A DECISION SUPPORT TOOL FOR PRODUCTION SCHEDULING

BY

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A Project Report Submitted to the school of Graduate Studies
in Partial Fullfillment for the Award of
Master of Science in Computer Science Degree of
Makerere University

February 2006
Declaration

I Okullu Andrew Robert do hereby declare that this Project Report is original and has not been published and/or submitted for any other degree award to any other University before.

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Dedication

This report is dedicated to my Parents Mr and Mrs Okullu, brothers, little Judith and sister. Without you, this wouldn’t be possible. I love u all.
Acknowledgements

This research report would never have been completed without the help of many people.

My special thanks go to my supervisor Dr. Ddembe Williams for his help offered. Without his criticisms, comments and advice, this report would never have been realised. I am very grateful for all that he did for me.

I also thanks my friends Gerald, Pam, Emma, Joanne, Saul Kidde and most especially my big bro Samuel King’oo thanks alot guys it really meant alot.

To the staff of Kampala Pharmaceutical Industries LTD especially Mr. Tarpan, Conso late and Patrick Owinyi thanks for making my research a worthwhile experience.

My Mum, Dad brothers, niece and sister are not forgotten because of the moral support they gave me all the way.

I am solely responsible for all the errors that may appear in this report. None of the people mentioned above are accountable except me.
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## Acronyms

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<th>Description</th>
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<td>DSS</td>
<td>Decision Support System</td>
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<tr>
<td>DBMS</td>
<td>DataBase Management System</td>
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<td>GUI</td>
<td>Graphical User Interface</td>
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<td>HTML</td>
<td>HyperText Mark-up Language</td>
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<td>www</td>
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Abstract

A decision support tool for production scheduling, will assist the low level managers in their daily tasks of production scheduling. Several criteria influence the requirements for this tool, namely: the preferences of the pharmaceutical industry, the number of products to be produced and the orders that have to be scheduled as well as the presentation of specific information. Unfortunately, scheduling is very complex, especially when done manually and centrally by an individual. To mitigate the problems caused by this complexity, a decision support tool for production scheduling for the implementation of scheduling system is presented in this study, which integrates various scheduling techniques.

Specifically this system allows for web access to the tool through an intranet based on the user rights and permissions. The scheduling information stored in a central server. All the services provided by this system, have been made available on the organisation’s intranet. The prototype was implemented using HTML, CSS, PHP and MYSQL. This scheduling tool can be adopted for use in industries, schools, hospitals and other institutions that require to schedule production.
Chapter 1

INTRODUCTION

1.1 Background to the Study

The onset of the industrial revolution which began in Britain from the mid 18th century to the mid 19th century came with dramatic changes in the social and economic structure as inventions and technological innovations created the factory system of large-scale machine production and greater economic specialisation as well as the labouring population formerly employed predominantly in agriculture increasingly gathered in great urban factory centers (Herrmann, 2005) [11].

The technological innovations that resulted due to the industrial revolution led to production scheduling, which concerns itself with the detailed planning and control of individual production units. It has been recognised that production scheduling ultimately determines the operational performance of a production system. Yet, in spite of the vast body of research that has been carried out in this field, and the fact that many practitioners in operations management are convinced of the fact that manual scheduling is to a great extent liable for improvement, the industrial practice of production scheduling has not changed substantially in the last decades (Wiers et al., 1996) [38].
Scheduling Problems encountered by operational level managers

Production scheduling which deals with the allocation of resources to tasks, has been carried out by operational level managers. A problem that many operational level managers of companies and organisations encounter is deciding how to schedule production in a way that would minimize production costs and evenly fill the production line schedule. Traditional methods prove unsuitable when dealing with a large assortment of products and complex production procedures since they are too time-consuming (Kljajic et al., 2002) [17]. Such methods which involve the managers manually setting up production schedules have resulted in production and delivery delays. Because of these time contraints managers are forced to work in a reactive rather than proactive mode (Jacobs and Lauer, 1994) [12].

Production scheduling is usually carried out by schedulers on the shop floor using a lot of practical experience, knowledge, intuition and a trial and error approach. However, it is done manually in most of the shops on a regular basis. The manually generated schedules could be feasible and meaningful, but, those solutions usually involve localized scheduling at each work center or machine without much comprehensive outlook.

