding the software developers, the developer come up with couple of in house developed software. While four in house

software are currently being implemented, namely Omni Inventory, Omni Payroll, Omni General Ledger, and Omni Fixed Asset, there is no documentation that specifies the requirement of the company that is produced by these external software developers.

Information Technology Service Head feels that the spatial nature of projects, the inherent differences that exists in projects, and the limited duration of life of projects, dictate special attention be given to develop an integrated information system that aids the head office and projects to manage and control their performance. And it seems that the management of the company also tends to support and appreciate the notion and initiatives to integrate the system. In fact key staffs of the company as well as the researcher share this idea. As Witten et al. (1989) stated, the impetus of system development efforts could be problems, opportunities or directives. In this connection, inability by the construction company to exploit the tremendous opportunity provided by adapting a computer network, given the spatially distributed nature of projects combined with the need to mobilize resources efficiently, is something that the company should give attention to. As Stair and Reynolds (1998), stated, the fact that computer network can be used to share hardware, programs and databases across the organization enables any organization to improve its effectiveness and efficiency. Networks enables geographically separated workgroups to share documents and opinions and foster teamwork, innovative ideas and new business strategies, which is an ideal situation for construction companies such as the one under consideration. The use of computer networks could enable to share expensive design software and other utility software in all the projects. Project engineers can also share ideas when they come up with a new type

of problems that is peculiar to one project and that requires collective and timely solution. Therefore this project makes the requirement analysis of the company and tries to develop design specification. But is worth noting that since the system development methodology is Object-Oriented methods the distinction between the analysis and the design is not clearly demarcated and is seamless.

1.2 Objective of the Study

1.2.1 General Objectives

This research has the following objectives:

a) To identify the key information requirements of SUR Construction S. Co. and the problems associated with satisfying the information requirements.

b) To explore the possibilities of exploiting the Object-Oriented methods, Approach, potentials in visualizing, specifying, constructing and documents system development efforts.

c) Assess the opportunity and benefit that a computer network can bring to the smooth flow of information between sits and their respective headquarters as well as among functional departments.

1.2.2 Specific Objectives

If we carefully observe the problems described in the problem statement (1.1.3) of this report, they are one way or another related to the management of the following basic resources of SUR Construction S. Co. Namely, the Construction Equipment and Machinery, the Cash, and the construction material. The specific objectives of this research are therefore:

a) To identify information requirements of the company in relation to:

- Construction machinery and Equipment Management System so that all data and operation that relate to these objects are modeled.
- Construction Materials Management System so that all data and operation that relate to these objects are modeled.
- Cash Management System so that all data and operation that relate to these objects are modeled and designed with possible prototyping.

b) To explore the possibility of applying Object-Oriented methods Approach in the process of requirement analysis of SUR Construction S. Co. which involves both problem analysis (domain analysis) and business solution requirement description. In fact both activities take place non-sequentially and they are not mutually exclusive.

c) To draw a recommendation, on the basis of the result of the work, how the same problem analysis and business requirement descriptions procedure developed for SUR can be reused and applied to other similar construction companies.

d) An attempt has been made to combine important concepts in to the system being built. Among other things cost control mechanisms, activity planning and scheduling, ABC Analysis has been all integrated in to the material subsystem.

1.3 Scope and Limitation of the study

Due to the size and complexity of the operations of company and the time constraints, the researcher has focused only on the construction material of the company. Even within the material subsystem, which involve the estimation and consumption, and the purchase

and distribution, the estimation and consumption is given more emphasis. Nevertheless attempt have been made to combine important concepts in to the system being built. Among other things cost control mechanisms, activity planning and scheduling, ABC Analysis have been all integrated in to the material subsystem which the writer believe includes the estimating process and purchase and distribution process.

This report does not deal with the detailed design of the system under study. In order for SUR to stay in the construction business, SUR has to win bids for new projects. However SUR has no models that aids top management in evaluating the risk and uncertainty associated with competing for a bid. With this in mind an attempt has been made to explore the possibility of applying Belief Network for bid competition of a new projects. However the discussion on application of belief network for business uncertainty and risk analysis is not complete but it is simply a start that the researcher plans to finalize in the near future.

1.4. Methodology

1.4.1 Data collection Methods

a) Review of documents

While identifying project and head office requirements, review of the following documents were made:

- Quarterly and annual plans and performance report of the company
- Contract documents of projects, organizational charts, operation procedures and manuals of the company.
- Job Description of the company

The first two documents were made available from the Planning and Contract Administration Department and the third were provided from the Human Resource Development Department. Some contract documents were very confidential and access was not allowed.

b) Interview and discussion

The requirements of the department in the head office were identified through an interview and discussion with the department heads and the division heads for missing facts. (See for List of respondents (interviewees) on Appendix B; and see for sample of the Interview Guide on Appendix E (1) and E (2). The respondents were very cooperative indeed.

1.4.2 Data analysis methods

This research employed the following basic techniques of Unified Modeling Language for requirement analysis.

a) Requirement model

- Use Case: to represent the functional requirement or the "what" of the system component.

b) Object Model

- Class Diagram: to show the static structure of data and operations that acts on the data.

c) Dynamic Model

- State Diagram: to represent dynamic models of how object change their states

in response to events.

- Sequences diagram: which represents dynamic model of interaction between objects.

d) Functional Model

- Data Flow Diagrams (DFD) to represent the functional dependency of the system.

The requirement analysis of the company is made using the Rumbaugh et al (1991) methods for system analysis as shown in their book titled "The Object-Oriented methods Modeling and Design". The method was really comfortable and easy to apply. The writer also used the UML notation for documenting the analysis in the form of Diagrams.

Also

For the estimation process a prototype is developed using MS Access 97.

1.5 Organization of the study

The report consists of seven chapters. Chapter two deals with the literature review of Construction Industry and some basics of the software and communication Technology. Chapter three deals with the requirement analysis of the company (SUR). It describes all the five departments in reference to their functional responsibility, data processing technique they employ, interaction with other departments, and the major problems encountered.

The fourth chapter deals with a detailed requirement analysis of one aspect of the company namely the construction material. The company starts to deal with materials while competing for a new project. Accordingly, the discussion starts with the estimation process. Although not detailed, discussions on the purchase and distribution have also been made.

Chapter five deals with the logical and physical database design in two parts. The first part deals with the logical design, which deals with the design of forms, reports as well as logical data modeling. This serves as a basis for building the relational databases. The second part deals with physical data base design.

Chapter six is an attempt to build a model with an application of the belief network appropriate for business uncertainty and risk analysis in the area of biding for new projects.

And finally the last chapter presents the conclusions and recommendations.

Chapter II

The Construction Industry: Literature Review

2.1. General

Basically there are three types of construction works that have different and distinct characteristics and consequently with substantial difference in the organization of work, contractual relationship between the employer and the contractor and information needs (Thompson, 1981). These are building work, civil engineering, process plant erection.

In order to have a clear picture of each type; a short description of each category is presented as below.

2.1.1 Building

This work is frequently repetitive and generally above ground level, with structural safety and aesthetic or beauty consideration tending to dominate the design process. There is predominance of small construction firms with structural engineers and a quantity Surveyor. The work also involves a wide range of different tradesmen and craftsmen such as bricklayers, joiners, plumbers, glaziers, and daily laborers. There are also general foremen who supervise the day to day work directly.

2.1.2 Civil Engineering work

This is mainly concerned with roads, bridges, railways, tunnels, marine structure and water works. They have more potential risks and uncertainty, particularly those, which are related to control of water and underground works. Such work frequently

involves large-scale operations that may extend across a considerable area of a country. The work is highly mechanized. As a result, equipment costs form a large element of the total construction cost.

2.1.3 Process Plant erection

This is the third branch of construction industry. Here the employer or client is expert in the design and operation of the plant or the project and will frequently undertake both the basic design and management of the project unit. The contractor is then responsible for detailed design sit fabrications and erection of the plant units. Much of the site work is repetitive and labor intensive.

2.2 Record keeping and file system in construction projects

The most important task of project engineer in any construction company is to ensure that adequate records regarding the project day to day activity is maintained, Twort and Rees (1995,pp. 125). The success of a project engineer to a great extent depends on the efficiency of the record system that the project engineer sets up. The maintenance of efficient record system would enable him to make a follow up on the process of the construction work and making timely the payment request for the volume of work done. Furthermore such record, according to Twort and Rees (1995), make it possible for designers to be assured, that the design assumptions are valid, and assists the redesign of a new modified one and throw light on the subsequent performance of the work of construction.

Twort and Rees (1995) also classified records of construction projects in to four major categories. These are:

2.2.1 Historical Record

These records show progress of construction work, stage by stage. Such record also includes records of weather, notes of discussion with foremen and other important personnel of the company as well as discussion made with head office, and other key maters influencing the job.

2.2.2 Quantitative and financial records

These records includes measuring of the work performed together with all relevant particulars, so as to form a fair basis of payment requests and maintaining figures that shows the cumulative cost of the job and its components.

2.2.3 Qualitative Records

These records include all records of all measurements and observations of quality and behavior under test of the component parts of the works. They include the type of and made up of materials used and other characteristics of materials, machinery or manpower qualities observed.

2.2.4 As Built records

This refers to a pictorial records of all the work completed. Showing the whereabouts and dimensions of all parts as they exist at completion together with factual descriptions of the work. Examples includes, Photographs, before any work is undertaken, of the site, any building to be demolished; the condition of any adjacent building liable to be affected by the works. They also include monthly progress, photographs of the work

during construction, and photos to illustrate any problem that has occurred on site and which needs to be reported to the head office.

2.3 Construction Companies and Information Communication Technology (ICT)

Construction industries, which involve themselves in any one or more of the above categories, require information for their day to day activity. As such the vital role that proper designed information system could play for their success can not be disputed. Since construction work is usually widely scattered and each project is somewhat unique, the manager of construction needs more information faster than does the manager of a centralized and production line factory (Rubey and Milner 1971 pp. 270). The reason is that delay in decision making in the construction industry is costly. Any project needs a continuous supply of the right material, machinery and labor at the right time on the right quantity. For example, if the head office sends a wrong material to project one can easily imagine the cost incurred not only in getting the right thing by sending the material back in to the head office hundreds of kilometer but also the costs incurred due to delay. Project has to pay idle labor force and machinery time associated with that material until the right material gets to the project which usually takes some days.

The construction process, namely the inception, design, production, use and decommissioning, is information rich and should utilize the ICT in order to effectively and efficiently generate, process, communicate and use this vast amount of information (ISO/TR 14177:1994(E): pp. 5).

Construction industries have projects, which are located hundreds of miles away from the head office. While all sorts of profit generating activities do take place in these remotely located construction projects, the head office is the source of all sorts of material, human, technical as well as financial resources. As a result there is a need for information system that supports continuous flow of information from the head office to the projects and vise versa.

Furthermore, under the modern philosophy of business, profit generation and maximization is by no means the only goal of any enterprise. It has equally social commitments. Without the proper addressing of these commitments, the first goal i.e. profit maximization will become sooner or later an illusion that can never be realized. Thus, there are a number of socio-economic development activities such as the construction of schools, health centers, transport infrastructures as well as power generating stations that are hampered by the efficiency of the construction industries. A delay in construction of these socio-economic development activities directly affects social welfare. In Ethiopia, it is a day to day experience to hear from the mass media that a number of construction companies fail to realize their commitments to hand over projects to their clients on time. In fact, this failure to a large extent could be due to delay caused by the poor information system that may be adapted by these construction companies.

2.4 Review of software in the construction Industry

According to Lounghborough Consultant's manual (1996, pp. 20) software systems that are currently used in the construction industry can be divided into three large categories: systems that deal with the technical issues of construction process; systems that deal with accounting aspect of the construction work; and general software. For our purpose we will only consider the first kind of application. These systems provides facilities that enables the users of these software to make drawings, cost estimation, tendering, scheduling and management of a construction project.

Numerous programs exit to assist architects and engineers in designing buildings. These applications assist diverse aspects including, the preparation of drawings, structural design, estimation of thermal performance of buildings and the analysis of soil conditions.

a) **Preparation of drawings**

In this category, the use of Computer Aided Design (DAD) software has gained popularity in recent years. In their basic form CAD systems allow two-dimensional drawings to be produced and more advanced systems permit three-dimensional representation of structures as well as a host of other more specific features that vary from product to product. Some of the latest developments involve, providing facilities that simulate the view that the computer user would experience feeling of just like the user personally is taking a walk inside the building. The trend being followed by the developers of CAD systems, therefore, appears to provide images that make it easier to visualize the proposed design.

This in turn allows users of CAD systems to communicate their ideas to their clients more effectively before any construction work is commenced. .

b) Measurement

This category involves quantifying the work necessary to erect a structure in accordance with the construction drawings. There are several types of programs that are available to service this area.

i) **CAD generated measurements**: The automatic production of measurements from drawings produced by a CAD system is an area that is receiving attention from the software industry. In theory, it should be possible to translate the coordinates held in a CAD system for particular drawings into the lengths, area and volumes of the structure in question. Most CAD systems are able to produce such measurements but problems arise, as the quantities produced in this manner need to conform to the requirements of the standard system of measurements. As this stages according to Lounghborough Consultants Manual (1996), no comprehensive solution to this problem appear to have been developed.

ii) **Keyboard entry of measurements:** Software of varying sophistication is available which allows one to type in dimensions from drawings and have computational tasks such as squaring, abstracting, and billing automatically performed by the computer system. In addition, facilities exist that allow

dimensions to be referenced with respect to their locations. This allows subsequent sorting and reporting of quantitative information in terms of location criteria.

iii) **Digitized entry of measurements**: This approach represents a more elegant use of computer technology and involves the use of a digitizer, which is a sensitized drawing board and stylus. Drawings to be measured are placed on the digitizer and this system calibrated to the required scale. The wall lengths and floor area to be measured are marked off in the case of curved elements traced using the stylus and the system then automatically calculates the appropriate length and area.

The cost of these systems varies, as the cost of the digitizer is directly proportional to the size of instruments required. In view of the expense involved these systems have only proved to be cost effective where drawings involves shapes that are difficult to measure by manual methods or inappropriate source scales need to be accommodated.

iv) **Automated measurement**: This technique uses software that adopts question and answer approaches to record and define dimension and specification to a project. From this information, schedules are generated not unlike traditional schedules. These are then processed by software, which generates dimensions, in accordance with the requirements of the standard system of measurement. Using

this approach, the recording of information is optimized, as there is minimal duplication of information e.g. Wall finishes in a room are recorded only once and then used for the measurement of finishes, the adjustment thereof in respect of doors and windows and the automatic computation of labors.

c) **Preparation of Bills of quantities**

The software systems referred to in this category are those traditionally used by quantity Surveyors. The main objective of these systems is to produce bills of quantities. To achieve this, facilities are provided which allow description of construction work to be stored. These data are then used, added to and or amended, to produce bills of quantities for specific construction projects. Some systems provide additional facilities for measuring drawings similar to that already described above, producing interim valuation work done, calculating the mass of steel reinforcing and calculating escalation costs based on the formula available.

c) **Bills of quantities estimating /tendering systems:**

Two categories of system exist, namely the bills of quantities estimating system and elemental estimating systems.

i) **The bill of quantities estimating systems**: These systems allow users to estimate the costs of construction projects based on bills of quantities. The facilities provided allow performance data from past construction projects to be collected in a library. These data are then reused and adapted in order to estimate

the cost of similar projects. The library usually provides two separate but dependent files. A resources file containing, the cost and descriptions of material, labor and plant is used in conjunction with an item file of performance data containing the production rates of resources used in specified condition to do specific tasks. The rational behind this approach stems from the volatility of resource prices. Users of these system generally need to revise prices frequently and have the cost of items updated accordingly. This is readily accomplished by storing price data separate from performance data (which generally remains constant) . A host of other facilities are also provided including those that allow the estimate to be converted into a tender by the addition of mark ups.

ii) **Elemental estimating /Tendering System**: These systems cater for lump sum estimates based on drawings and specifications. Their main advantage is that they speed up and simplify both measurement and estimating.

The problem that exits with estimating and tendering systems include, a comprehensive database is essential if these systems are to be used effectively. If these data are not available, computer-aided estimating is unlikely to provide a cost-effective means of producing a tender. It is essential that resource prices be kept up to date

e) **Planning /scheduling systems**

Computer aided critical path method (CACPM) systems have gained considerable acceptance in construction. These systems allow a builder to define a series of operations such as set out site, excavate footings, pour concrete and so on and

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allocate logic, duration and resources to each activity. Thus, for example it is possible to instruct a CACPM system that the excavation of footings can only be done after the site has been set out and that a back actor and three general workers are required to accomplish this task.

A link between the productivity used in estimating/ tendering systems and CACPM system would seem logical. However, the practicalities of establishing this link have proved difficult to accomplish in a logical manner. There are thus few programs that allow this link to be affected though this area appear to be receiving more attention from the authors of construction computing software.

f) **Interim valuations of construction costs**

The computer systems available to provide interim valuations allow work completed on a construction site to be monitored on a month by month basis. Use is generally made of the data assembled in estimating/tendering systems to prime these programs. Quantities of work completed on site are then accumulated against each item found in the bills of quantities and comparative reports produced. Two main categories of report are generally provided, namely a bill of quantities report showing the work completed to date or during the last payment period; and reports used for internal management purpose. (e.g. reports showing under and over measurement of interim quantities, as well as reports indicating the quantities of labor, plant and material that should have been used to complete the work monitored.) Because of the similarity between these systems and

estimating/tendering system in computing terms most vendors of construction software systems provides both application, although the facility provided by the various software houses vary.

g) **Escalation calculating systems**

Most of the time these applications are not provided separately, rather they are provided with applications that deals with interim valuation of construction costs discussed. The logic behind these software is that if there is any change in the volume of work done or in inflation in price then such software are adapted to calculate the required claim that has to be made to the client of the project.

2.5 Computer Networking and Communications

2.5.1 General

Contemporary practice shows that information systems development involves the use of networks. This is because the resources required to establish such an infrastructure is becoming much less than the return generated from such an investment. Predominantly, organizational productivity can't be realized independently but through continuous interactions and information exchange between different units of an organization, or even with external environments. Thus networks are becoming the backbone (platform) of conducting all sorts of organizational activities, and information is the content (substance) that needs to be manipulated and put into use.

2.5.2 File server and the client/server network architecture

In distributed processing, a computing task is divided in to two processes. A front end that requires minimal resources and runs on a client work stations and a back end that

requires large amount of data, number calculation, shared processing rules or specialized hardware, that runs on a server. The server shares its processing power executing tasks on behalf of clients. The client and server components can be from a common application or from different application. On the other hand when an organizations is geographically dispersed, it may choose to store its database on a central computer and make this data available over telecommunication lines to multiple users. Therefore the client/server network architecture supports the both distribution of data and the distribution of processing, whereas the file server architecture supports, only the distribution of data. The latest extension of the client/server model for example the Window NT 4.0 incorporates internet/intranet technologies into the client/server environment.

2.5.3 Internet and Intranet

According to Microsoft Official Curriculum (1998, pp. 366-367) Internet is a global network of computers that communicates using common language and protocols. Intranet is defined as internal network that uses Internet technology such as the Hypertext Transfer Protocol (HTTP) server to improve an organization's internal communication. And application development process. Intranet refers to any TCP/IP based network that is not connected to the Internet. But it is possible to integrate a company Intranet with Internet as far as security issues are carefully handled. For example it may not be advisable to grant full intranet access to Internet users and proprietary documents be kept separate so that they can only be downloaded from the Intranet site but not from the internet.

2.5.4 Network Topology

There should be a mechanism on how the various computers on the network should be connected. There are four major connectivity options: bus, ring, star and hierarchy.

a) **The Bus Topology**: The main problem with the bus topology is the cost of connecting computers. Since it is unlikely that all connected computers will be heavily utilized equally it is prohibitive (cost wise) to use the bus topology.

b) **The ring topology**: on the other hand, Ring can enable to transmit messages, instructions and data to only one other computer or node on the network. This uni-directional message transfer has the benefit of increasing network efficiency provided several messages are sent concurrently in the same direction. However, when the number of messages to be transferred at a time is minimal, there will be under use of network resources. Moreover, the uni-directional message transfer prohibits message sending and receiving at the same time.

c) **The star topology**: The star topology links multiple computer systems through a central computer. The role of the central computer (server) under this topology is to manage the transmission of data and messages between interconnected client computers and other servers with in the network.

One can use the UML deployment diagram to visualize, specify and document the decision about the topology of the client/server system and how its software components are distributed across the client and server.

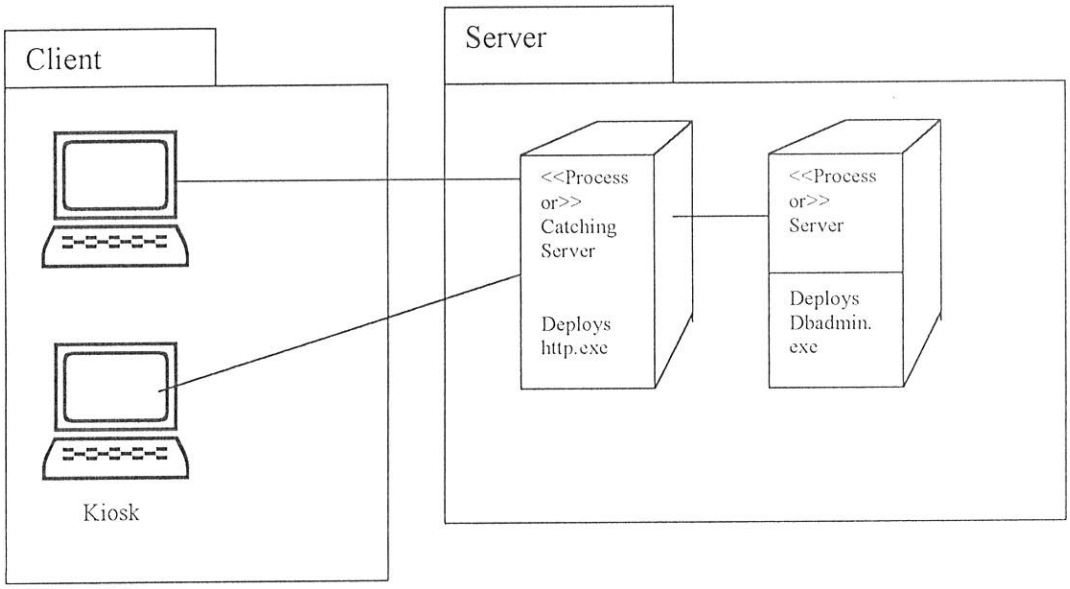


Fig 2.1 Modeling a Client/server system using UML.