Production managers are often faced with problems such as; matching output to demand that often fluctuates, matching inputs to output so no excessive/shortage of inputs, knowing just how much stock to hold; determining what the minimum level of stock to hold should be and when to reorder, and lastly determining the order in which to use stock: FIFO or LIFO. Furthermore, their effectiveness and efficiency, and their consequences on job delivery times and resource utilization may not be easily known since no human mind can think comprehensively, particularly on the shop floor on a regular basis. Moreover, the uncertainty in processing times, resource availability, material availability, changes in engineering, priorities, and due dates, besides, some scheduling parameters like the durations of the tasks may be ill-known, and this discourages the schedulers from assessing the full consequences of their real-time scheduling decisions. Such uncertainty creates a lot of tensions on the shop floor for meeting production targets and due dates (Dubios et al., 1995) [8].
As a result the schedulers on the shop floor try to get a quick real-time solution without having much time and patience to look for better schedules (Jacobs and Lauer, 1994) [12].

Managerial work revolves around decision-making, the lack of a Decision Support System (DSS) to enhance his decision-making capabilities puts the manager at a major disadvantage. The introduction of computers which are more effective in knowledge handling because they are not subject to oversight, forgetfulness, miscalculation, bias and stress puts the manager with access to a computer at an advantage.

The concept of Decision support means different things to different people Druzdzel (1999) [7], Turban and Aronson (1998) [36] define a DSS as an interactive, flexible and adaptable computer based information system, especially developed for supporting the solution of a non-structured management problem for improved decision making. It utilizes data, provides an easy-to-use interface, and allows for the decision makers own insights.

Power (2003) [23] describes DSS as a class of computerized information systems that support decision-making activities. They are interactive computer-based systems and subsystems intended to help decision makers use communication technologies, data, documents, knowledge or models to complete the decision process tasks. Decision-makers receive and analyze information using different media such as traditional print, group and interpersonal information exchanges, and computer based tools(Power, 2000) [25].

The development of DSS begun in the late 1960s with model-oriented DSS, theory developments were in the 1970s and the implementation of financial planning systems and Group DSS in the early and mid 1980s. Web-based decision support systems implementation begun in the mid 1990s (Power, 2003) [23].

Prior to 1965 it was very expensive to build large-scale information systems. It was more practical and cost effective to develop Management Information Systems (MIS) in large com-
panies. MIS focused more on providing managers with structured periodic reports. Much of the information was from accounting and transaction systems (Power, 2003) [23].

The use of mainframe computers at the initial development of DSS meant that only senior managers had access to DSS. These days the processing power of computers has been brought to the desktop through web-based DSS and as such the need for operational management at the job shop to acquire DSS has arisen.

1.2 Statement of the Problem

Operational level managers are often faced with problems of manually making production schedules, this coupled with the time wasted results in increased production costs and delays in delivery of completed products. Traditionally DSS have been built to support the decisions of high and middle level managers. The proliferation of Decision Support tools for low level management is needed to address issues which operation managers face such as production scheduling. As a result this study aims at developing a Decision Support tool for production scheduling.

1.3 General Objective

To develop a Decision Support tool that will aid low level management in production scheduling tasks.

1.3.1 Specific Objectives

The specific objectives for the proposed project were:

i. To review literature relevant to Decision Support tool development, with a focus on production scheduling.

ii. To find out the extent to which operational level managers fail to utilize information
available to them and thus affecting their effective decision-making during production scheduling.

iii. To develop a Decision Support tool for production scheduling that will enhance the decision-making capabilities of operational level managers.

iv. To test and validate the Decision Support tool after its development.

1.4 Scope

The envisaged project will entail the development of a DSS tool for production scheduling; and will dwell more on operational management level of the organisation, particular focus will be on the tasks associated with production scheduling, at the Kampala Pharnaceutical Industries LTD.

1.5 Significance of the study

The study will build on knowledge and this will help students of DSS during their study and also build on academics. A DSS for operational-level management will avail the manager the ability to make timely decisions to the same level attained by high-level managers who have access to DSS. Managers often face a multitude of potential management goals and actions from which they must base their management decisions (Sojda, 2001) [32]. In the case of organizations, the level of knowledge and understanding of managers is varied. Even though DSS have been incorporated in day-to-day running of many organizations, there is no evidence of them being developed for operational level managers.

Operational-level managers are burdened by the amount of information that comes their way with the increasing technology trends. Without the use of an effective DSS, managers will face difficulty in making rapid decisions on the job shop, time will be wasted in making
manual production schedules and as a result they will operate in a reactive rather than proactive mode (Kljajic et al., 2002) [17]; (Jacobs and Lauer, 1994) [12]. The development of a Decision Support Tool for production scheduling will aid operational management in making better quality decisions and production schedules. (Kljajic et al., 2002) [17] states that "A good schedule leads to smaller production costs and better personnel satisfaction." The Decision Support tool will enable organisations cut down on production costs, improve productivity hence more wealth for the organisation.
Chapter 2

LITERATURE REVIEW

2.1 Scheduling

Scheduling means the assignment of resources to activities, sequencing of activities and determination of starting respectively ending times for the execution over a short period of time (Stobbe et al., 1999) [33]. Scheduling is the problem of assigning a set of tasks to a set of resources subject to a set of constraints. Wiers (1997) [38] likens scheduling to making the most out of a limited amount of time. Scheduling emerges in various domains, such as nurse scheduling, airplane landing scheduling, train scheduling, production scheduling. This project focuses on production scheduling.

2.2 Production Scheduling

Production scheduling is an essential part of the management of production systems: it lies at the very heart of the performance of manufacturing organizations. Effective scheduling can lead to due date performance that results in meeting the organisations customer service goals, and reducing work in process inventories and production times. Production scheduling is an important manufacturing function that is responsible for allocating resources over time to perform operations required to fulfill customer orders (Yongjiang, 2003) [41].
Required products in the customers orders are to be manufactured concurrently in the scheduling horizon and almost for sure, they will compete for certain resources, such as machines, tools, and fixtures. Therefore scheduling task is to arrange the manufacture of various products on specific machines so as to attain scheduling objectives. Popular scheduling objectives can be to minimise production cost, makespan or tardiness to produce all required products (Kljajic et al., 2002) [17].

Production scheduling has two basic inputs: customer orders specifying what products and how many products to be produced with the given due dates, and process plans for the products describing the sequence of operations (including the time and cost information) on corresponding resources for realization. With these inputs, the product scheduling system needs to generate a suitable time schedule to fulfill the released customer orders by allocating the resources over time to operations specified in the corresponding process plan. The combination of customer orders and the processing plans builds a detailed description of the jobs to be scheduled (Yongjiang, 2003) [41].

### 2.2.1 Production Scheduling Algorithms

Production scheduling is a relatively mature field of research. The main focus of this project is production scheduling in job shops. Although production scheduling is simple to formulate, it is one of the hardest combinatorial optimisation problems (Heesen and Jorna, 1995) [10]. Not only is it NP-hard, but even among the members of the latter class, it appears to belong to the difficult ones (Wu and Sun, 2003) [39]. There are many promising heuristic algorithms that have been reported to find good quality solutions in a short time, however none of them dominates in overall performance. Some popular heuristic algorithms are reviewed below:

**Shifting Bottleneck procedure (SBP)**

The SBP uses a combination of schedule construction and iterative guided by solutions to
single machine problems. It sequences the machines one by one, taking into consideration each time the machine is identified as a bottleneck among the machines not yet sequenced. Everytime after a new machine is sequenced, all previously established sequences are locally re-optimised. Both the bottleneck identification and the local re-optimization procedures are based on repeatedly solving certain one-machine problems (Adams et al., 1988) [1]; (Kampstra, 2004) [14].

**Branch-and-Bound method**

Branch and bound is a general method for finding optimal solutions of various optimization problems, especially in discrete and combinatorial optimization. It belongs to the class of implicit enumeration methods. The method was first proposed by A. H. Land and A. G. Doig in 1960 for linear programming (Morrison, 1997) [19].