(Source: The Unified Modeling Language, User Guide, Booch et al, pp. 414)

2.5.5 Data architecture

Whitten et al (1998) indicated three guidelines for data distribution over network processors. Similarly Hoffer et al (1999, 736), indicated that research and practical experience have found that there are four major strategies for distributing a database. These are

a) **Data replication**: A separate copy of the database is stored at each of two or more sites. The major advantage of this approach is, it is more reliable and has faster response. The major disadvantage is that it requires more storage and it is complex and costly to update.

b) **Horizontal partitioning**: Here, some of the rows of the table are put at one site and other rows are put on another site. The advantage of this type of data distribution is

Chapter III

Requirement Analysis of

SUR construction Share Company

3.1.General

This requirement analysis is basically made on the data collected from the discussion with the head of each department of SUR (See Appendix E for sample Discussion Guide). Since the interview is arranged out of office hours it has been conducted with very smoothly and it was successful. Although the writer was considering at first to use a more modern data collection methods such as JAD (Joint Application Development), the use of the traditional approach, the interview method was found more than sufficient for collecting the necessary information from the target users. Before the discussion with the department, sufficient review of annual reports and the job description of each department heads as well as their subordinate division heads were made. Furthermore a review of the contract documents and working papers (Pads) were made after the discussion with the departments. Observations were also been made on some maters of the organization such as the type of and capacity of the computers of the company. No significant problems were encountered except for the inaccessibility of some contract documents, which were deemed to be very confidential and I was also convinced that the documents were really confidential these documents does not have an impact in any way the outcome of this study.

3.1.1 Organizational Background

SUR Construction S. Co. is a profit making organization that involves in the construction of roads, bridges, airfields, dams and buildings. It is established in 1984 (E.C.) with a capital of Birr 200 million. It operates through out the country with particular emphasis in the northern part of Ethiopia. According to adept report (1997 GC), the clients of the company are from international funding agencies, public and government organizations and private enterprises. Since most of the projects of these clients are offered internationally, competition to win tender is extremely fierce. As a result, SUR makes strong effort in order to qualify to be in the bidders list and get the award of the project (Adept, 1997)

3.1.2 Organizational Structure

SUR Construction S. Co. is organized in to two line departments and three-service department and two advisory divisions. The line department are the Planning and Contract Administration Department (P&CAD) and the Construction Department (CD) the service departments are the Finance Department, the Human Resource Development Department and the Purchase and Supply Department. The three service departments have a functional relationship with all the projects. As a result information flows from these department to projects and vise versa as well. In principle, the projects directly report to the Construction Department. The advisory divisions are the Audit Service and the Legal Advisors Divisions.

The organizational structure of the company is therefore a matrix organization, with line functions of projects reporting to the Construction Department and the stuff function reporting to the corresponding departments in the head office. For example the finance section of each project has a direct functional relationship with the Finance Department of the Head office. The organizational chart is shown below (Source: Job Description Manual of SUR, 1991)

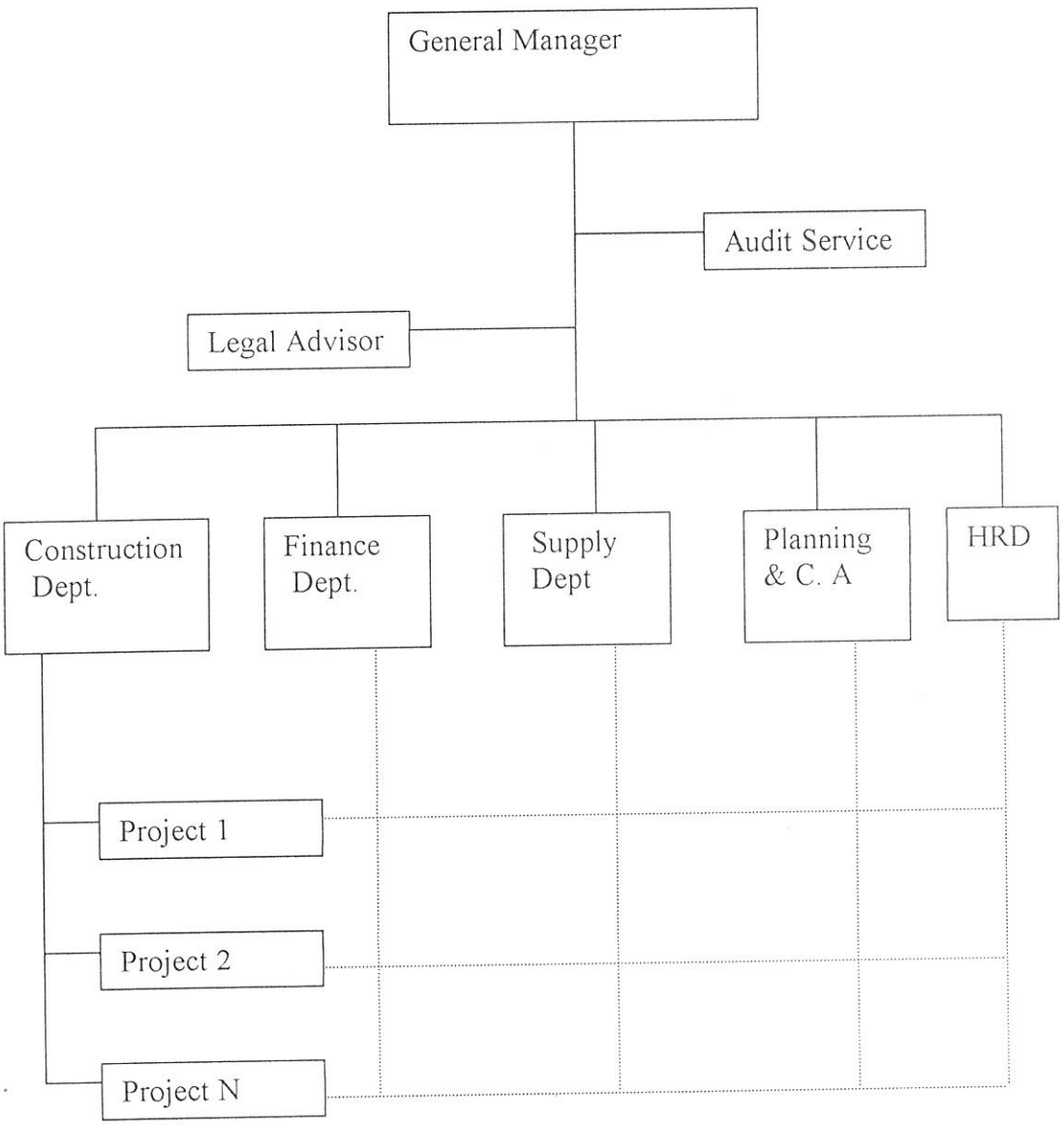


Fig 3.1 Organizational Chart of SUR

3.2 Company Plans and performance

3.2.1 Strategic Plans

Given the fierce competition to win a project, the company adapts various strategies. The company's strategic goals for 1996 - 2000 had been to seize a substantial share of the market for construction projects and make use of the opportunities created. With this in mind the company has adopted a variety of strategies some of which include. Adopt (1997)

a) Participating joint venture with overseas companies even at a lower profit partnership to gain practical experience. An example of such project is the Tis Abay Hydroelectric project that is currently being undertaken jointly with a Yugoslav construction company.

b) Skill and technology transfer agreement with oversees companies. A typical example being the agreement made with Adept - a British resident company on various capacity building projects.

c) Making a huge investment in procurement and owning and operating additional construction equipment. This includes the purchase of five crashing machine and two-tower crane at a total cost of 50 million Birr.

3.2.2 Company performance

Just to give a picture of the company, let us look at the following two tables that states the company profit and loss report for the last seven years (1985 EC - 1991 EC) and summary of annual plan and performance for the year 1990 (E.C.).

No.	Year of Financial Statement	Annual Company profit (loss)
1	1985	(3,552.734.31
2	1986	(1,287,513.25)
3	1987	1,780,877.36
4	1988	1,522,134.62
5	1989	2,022,321.41
6	1990	2.322,000.00
7	1991	2,599,667.06

Table 3.1(a) Profit and (Loss) statement of the company from 1985 (E.C.) to 1991 (EC)

(Source: the respective year of the Financial Report of the company)

1990 (E.C.) Project	Plan Revenue.	Plan Cost	Plan Profit	Actual Revenue.	Actual Cost	Actual Profit	Rev. Var.	Cost Var.	Profit var.
	144.68	117.21	27.49	101.30	95.78	5.50	-43.4	21.4	-22.99
Gross profit Margin			19%			55			
Profit Before Tax			17.87			3.57			
Tax @ 35%			6.25			1.25			
Net Profit			11.62			2.32			

Table 3.1(b) SUR Profit and loss planned vs. Actual analysis in million of Birr

(Source: 1991 (E.C.) Financial Report of SUR)

An obvious question that one can raise is that, why so much discrepancy between plan and performance? Does the plan depend on dependable information and source of information? Are there mechanisms that enable to track data on business events? Are the measurements of progress of construction work on the site well registered and reported efficiently?

3.3 Review of Departments

3.3.1 General

Generally the activities of the company and the work of any civil engineering activities, for that matter, can be categorized in to three major broad categories. These includes

a) Pre tendering procedure

b) Pre construction procedure

c) Construction procedure

Therefore each departments is reviewed according to this natural procedure. Some departments seem to have more role in one procedure and a very less roll in others. For example it has been found that the Planning and Contract Administration Departments has more roles in the pre tendering and pre construction procedures and a very less involvement in the construction procedure. On the contrary the Construction Department has very little role in the pre tendering procedure and very high involvement in the construction procedure.

3.3.2 The Planning and Contract Administration Department

a) **Functional Responsibility**

The Planning and Contract Administration Department has five divisions. Namely, the Tendering and Cost Estimation Division, the Contract Administration Division, the

Planning and Programming division, the Information Technology Division and the Quality Control Division. With these functional division the department performs the following basic functions. (Source: Job Description of SUR, 1991)

- Prepares company long term and short term plan.
- Prepares cost estimates for purpose of tendering, negotiations, variation order, and supplemental agreements.
- Prepares claims on time extension as well as financial claims.
- Compiles company qualification documents and company profile documents.
- Communicate with clients and consultants about time extension.
- ensure that any bond, guarantee or bid security payments are timely released.
- Checks payments certificates are collected on time.
- Collect provisional and final acceptance certificates, recognition letters.
- Ensures the performance of the projects meets an acceptable standards
- Provides and facilitates laboratory test result requested by projects
- Ensures that the company is utilizing the state of the art technology and persuades top management to make sufficient investment for new information technologies.

b) **General Work flow**

i) **Pre Tendering procedures**

The main objective of this department is to assess new markets in the form of construction project bids that can be undertaken by the company. The main source of information is government newspapers such as The Ethiopian Herald

and The Addis Zemene Gazetta. If a bid for the construction of a new project is posted in these news paper that is within the construction level of the company i.e. GC1 (General Contractor level 1) level, then the necessary biding document is collected from the promoter by the Planning and Contract Administration department. The promoter, as sometimes called an employer or the client, is a legal entity that defines its needs of commissioning construction, in the form of preliminary design together with a bill of quantities for the work to be done.

Upon the receipt of the bid documents and approval by the General Manger of SUR Construction, the P&CA Department will make the necessary feasibility study on the site, on which the promoter suggested the construction work will take place. The study may include an assessment of the following fundamental issues

- How far is the site from a near by town?
- Where is the nearby market for laborer?
- What is the cost of skilled, semi skilled and unskilled labor?
- Does the location of the site need to construct a camping for residence of the laborers?
- Where is the near by market for materials and how difficult is to mobilize construction machinery and equipment?
- What will be the cost of mobilizing?
- What is the type of soil in the site?
- Is it convenient for the construction work? Etc.

After assessing all these issue in terms of their impact on the unit cost of the resources namely, the material, labor, and machine that is going to be used in the construction work, then a proposal is prepared and submitted to the General Manager of SUR for decision. Most of the information for preparing this tender proposal is collected from site observation and laboratory test results. The proposal contains

- The estimated cost of the project
- Potential traits and opportunities that the project has. For example if there is a near by project of the company that is near to be finalized then this is considered as an opportunity because mobilizing of basic resource from this project to the new one is possible at a very lower cost.
- And recommendation on the part of the department for continuation

The General Manager of SUR evaluates the proposal of the planning and contract administration in terms of a variety of perspective including the companies over all capacity to add up a new project, in terms of meeting the projects proposed deadline and keeping the required quality of the construction work. Furthermore, experience in similar projects will be evaluated and the proposal will be approved or rejected.

If the General Manage of SUR approve the proposal, then the next step is to compile the necessary data for finalizing the tender document. This includes the compilation of four major documents namely,

- **Preparation of the work program or master work schedule**: The preparation of tentative work schedule among other things includes the break down of the project works into major activities and allocating a time frame for each major activity and The preparation of resource requirement schedule. This requirement schedule is composed of four major requirement schedules. Namely,
  - **The material requirement schedule**: which states the specification of the material required and its quantity apportioned over the projects life indicating the specific month the stated quality should be delivered to the project.
  - **Equipment requirement schedule**: which indicate the type of construction machinery and equipment required together with the time schedule for their delivery to projects.
  - **Manpower requirement schedule**: the type of manpower required and the time schedule when labor force must be available to projects; and
  - **Financial requirement Schedule**: It shows the periodic flow of financial resource to the project under consideration.

- **Preparation of qualification document**: The second task in the compilation of tender document also known as company profile. Company profile or qualification document describes all the financial, machinery and the list of the qualified personnel that SUR has at its disposal. The department therefore interacts and gathers up to date information from various departments. Human Resource Development Department given information about the resume of key engineers in the company. The Purchase and Supply Department provides the list of machinery owned by the

company and their capacity. And the Finance Department provides the financial status of the company that is certified by external auditors and the companies lending power certified from financial institutions.

- **Preparation of Work Methods**: Preparation of work methods is the third task that the Planning and Contract Administration Department performs while compiling the tender document. It shows how each resource is combined optimally in order to produce a certain level of output of a construction work. To produce work method it requires collecting productivity rate of labor, machinery and material based on past experience of the company itself or the experience of others if obtained.
- **Determination of Tender Prices**: The fourth and the last task is finalizing the price of each activity listed in the bid document. The current prices of materials are collected from the Purchase and Supply Department. The labor costs are compiled from the Human Resource Development Department. Rented equipment fees are collected from Ethio Rental House S. company, a machinery renting enterprise, Fabrication of some metal and metal products are collected from Mesfin Industrial Engineering, metal rolling and milling factory, and finally transport costs are collected from Trans Ethiopian , a transporting enterprise. These last three companies have a long-term agreement with SUR for the supply of their products and service to SUR subject to the revision of current price on the market.

  As a complement of finalizing the prices of the tender,

  - Indirect project costs e.g. administrative costs, technical salaries, and temporary facilities expenses.

- Company overhead costs in the proportion of the bid price to SUR's total projected over head costs.
- Profit margin are compiled and included in the cost build up.

The final result of all this is a tender document that can be sent to the owner of the project for bid.

ii) Pre construction procedure

This the second major activity that follows the pre tendering procedure. If the SUR wins the bid, then the employer or owner of the project will declare the award of the project to the company (SUR), and thereafter the necessary preparation for contract agreement will be undertaken. It is also the Planning and Contract Administration Department, which is responsible for the proper planning and follow up of the contract.. If necessary the department will exchange views and information with the legal advisor of the company for possible effect of each article on the draft contract document sent from the employer. If the draft contract is acceptable as presented then the company will sign and send back the contract to the employer. If there is any amendment to be made difference then the department will work with the employer to finalize the contract.

iii) **The construction procedure**

This is the third major activity that follows the pre construction procedure. The Planning and Contract Administration Department has less involvement in this phase of the companies work. The department's emphasis is on the documentation

of the plans and performance report of all the departments of the company. It also sets procedures and designs forms for preparation of plans and reports for projects as well as for other departments. The planning and performance report procedure of the company is as follows.

- Each departments receives monthly reports and monthly plans not later than two days after the end of the month from the projects and compiles it and then submits the consolidated monthly report and monthly plan to the Planning and Contract Administration Department. The Planning and Contract Administration Department then compiles and submits it to the General manger.
- The quarterly reports and quarterly plan are received no later than three days after the end of the quarter to by the departments and then the department compiles a consolidated quarterly report and plan, and submit it to the Planning and Contract Administration Department. The Planning and Contract Administration Department then compiles and submits it to the General manger.
- The annual report and plan shall be submitted not later then five days after the end of the budget year to the department and the department compiles it and then submits it to the Planning and Contract Administration Department. The Planning and Contract Administration Department then compiles within two days and submits it to the General manger.

Generally the Planning and Contract Administration Department compile company level monthly, quarterly and annual performance plans and reports, and documents them properly for future references.

c) **Interaction with other units**

The department interacts with both internal and external units. Externally, it interacts with suppliers, Standard organizations such Ethiopian road authority, consulting firms. Internally it interacts almost with each of the department and with the General Manager.

d) **Data Processing Technology**

i) Hardware: Currently the department is using three high capacity computers, with 64 MB RAM 366 MHz processor and 6 GB hard disk. It has also one Laser Jet Printer with a speed of 8 lines per second printer and one plotter. The plotter is used very occasionally for making preliminary drawing for the purpose of contract negotiations. It also utilizes Microsoft project management software for scheduling the activities of projects. Furthermore it has one server with 128 RAM and located in the Information Technology service division, with 6 workstations in the finance and Purchase and Supply Department. As a mater of priority, the computers in this department are not connected to the Local Area Network. Because the application software that are currently being developed are meant to be shared by the Purchase and Supply Department and the Finance Department.

ii) Software: The most dominantly used application software used by this department is the Microsoft Excels and This software is used for compilation of tender documents and consolidating the various reports and plans that come from departments. The department also uses an in house developed MS Access based programs that designed to track productivity of resources such as machinery, material and labor which is then used for cost estimate during tendering. Furthermore, the department has got design software, which is bought for about 46,000.00. Although currently the company does not have any staff that is assigned to work on drawings, the company has a plan to have one design division head. But now the company gets a design service from external design organization such as Addis Engineering for fees.

iii) Training: Five of the employees in this department including the department head, are trained in the Microsoft Windows, MS Word and MS Excel software. Currently two of the employees are being trained in the new design software. Two of them have taken the Microsoft Project Management Software as well.

e) **Problems**

The major problems that are reported by head of the Planning and Contract Administration Department, is the absence of a mechanism that enables verify that estimated costs of projects used during tendering against actual cost incurred on each activity. This enables to modify productivity data when estimating costs for new projects. According to the head of the department the major problem is associated with compilation of productivity data on projects. Productivity data is an important and

integral part of the tendering process. If machine productivity is erroneous then the total estimated cost of the project as well as the time schedule allotted will definitely be erroneous. Therefore data must be continuously compiled on the efficiency of machinery and the other resources so as to come with accurate productivity data. This is also true with the productivity of the labor force and material..

In fact most projects had collected the data as per the given format but they were reluctant to send it to the head office timely. And even those that are sent from project are incomplete. The reason is that the data collectors are not consistently made because separate staff is not assigned for this data collection. And usually the data collection is considered as secondary for them. Secondly, The other problem reported by this department according to the head of the department is that there is a delay of data flow from projects. Plans and reports are not compiled on time and did not meet scheduled deadlines for submission. One reason for delay is given the distance, reports prepared on hard copies have to travel a long way to get the head office.

3.4.2. The Construction Department

a) **Functional Responsibly**

According to the Job Description Manual of SUR (1991 EC), the Construction Department has three divisions namely, the Road Construction Division, Water Works Division and Building Construction Division and carries out the following functions.

- Work plan preparation
- Resource scheduling.

- Verifies payment certificate prepared by projects.
- Monitors that construction work progress of projects
- Monitors construction work meets a specified standard contained in the contract.
- Reports to the general manger the work progress.
- Accepts complaints form clients for completed project during the defect liability period.
- Manages the resource sharing among projects.
- Maintains the full utilization of plant owned or leased by the Purchase and Supply Department
- Approves store requisition from projects.
- Given technical assistance to the Purchase and Supply Department during the purchase of construction materials and plant.
- Prepares specification and bill of quantities for subcontracting and tendering process for the Planning and Contract Administration Department .
- Ensures that Purchase and Supply Department is sending materials and plant as schedule.
- Ensures that the HRD is providing manpower to projects as scheduled.
- Handles and processes change order and price escalations.
- Evaluates problems reported by project and proposes a solution.

b) **General Work flow**

i) **The tendering stage**

The Construction Department has very less involvement in the pre-tendering phase of the construction procedure. During the pre construction period, the department would provide the necessary data to the Planning and Contract Administration Department on the productivity of the machinery that belongs to the company based on records of their performance rate collected from previous projects. Furthermore, the department also works out the last and most refined work schedule and resource requirement schedules for a new project and is distributed to pertinent department. For example, before the commencement of the construction of a new project; cash flow schedule is submitted to the Finance Department; the material requirement schedule is submitted to the supply deportment; the manpower schedule for the Human Resource Development ; and a copy of all these schedule are then given to the assigned new project engineer.

ii) **Pre Construction stage**

It is the Construction Department that takes over the project site and constructs temporary offices of the projects, warehouse, access roads and maintenance rooms. It is also the Construction Department that establishes the construction method that can be applied to the new project. Here the work method prepared by the Planning and Contract Administration Departments reworked more accurately and by incorporating specific information gathered since its preparation.

iii) **Construction Stage**

During the construction procedure or phase the Construction Department is highly involved in the day to day operation of the construction work of all projects. If projects face shortage of material, shortage of working capital (and any other problem for that mater), it is the first department that is informed and that looks for a solution.

It also consolidates the monthly, quarterly and annual performance plan and report that are sent from projects.

c) Interaction with other units

The construction department makes the highest interaction with projects, and the Purchase and Supply Department. Although to a limited extent, it also interacts with other departments. Moreover it makes continuous relationship with the consultant of the project represented by the owner and the consultant.

d) Data Processing Technology

i) Hardware: Currently the department is using three computers, two of which has 64 MB RAM, 366 MHz processor and 6 GB hard disk and the other one has 32 MB RAM, 100 MHz speed of processor and 2 GB hard disk. It has also one Lesser Jet printer with a speed of 8 pages per minute. Further more each of the 10 projects has one personal computer and one Laser Jet printer.

ii) Software: The most dominantly used application software is the Microsoft Excel and it is used for compilation of consolidated reports and plans that comes

from projects. Although there is design software in this department, it is not utilized yet.

iii) Training: Five of the employees including the department head are trained in the Microsoft Windows, MS Word and MS Excel software. Currently one of the employees are being trained in the new design software.

e) **Problems**

In the first place, evaluation of the radio message record shows that the department is the first as compared to all the departments in the head office, in the usage of High Frequency Radio intensively. It has been reported that for those remotely located projects since there is no telephone, communication is through High Frequency Radio (HF Radio) messages. The HR radio is noisy and sometimes difficult to get connected and to convey messages with projects as desired. Secondly, it has been also reported that, to have a drawing done usually takes a little bit longer time in the design service providers, this has a direct impact on the extension of the completion of a project, particularly the design of modification.. Thirdly, the Construction Department Head has also disclosed the delay in the preparation of performance report and planning. Although the department reviews the report that comes from projects, it usually requires the rewriting of these reports, since these report come in hard copy. Besides to augment any data and activity that is performed by the department to the report, it usually means to manually search in the piles of physical report in order to track data important for the report. Last, but not least, is that it is almost difficult, if not impossible to get any information required after it has been closed and the project is submitted to the client.

There is no proper way to assess the information found in piles of documents of completed projects.

3.4.3 The Purchase and Supply Department

This department has very little involvement in the pre tendering and pre construction phases. Except the provision of current price for the Planning and Contract Administration Department during the pre-tendering phase.

a) Functional Responsibility

The department has three divisions. These are the purchase division, the store and distribution division and the Equipment Administration Division. The department's responsibility includes the following. The Purchase and Supply Department performs the following activities. (Source: Job Description of SUR, (1991 EC).

- The material requirement schedule or any store requisition is checked for materials, quantity and their lead time to start the purchase of materials.
- The requested material is checked if it is available in stock.
- If there is no in stock, then purchase requisition is filled and given to a purchaser.
- The purchaser collects Performa invoice from suppliers.
- The purchase clerk prepares an evaluation sheet and submits it to the purchase committee for decision.
- The purchase committee selects the supplier from which the material is to be purchased.
- Purchase order is sent to the supplier.

- The supplier sends the material and a pack list to the store.
- The store clerk checks the materials against purchase order.
- The store clerk sends the material to the right project.
- The projects send Goods Receiving Report to confirm its proper receipt.
- Arrange the necessary transport for dispatching the purchased materials
- Make periodical maintenance of the equipment and machinery as well as the vehicles of the company

b) General Workflow

The objective of the Purchase and Supply Department is to provide projects with the right quality and quantity of the construction materials and machinery at the right time, as per the material requirement schedule, and machinery requirement schedule.

The Purchase and Supply Department head explained the process of the purchase and distribution of materials as follows

Requests are made in two ways. The Construction Department could initiate requests by providing material requirement schedule to the Supply Department. This material requirement schedule contains description of the item, the name and address of the project, quantity requested, the month when the material is requested at the project site. Sometimes, requests can also come directly from projects and the head office staff by filling store requisitions.

The first step that the department does is, it checks if the request is available in the store. If it is not available, the department fills a purchase requisition form and sends to a number of suppliers. The suppliers provide Performa Invoice. The Purchase and Supply Department prepares an evaluation sheet on the basis of the Performa Invoice, and

provides it to the Purchase Committee to select the supplier. Once the supplier is selected the department sends a purchase order to the supplier. Copy of evaluation sheet, purchase requisition and purchase order is sent to the Finance Department for payment.

The supplier having received the payment /check and the purchase order sends the material with packing list and invoice to the store. The store after checking the physical condition of materials and comparing against the purchase order, issues the Transit Receiving Note (TRN) to the purchaser. The supply Department arranges transportation, and the store dispatches the goods to projects. The project having received the materials will send Goods Receiving Report (GRR) to the Purchase and Supply Department to confirm its proper arrival.

c) **Interaction with other units**

In order to accomplish the function the Purchase and Supply Department interact with the Finance Department, Construction Department and with Projects as well as with the planning and Construction Department. It also interacts more often with suppliers, hauling agents as well as equipment and machinery renting enterprises.

d) **Data Processing Technology**

i) Hardware: Currently the department is using Six computers, three of which has 64 MB RAM, 366 MHz processor speed and 6 GB hard disk and the other three has 32 MB RAM, 266 MHz speed of processor and 2 GB hard disk. It has also one Lesser Jet printer with a speed of 6 pages per minute and one Epson printer.

ii) Software: The most dominantly used application software is the Microsoft Excel and it is used for compilation of consolidated reports and plans that comes from projects and follow up of purchase status, preparation of evaluation sheet. It also uses the MS Word for corresponding with suppliers. Currently three software is developed for the Purchase and Supply Department these software are used to track the purchase process, the inventory and the fixed Asset. This software is network-based software developed using Fox pro programming environment. This software is initially developed for other company and are being customized for the company purpose. But although these software are sill under test, generally the users of these software has reported that it usually takes a very long time to modify a specific request made by the users for modification.

iii) Training: Eight out of 16 employees in this department are trained in the Micro soft Windows, MS Word and MS Excel software. (Please organize it in to hardware, software, training)

e) **Problems**

The followings are the major problems that have been reported by the Purchase and Supply Department Head.

First, it has been reported that it takes three to seven days to consolidate and submit to the concerned body i.e. Planning and Contract Administration Department. The later expect to receive the reports with in two days for monthly report, within three days for quarterly report and within five days for annual reports to the latest after each of the reporting period.

Second, Planning and Contract Administration Department highly depends on the provision of accurate, timely, and complete specification of information given from the Purchase and Supply Department to participate in a bid. The Purchase and Supply Department stated that current prices are searched from the large volume of piles of purchase orders when a query comes. Such manual based searching of current prices usually takes times and this delay is totally unacceptable by the Planning and Contract Administration Department. The price provided may not also represent the current price.

The third major problem reported is that projects usually make a telephone call or made a HF radio connection to the Purchase and Supply Department to know about the status of a certain item in the list of the requirement schedule. A construction material could be in either of the following status at any given time.

- At Performa Invoice collection state,
- At evaluation state
- At the ordered from supplier state,
- At the head office store state, or
- At the dispatch state.

Therefore the state at which the material is found is a key information required by projects and the Purchase and Supply Department has to refer to a multiple of purchase processing documents and pads to given an answer to such request from projects.

Lastly, it has been observed that a single item has to be rewritten seven to ten times in the pads used by the department (See Appendix A For the list of operational pads together

with their total annual consumption). In almost all the operation pads a single material specification has to be rewritten. It has been observed also that, the material specifications are too long and a single material name is written in four to six lines in the pad. Generally, a single material appears in the following pads: Store Requisition, Purchase Requisition. Supplier Price Evaluation Sheet, Purchase Order, Transit Goods Note, Dispatch Note, Goods Receiving Report (by projects), Sore Issue Notes. This duplication of recording leads to delay in processing of the purchase of an item.

3.4.4 The Finance Department

a) **Functional Responsibility**

The department has two divisions, namely, the General Accounts division and the Cost and Budget division. Through the help of these two divisions, the department performs the following basic function (Source: Job Description of SUR (1991 EC)

- Coordinate that the company's accounting documents are audited annually by external auditors.
- Checks that all receivable from clients are collected in time.
- Checks that all payments are made to debtors, suppliers as per the company procedure and within the budget limit.
- Prepares annual financial budget.
- Secure external finance for operation and capital expenditure.
- Provides financial reports to the General Manager.
- Ensure every financial transaction is recorded.
- Ensure that all bank accounts of the company are reconciled.

- Prepares cash flow report.
- Transfers working capital to projects.
- Prepares trial balance for the recorded transaction.
- Keeps records of fixed asset and registers their cost and depreciation.
- Ensures that physical count of propriety of the company is done and reconciles it with financial records

b) General Work Flow

i) Pre tendering procedure. The finance department has almost no involvement in the pretending activity except allocating and making payments for buying of the bid documents and blocking of money for bidding purpose. The blocking activity is a little more than writing a letter to a bank that states to block an amount for the bid purpose. It also cooperates with Planning and Contract Administration Department while the later prepares the qualification documents and collateral required for bidding a new project.

ii) Post construction procedure: The finance department has still a very minimum involvement in this procedure. In fact the department has explained that currently there is a consensus between management of the company that field visit and the establishment of the camping is going to be undertaken by a group of people represented from each department. In fact still the disbursement money and activity related with the disbursement is done the finance department. Furthermore the department cooperates with the HRD department in the assignment of personnel doing the financial and accounting aspect of the project.

iii) Construction procedure: Most of the finance department activities deal with this procedure. Having received the financial requirement schedule of a new project, the finance department will allocate through a budgetary process the amount necessary to run the project in the fiscal year. Based on the financial schedule of a new project as updated through the budgetary process, the department transfers monthly the sum of money through convenient means a sum of money for the following purposes:

- For wage and salary of employees of the project
- The purchase of the materials made at project level such as construction material that are available locally such as tree logs, stone and sands etc .
- Purchase and rent of material and equipment that will be made at the head office purchase division.

The finance department then collects all source document and supplementary documents of all expenditure made and transfers them to the head office. The project in facts registers all expenditures made at project on journal vouchers and prepares a trial balance to check their accuracy of recording. Then posting are made monthly and centrally in the head office by the finance department.

Similarly payment certificates prepared by projects are sent to the Construction Department and this department notifies the Finance Department to make the collection. And the Finance Department after making the collection, it records and posts them in the main (general) ledgers and subsidiary ledgers.

And finally the departments generates financial report including, balance sheet statement, Income statement, and cash flow statements for each project as well as for the company as whole and distribute them to the general manager and to the project managers of the respective projects.

c) **Interaction with other units**

As it has been stated in the workflow of the department, the finance department make interactions with all departments and projects. And it also interacts with suppliers when it is making payments of rented or purchased material, with the clients when collecting payment certificates. It has also a close relations with banks and insurance companies.

d) Data Processing Technology

i) Hardware: Currently the department is using four computers, two of which has 64 MB RAM, 366 MHz processor and 6 GB hard disk and the other two has 32 MB RAM, 266 MHz speed of processor and 3 GB hard disk. It has also one Lesser Jet printer with a speed of 6 pages per minute and two Epson printers.

ii) Software: The most dominantly used application software is the Microsoft Excel and it is used for preparation of payrolls, compilation of consolidated reports and plans that comes from projects. It also uses the MS Word for corresponding with commercial institutions. Currently two software systems are developed for the Finance Department. The first one is general ledger software used for recording

and preparation of the financial statements and the second one is used to prepare payroll of employees. Both software are network-based developed using Fox pro programming environment. These software systems are initially developed for other company and are being customized for the company purpose. Just like the software developed for the Purchase and Supply Department it is under test and similarly the users of these software has reported, it usually takes a very long time to modify a specific request made by the users for modification. Furthermore the software can only generate a limited number of report and the report format can not be customized as required by the users of the software.

Training: Nine out of fourteen employees in this department are trained in the Micro soft Windows, MS Word and MS Excel software.

c) **Problems**

The major problem that has been reported by the Finance Department is directly associated with cash collection. The volume of cash that are over due is extremely high as indicated in Table 3.2 below even for a single quarter. This is partly due to delay in the preparation of the payment certificate that can be sent to clients for payment for the volume of work done by projects.

Projects	Outstanding Collection end of year	Payment certificate issued (1 quarter, 1990	Actual Total Collec table	Collecte d During the	Outstanding Collection end of the quarter

		E.C.)		Quarter	
All projects	51.6	16.7	68.3	32.0	36.2

Table 3.2 Cash collection status in million for the first quarter of 1990 (EC)
(Source Financial Report of the Company, 1990 (E.C.))

The other major problem reported is communication with projects. Transactions recorded by projects are centrally posted and a consolidated trial balance is made at head office level, and yet physical documents sent from projects may take on the average seven to ten days. This has a direct impact on the performance of the head office and when an error occurs it is not possible to take a remedial action immediately. It has been found that next to the Construction Department, the Finance Department uses the HF Radio of the company, and reported for the difficulty associated with conveying the message to projects with out loss of valuable information. It has been also reported that the compilation of reports demands the temporary suspense of routine works of the departments because most employees participate in compiling data necessary for the preparation of the reports and plans. It has been indicated that the compilation of monthly, quarterly annual reports will take at least three to five days with almost all key employees of the department participating in the process.

3.4.5 The Human Resource Development Department

a) **Functional responsibility**

The Human Resource Development Department has two divisions. These are Personnel division and the Training divisions. It performs the following key functions (Source: Job Description Manual of SUR (1991 EC).

- Directs a position classification program, which provides for the continuous review of the classification, structure, and utilization of all positions in the company.
- Provides for the establishment, and development of sound personnel management policies and programs.
- Directs the administration of the employees benefits program.
- Upgrades the skill of the employees of the company by corresponding and arranging training, conferences, and workshops programs both within and outside the company.
- It mobilizes the existing manpower of the company when a new project is opened and selects and recruits new employees to projects when requested.
- Ensures that performance evaluations of employees are made periodically and merit systems are closely associated with the result of such evaluation.
- Based on the company policy and related government regulation, it determines the severance, compensation payment for employees leaving the company
- Resolves any kind of complaints that comes from employees of the company.
- Supervises the general service of the company including services related to telephone, water, electricity and transport for the company.

b) General Data Flow

i) Pre tendering: The Human resource department has almost no involvement in the pre tendering procedure of the company.

ii) Pre Construction procedure: The HRD normally moves with some other departments particularly with the Construction Department while making a field visit for the preparation of resource schedules. And during the preparation of site camping, it selects and recruits employees that supervises and undertakes the camping and other related activities.

iii) Construction phase: The HRD recruits the necessary personnel as per the human resource requirement schedule delivered from the Planning and Contract Administration. The HRD usually posts the vacancy through the Ethiopian Herald New paper before the commencement of the projects and makes the selection procedure together with other departments. HRD make requirements not only for new projects as stated in the schedule but also for any vacancy either in project or at head office which becomes vacant because of termination of an existing employee of the company.

Then the HRD monitors and keeps every record of the employee related with its benefits, performance evaluation, promotion, transfer as well as terminations. And provides these information when requested by other departments, projects or the General Manager.

c) **Interaction with other units**

The HRD interacts internally more often with projects, and the finance department. But it also interacts with other departments on matters that is related to the employees of their

respective departments. Externally the HRD departments interact with training institutions such as the Ethiopian Management Institute and Computer agents.

d) **Data Processing Technology and distribution of outputs**

i) Hardware: Currently the department is using three computers, one of which has 64 MB RAM, 266 MHz processor and more than 3 GB hard disk and the other two has 32 MB RAM, 100 MHz speed of processor and 1 GB hard disk. It has also one Lesser Jet printer with a speed of 6 pages per minute.

ii) The most dominantly used application software is the Microsoft Excel and it is used for compilation of consolidated reports and plans that comes from projects. In this department there is also an in house developed MS Access based program for the employee Database.

iii) Training: Six employees in this department are trained in the Micro soft Windows, MS Word and MS Excel software. And two of them are also trained in the Micro Soft Access.

e) **Problems**

In the projects, there is a shortage of engineers and technical manpower. According to the HRD head, the acute shortages are of Foreman (Surveyors, Finishing & Earth works), Superintendent, Civil Engineers and structural Engineers. There is also a shortage of skilled equipment operators.

According to the HRD the high rate of staff turnover has contributed to this problem. The annual leaving rate seems to be at 14% for core (permanent) staff and 16% for contract staff. And the average length of employment is 3.5 years and 3 years for

permanent and contract employees respectively. The following table shows the companies turn over rate for the year 1990 (EC) and 1991 (EC)

Type	Total Employee Core 1990 (E.C.)	No of leaving	Loss %	No. Recruited
Core	118	17	14%	7
Contract	328	52	16%	117

Table 3.3 Employee Turnover rate for 1990 (E.C.)
(Source 1990 (E.C) annual HRD Report)

Type	Total employee Core 1991 (E.C)	No of leaving	Loss %	No. Recruited
Core	108	10	14%	10
Contract	494	52	16%	158

Table 3.4 Employee Turnover rate for 1991 (EC)
(Source 1991 (E.C) annual HRD Report)

The second problem reported by the HRD department is that, similar to the other department, compilation of reports takes a three to four days longer time than expected.

Moreover the reports from projects come by letter and takes on the average one-week until it reaches head office.

3.5 Structuring the Requirement

3.5.1 Use Case Diagram

The general representation of the requirement analysis from pre tendering to the stage of construction is modeled using the following Use Case Diagram. The identification of the use case and actors are shown as below.

NO.	Use Cases
1.	Assessment of Market
2.	GM instruct P&CAD to prepare Bid
3.	P&CAD organizes Site Visit
4	P&CAD obtains bid information from, Supply Dept, and Suppliers and completes Bid Documents
5.	P&CAD prepares method statement and Preliminary buildup
6	Approval of Bid document by GM and delivery of Bid document to Promoter
7	Conclusion of contact with Client
8	P&CAD distributes resource Schedule to HRD, Supply Finance and Construction Department s
9	Delivery of Resources to projects by respective

	Department
10	Commencement of construction work by project
11	Prepares dairy and evaluation of everyday activities
12	preparation of monthly progress, cost, payment certificate & claims & reports for Construction Department
13	Construction Dept. processes all payment & claims with consultants & clients and informs Finance Department for collection of payments.
14	Collection of payments by Finance Department from Clients
15	Compilation of monthly, quarterly and annual report by all department and projects
16	Evaluation of Reports and plans by GM

Table 3.5 Use Case Scenario for the SUR requirement

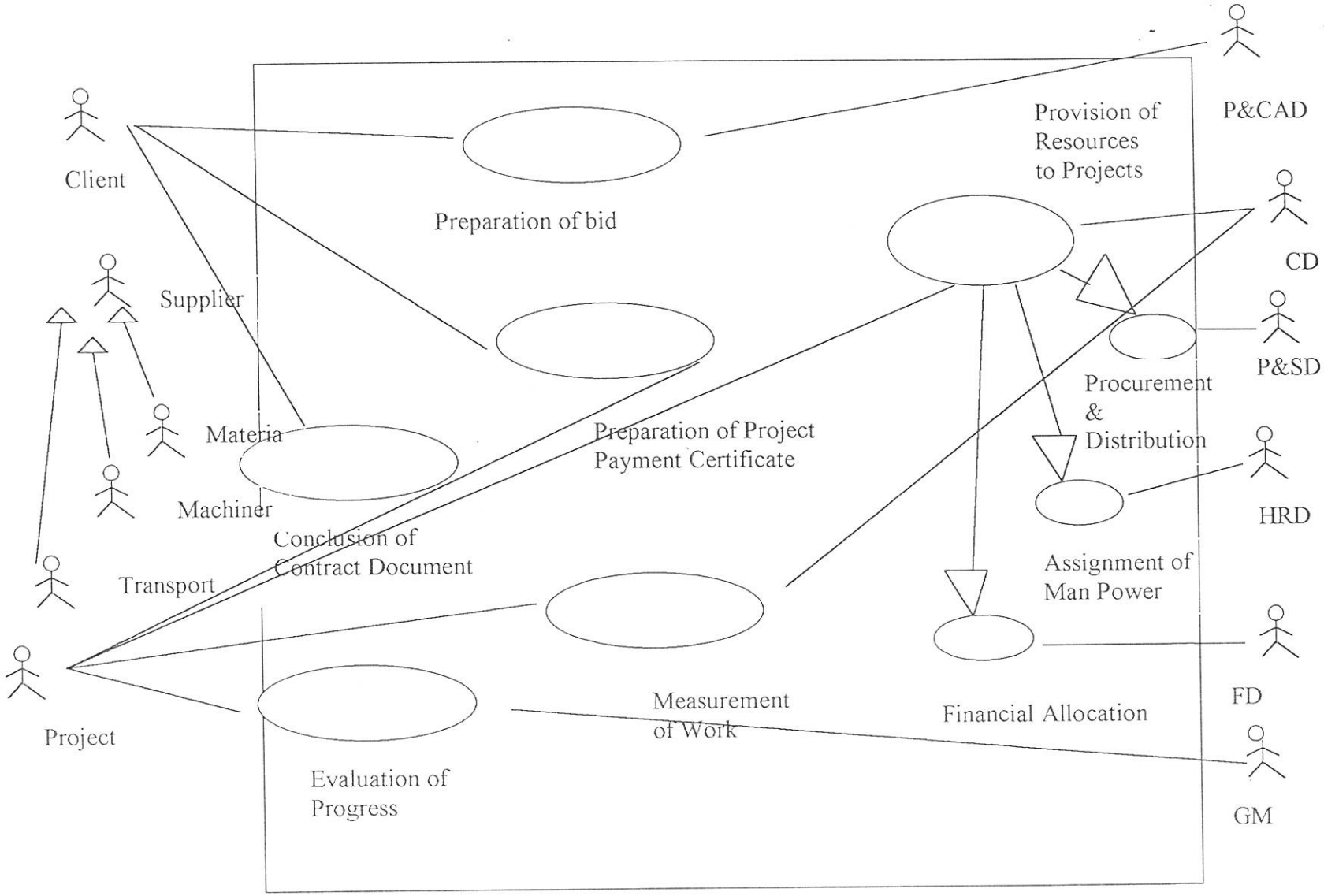
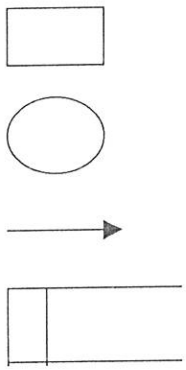


Fig 3.2 Use Case Diagram for SUR

3.5.2 Data Flow Diagram

The System's Requirement is represented using the Data Flow Diagram (DFD) for is indicated in Fig 3.3 below: The Source \Sink and the Data store is indicated in the DFD diagram and the process and the Data flow are indicated in Table 3.6 and 3.7 below.

The process symbol is used that of the DeMarco & Yordon and The Data Store is adapted from Gane & Sarson Symbols.