The major advantage of the algorithm are the rules constructed to identify partial sequence for one-machine problem. The application of the rules to each one-machine sub-problem, pruning can be carried out which is the removing of a significant part of the search tree which can be used to improve efficiency of the algorithm. The branch and bound method algorithm is often used to minimise the makespan in job shops. One weakness of the branch and bound search method is that it can take a great deal of computer time since many sub-solutions need to be examined. Another weakness is that it is possible to miss the globally optimum solution (Morrison, 1997) [19].

**Simulated annealing**

Simulated annealing technique is one of the best local search methods to find minimum cost function in a job shop based on randomized version of iterative improvement. The simulated annealing approach has the property that it accepts cost increasing transitions with a non zero probability to avoid getting stuck in local minimum (Kirkpatrick et al., 1983) [16].

**Simulated Annealing Method**

Simulated annealing is another, commonly used, metaheuristic designed to permit escaping from local optima. Simulated annealing is used to ensure the highest quality solution by repeated iterations. It is modeled on processes for strengthening glass or metal by repeated
heating and cooling. Simulated annealing works from an initial point in the total field of possible solutions, the "neighborhood" of solutions is searched for a better solution. If there is improvement, the new solution is kept and a new search run from that point. In cases where there is no improvement, resulting in a "two steps forward, one step back" pattern until the optimum is reached (Silver, 2004) [29].

The name simulated annealing is due to the fact that conceptually it is similar to a physical process, known as annealing, where a material is heated into a liquid state then cooled back into a recrystallized solid state.

SA’s major advantage over other methods is an ability to avoid becoming trapped at local minima. The algorithm employs a random search which not only accepts changes that decrease objective function $f$, but also some changes that increase it. The latter are accepted with a probability $p = exp(-\delta f/T)$ where $\delta f$ is the increase in $f$ and $T$ is a control parameter, which by analogy with the original application is known as the system ‘temperature’ irrespective of the objective function involved.

The Simulated annealing algorithm starts with an initial complete feasible solution and iteratively generates additional solutions.

The algorithm can exactly or approximately evaluate candidate solutions.

It also maintains a record of the best solution obtained so far.

The simulated annealing algorithm must have a mechanism for termination. When the search is terminated, it makes sense to do a subsequent local search to ensure that the final solution is at a local optimum.

However simulated annealing is memoryless and as such is not guided during its progress. Simulated annealing can move to temporary poorer solutions at anytime even if it is not in the vicinity of local optimum.
Genetic Algorithms (GA)

A genetic algorithm (GA) is a heuristic that is used to find approximate solutions to difficult-to-solve problems through application of the principles of evolutionary biology to computer science. Genetic algorithms use biologically-derived techniques such as inheritance, mutation, natural selection, and recombination (or crossover). Genetic algorithms are a particular
class of evolutionary algorithms (Turban and Aronson, 2001) [35].

Petrovic and Fayad define genetic algorithms (GA) as search procedures that maintain, in each iteration, a population of candidate solutions, and simulates the evolutionary process of breeding new solutions, and competition and selection of solutions, which survive for the subsequent iteration (Petrovic and Fayad, 2004) [21].

Genetic algorithm is another type of search algorithm with a good quality/speed ratio (Kljajic et al., 2002) [17]. When applied to scheduling, it treats sequences or schedules as individuals or members of a population. Each individual is characterised by its fitness. The fitness of an individual is measured by the associated value of the objective function. The procedure works iteratively, and each iteration is called a generation. The population of one generation are consists of individuals surviving from previous generation plus the new schedules or children from the previous generation. Population size is usually constant while moving from one generation to the next. The children are generated through reproduction and mutation of individuals that were part of the previous generation. Individuals are sometimes referred too as chromosome. In a multi-machine enviroment, a chromosome may consist of sub-chromosomes, each one containing the job sequence on a machine. Mutation is a genetic operator used to maintain genetic diversity from one generation of a population of chromosomes to the next. In each generation the most fit individuals reproduce while the least fit die. The birth, death, and reproduction processes that determine the composition of the next generation can be complex and usually depends on the fitness levels of the individuals of the current generation (Fang et al., 1993) [9];Turban and Aronson, 2001) [35].
Structure of A Genetic Algorithm

Figure 2.2: Structure of a Genetic Algorithm
2.3 Modeling Decision-Making

The decision making process involves three phases, intelligence, design and choice. Two other phases implementation and monitoring were later added. On the other hand monitoring is viewed as the intelligence phase as applied to the implementation phase (Turban and Aronson, 2001) [35].

The decision-making process starts with the intelligence phase, where reality is examined and the problem is identified and defined. Problem ownership is established as well. In the design phase, a model that represents the system is constructed. This is done by making assumptions that simplify reality and by writing down the relationships among the variables. The model is then validated and criteria are set for evaluation of the alternative courses of action that are identified.

Often the process of model construction identifies potential alternative solutions and vice versa. The choice phase includes the selection of a proposed solution to the model (not to the problem it represents). This solution is tested to determine its viability. Once the proposed solution seems to be reasonable, we are ready for the last phase: implementation, successful implementation results in solving the real problems. Failure results to a return to an earlier phase of the process. In fact a return to an earlier phase can be done during the execution of any of the latter three phases.

Modeling decision making will involve the steps that the human decision makers will follow to reach a particular decision after fulfilling the decision making criteria. Models of decision making try to account for how the decisions are made by humans, these models also try to explain why it is that human decision making differs from the ideal of normative (or even descriptive) decision making. The models of decision making are therefore very essential as a basis for the design of DSS as a result the design of a DSS should critically assess the
underlying assumptions, and never take the correctness for the model for granted (Turban and Aronson, 2001) [35].

The decision maker might employ decision analysis concepts which are a structured way of thinking about how the actions taken in a decision would lead to a result. The decision maker has to distinguish three features of the situation: the decision to be made, the chance and unknown events which can affect the result, and the result itself. Decision analysis then constructs models, logical and perhaps even mathematical representations of the relationships within and between these three features of the decision situation. The models then allow the decision maker to estimate the possible implications of each course of action that he might take, so that he can better understand the relationship between his actions and his objectives (Spradlin, 1999) [30].

Superiority of even simple linear models over human intuitive judgment suggests that one way to improve the quality of decisions is to decompose a decision problem into simpler components that are well defined and well understood. A complex problem is broken down or decomposed into smaller, manageable portions. The process of decomposing and formalizing a problem is called modeling. Modeling amounts to finding a simplified, abstract representation of a real world system that simplifies and assumes as much as possible about the system and, while retaining the system's essential relationships, it omits unnecessary detail. Building a model of a decision problem, as opposed to reasoning about a problem in a holistic way, allows for applying scientific knowledge that can be transferred across problems and often across domains (Dhillon, 2000) [6].

2.4 Components of a Decision Support System

The available literature points to the building of DSS as entailing four major components; Conceptually, a conventional DSS model is comprised of four main components: (i) Database management capabilities with access to internal and external data, information and knowl-
edge; (ii) Modeling functions accessed by a model management system; (iii) A powerful, yet simple user interface design that enables interactive queries, reporting, and graphing functions; and (iv) The DSS architecture and Network (Power, 2000)[25].

i. Database Component, which serves as a data bank for the DSS. It stores large quantities of data that are relevant to the class of problems for which the DSS has been designed and provides logical structures with which users interact.

ii. Model Component, which is analogous to the Database component. Its primary function is to provide independence between specific models that are used in a DSS from the applications that use them. The purpose of the Model Component is to transform data from the Database Component into information that is useful in decision-making.

iii. Communications Component: The DSS architecture and networking design component refers to how hardware is organized, how software and data are distributed in the system, and how components of the system are integrated and connected. A major issue today is whether DSS should be available using a web browser on a company intranet and also available on the Global Internet. Networking is the key driver of communications-driven DSS.

iv. User Interface Component In many ways the user interface is the most important component. The tools for building the user interface are sometimes termed DSS generators, query and reporting tools, and front-end development packages. Much of the design and development effort should focus on building the user interface. A good interface leads to faster understanding of the system and hence easier acceptance of the system. On the other hand, if the interface is confusing, the users could reject the system offhand. A good user interface should make it easy to access, examine and refine its models. Since DSS do not replace humans but rather aid them in their decision-making, their user interfaces will determine whether they will be used if at all. It should be noted that the screens and displays in the user interface heavily influence how a manager perceives a DSS.
Chapter 3

METHODOLOGY

This section outlined the research methodology that was used in the study. This section also stated some of the production scheduling methods that have been used to solve production scheduling problems and also proposed a methodology that would be used in developing a DSS tool for production scheduling. It covered the planning, analysis, design, implementation, incremental design and final implementation.