Source \ Sink

Process

Data Flow

Data Flow

The processes indicated in the DFD are:

Process Number	Process Name
1	Search for new projects
2	Make feasibility Study
3	Detail Analysis
4	Preparation of Bid
5	Preparation of Resource Schedule
6	Provision and Recording of Financial Resource
7	Procurement of material and equipment
8	Hiring and maintaining of personnel
9	Follow up and supervision of projects
10	Performance

Table 3.6 List of Processes for Data Flow Diagram (DFD) as shown in Fig. 3.1

Data Flow

Data Flow Number	Data flow Name
1	Request for new project
2	Market assessment Result
3	Feasibility study proposal
4	Analyzed Market assessment
5	Feasibility study
6	Approved feasibility study
7	New Project details
8	Site Investigation
9	Productivity Standard rate
10	Bid
11	Prices of resources
12	Summary of analysis
13	Financial Requirement Schedule
14	Material Requirement Schedule
15	Man Power Requirement Schedule
16	Work flow Schedule
17	Consolidated financial requirement
18	Consolidated material and equipment requirement
19	Consolidated manpower requirement
20	Consolidated work flow requirement
21	Transferred cash
22	Dispatched material
23	Employed personnel
24	Up dated work flow
25	Purchase requisition
26	Purchased material and equipment
27	Measured Performance
28	Measured volume of work
29	Report of performance
30	Ratified volume of work performed

Table 3.7 List of Data Flows for the Data flow diagram of SUR shown on fig 3.1

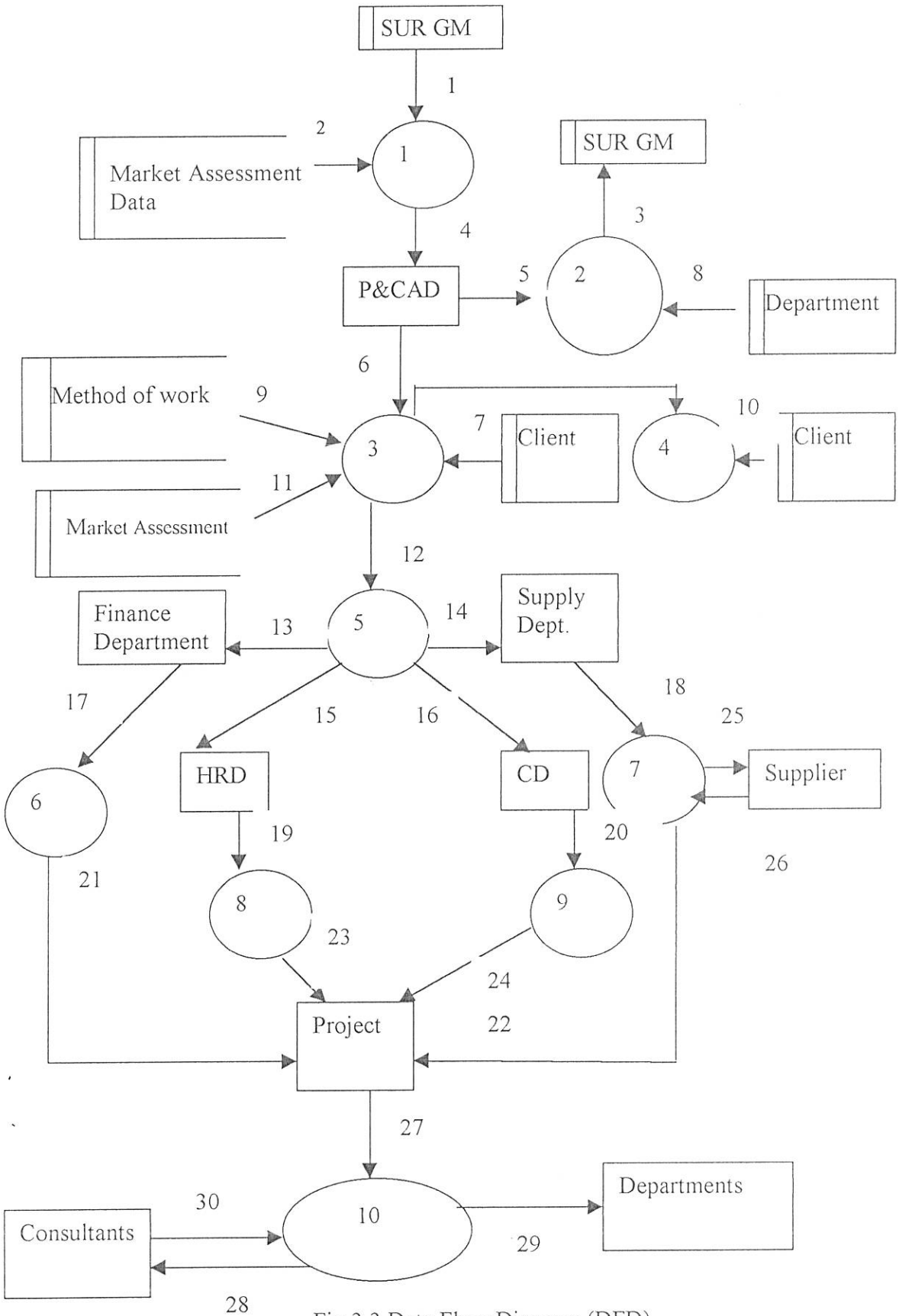


Fig 3.3 Data Flow Diagram (DFD)

3.6 Alternative Design Strategy

3.6.1 Evaluating alternatives

a) The company has 21 personal computers in the head office and one in each of the projects. Furthermore it, has High Frequency Radio in six of the projects, 4 direct line telephone in four of its projects and a fax machine in each of its three projects.

The mandatory requirements of the company is communicating with projects on various issues related to material, human, financial and work in progress issues. Therefore, under these circumstances project plans to send daily occurrence and events related to these resources through a diskette. Every project needs to be supplied with a standard reporting and data collection formats so that the data process and report consolidation become easier. The projects may use any generic software. The diskettes may be sent periodically for example monthly reports may be compiled at project and send to head office at the end of each month. Daily transactions may also be entered into project computers so that they can be sent to head office at end of the week.

The basic constraints on such arrangement is that diskettes can be physically damaged while in transit and projects may not find a person who can deliver these diskettes to the head office. In fact, such design arrangement can work very well for monthly reports as well as for payment certificates that are usually prepared and sent to the head office on monthly basis. The risk of diskette damage can also be minimized or avoided by preparing two separate diskettes that contain the same file content and send them separately. Under this deign arrangement, daily communication of problems such as

reporting of delay for expected construction materials, defect or damage in the materials received, request for replacement or transfer of manpower, the mobilization of equipment and a request for clarification of specification on drawings, still requires the use of the telephone, fax and H.F. radio.

b) Given the positive attitude of management of the company for introduction of the state of art Information Technology into the company, with almost no limit for budgetary /financial consideration, another design arrangement is that a network based construction software that includes the following to be purchased and implemented.

- Civil Engineering Design Software (Structural Design software)
- Estimation Software
- Planning Software
- Measurement Software
- Construction Work valuation software
- Construction Cost Control Software
- Construction Cash Flow Forecasting software

All of these software systems are currently available in the market (See the following Internet site for details of prices etc http://www.constructionmanagement.com/) . Moreover, the company can adapt a client server system that enables the exchange of information with projects on online/batch processing basis. That is, data are collected and keyed into computers and processed on projects and then transmitted to head office server at the end of every day/ every week. The department may use such information for various decisions and reporting purpose. Each personal computer (with a modem) at

reporting of delay for expected construction materials, defect or damage in the materials received, request for replacement or transfer of manpower, the mobilization of equipment and a request for clarification of specification on drawings, still requires the use of the telephone, fax and H.F. radio.

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project can also use the public telecommunication line to transmit information and to access data from the head office. And those projects that have no access to public telephone can use the High Frequency (HF) Radio with modem and personal computer interface and data loggers. These high frequency radios with a personal computer interface are available in the market for (USD 4000.00) Birr 35,000.00, as stated by The Addis Ababa Electronics S. Co, Distributor of High Frequency Radio. Such H.R Radio can alternatively be used for verbal communization.

The constraint with the implementation of this second alternative is that given the large no of off-the-shelf software users have to be trained in order to unitize effectively the software. Furthermore, such software requires a support service from the seller or agent of the seller and such support service may not be available locally.

Since such service also includes an e mail service (this service already is included in the Window NT server 4.0 platform) daily verbal communication that were not documented for reference and for accountability and appraisal purpose of decision made would be possible in the current system. For example, any changes that are made to previously requested material has to be documented for future reference.

c) In between the above two design alternatives there here is another alternative. The project may not necessarily require using specialized software, which may not only be difficult, but also costly. But, they can use generic software such as MS Access or MS Excel. They register daily based on certain format and such register are then sent to

head office by logging into the server at head office. For example a daily work in progress of construction activity together with the volume of resource material, equipment, and labor can be transmitted on daily/weekly basis. This information is then processed using specialized software at head office or using similar genetic software. Still for this alternative design strategy, it requires a server with Window NT software, a modem and a telephone at head office and a personal computer, a modem a telephone or HF Radio with PC interface at project level. The cost of a modem with transmission speed of 65 k/second is Birr 3500.00.

3.5.2 Selecting the Design strategy

Evaluating the three alternative in terms of current and future requirements of the company and in terms of the constraints associated with each possible alternative, The company has opted for the 2nd option with specific requirement for developing a system for handling materials both at project and head office. Furthermore there seems a need to build a model that makes a risk evaluation when competing in tender. Once the model is built it can be implemented using a belief network supporting software. Such software is available in the market for USD 2000.00.

Already it has been stated in a number of meetings, according to the company IT service head that management wants to see implemented the state of the art information technology as this is strongly emphasized in a number of IT related meetings. The head further stressed that management does not want to see any risk of technological obsolescence particularly hardware before these IT hardware return their expected

benefits. The company wanted to interconnect the remote projects through the High Frequency Radio that has a personal computer interface or the public telephone to the centrally located server with client/server architecture and the connection of the departments computers through Local Area Network that has an access to the internet service as seen in the figure below . Furthermore as far as software is concerned it wanted an integrated system that support most functions of the company that islands of software that are peculiar to one department. Therefore the company wanted the purchase of the some software system that deemed to be so complex for integration at least at the company level, which in most cases are very technical software. And it also support the development of integrated software that support the functions several departments, these are believed to be software system that are not very technical. Therefore the company wanted to see an integrated system that handles function of the company during estimation, purchasing, distribution, consumption, preparation of payment certificates in one set of software.

The contract document evaluation of projects showed that the most important component of the project cost is material cost. It is believed that it is possible to integrate, the remaining resources of the company namely the equipment as well as the human resources, step by step (because the methodology used support future easy maintenance and extensions). The company as a mater of fact opted to focus the current design effort on the material aspect of the company, just one important object (entity) of the company. And then proceed with the equipment and the human resource according to their importance in the build up of the project costs. But the material object involves a number

of functions assigned to several departments. Among other things the estimation of cost of material for tendering purpose, the preparation of material requirement schedules, the purchase and distribution of materials and the utilization of materials are functions that need to be integrated around a system that deals with the material object. The next chapter, chapter IV will take up the detail.

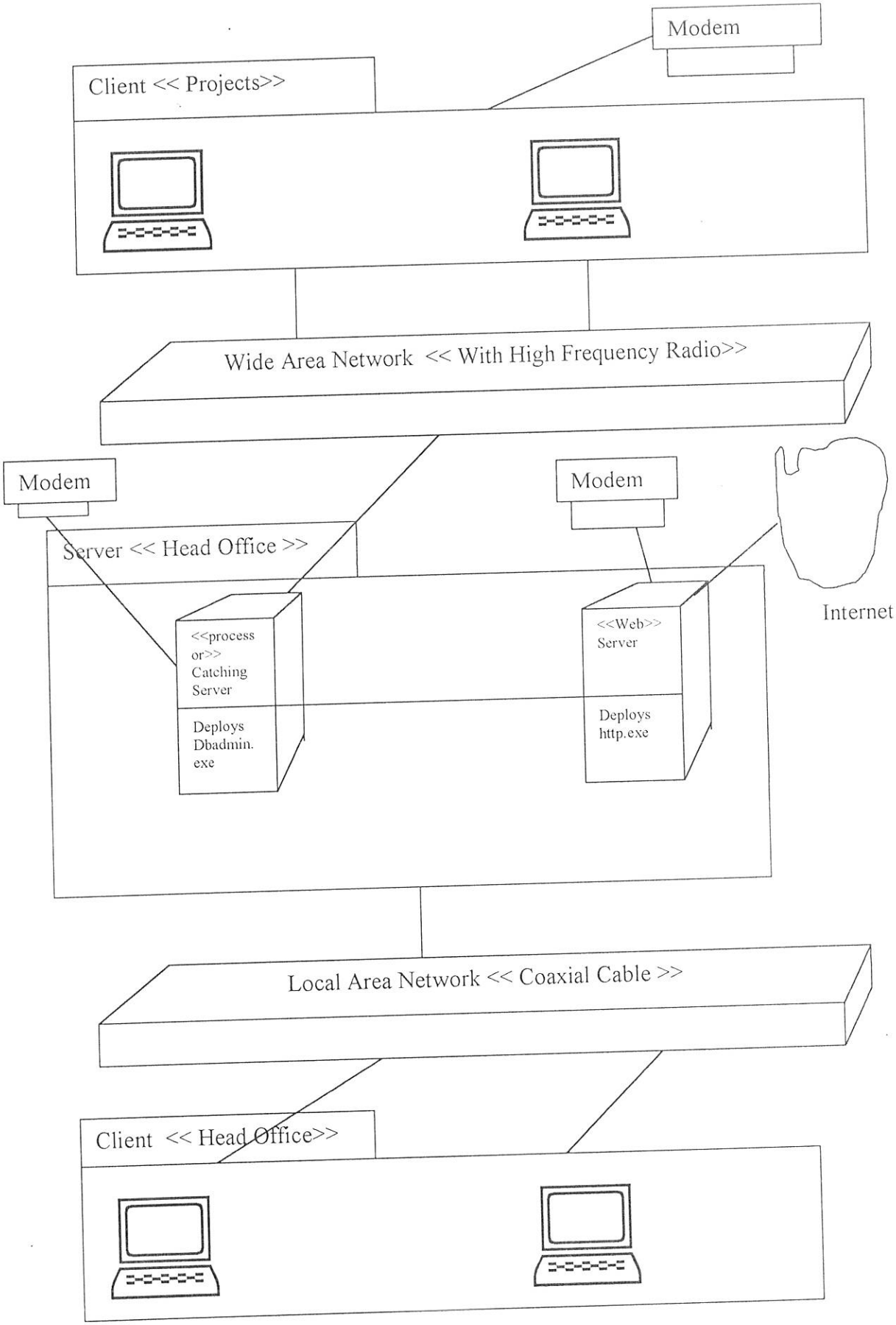

Fig 3. 4 The Client/Server Architecture of SUR

CHAPTER IV

REQUIREMENT SPECIFICATION OF THE MATERIAL SUBSYSTEM OF THE COMPANY

4.1 General

Evaluation of contract documents of the active projects of the company shows that the break down of the contract price as follows

Cost Type	% of the total contract price Building Projects	% of the total Contract Price For Road Projects
Material Cost	60%	25%
Machinery Cost	22%	55%
Labor cost	18%	20%

Table 4.1 Break down of contract price

This indicates that the largest share of the over all cost of a construction project is the material cost. Furthermore, almost all departments as shown on the previous chapter deal with the material entity of the company, through out the pre tendering, pre construction and construction phases of the construction activities.

In chapter three, the whole system has been discussed at a higher level of abstraction. Now, it is time to closely look into one of the important subsystem of the company namely the material subsystem. The high proportion of the cost of material in the over project cost means that it deserves more attention for better control and management.

Also all the problems reported by the department heads directly or indirectly is related with materials. It is probably the single most important resource that most departments are concerned with. Hence designing information system for such system should be given priority and every resource comes after that. In fact what the writer believes is that similar system that focuses on the equipment and machinery as well as the manpower will be relatively smooth and easy once we design the system for the material subsystem.

The material subsystem has two categories. These are the material estimating and consumption category and the material purchasing and distribution category. Although both category are the concern of particularly three departments, all are concerned about one entity i.e. the material entity. And hence naturally it must be considered as whole. As a result the system analysis and design process for this object using the Object-Oriented methods approach recommends both category to be integrated to provide better information for decision making of management at all level, because both category deals about one object, namely the material object.

4.2 Material Estimation and Consumption Subsystem

4.2.1 Requirement Specification for the material estimating and consumption

One of and the major functional responsibility of the Estimation Division of the Planning and Contract Administration Department is to provide an realistic cost estimation of a project for tendering purpose. The division compiles the information that is necessary to complete the tender document and the preparation of the resource requirement schedule of a new project. The major source of information for compiling the tender document

includes: the bid document that is collected from the client of a new project; the three standards namely the material productivity standard, the equipment productivity standard and the manpower productivity standard; and the price list for each of the resource type (material, machinery, and manpower).

The bid document that is collected from the client has two among other things, important set of data. These are the list of the activities that the project has together with the corresponding bill of quantities and the location of the project to be undertaken. The productivity standards contain information necessary to compile the tender document. The standard lists out the resources, material, equipment and manpower and their corresponding quantities necessary to produce one unit of an activity.

The estimator then uses the productivity standard to determine the quantity of materials, required to complete a unit of an activity and then multiplies the quantity of each with their corresponding prices to get the direct material cost for a unit of one activity. And the direct material cost for a unit of activity is multiplied against the bill of quantity of the activity to get the total direct material cost for a single activity. Then similar procedure is followed for each activity and then summed up to arrive on the total direct cost for the bid. Again similar procedure is followed to get the total equipment cost and total labor cost to arrive at the total direct cost for the bid. On the basis of past records the overhead cost of the project is calculated as some percent of the total direct cost. Similarly, the profit margin percent is applied on the direct cost and the profit is determined. The total overhead and the total profit are then distributed for each activity on the basis of the

dollar value of the direct cost of each activity to determine the quotation price of each activity and the project as a whole.

After the tender document is produced and other supporting documents such as the qualification documented are prepared, the tender document is sent to the client for bid competition. If the client declares the award of the project to the company (SUR), then resource requirement schedule is prepared. These resource requirements are the material requirement schedule, the equipment requirement schedule and the man power requirement schedule. The working paper that is used for this purpose is called the price analysis sheet (See Appendix D for sample)

Different activities may use the same material. The material requirement schedule is abstracted from the price analysis sheet by grouping the materials used in different activity and summing their corresponding quantity. By doing so, the purchase activities are integrated with the estimation activities. The lists of activities are scheduled so that the activities on the critical path can be identified using the project evaluation and rating technique. The critical path refers to the shortest time in which a project can be completed (Hoffer et al, 1999, pp. 94). The activities on the critical path require a material that can be called a critical material. The delay in the purchase and supply of a certain critical material to the project would lead to a delay in the life of the overall project. Therefore, the critical materials are determined and listed out separately so that management, can give a special attention to the purchase and distribution process of these critical materials. In fact, the system also lists out each item together with the latest time

it must be provided to the project. Hence, estimation activities are integrated with project programming and scheduling. Also purchase activities are as well integrated with the project planning and scheduling. The system also applies an ABC analysis. An ABC analysis is an important concept in stock management. The idea behind making an ABC Analysis is that not every material used in the construction of a project is all equally important. There are some materials, which are a few in numbers, but are significantly important in amount which are called Category A. On the other extreme there are materials which are large in number but contribute very little to the total value of the direct material cost, which are called Category C materials. In between these two categories there is called the Category B, which consists of materials that are moderate in number and in value. Hence management must take a close look and give an appropriate attention not only to the critical materials but also to those materials under category A {which are a small in number may be 25% or below but which can cover 75% or above in the total project costs).

As it has been stated at the beginning of this chapter, the detailed analysis in the reminder of this chapter emphasis on materials resource of the company. The issue of equipment and manpower subsystem will be discussed when it seems necessary for the explaining the material subsystem

The company starts to interact with the material object conceptually, when the company is competing to get an award of a new project. When the company considers bidding a new project, material will then be the first issue to be deal with. Since the material build

up 60% to 70% of the direct cost of new projects, it is worth to establish a system that integrates all the activities concerned with material. The activities that focuses on the material includes, estimation process of a new project, purchase and delivery of these materials to the projects, keeping track of consumption data and updating of the productivity standards based on the consumption data.

4.2.2 Building the Object Model

a) Why Object-Oriented methods?

The writer makes the analysis and design (although not detailed) of the proposed system using Object-Oriented methods. The first reason is that an Object-Oriented methods method allows building software that can easily be maintainable when future requirement changes. Lee (1997) stated that Object-Oriented methods method can help developers produce more flexible and more maintainable software. Lee further indicated that under the traditional software development methods, of all the system development phases, software maintenance is the most costly one. Wirfs_brock (1990), indicated that Object-Oriented methods design aims for robust software that can be reused, refined, tested, maintained and extended thereby ensuring a productive maturity.

Coad and Yourden in Hoffer et al (1999, pp. 436), identified several advantages of Object-Oriented methods modeling. These are:

- The ability to tackle more challenging problem domains.
- Improve communication among users, analysts, designers and programmers.
- Increase consistency among analysis design and programming activities

- Explicit representation of commonality among system components.
- Robustness of systems
- Reusability of analysis, design and programming results
- Increase consistency among all the models developed during Object-Oriented methods analysis design and programming.

According to Singer (1996), Client/server Systems, distributed processing systems and system based on a Graphical User Interface are new needs that can only be meet by OO approach.

As a result given the future requirement of the company to interconnect all projects with the company with a network requires its system be developed in an Object-Oriented methods Approach.

b) **Identification of the classes**

The writer of this report prefers to use the OMT methodology as presented in the book titled 'Object-Oriented methods Modeling and Design" , by of Rumbaugh et al (1991). The OMT methodology requires building of three fundamental models namely the Object model, the Dynamic model and the Functional model, in order to complete the Object-Oriented methods analysis. It also requires the further refinement of the object model, the dynamic model and the functional model as part of the Object-Oriented methods design process. The diagram, however, are built using the UML notation, which is supposed to be the standard to visualize, specify, construct, and document the artifacts of a software

intensive system. But only the basic one is used.

First let us define what an object is. According to Rumbaugh et al (1991, pp. 21), an object is a concept, abstraction or thing with crisp boundaries and meaning for the problem at hand.. Hoffer (1999, PP. 443) defined an object as an entity that has a well-defined role in the application domain and has state, behavior and identity. Rumbaugh noted that objects serves two purpose. First objects promote understanding of the real problem at hand and secondly they provide a practical basis for computer implementation.

A class describes a group of objects with similar properties or attribute, common behavior or operation, common relationship to other objects and common semantics (Rumbaugh et al, 1991, pp21). Rumbaugh further indicated that the purpose of a class is to serve abstracting a problem by grouping objects into classes and enables to generalize from few specific cases to a host of similar cases.

According to Brown (1997, pp.293), One way of identifying classes are to list down the nouns that appears in a requirement statement. From the requirement statement in the preceding section, the following nouns are identified as possible candidate for Class.

Client	Unit	Purchase and Supply Department	HRD
Department	Project	Finance Department	Construction Dept.
Standards	Client	value	owner
Price	Bid	Guess	price

Quantity	Activity	Quantity survey	Estimation
Manpower	Requirement schedule	Performance	document
Equipment	Material	Items	Data
Mark up	Cost	Machinery	Information

Table 4.2 : List of Candidate Classes

The following criteria are used to refine the classes and to eliminate and discard the unnecessary classes.

i) Redundant Classes: In the requirement definition machinery and equipment; material and item, manpower and labor, over head cost and indirect cost, bill of quantity and quantity survey are used interchangeably to mean the same object. Therefore, we select the most descriptive one for our problem domain and discard the rest. Hence the noun machinery, item, labor, overhead, quantity-survey are all less descriptive and are therefore discarded from the lists of candidate classes. The rest are maintained for modeling.

ii) Vague classes: A class has to be specific and should have a crisp boundary. In the problem statement, classes such as planning, scheduling, analysis, information, data, estimation, documents are not specific and do not have a crisp boundary and are eliminated from the list of classes.

iii) Attribute: The following nouns primarily describe other objects and as a result are attributes. Therefore, they are discarded from the list of classes, quantity, unit of measure, price, value describes material, equipment and labor are discarded from the list of classes. bill of quantity also describes an Activity and is discarded from the list classes.

iv) Operation: If a name describes an operation that is applied to objects and not manipulated in its own right then it is not a class. Therefore the noun estimation, performance, accumulated are operation that can be applied to the object material, equipment and Labor and are discarded from the list of classes.

v) Role: The name of a class should reflect intrinsic nature and not a role that it plays in an association. The noun owner describes the role of the client to the project and does not have an intrinsic value hence it is discarded from the list of classes.

c) **Identification of Association**

Association represents relationship between instance of classes Fowler & Scott (1997, PP. 56), Brown (1997, pp. 305), Hoffer et al (1999, PP. 447). Link, multiplicity, role (name), aggregation & composition and generalization or inheritances are concepts that refer to or describe one way or anther the existing association between classes. A link is an instance of an association and it is a physical or conceptual relationship between object instances. Multiplicity describes how many instance of one class are related with a single instance of an associated class. A role is a name that uniquely identifies one end of

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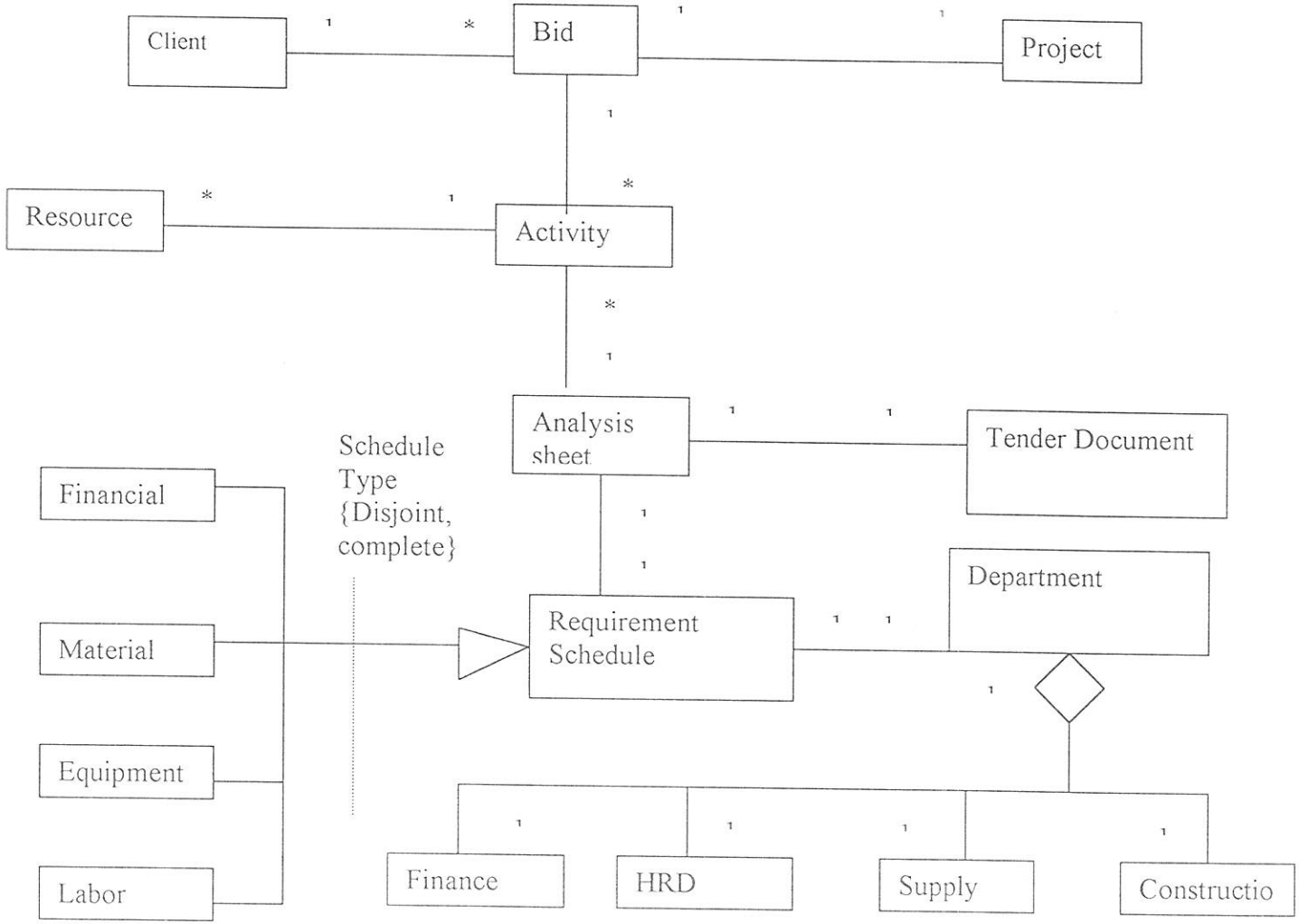
an association. Aggregation is a special and stronger form of association that refers to "a part of" relationship in which objects representing the components of something are associated with an object representing the entire whole. Generalization refers to the relationship between a class and one or more refined version of it (Rumbaugh et al, 1991). Composition refers to still a stronger form of aggregation whereby the part belongs to only one whole (Fowler and Scott (1997, pp. 80) and UML notation Users Guide (1997).

Accordingly, from the requirement statements under consideration, the following relationships are identified.

- Client prepares bids
- Bid are collected by the planning department
- Bids list out activities.
- Activities require resources.
- Resources consist of material, equipment and manpower.
- Activities are analyzed with the analysis sheet.
- The estimator prepares the analysis sheet.
- The estimator compiles the tender document.
- Analysis sheet are used to compile the tender document.
- Analysis sheet are used to compile the resource requirement schedule.
- Resource requirement schedule consists of material requirement schedule, Equipment. requirement schedule, manpower requirement schedule and financial requirement schedule.

- The departments use resource schedule.
- A department includes Purchase and Supply Department.

Class Diagram for the material estimation problem domain is shown on the next page. And the graphical notation (symbols) used in the diagram are shown in Appendix C which is directly taken from Fowler and Scott (1997)


Client
Bid
Project
Resource
Activity
Analysis sheet
Tender Document
Schedule Type {Disjoint, complete}
Financial
Material
Equipment
Labor
Requirement Schedule
Department
Finance
HRD
Supply
Constructio

d) Identification of Attributes

The next step in building the object model is the identification of the attribute. Attribute refers to properties of individual objects. Since an attribute does not affect the basic structure of the problem, only the basic attribute need to be identified and details can be added later Rumbaugh et al (1991, pp.161). Furthermore, Rumbaugh noted that although Object-Oriented methods incorporate the notion of an object identifier for unambiguously referencing an object, it must be omitted from object model.

The list of the Classes, identified above together with their corresponding attributes are indicated in Fig 4.2 below.

Normal System Scenario

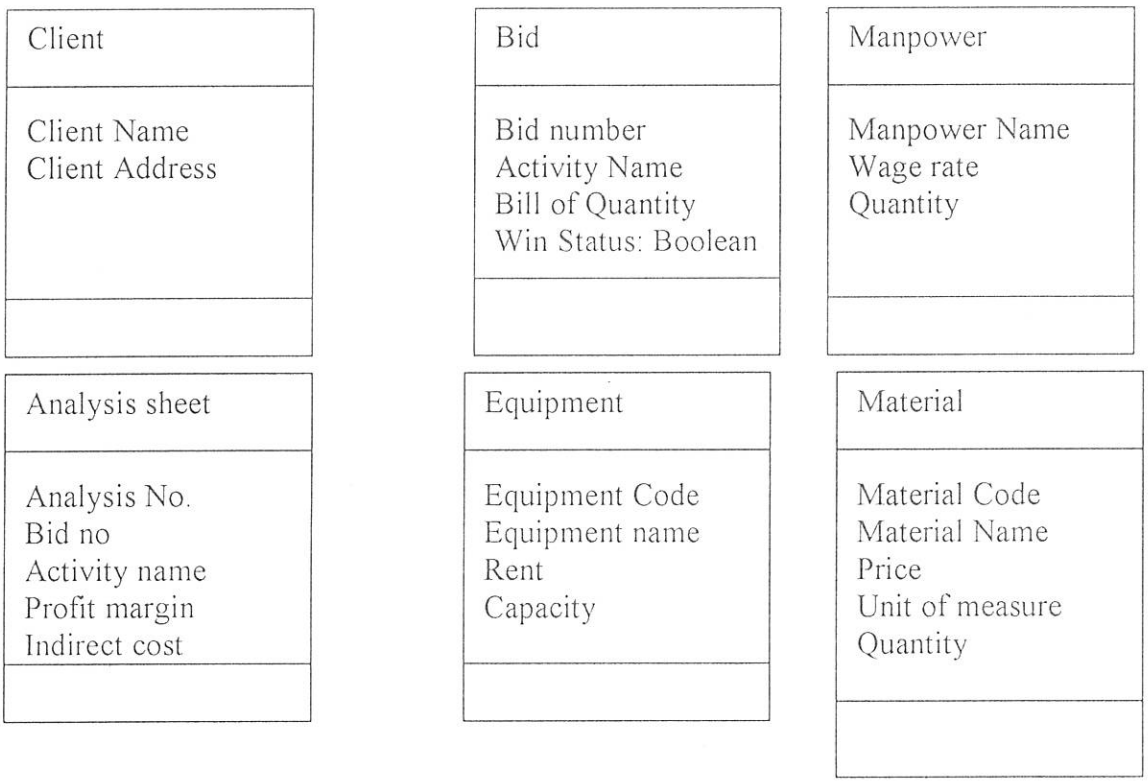


Fig. 4.2 Classes with attributes (Continued)

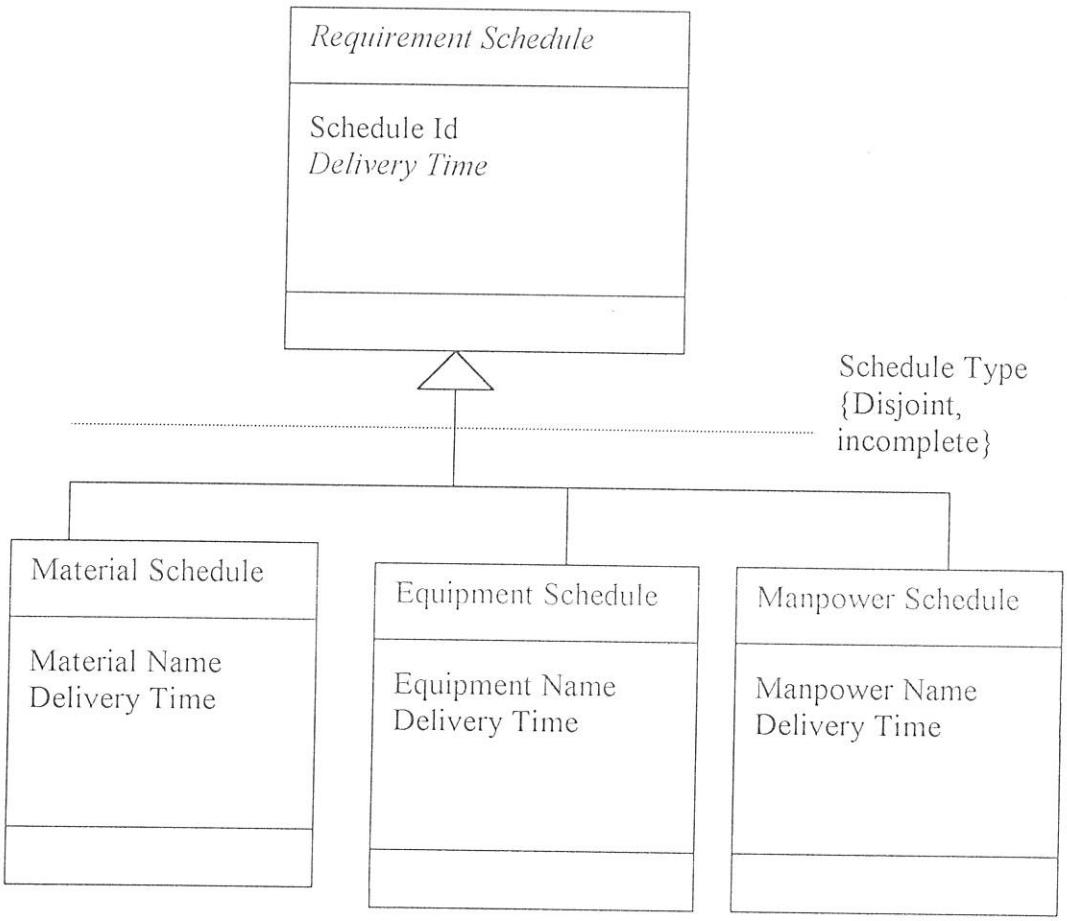


Fig 4. 2 Classes with attributes

Note that the Requirement Schedule is an abstract Class, because it does not have a direct instance of its own. A class with no direct instance of its own but whose descendants have direct instance is called an abstract class Rumbaugh et al (1991, pp. 61), Brown (1997, pp. 262), Hoffer et al (1999, pp. 454). When using a UML notation it has to be italicized (Fowler and Scott (1997, pp. 85).

4.2.3 Building a Functional Model

Functional model shows how values are computed, which values depend on which other values and the functions that relate them (Rumbaugh et al, 1991,pp.179).

a) **Identifying input \ output value**

The Estimation Division head requires the following key documents in order to carry out its activities.

i) Tender Documents: this document is prepared by the client of the project and contains the following data.

- Project name or code
- Place of the project
- Distance from Addis Ababa
- Type of project that is Road, Building or Dam
- List of Activities
- Bill of Quantity or Quantity survey

ii) Material productivity standard: This document is prepared by standard organization or the company can build it based on its own experience. The document contains the following information.

- List of activities or activities code.
- List of materials used to produce one unit of activity.
- Quantity of each material necessary to produce the unit of activity.
- Unit of measure of the activity
- Unit of measure of the material

iii) The price list: The current price of each component (material, equipment, wage) of an activity has to be registered and updated every time. This includes

- Material price: This contains the following data.
  - Material name or material code.
  - Unit of measure for each material
  - Unit price for each material

iv) Performance Records: Projects record periodically what resource is utilized to produce a completed activity, and the duration it took to complete that activity. This data is then compared to productivity standards. Then necessary action will be made to either adjust the standards so that it can serve future estimation of new projects. Furthermore payment certificate is compiled from this record and multiplied by its corresponding price to request the client for interim payments.

d) **Building the Data Flow Diagram**:

The second step in the building of the functional model is the building of the Data Flow Diagram for material estimation. The DFD is shown on Fig 4.3.

e) **Describing the functions**

After the DFD is built, the next step of building the functional model is describing the functions.

The following major operations are involved in the material estimation subsystem.

i) Based on the material productivity standard for completing a unit of construction activity, and a corresponding unit price for the material, The system determines the total material cost necessary to complete a given quantity of activity as indicated in the bid document prepared by the owner of a new project.

ii) Do the same operation as above for the equipment and the manpower on the basis of their corresponding productivity standard and price list and sum up the three costs (material, equipment, and labor) to arrive at the direct cost necessary for the list of all the activities in a bid document of a new project.

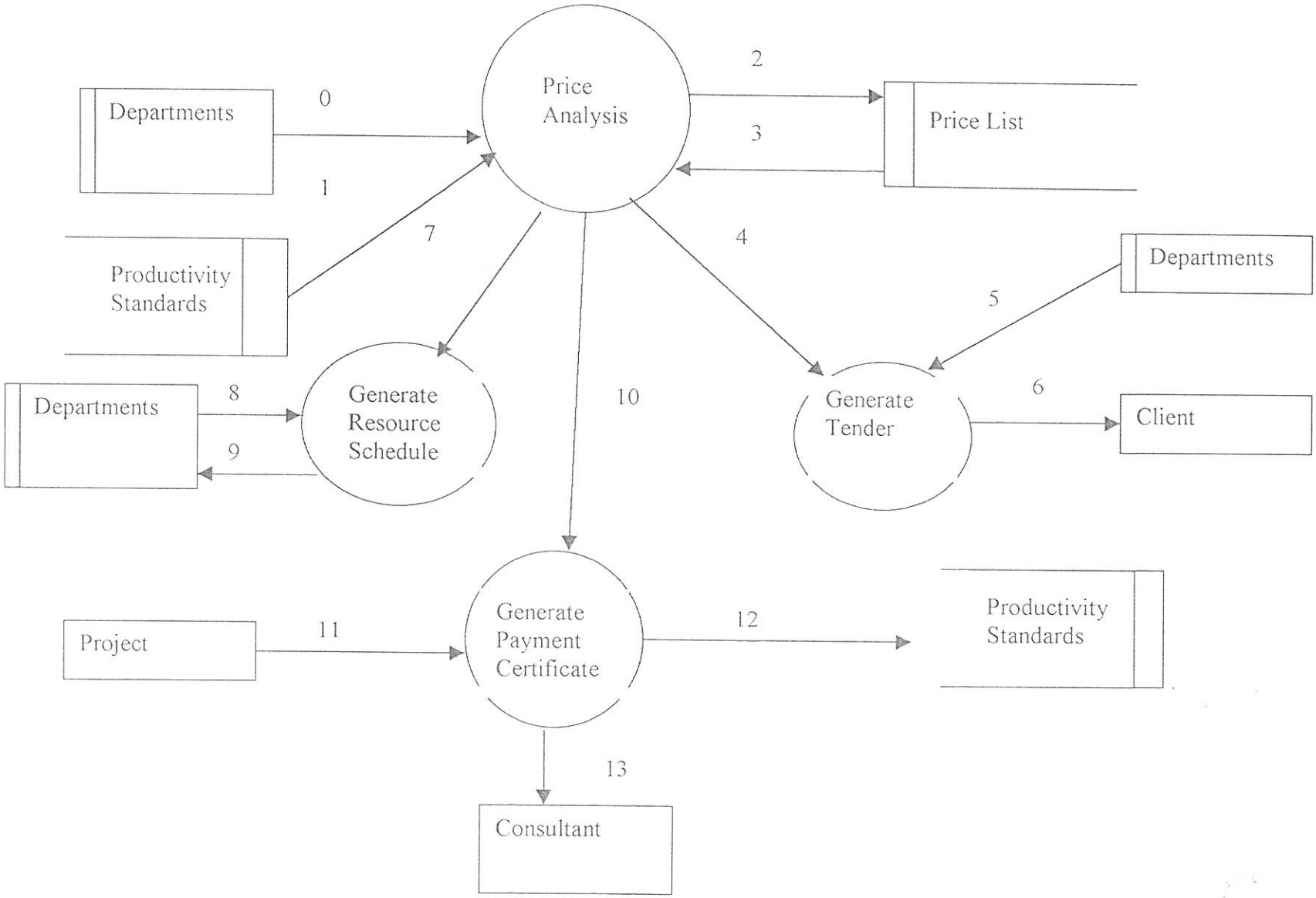
iii) Makes an estimate of the Indirect cost of a new project as some percentage of the direct cost.

iv) Estimate markup (profit) for the project as a percent of the direct cost.

v) Sum up the Indirect cost and the markup and distribute it to each activity according to the magnitude of respective direct cost.

vi) Determine the unit price of the activity by summing the unit direct cost, the unit indirect cost and the unit markup.

vii) Multiply the unit price for each activity calculated above by the respective bill of quantity to arrive at the total price of the project.