3.1 Current Production scheduling Methodologies

The current production scheduling methodologies that have been used before to solve production scheduling some of which include; The Shifting Bottleneck procedure, Genetic Algorithms, Branch and Bound methods, Simulated Annealing.

3.2 Proposed Production Scheduling Methodologies

Genetic algorithm will be the proposed method used to develop the DSS production scheduling tool. The reason for this choice is that GAs are the only methods that can be applied for practical scheduling problems because of their ability to get easily adapted to new problem types (Kaschel et al., 1999) [15]. According to Kamarainem et al., [13] they have proven
to be better at production scheduling since production scheduling often relies on priority by using sequences to determine which job a machine should process when that machine becomes available.

3.3 Case Study method

A cross sectional research study was be adopted because the research project dealt with a case study. A case study was used as a means of research because it helped with a focused analysis and study. In Cross-Sectional Studies, subject variables are measured at a single point in time to study information. The advantages which arise from cross-sectional studies include; Short duration, relatively inexpensive, subject dropout not a problem, can study several outcomes, better control over subject selection and measurements [44], (Olsen and Marie, 2004) [20].

3.4 Instruments of Data Collection

Interviews
The interviews were conducted with operational managers that used TPS data for decision-making. Interviews were also used to understand the current system, how information was kept, retrieved and how it was being used to effect decision-making and come up with production schedules.

Observation
Observation was used whereby the researcher joined the activities of the production processes of the company.

Data Analysis tools
The problem was analyzed further and the researcher proceeded to gather data using the instruments mentioned above.
Data analysis
After the interviews had been carried out and the questionnaires and interview guides filled and returned the data was then edited and coded using SPSS. Data flow diagrams were used to depict information flow, map the flows of process input and out puts of the old system.

Implementation
The researcher designed the prototype using the iterative prototyping model. This model was based on the general Prototyping Process Model. When using the Prototyping Model, the researcher will build a simplified version of the proposed tool and present it to potential users for consideration as part of the development process. The users in turn will provide feedback to the researcher, who will go back and refine the tool to incorporate the additional information.

The process consisted of the following steps:

i Analysis: The information collected is usually limited to a subset of the complete system requirements.

ii Design: Once the initial layer of requirements information is collected, or new information is gathered, it is rapidly integrated into a new or existing design so that it may be folded into the prototype.

iii Implementation: The information from the design is rapidly rolled into a prototype. This may mean the creation/modification of paper information, new coding, or modifications to existing coding.

iv User Testing: The prototype is presented to possible users for review. Comments and suggestions are collected from the users and reported back to the team.

v Refinement: Information collected from the customer is digested and the prototype is refined. The developer revises the prototype to make the tool more effective and efficient.
Final implementation: The results of the tests are used to guide the changes to the system. As some parts or phases of the software are implemented, other parts are prototyped and tested.

**User Interfaces**
The Graphical User Interfaces will be developed using HTML and Javascript.

**Database Management System**
The underlying database structure will be of a relational database structure used MySQL, which was used in development. The Data Base Management System (DBMS) will contain the functions to manage the database.

**Environment and Tools**
The proposed development platform was be Linux. The instruments of development included HTML and PHP. This was because the Decision Support tool was web based.
Chapter 4

SYSTEMS STUDY

This chapter looks at the different methodologies that were followed during the system study. It looked at how the existing system functioned and the problems that it faced.

4.1 System Study

System study was conducted to find out how the existing system functioned. Interviews were carried out with the production supervisor for he is the person that makes the production schedules. The interviews where both qualitative and quantitative in nature.

4.2 Current System

The system study revealed that, in the current system, production schedules were manually made by the production supervisor. Production scheduling and planning was usually done at the end of every month with all the departmental heads present during a meeting. Production planning is usually done monthly, weekly and then daily.
Figure 4.1: Data flow diagram level 1 of the existing system
After the production plan and schedule have been produced they are later sent by email to the various departmental heads who must later confirm whether there are enough resources to start and complete the production of a product.