Departments
0
Price Analysis
2
Price List
3
1
7
4
Productivity Standards
Departments
5
Departments
8
Generate Resource Schedule
10
Generate Tender
6
Client
9
Project
11
Generate Payment Certificate
12
Productivity Standards
13
Consultant

The Data flows are:

Data Flow Number	Description of Data Flow
0	Request for estimation
1	Consumption Rate of Resources
2	Up dated Price of Resources
3	Price Analysis
4	Qualification Data
5	Tender Document
6	Price Analysis
7	Work flow and schedule proposal
8	Resource Schedule
9	Price Analysis
10	Performance data and resource usage
11	Update standards
12	Request payment

Table 4.3 List of Data Flows for the DFD on the Fig 4.3

viii) Generate tender document that can be sent to the client.

ix) Summarizes the materials that are required in each activity separately, sum up their quantity and produce the material requirement schedule for use the Purchase and Supply Department.

x) Summarizes the Direct cost of the new project and the necessary Indirect cost and produce a financial requirement schedule that is going to be used by the Finance Department.

xi) Compares the actual data on the material resource used to produce a unit of activity and if it has material deviation then amend the standard that are used as a basis for future estimation of new projects.

xii) Produce a payment certificate to request an interim payment from the client and sent it to the consultant for approval.

f) **Adding operation to classes**

According to Rumbaugh et al (1991,pp. 183) the list of potentially important operations is open-ended and is difficult to know when to stop adding them. Operation in Object-Oriented methods corresponds to queries about attribute and association in an object model, events in a dynamic model and functions in a Data Flow Diagram of the functional model. Operations related to query, and to events are explicitly indicated in the class diagrams, and only key operations from the functional model should be explicitly listed on the object model Rumbaugh et al (1991), Fowler and Scott (1997), and Hoffer et al (1999). Accordingly Fig 4.4 shows the classes with their key operation on the third compartment. (See Appendix E for UML class diagram notations)

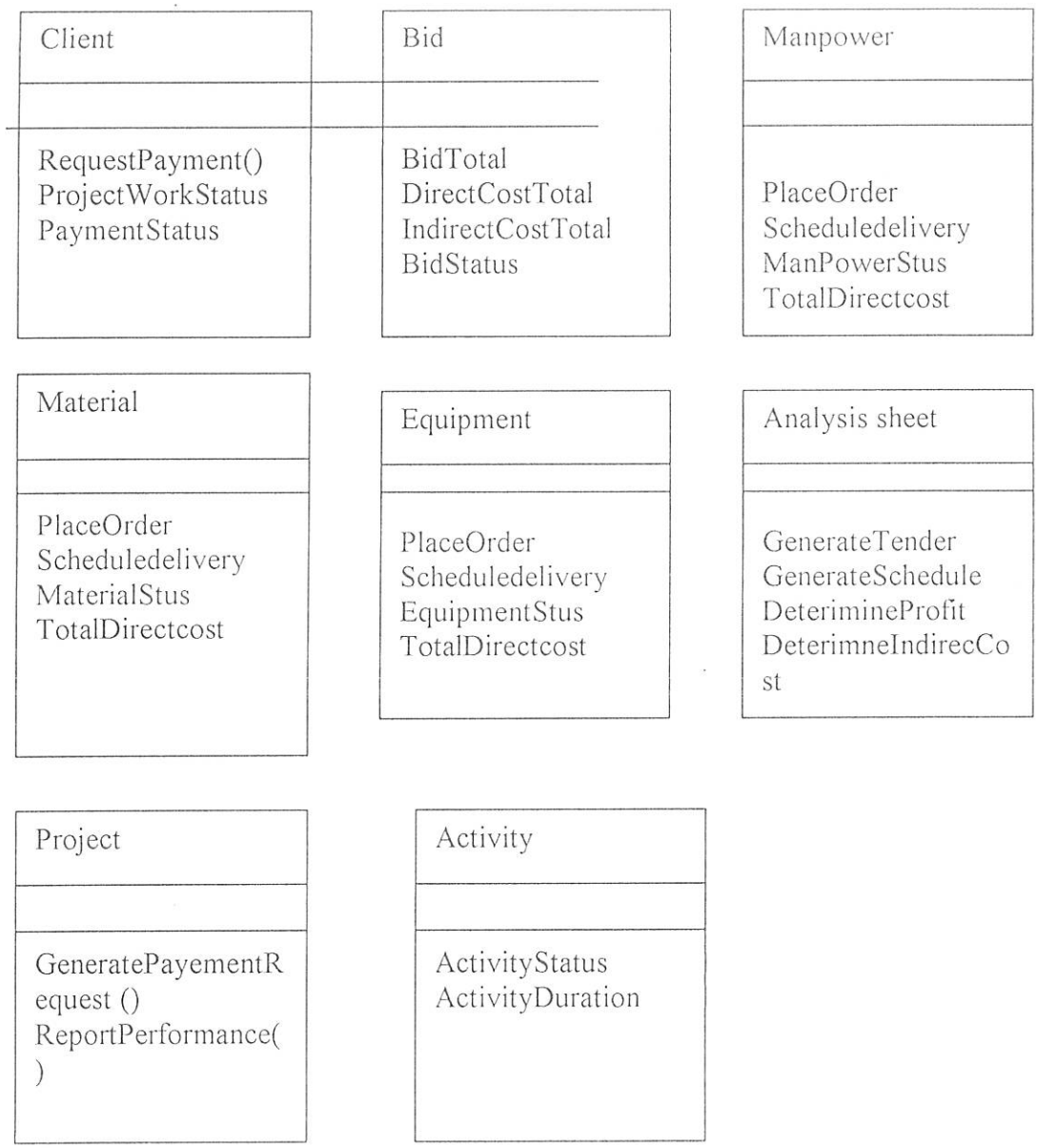


Fig 4.4 Classes with operation

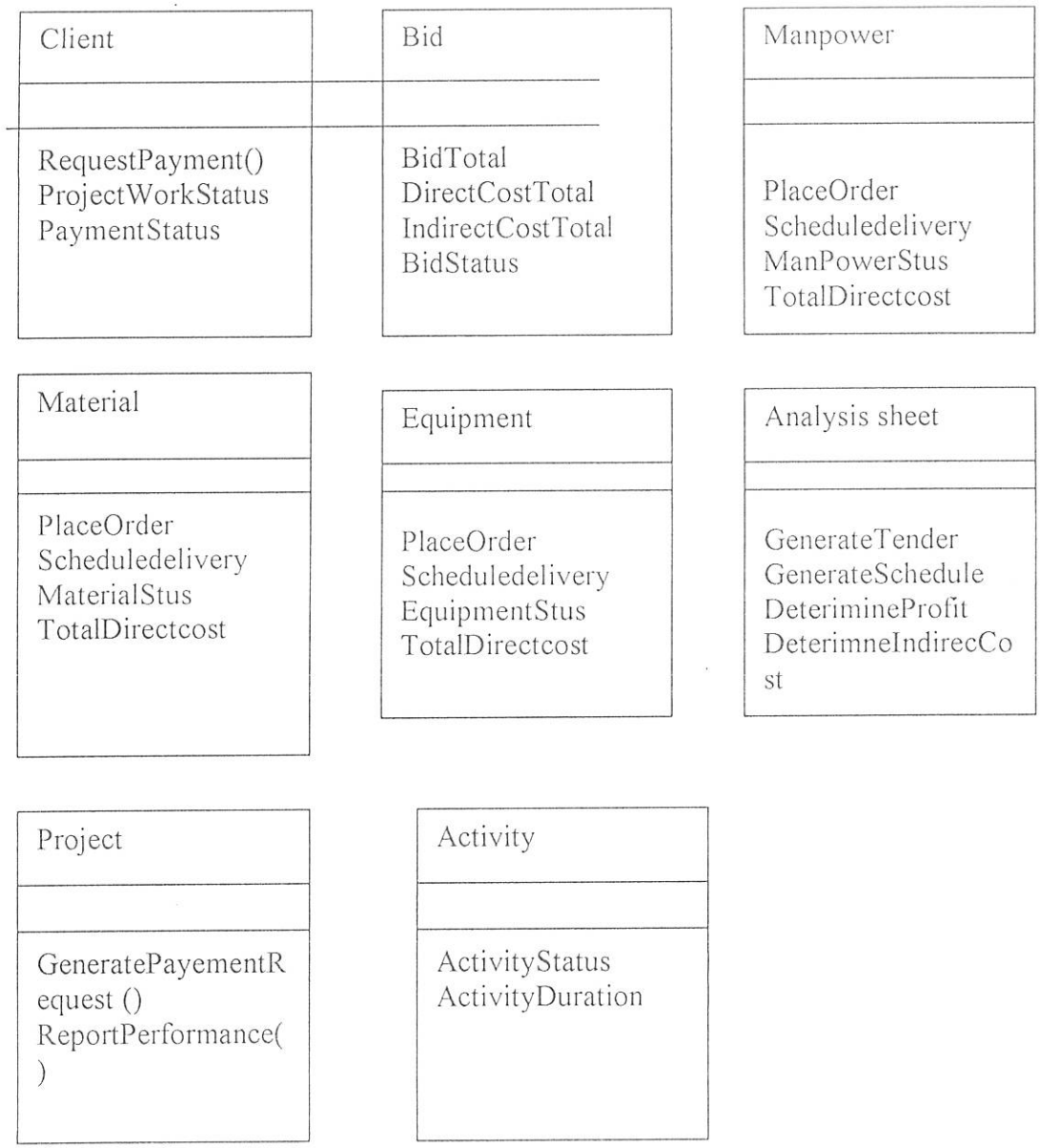


Fig 4.4 Classes with operation

4.3 The purchasing and distribution sub System

4.3.1 Functions

After the Construction Department forwards the material requirement schedule of project to the Purchase and Supply Department, the Purchase and Supply Department performs the following activities.

The Purchase and Supply Department head explained the process of the purchase and distribution of materials as follows. Request are made by two way- requests could be initiated by the Construction Department by providing material requirement schedule. This material requirement schedule contains description of the item, the name and address of the project, quantity requested, the month of material is requested at the project. Sometimes requests can also come directly from projects. And the head office stuff by filling store requisitions.

The first step that the department do is , it checks if the request is available in the store. If it is not available the department fills a purchase requisition form and sends to a number of suppliers. The suppliers provide a Performa invoice. The Purchase and Supply Department fills evaluation sheet and provides it to the purchase committee for selection of the quotation. Once the supplier is selected the department send a purchase order to the supplier. Copy of evaluation sheet, purchase requisition and purchase order is sent to the Finance Department for payment.

The supplier having received the payment check and the purchase order sends the martial with packing list and invoice to the store. The stores after is using a transit receiving report and after checking the physical condition of materials and against the purchase order dispatch it to projects. The project having received the material will send good receiving report to the Purchase and Supply Department to confirm its proper arrival.

4.3.2 Identification of actors and use cases

The material subsystem has the following list of actors.

- Stock clerk
- Purchaser
- Purchase clerk
- purchase committee
- Supplier
- project
- Construction Department /materials/
- Finance Department
- Material requirement schedule

4.3.3 Identification of use cases

The stock management system has the following use case

- Stock checking
- Request checking
- Quotation evaluation
- Purchasing /Order/
- Goods Receiving
- Distributing
- Dispatching of goods

3.3.4 Building a use case Diagram

a) Quotation Evaluation Use case

Actors

♦ Purchase clerk	♦ Supplier
♦ Purchaser	♦ Purchase committee
♦ Head	♦ Accounting department

Use cases

- ♦ Check for the validity and completeness of quotations
- ♦ Purchaser collect quotation from supplier
- ♦ Purchase clerk prepares evaluation sheets
- ♦ Purchase committee selects the vendor

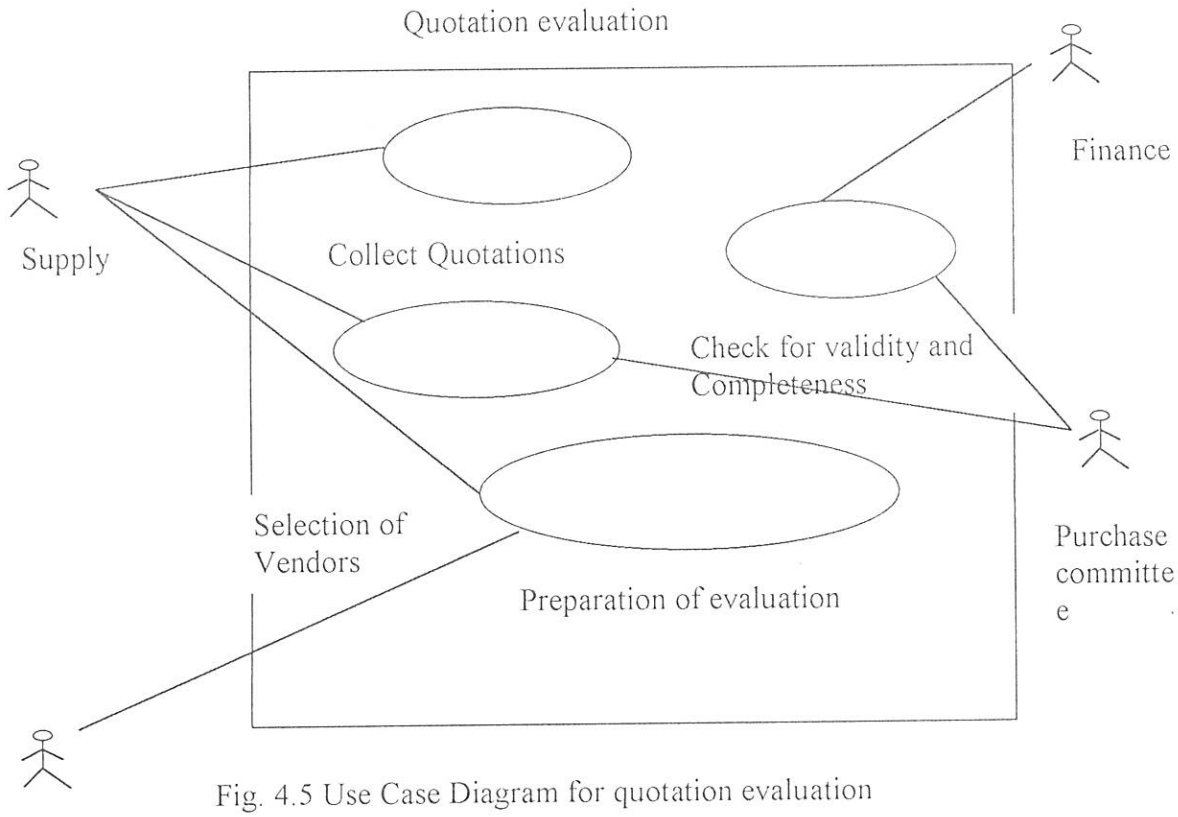


Fig. 4.5 Use Case Diagram for quotation evaluation

b) **Purchase order use cases**

Actors

- Finance
- Purchase Division
- Store And distribution Division
- Vendor
- Store

Use cases

- Approval of purchase order
- Notification of supplier
- Settlement of payment to finance
- Material collection from the supplier

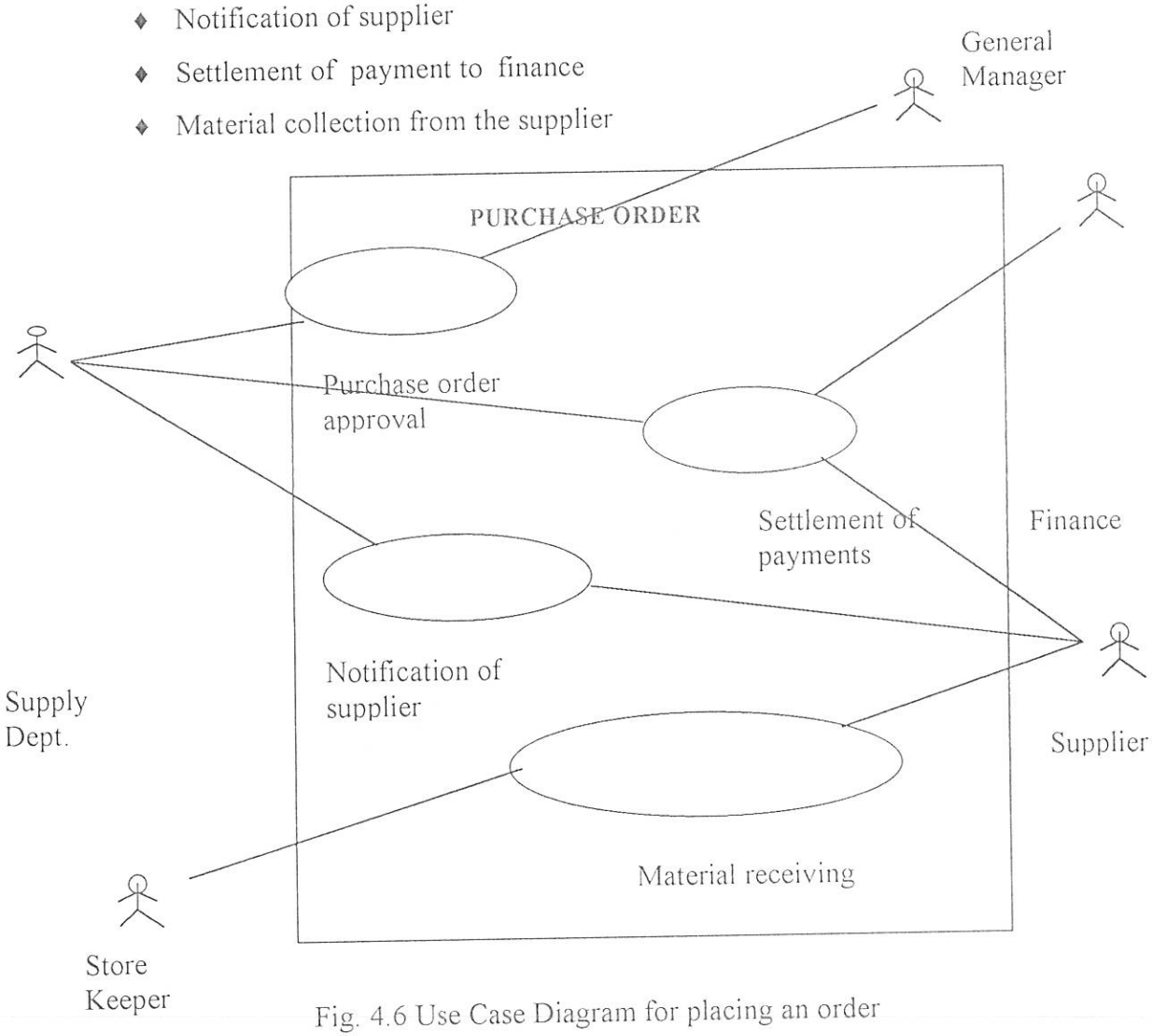


Fig. 4.6 Use Case Diagram for placing an order

b) **Purchase order use cases**

Actors

- Finance
- Purchase Division
- Store And distribution Division
- Vendor
- Store

Use cases

- Approval of purchase order
- Notification of supplier
- Settlement of payment to finance
- Material collection from the supplier

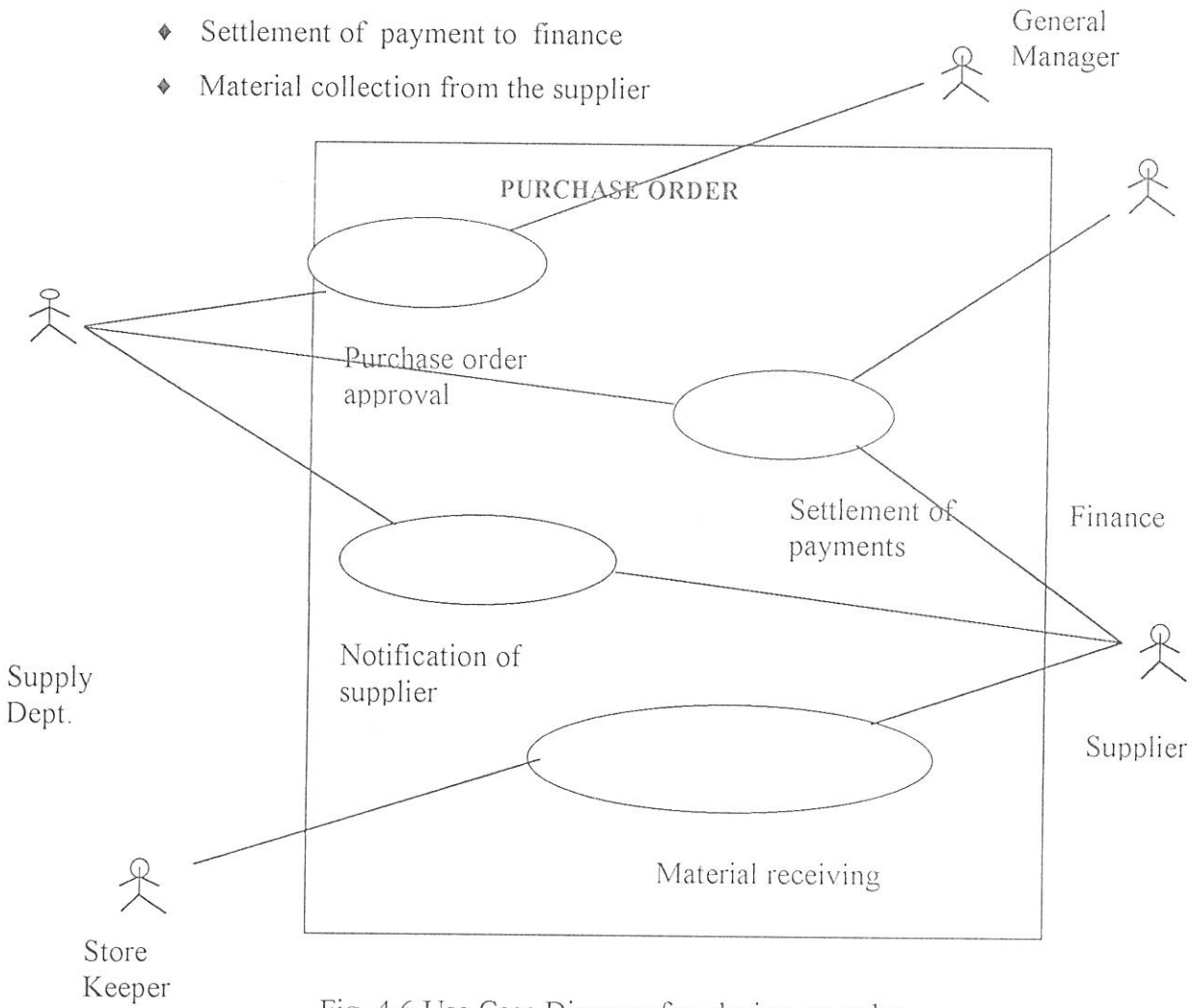


Fig. 4.6 Use Case Diagram for placing an order

c) **Material Dispatch use case**

Actors

- Transport enterprises(Hauling agent)
- Purchase and Supply Department
- Project
- Construction Department
- Supplier

Use case

The use cases are:

- Receipt of material
- Arrangement of Transport
- Shipment of material
- Receipts of acknowledgement

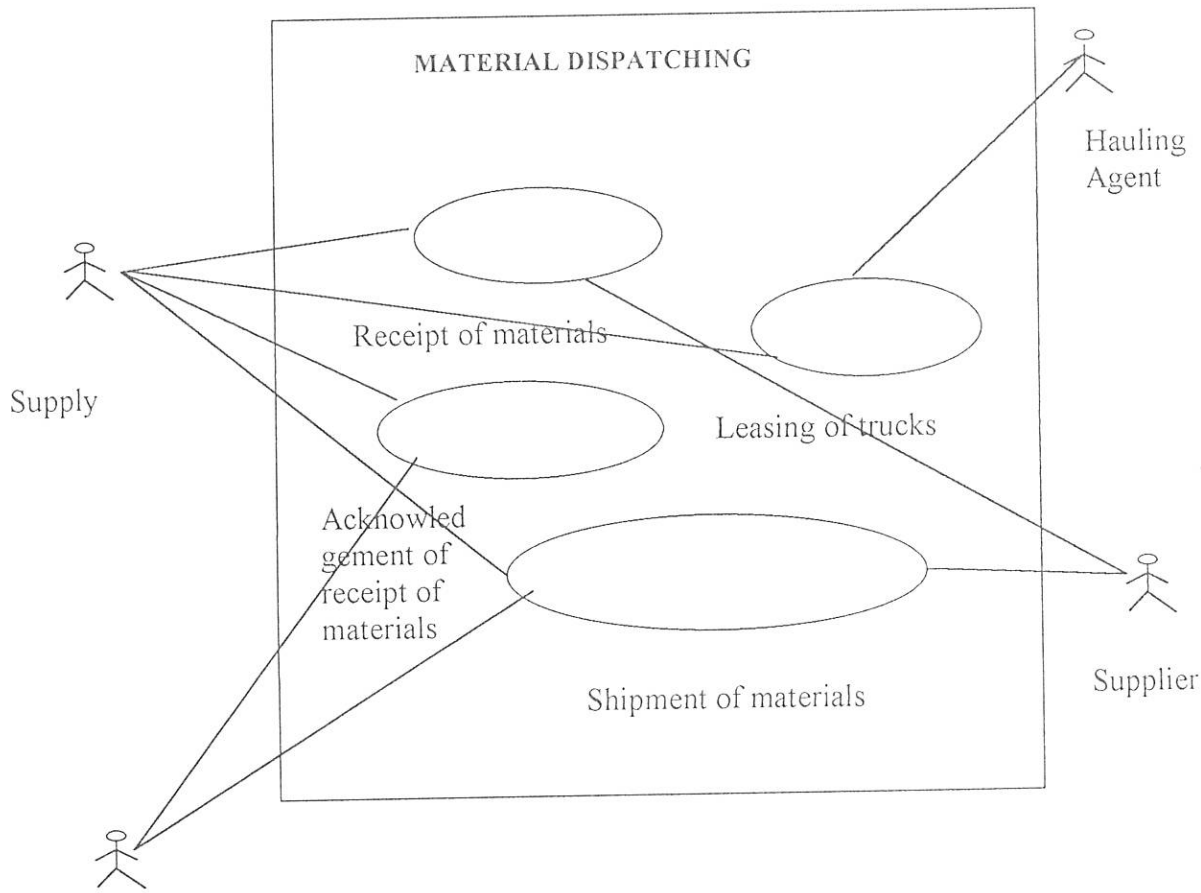


Fig. 4.7 Use Case Diagram for material dispatch

Chapter V

Logical and Physical Database Design : Prototype

In the last three chapters attempt is made to document the basic requirements of the company as formulated on the basis of the interviews and the review of documents of the company. And an attempt is also made to further refine further the requirement of the company that relates to the material system. In this Chapter the following designs are made for purpose of prototyping of this material system of the company.

- Form and Report Design
- Logical Database Design
- Physical database Design
- Distributed system Design

5.1 Forms and Report Design for material subsystem

The Estimating- scheduling - purchasing System (ESPS) as it has been stated in chapter IV has three sub system. These are,

- The material subsystem
- The equipment management subsystem
- The manpower management subsystem

Given the time constraints only the design of the material subsystem is made. But once

this subsystem is designed the other two are designed in similar way with slight difference.

The management of material should encompass its estimation, purchasing and distribution, as well as its consumption. The form and report for this sub system has about two major categories. These are

1. The material Estimation and Utilization category
2. The purchase and Distribution Category

5.1.1 Reports Design

The Material Estimation and Utilization Category generates four Fundamental Reports. These are

a) **The material requirement schedule Report**

i) **Data Element**: The material requirement schedule report has the following data Elements

- Name of Project
- Distance from Head Office
- Name of Project Engineer
- Material Description
- Unit of Measure
- Quantity of material
- Delivery Time

- Maximum Item Price

ii) **Users of the Report**: the estimation division produces the material requirement schedule report. It is used by the purchasing division and store and Distribution division of the Purchase and Supply Department. The maximum-price of the material data element is filled by the estimator as a certain percent of the current price of the material. It warns the Purchase and Supply Department that the ceiling (maximum) unit price should not exceed this amount. If it exceeds the purchase process must be approved by the General manger to make the procurement. This procedure helps the Construction Department request the client the necessary price escalation. This is part of the cost control mechanism that the system intends to introduce. The higher the unit price of the purchased material from that indicated in the material requirement schedule, the higher will be the total direct cost of the project. And the higher the cost of the project the lower will be the profit margin realized.

Furthermore the report also clearly indicated the delivery time of the material to project. Since the system also identifies the critical activities, this enables to identify critical materials that are necessary to accomplish the critical activities. This delivery time for these critical materials warns the Purchase and Supply Department that the necessary caution should be made while starting the purchase process of the material and their lead-time must be well taken into consideration. Otherwise delay in the supply of these material to the project will cause extension of the life of the project by same number of days. The extension of project life has a clear impact on the cost of the project. Because most indirect costs such as salary, equipment rent, and telephones and electrical utilities

increase as project completion date increases and hence cost is directly related to the number of days. This is another strong cost control mechanism introduced by the new system.

The material requirement schedule is also used by the Construction Department and the project for follow up purpose.

b) **Tender document**:

i) **Data Elements**: The tender document has the following data element

- Name and address the project
- Name and address of the client
- Name and address of the company
- Bid number
- List of activity and the corresponding quoted prices
- Tentative Work Schedule for each activity.

ii) **User of the Report**: This report is generated by the estimation division of the planning and contract administration. And it is used by (sent to) the client. Since this report is sent to external organization the system also automatically generate an attachment, letter if needed, by pressing a button in the system while at the same time generating the tender document. If the company wins the tender then this report together with some supporting document such as drawings are sent to the Contract administration division for contract purpose.

c) **Total material Estimation**

The purpose of this report is to inform and provide a summary of the new projects that the company participates in the fiscal year. This report includes not only these projects that are awarded to the company but also those that the company fails to win and the winners price for the project.

i) **Data Elements**:

- A list of projects awarded to the company and their total value
- A list of the projects not awarded to the company and their winning value.
- Estimated revenue generation for the fiscal year.

iii) **User of the report**: This report is generated by the estimation division of the planning and contract administration department. The General Manager and the Planning and Contract Administration Departments this report.

d) **Material Consumption report**:

The main purpose of this report is to evaluate whether estimation is correctly made or not. Although estimation can not be exact, there should not be significant error in estimation. Significant error in estimation has an adverse effect on the company's profitability and competitive power. Under estimation leads to winning of new projects that does not render a profit to the company. On the other hand overestimating could lead to loosing of new projects unnecessarily. Hence consumption of materials per activity should be taken and compared against standards. If there is a significant deviation then either of the following adjustment needs to be taken. If the standards on

the basis of which the material direct cost of activity is calculated is wrong, then the necessary adjustment must be made to these standards so that they can serve as a standard for future new projects. The two important components of standards are quantity of material and the price of material. And these components of material standard must be examined properly.

i) **Data Element of the report**: The report contains the following data elements.

- Project name
- Project Engineer Name
- Activity description
- unit of measure of activity
- Bill of quantity
- List of materials
- material description
- unit of measure of material
- Quantity estimated and Quantity used
- price estimated and actual price
- Activity start date and Activity finish data

When an activity is finalized in a project, the system has an interface for filling out the actual material consumption data from projects through remote login.

ii) **User of the report**: This report is generated by the estimation division. Most if not all of the data necessary to generate this report is supplied by the corresponding project. The

user of the report includes the Purchase and Supply Department, the planning and contract administration and the Construction Department.

The Purchase and Supply Department must receive this report when there is a significant price deviation, the department must provide reason for the deviation. If the reason for deviation seems to persist, then the planning and contract administration should adjust the price of the materials that shows deviation in the price list. On the other hand if there is deviation on the quantity of material used, then the Construction Department should receive this report so that the Construction Department can give adequate reason. The Construction Department should undertake the necessary investigation to come out with the causes of the deviation. The deviation in material can be due to skill deficiency of the engineer and the associated workmen doing that particular activity. Besides it could be due to unacceptable wastage of materials. If in any case this cause of the deviation seems to persist for a longer period of time then the standard must be adjusted accordingly.

iii) **When is this report used**: This report is generated periodically when a given activity is finalized. The material consumption data for preparing this report is feed to the system on line on batch basis. Further more projects feels online forms the start and finish date of each activity. Then the report for a collection of activity finalized during a month is compiled and this report is accessible by projects online through remote login to the server.

During the design of the reports, the researcher used the following prototyping

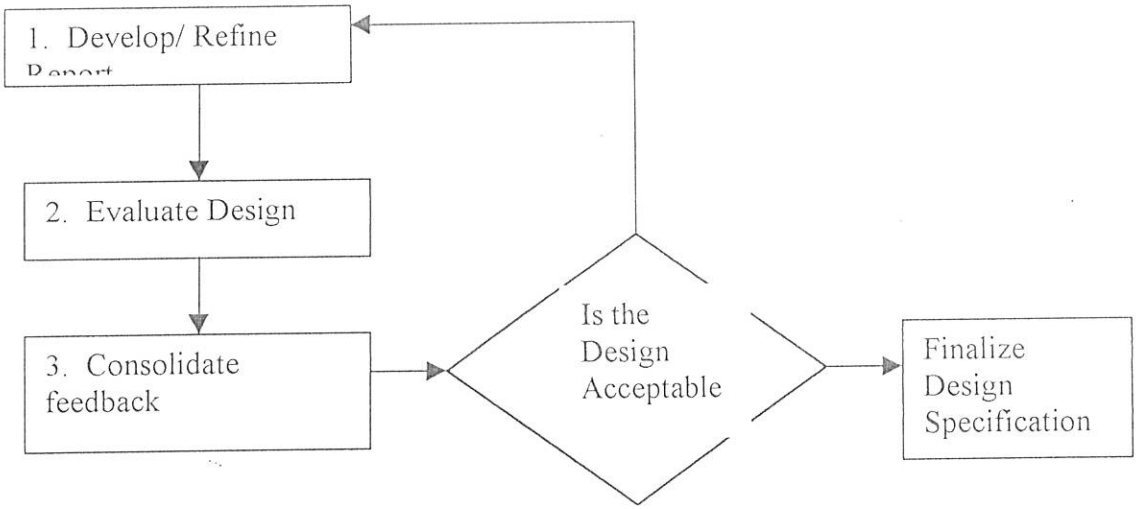


Fig 5.1 Report and Form prototype Design processes
Source: Hoffer et al (1999, pp. 548), Modern System Analysis and Design

The system responds to a number of queries that usually come from projects and the Construction Department. Further more the system generates Three category of reports can be identified by this sub system

- List of material dispatched to project summarized by project name and the material type
- List of material on order
- List of materials on hand

The detail design are very similar to the reports design of the above and are intentionally left out.

5.1.2 Form Design

The system has a number of forms for accepting input to the system. These includes

- Password entry form
- Company profile Form
- Project Profile form
- Standard Form
- Bid/Activity Form
- Price List form
- Material Consumption form
- Price Analysis form
- Unit of measure form

a) Password Entry Form:

i) Data Entry Fields: This Form has the following data entry fields and controls:

- User name
- User Password
- The OK control
- The Cancel Control

The user can edit both fields before the OK button is depressed. If the user makes an error in either of the fields then the system prompts to enter the write user and password. After three unsuccessfully attempt the system exits. The system has three level security

system.

- When opening the system for the first time
- When you enter a specific module
- When the user intends to change password.

Sample Design

b) Company profile

a) Narrative overview

Form: Company profile form

Users: The Estimation Division Head uses this Form, when the system is used for the first time. The system takes this form when printing reports on screen or hard copy.

System: Window NT and Microsoft Window

Environment Normal Office Environment; it has adequate lighting, no sound, no humidity, minimum interruption of phone calls.

b) Sample Design of the Company Profile:

c) Testing and Usability assessment

The user of this Form is the Estimating Division head of the system Administrator. Both have an adequate acquaintance with many window-based programs. The usability assessment indicated that the form is consistent. By consistent it means that tittles, error messages menus options and other design elements appear in the same place and look the same on all forms and reports (Hoffer et al., 1999, pp. 538).

(High = 1; moderate = 2; Low = 3)

Usability Factor: Consistency.

Rate: 1.5

3) The project Profile Form

a) Narrative Overview:

Form: Project profile form

Users: The Estimation Division Head uses this Form.

System: Window NT and Microsoft Window

Environment Normal Office Environment; it has adequate lighting, no sound, no humidity, minimum interruption of phone calls.

b) Sample Design

c) Testing and Usability Assessment: The assessment of this form show that the consistency rate is High.

4) Material Standard Form

a) Narrative Overview

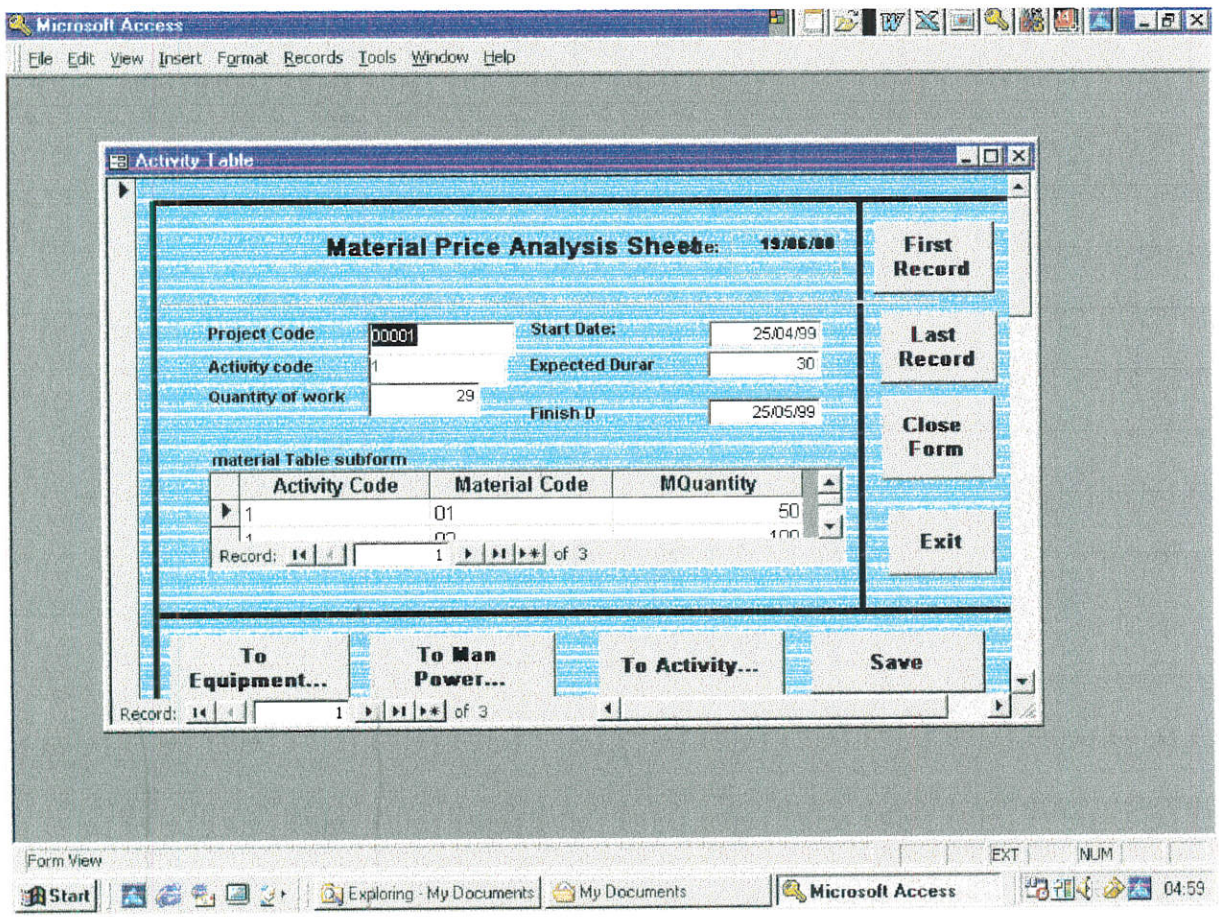
Form: Material Standard form

Users: This form is used by the Estimation Division Head and in his absence this form is used by the planning and contract Administration Department. The department head is also well aquatinted to a number of Window environment

System: Window NT and Microsoft Window

Environment Normal Office Environment; it has adequate lighting, no sound, no humidity, minimum interruption of phone calls.

c) Test and Usability assessment: This form has a usability rate of 1.5 for the consistency factor.


Microsoft Access
File Edit View Insert Format Records Tools Window Help
Activity Table
Material Price Analysis Sheet
Project Code
00001
Activity code
1
Quantity of work
29
Start Date:
25/04/99
Expected Durar
30
Finish D
25/05/99
material Table subform
Activity Code
Material Code
MQuantity
1
01
50
Record: 1 of 3
First Record
Last Record
Close Form
Exit
To Equipment...
To Man Power...
To Activity...
Save
Record: 1 of 3
Form View
EXT
NUM
Start
Exploring - My Documents
My Documents
Microsoft Access
04:59

5.2 Converting the Classes model in to relations

For each Forms and Reports so far discussed, as well as for the class diagram we have built, a logical model is built by converting them in to their corresponding relations. Then the this logical model is integrated and normalized.

For each of the above relations are normalized. 1NF insured by check for atomic Cell, 2NF is insured by checking all non-key are fully functionally Dependent on the primary key and only the primary key, and 3NF is ensured by checking that there in no transitive dependency.

5.3 View Integration

To integrate all the normalized user view in to consolidate Logical relational model is the next step. Hence are integrated as follows.

Password (UserId, UserName, Password)

Company Profile Form

CompanyProfile (CompanyName, Location, City, Telephone, Postal Address, Email)

Project(ProjectId, Bidno, ProjectName, Distance,Location,ProjectEngineerName)

MaterialStandard (StandardId, ActivitityCode,MaterialCode,Qty)

Activity (ActivityCode,ActivityName, UnitCode)

Material (MaterialCode, Description, UnitCode)

Unit (UnitCode, UnitDescription)

BidList (Bidno, ClientId, ConsultantId,SubContractorId, BidDate, ActivityId, BillOfQuantity,WinStatus)

Material_Price (MaterialCode, Unitprice,DateUpdate)

MaterialConsumption (MaterialCode, UnitCode,Quantity, Activity, BillofQuantity, MaterialPrice, DateStart, DateFinish)

MRS (ProjectId,ActivityId ,ItemCode, UnitCode, Deliverydate)

Tender (ProejctId, ActivityId, BillofQuantity, AnaliseId)

Analysis (AnalysisId, ActivityPrice)

Schedule (ProjectId, ActivityId, Startdate, Duration, Predecessor, CriticalStatus)

The Class Diagram has to be converted in to a relation and should as well be normalized then is integrated with the relation derived from the reports and forms. It has been found that all the attributes of the classes are included in the above list of relations and the relations are checked for their 3NF (Third normal form.

5.4 Physical Database Design

5.4.1 Field Design

Table Name: Activity Table

Field Name	Field Type	Field Size	Indexed
Project Code	Text	30	Yes
Activity Code	Text	30	Yes
Quantity	Number	Long Int.	
Start Date	Date	8	
Expected Duration	Number	Long Int.	
Finish Date	Date	8	
Predecessor Activities	Text	30	

Table Name: Project Table

Field Name	Field Type	Length	Indexed
Project Code	Text	30	Yes
Project Name	Text	50	
Project Engineer Name	Text	50	
Location	Text	50	
Start Date	Date	8	
Distance	Number	Long Int.	
Project Value	Currency	Default	
Win Status	Yes/No	1	

Table Name: WorkTable

Field Name	Field Type	Length	Indexed
Work code	Text	30	Yes
Work Description	Text	50	50
Unit of Measure	Text	50	5

Table Name: Material Table

Field Name	Field Type	Length	Indexed
Activity Code	Text	30	Yes
Material Code	Text	30	
Quantity	Number	Long Int.	

Table Name: Equipment Table

Field Name	Field Type	Length	Indexed
Activity Code	Text	30	Yes
Equipment	Text	30	
Quantity	Number	Long Int.	

Table Name: Man Power Table

Field Name	Field Type	Length	Indexed
Activity Code	Text	30	Yes
Man power ode	Text	30	
Quantity	Number	Long Int.	

Table Name: Material Price Table

Field Name	Field Type	Length	Indexed
Material code	Text	30	Yes
Material Description	Text	50	
Unit of Measure	Text	5	
Current Price	Currency	Default	
Max price	Currency	Default	

Table Name: Equipment Price

Field Name	Field Type	Length	Indexed
Equipment code	Text	30	Yes
Equipment Description	Text	50	
Unit of Measure	Text	5	
Current Price	Currency	Default	
Max price	Currency	Default	

Table Name: Man Power Price Table

Field Name	Field Type	Length	Indexed
Man Power code	Text	30	Yes
Man Power Description	Text	50	
Unit of Measure	Text	5	
Current Price	Currency	Default	
Max price	Currency	Default	

Table 5.1 List of Tables showing field design

5.4.2 Selecting Index

Index must be used generously for databases intended primarily to support data retrievals and it must be used judiciously for databases that supports transactions processing (Hoffer et al, 1999,669). Therefore the system for the company that focuses on the purchasing process provides facility for different type of answering queries that come from both projects and the Construction Department about the status of a specific

purchase request or store request. Hence it is good to use indexes in more of the fields of the relations, including the primary keys, foreign keys and non-key fields. On the other hand estimating operations are of more a transaction processing type with a very minimum requirement for retrieval of information from the tables and hence the use of index are only limited to the primary keys.

5.4.3 Referential Integrity

Referential Integrity is enforced in to the material table, Equipment table, and Man Power table from material price table, equipment Rate table and manpower wage table respectively. The idea behind enforcing such integrity rule is that no estimation can be made with out first defining the price of the corresponding resource.

5.4.4 Selecting Database Architecture

Out of the four data base architecture, namely the hierarchical, network, relational and Object-Oriented methods, the relational database model is chosen for the system. Microsoft Access 97 is one type of data base management system that is built around the relational database model.

1. Brown (1997, pp. 450) stated ' This early in Object-Oriented methods history, a lost of systems are still being developed using object methods, but built around a relational database. He further noted that most major relational databases have already Object-Oriented methods front ends and screen builders. MS Access '97, in addition to its multi-user environment, has Object-Oriented methods features.

5.4.5 Designing Distributed Systems

The company can use the existing server for a client server distributed system. Projects that are very remote from direct telephone lines can be provided with a High frequency Radio, with modem and Personal computers interface. Since the price of this HF radio is not significantly different the difference is between 5000.00 to 7000.00 Birr. Further more since the later also can be used to transfer analog messages it by far superior. Those projects that have a direct telephone access can be connected to the central server through a remote dialup. The departments in the head office are connected to the server through the Local Area net work. And can pick any information that can come from projects through the server.

Chapter VI

Decision Making Process under Uncertainty

6.1 General

We have so far discussed what important functions of the company should be integrated in a software system that is built around the material object. This would allow providing an information that is requested by departments to carry out their respective function. Department Heads are not only making structured decision that can be improved by provision of a pertinent, timely and accurate information, they also involve themselves around a multitude of unstructured decision. One aspect of this is that at what price the company should quote in order to guarantee wining of the award of a new projects. Such uncertainty should be supported by models that simply formalize and structure the best skills of the decision-maker over time.

Risk and uncertainty are fact of life. Understanding and managing uncertainty explicitly using probabilities is an important approach to conducting business effectively. Effective decision-making not only requires a shared understanding of a key business issue but also looking ahead how these issues behave. Opportunities and threats surround enterprises. Opportunity and threats are uncontrollable and external to the enterprise. An organization could have strength to make use of the opportunity and to minimize the effect of threats. Similarly, organizations have weaknesses that would contribute adversely to the gripping of opportunity and/or the minimizing of the threats.