### 4.3 Problems with the Current System

The manual tasks associated with making production schedules makes it a very tedious process and becomes very difficult as the number of resources to schedule increases. Although this method gets the job done, it is extremely time consuming. Furthermore this method makes it hard for the human scheduler to know whether there are enough resources to allow the production scheduling of a product to commence.

### 4.4 User Requirements

The proposed decision support tool for production scheduling is a tool that will aid in the scheduling of production in order to reduce on the time wastage and cost when making production schedules.

Out of the data gathered the following where identified as the system requirements.

- The tool would provide easy inputs for product orders that are input by the marketing executives.

- The tool should enable the departmental heads to access the production plans and schedules without having to wait for an email regarding the production plan and schedules from the production supervisor.

- The system should store all the collected scheduling information in a database, thereby allowing users to query the data as desired.

- The system should have a GUI that is easy to navigate.
• The system should be able to report the stock levels in the raw materials store.

• The administrator should be able to input the details of the users that are entitled to access the system and these details must be stored in a database.

• Apart from the production department the system should also enable other departments view only the information that they are entitled to access and nothing other than what their departments are entitled to view.

4.5 Functional Requirements

The following were identified as functional requirements of the system:-

• Be queried to generate production schedules.

• Allow all the other departmental head view production schedules.

• Authenticate users in that it should not accept unauthorised users access the system.

• Be able to report stock levels in case a product order is made to prepare for the production of a product.

• The tool should be able to aid the human scheduler in deciding whether the production of a certain product is feasible.

• the system should be able to determine in which order stock can be used.

• Should be able to determine the minimum stock levels to hold.
4.6 Non-Functional Requirements

1. Operational Requirements

- The system should be integrated with other systems such as the raw materials data store, marketing departments information systems to know which products have been ordered.

- Should be platform independent. i.e It should be able to work on any operating system.

2. Security Requirements

- Users of the system should be authenticated with a user name and password inorder to use the system.

3. Social and Cultural

- No social and cultural issues are expected.

4. Availability

- The system should be available most of the time.
Chapter 5

System Design

This chapter looks at the methodologies and methods that were used in the design of the tool. It tackles issues like architectural design. The proposed system design is intended to meet the functional requirements described in chapter four. It covers the design of the system in terms of its system architecture, dataflow diagram, entity relationship diagrams and GUI.

Structured systems analysis and design (SSAD) is used because it is a more methodological approach to software design for it proposes structured methods which are the sets of notations and guidelines for software design (Sommerville, 2001) [31].

5.1 Architectural Design

5.1.1 System Architecture

Architectural design defines how the various components such as user interfaces, web technologies and database are linked to work as a system. The proposed system has a three tier architectural design.
Figure 5.1: System architecture for Decision Support Tool for the production scheduling
Data Flow Diagram

The data flow diagram is used to map the flow of the processes, inputs and outputs in the proposed system. Data flow diagrams are used because they show how data flows through a sequence of processing steps. Furthermore, DFDs are valuable because tracking and documenting how the data associated with a particular process moves through the system helps analysts understand what is going on (Sommerville, 2001)[31]. The simplicity and intuitive nature make it possible to explain them to potential systems users who can also participate in validating the analysis.

Figure 5.2: Data Flow Diagram level 1 for the Proposed system
5.2 Conceptual Design

System flow diagram highlights how the information flows, right from when the user access the system by typing a url, up to when the user leaves the system. Figure 5.2 above shows the information flows in the system.

5.2.1 Relations

The relations identified include:

- Customer
- Employee
- Order
- Product
- Raw material
- Schedule
- Department
- Supplier

5.2.2 Relationships

The relationships identified include:

Department - Schedule relationship

View
Every department can view the production schedules. That means the one or more departments can access one or more production schedules.

**Schedule - Product relationship**

**IsMade**
Every product that has been ordered has a production schedule made before it can be produced. That is to say one or more schedules are made for one or more products that have been listed for production.