There are a number of computer software systems that deals the building of business models (mathematical, or heuristic models etc.) and aids enterprise to deal better with risk and uncertainty issues. Example of such package includes those based on Bayesian Belief Network such as Hugin, Netica etc.

Before the use of these packages, however, the necessary analysis of the problem has to be made thoroughly and the problem needs to be defined clearly. Moreover the alternative solutions or models have to be developed, and then by applying the software, the optimum solution may be selected more easily, through processes of experimentation, verification and implementation.

The development of alternative course of action or tentative solution usually takes the form of mathematical models or other convenient model types. (Thierauf and Klekamp, 1975, pp. 35). Model, development entails three stages as follows.

a) Data analysis: Here assumptions, constraints, events, relationships, variables and other factors are defined. The following type of variable need to be identified

- Decision variables: variables that you can control.
- Objective variables: variables or quantities that you are trying to optimize.
- Chance variable: variables that depict the uncertainty of something you can not control or predict with precision.
- Other variables: variables that depend upon the decision or chance variables, but you can not control or predict with

precision

b) Model Development: It is concerned with the setting up of the model, which is structured according to the parameters defined in the analysis. The model will normally consist of mathematical relation expressed as equation and function.

c) Model validation: validation refers to programming and debugging of the model.

6.2 SUR construction Risk and Uncertainty Analysis

The company wants to know the probability of winning or loosing a competition for a new project. If the company bids with a lower price then there is a risk of getting no profit (or a loss) out of it. If the company bids with higher prices then the company can lose potential projects. So how can it solve this difficult-to-foresee circumstance of uncertainty. What follows is a brief description of information, obtained from domain experts.

6.2.1 Determination of variables - Bid Prices

Probability of winning depends on the size of bid price of the project. The higher the price of a bid offered, the lower will be the probability of winning it. And the lower the price offered, the higher will be the probability of winning. The selection criteria that most owners of project use is to select the least price offered for the bid, from among those that have met the minimum pre qualification criteria.

Bid price has a lower and upper bound. The lower and upper bound of the offer is

usually determined by two important components of the price of the bid. These are

1) The size of the Cost.
2) The size of the profit margin.

a) **Cost of project** Size of the cost of the project is an estimate. But it is objectively determined by taking the quantity of resources used complete a given construction project and then multiplying it by its corresponding prices. But since the size and price of such resource is an estimate, taking a single value is not the right way of estimate but we can be sure with certain confidence interval that the estimate would assume. It can be calculated to indicate a range. The higher one is a very worse situation, which we refer to as a pessimistic cost of project. Or it can as well be calculated under favorable condition, assuming every thing is reasonably Ok. We refer to this cost the optimistic project cost. The actual cost can only lie in between. That is as the competitors can only quote within these ranges. A risk-taker contractor can assume that every thing is Ok and estimate the cost of the project as low as the optimistic project cost. And since its bid quotation price is based on this lower optimistic cost of project then its biding price is consequently lower just near the pessimistic cost of project. On the other hand risks avert contractors prefers to bid on higher portion of the range. Here one important assumption is that every contractor utilizes the same level of technology. Every contractor uses what the market provides. There is no cost difference because of the technology they use.

b) **Profit margin:** the second variable that the project bid price depends is the profit margin the contractors set. Similarly we can set a range of optimistic profit and

pessimistic profit. And it is within this range that the competitor companies set their profit.

Every competitor is within the following range. We have an upper limit set by a pessimistic cost and an optimistic profit margin. On the other side we have lower limit for the biding prices of contractors that is set by the pessimistic profit and optimistic cost.

As indicated above there are a number of software tools that could be used for building models on the basis of the foregoing observations that helps contractor come up with competitive bids. With this view, an attempt was made in the current work to utilize such software tools (in particular Hugin and Netica) by downloading free versions from the Internet. However, due to lack of time, particularly time required to download because of connection problems and time spent on the development of experience in the use of such tools on the part of the researcher, it was felt that the experiment conducted in this direction is not yet ready for demonstration and reporting for the purpose of this thesis. Instead experience gained from such exercise is used in coming up with a simple model proposed for use in this area is reported below. What follows is a simple account to demonstrate the possibilities of modeling the bid price determination related decisions.

6.2.2 Demonstration

Assume the following data of five bidders participating in three bids. And assume further that the fourth bid is under competition.

	Bids		
Bidder	Bid1	Bid2	Bid3
A	75	10	1000
B	80	8	750
C (SUR)	90	9	600
D	100	12	
E	80		

Table 1: Historical data of bidders

From the above table it is clear that the bid1, Bid2, Bid3 are awarded to Bidder A, B, C respectively.

Steps 1: Evaluate the performance of SUR on the past bids against Winner of bids.

Bidders	Bid 1	Bid 2	Bid 3
Winner	75	8	600
SUR (C)	90	9	600
Deviations	15	1	0

Table 2: Deviation Table

Step 2: Construct the Optimistic – Pessimistic Matrix

PP = Pessimistic Profit OP = Optimistic Profit
PC = Optimistic Cost OC = Optimistic Cost

	OC	PC
PP	PP + OC = PPOC	PP + PC = PPPC
OP	OP + OC = OPOC	OP + PC = OPPC

Table 3: Optimistic- Pessimistic Table

Probability of bids price $X = \frac{P(Xi) = OPPC - Xi}{OPPC - PPOC}$

Step 3 : Convert the past Bids into the Optimistic – Pessimistic Table

For Bid 1:

	OC	PC
PP	60	90
OP	65	100

Table 4 : O-P Table for Bid 1

Using the formula for finding the probability of winning the a given tender:

$$P(X= 90) = \frac{100 - 90}{100 - 60} = 10/40 = 0.25$$

For Bid 2:

	OC	PC
PP	7	13
OP	8	15

Table 5

$$P(X= 9) = \frac{15 - 9}{15 - 7} = 6/8 = 0.75$$

For Bid 3:

	OC	PC
PP	550	750
OP	600	950

Table 6

Step 4 : Determining the probability of past bid prices offered by Bidder C (SUR)

For Bid 1 : Bidder C (SUR) participated in Bid 1 with offer price of 90 million Birr. The bid was not won. Its probability for winning was 0.25 as it can be seen from the following formula that is based on the optimistic and pessimistic tender price analysis of the company for that specific construction project under Bid 1.

$$P(X = 90) = \frac{100 - 90}{100-60} = 0.25$$

Similarly:

For Bid 2: Bidder C (SUR) participated in Bid 2 with offer price of 9 million Birr. The bid was In fact won by SUR. Its probability for winning was 0.75 as it can be seen from the following formula that is based on the optimistic and pessimistic tender price analysis of the company for that specific construction project under Bid 2.

$$P(X = 9) = \frac{15 - 9}{15 - 7} = 0.75$$

Similarly:

For Bid 3: Bidder C (SUR) participated in Bid 3 with offer price of 600 million Birr. The bid was not won. Its probability for winning was 0.77 as it can be seen from the following formula that is based on the optimistic and pessimistic tender price analysis of the company for that specific construction project under Bid 3.

$$P(X = 9) = \frac{950 - 600}{950 - 550} = .0.77$$

Step 5: Formulate the expected deviation:

Bid	Probability	Deviation Amount	Base of Deviation (Winner price)	Percentage of deviation *
Bid 1	0.25	15	75	20
Bid 2	0.75	1	8	12.5
Bid 3	.077	0	600	0

Table 7

* Percentage of Deviation = $\frac{\text{Deviation Amount}}{\text{Winner Price}}$

Expected Deviation $= \frac{\sum (\text{Percentage of Deviations})}{\text{Number of Bids}} = \frac{20 + 12.5 + 0}{3} = 10.83$

Step 6: Formulate the Optimistic and Pessimistic Table for the new bid on the input variables of

1. Bill of quantity as it has been given in the bid document by the owner of the project. (Is always fixed for all Bidders}
2. Current Price considering into account the variation it might have. (Can have both pessimistic and optimistic values)
3. The resource requirement for a unit of activity as it has been stated in the productivity standard (Can have both pessimistic and optimistic values)
4. The Indirect cost [ID] that is needed to run the project (including electric, telephone and transport etc utility expenses, as well as office salary and stationary material expenses (Can have both pessimistic and optimistic values)
5. The profit margin [PM] as determined by the needs of the company. (Can have both pessimistic and optimistic values)

The tender price for the new price can be calculated as
Direct Cost of the project [DC] = [1] x [2] x [3]

Total Bid Price = DC + IC + PM

Assume that the calculation of the above for the fourth Bid (Bid 4) is carefully made and appears as below.

	OC	PC
PP	100	135
OP	105	150

Table 8

Xi = is possible value of bidding price for Bid 4 (Xi can assume any value between the new lower tender price here 90 and the upper one 150) Some figures are randomly selected and their probability determined.

	Old chance of winning	New chance of Winning $\frac{(150\text{-}xi)}{} \times \frac{100}{}$

Xi		(150 - 100) 110.8
100	1	0.9
150	0	0
120	0.6	0.54

Therefore it is clear from the above that if the company wanted to win the Bid 4 (the new bid) it has to quote as minimum as 90 million Birr. Otherwise the old assumption tells us that if SUR quote 100 million Birr for the project then it has a 0.1 chance of failure or not winning the new project.

Chapter VII

Conclusion and Recommendation

1) Analysis of tender document shows that the material cost share of the direct cost is very significant and is about 60% to 70% of the total Direct Cost. This shows how far the material and information associated with material is important. Furthermore it has been found that out of the list category of items of materials still there is a hierarchy of importance. The most important being the cement and reinforcement bars. These importance analysis is used by management to spend considerable time and attention for the decisive resources of the company and without spending considerable time for resources that turn out not to matter very much.

2) The company has no standard format of coding of material. Yet every computer software can not properly applied with out having such coding of materials system. This coding also can serve for better communication between project personnel and head office staffs. Also it is preferable to use an international standards of coding so that exchange of information is possible with other organization.

It is recommended to adapt an international standard than that of using a code developed at company level. Because this does not allow us to exchange information with other external organizations

3) There are a number of applications software on the market that are built for construction industry, Among other things the fundamental one are:
Computer Aided Design/(Drawing (CAD), Computer Aided Construction Work Measurement (CAM) Computer Aided Estimation (CAE), Computer Aided Construction Planning (CAP), Computer Aided Valuation of construction work (CAV), and Computer Aided construction Cost Control and Cash Flow Forecasting (CFF). It seems there is very little awareness for the existence of the software in the market and no attempt is made to evaluate their merit and demerit to the company. The first two software namely the CAD and CAP although it exist in the company are not fully utilized. The CAD is used mostly for Negotiation designs. Some office engineers also use the planning software.

4) Since some of the projects of the company are road construction projects, they are far from telephone lines. Instead these project make the necessary communication by High frequency Radio, which are usually noisy and difficult to use. And such projects can connect with the head office server through a high frequency radio having a PC Interface with a Modem and Data loggers. Furthermore projects that have access to telephone lines can used the public telephone line to make a remote login with the head office server.

5) There is a problem of finding current price of material for preparation of tenders and the searching of current price manually adapted by the Purchase and Supply

Department is not satisfactory. Any ways what price does the P&CAD require for tender, average price, moving average price, or current market price. So we can solve these problem by designing a small database that registers the prices and date of purchase order. It is also possible to develop a program that track a construction material price on the Web although the company dominantly use the local market for share local market purchase being 65% up to 70% of the total purchase.

6) The researcher believes that an attempt be made to register the actual material, labor, and equipment consumption of an activity and a comparison made with the estimate. And based on the deviation make the necessary action to amend the standard if it is found unreasonable or take the necessary caution and follow up on part of the projects to produce and use resources according to the standard. While discussing, with the concerned personnel for estimation and tendering, it has been reflected by the division head of the estimation that the importance of maintaining such gathering of data on the volume of resource per completed activity. The benefit of such data has a paramount contribution for accurately estimating and tendering purpose. Therefore the company has to look for way of assigning personnel and the necessary support to make this collection of performance data possible.

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Appendixes

Appendix A

Total Consumption of Pads that are used by the Purchase and Supply department and their annual cost for the year 1997/98.

Name of the Pad	Annual Consumption (pads)	Cost	
		Per Pad	Total
Store Requisition (SR)	36	18	648
Purchase Requisition (PR)	36	18	648
Evaluation Sheet	10	70	700
Local Purchase Order (LPO)	48	15	675
Store Dispatch Note (SDN)	36	22	792
Store Issue Voucher (SIV)	36	20	720
Goods Receiving Note (GRN)	46	13	598
Fixed Asset Receiving Memo (FARM)	24	22	528
Fixed Asset Issuing Voucher(FAIV)	24	13	312
Goods Short Advise (GSA)	12	15	180
Store Return Note (SRN)	24	13	312
Inter Store Transfer Voucher	12	13	156
Document Transit Form	12	13	156
Bid Card	5000	.019	950
Stock Card	7000	0.26	1820
Total			9596

Appendix B

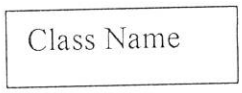
List of Respondent

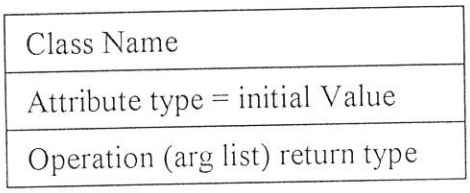
No.	Name	Position
1	Mulegeta K	Head, P&CA Dept.
2.	T/Himanote G.	Head, HRD Dept.
3.	Monhamed N.	Head, Finance Dept.
4	Merid A	Head, Supply Dept
5	Beshiwa	Head, Construction Dept.
6	Tiebe B.	Building Office Engineer
7	Tewelde	Contract Administration Division H
8	Mekonnen W	Senior Accountant
9	Hanna M.	Purchase Officer
10.	Woldu M	Project Office Engineer

Appendix C

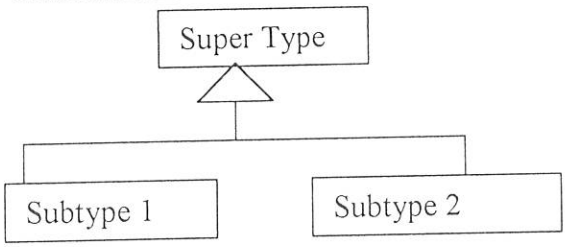
UML Notations:

Class





Generalization



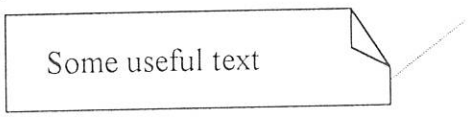
Constraints

{Description of constraints}

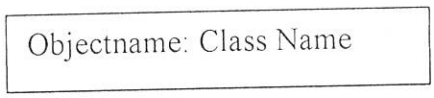
Stereotype name

<<Stereotype name>>

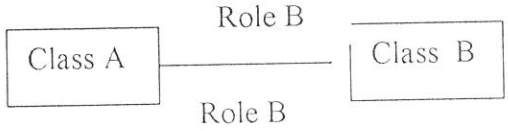
Note



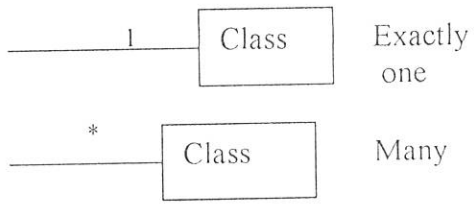
Objects

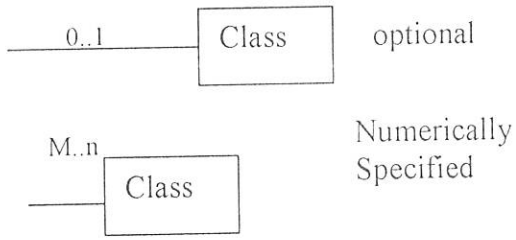


Association

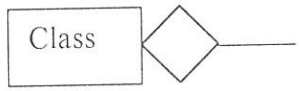


Multiplicities

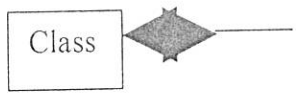




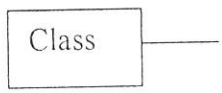
Aggregation



Composition



{ Ordered Role}



Appendix D

Sample Price Analysis sheet

SUR CONSTRUCTION SHARE COMPANY

PRICE ANALYSIS SHEET

PROJECT _____ DISTANCE IN KMS _____

LOCATION _____ LABOUR HOURLY OUTPUT _____

ITME OF WORKS _____ OUTPUT OF EQUIPMENT _____

_____ RESULTANT _____

1. MATERIAL COST						2. LABOUR COST					3. EQUIPMENT COST				
TYPE OF MACERIAL	UINT	QTY	INITIAL COST	ADDIT. COST	TOTAL COST	LABOUR BY TRADE	NO OF LABOUR	WAGE PER HOUR	* UF	TOTAL HOURLY COST	TYPE OF EQUIPMENT	NO OF EQUIP.	RENT PER HOUR	* UF	TOTAL HOURLY COST
SUB TOTAL 1						SUB TOTAL 2					SUB TOTAL 3				

OTHER EXPENSES :

3.social Benefit _____

4.Total of (a+b) _____

5. PERFORMANCE RATE/HR

6. DIRECT UINT COST = 1+ (2+3+4) / 5

= _____

7. SMALL PLANT & TOOL COST _____

8. TOTAL DIRECT COST (6+7)

9. INDIRECT COST _____

10. PROFIT _____

11. SERVICE TAX _____

12. AGGREGATE UINT COST _____

* Additional cost including transportation and handling

Appendix E
Sample Interview Guide

Interview Guide (Outline)

Interviewee: Ato Mulegeta K.: (Planning and Contract Adm. Dept Head)
Interviewer: Tesfaye Tafere

Location: SUR Building office No. 204:
Appointment Date: March 10/2000 5:00 PM - 5::45 PM.

Objective

1. To understand the specific roll of the Planning and Cont. Adm. Dept. has in the pretending, reconstruction and Construction states of projects
2. To explore what software is most frequently used and for what purpose, the limitation of these software etc.
3. To discuss major interaction with other departments.
4. To explore reason for deviation between plans and performance
5. To Explore Problems encountered in the department and problems with data collection, processing, and Generating reports.

Agenda:

Introduction:

(I shall tell him my name, where I come from and why I am interested to study the company.)

Background on Projects:

(Tell him the purpose is for academic purpose)

Question No 1.: (Functional Responsibility)

1. What is the roll of the department and each of the divisions under this department in the pre tendering stages of a new project?
2. What is the roll of the department and each of the divisions under this department in the pre Construction stages of a new project?
3. What is the roll of the department and each of the divisions under this department in the construction stages of a new project?

Q. 2: (Software and Hardware).

1. How many computers are there in the departments?
2. What are the software available in these computers?
3. Which software is the most dominantly used one?
4. What quality of this software do you appreciate?
5. How many of the staff in your deportment have computer skills?
6. Do you use in house developed software?
7. If there is who developed it? When?
8. How did you find this software?
9. Does it help to your expectation?

Q. 3: (Interaction with other departments)

1. With which of the departments your department interacts?
2. What are the issue or the subject mater of the interaction?
3. Can you arrange the department in terms of the frequency of relationship?
4. What type of media do you use when interacting?

5. With external organization does your department interact?
6. What are the issues of interaction?
7. Can you arrange the external organization in the frequency of interaction?
8. What media do you use for communication with these external organizations.

Q. 4 (problems encountered)

1. What are the most frequently encountered problems in the department?
2. What do you think is the source of these problems?
3. What are the impact of these problems in the over all success of the company?
4. What solutions do you propose?
5. Do you thing computerization help solve these problems?

Q. 5 (Question about estimation)

1. Can you describe me how the estimation process works?
2. What are the outputs of the Estimation process?
3. Were does these outputs go? Who are the users of these outputs?
4. What are the input to the estimation process?
5. Which departments does this input provide?
6. Is there any input produced within the estimation division?
7. What data elements does these inputs contain?
8. What processes are undertaken to this input?
9. What rules is the process of estimation governed by?
10. Do you make any effort to combine scheduling technique to the estimation process?
11. Do you make any effort to combine cost control mechanism to the estimation process?
12. Do you make any effort to combine and support one another performances as reported by projects and estimates?
13. How well is the estimation, scheduling, purchasing, cost control and performances integrated in one system? Do you see any disadvantage or constraints that prohibits such integration?

General Observation:

The time was arranged to be out of office hours, as a result no interruption occurs.

Unresolved Issues/ Topics not covered

No topics have been uncovered. In fact some questions were directly forwarded to the estimating division head.

Appendix F

Report and Form design Assessment Form

Report and Form Design Assessment Form

Sur Construction S. Co.

Report and Form Design Assessment Form

Name:_____

Location:_____

Report: _____ Version: _____

☐ I accept the current design.

☐ I request that the following changes be considered

_____

Importance (Circle One)

Low	Med.	High	Description of Change
1	2	3	_____
			_____
			_____
1	2	3	_____
			_____
			_____
1	2	3	_____
			_____

Appendix G

The Capital, equipment and Staff minimum requirement for General Contractors grade 1 (GC1) and Building Contractor grade 1 (BC 1) are indicated in the following table.

a) Equipment Requirement

Item	Equipment type	GC 1	
1	Dozer 200HP and above	5	
2	Crane 15T or above	1	1
3	Loader 2M3 and above	3	2
4	Crusher 30 T/hr and above	2	
5	Crusher 10 - 30 Ton/hr		
6	Crusher 5 T/hr		
7	Grader 100 HP and above	2	
8	Excavator 0.5 M or above	1	1
9	Sheep Foot Roller 10 T& above	1	
10	Roller 10T and above	4	1
11	Dump Truck 7M3 and above	12	8
12	4W Drive	4	
13	Pick UP	3	4
14	Concrete Mixer 500-750lt.	3	3
15	Concrete Mixer 250 -500lt.		
16	Hand Compactor	6	6
17	Courier Truck		1

b) Capital Requirement

Contractor Type	Minimum Capital Required	Remark
GC 1	20,000,000 Birr	
BC1	20,000,000 Birr	

c) Staff Requirement

Item	Staff Type	GC1	BC 1
1	Professional Engineer IV (Bsc in Engineering Ten Years of Service)	2	2
2	Associate Engineer IV (12 years of service, advance diploma from Collage in Building)	1	1
3	Associate Engineer III (10 years of service and advance diploma from Collage)	1	1
4	Engineering Aid III (16 years service and diploma from technical school.)	1	1
5	Engineering Aid II (14 years service and diploma from technical school)	2	2

aration:

hesis is my original work, has not been presented for a degree in any other ersity and that all sources of material used for the thesis have been duly nowledged.

aye Tafere — DENT NAME

SIGNATURE

May 21/2000 — DATE

thesis has been submitted for the examination with my approval as a ersity advisor.

faye Birru — VISOR NAME

SIGNATURE

May 21/2000 — DATE