**Order - Product relationship**

**IsMade**
Every order is made for a product through the organisation’s marketing department. This makes it optional on the order side and thus resulting in a one to many relationship.

**Customer - Product relationship**

**ordersFor**
Every customer makes an order for one or more products. This makes it optional on the customer side and thus resulting in a one to many relationship.

**Customer - Order Relationship**

**places**
One or more orders are placed by a customer. This makes it optional on the customer side and thus resulting in a one to many relationship.

**Raw material - Supplier relationship**
Supplies
Every supplier supplies raw materials that will be needed during the production process.

Raw Material - Product Relationship

isRequiredFor
One or more raw materials are needed before the production of a product can start. Thus each product can have either one or more raw materials bringing in a one to many relationship.

Employee - Department relationship

belongsTo
Every employee must belong to one department. Therefore this is a mandatory condition whereby an employee must belong to one department and thus resulting in a one to many relationship.
Entity Relationship Diagram

The entity relationship diagram is used to create a useful and accurate conceptual model.

Figure 5.3: Illustration of the Entity Relationship Model of the proposed system
5.3 Logical design

5.3.1 Mappings

Mapping 1:M Relationships
Customer Places order relationship

- customer (customerID (PK), firstName, lastName, customerAddress, customerPhoneNumber, customerOrder, orderDate, productID, productQuantity)
- order (orderID (Pk), orderNumber, orderDate, quantityOrdered, dueDate, customerID (FK), productID (FK) scheduleID (FK))

ismadefor (Order - Product)

- product (productID (PK), productName, productNumber, productOrderDate, productAmount, productType, productDescription, dueDate, orderID (FK), customerID (FK))
- order (orderID (Pk), orderNumber, orderDate, quantityOrdered, dueDate, customerID (FK), productID, scheduleID (FK))

madeFor (Schedule - Order)

- order (orderID (Pk), orderNumber, orderDate, quantityOrdered, dueDate, customerID (FK), productID, scheduleID (FK))
- schedule (scheduleID (PK), productID (FK), amountScheduled, dateScheduled, startTimeOfProduction, endTimeOfProduction)

belongsTo (Employee - Department)

- department (departmentID (PK), departmentName, employeeID (FK), scheduleID (FK))

places (Customer- Orders )
• order (orderID (Pk), orderNumber, orderDate, quantityOrdered, dueDate, customerID (FK), productID (FK))

view (Departments - schedules)

• schedule (scheduleID (PK), productID (FK), amountScheduled, dateScheduled, startTimeOfProduction, endTimeOfProduction)

supplies (Supplier - Raw Material)

• rawmaterial(rawMaterialID (PK), quantityIn, quantityOut, rawMaterialType, , supplierID(FK))

• supplier (supplierID (FK), supplyDate, quantitySupplied, supplierAddress, supplierName)

Mapping M: M Relationships

isrequiredby (Raw Material - Product)

• requirement (productID, rawmaterialID, requiredDate)

Resultant Relations

Product (productID, productName, productNumber, productOrderDate, productOrderBy, productAmount, employeeID, productCategory, productDescription, productCompletionTime, unitPrice, orderID, customerID)

Department (departmentID, departmentName)

Order (orderID, orderNumber, orderDate, customerID, customerName, quantityOrdered, dueDate, productID, employeeID, orderPaid)

Customer (customerId, firstName, lastName, customerAddress, customerPhoneNumber, customerOrder, orderDate, productID, productQuantity)

Employee (employeeID, firstName, lastName, departmentID, dateOfBirth, maritalStatus, position)
Schedule (scheduleID, productID, amountScheduled, dateScheduled, startTimeOfproduction, endTimeOfProduction)

Supplier (supplierID, supplierName, supplierAddress, quantitySupplied, rawMaterialID, supplyDate)

Raw Material (rawMaterialID, quantityIn, quantityOut, rawMaterialCategory, productID, supplierID)
Chapter 6

System Development Implementation

This chapter discusses how the design solution in the previous chapter was implemented. The main aim of this chapter included how the implementation was conducted using the available technologies to realise the specification and designed of the system and meet the requirements of the pharmaceutical industry.

6.1 Development

The project was developed using relevant application software such as HTML for the user interfaces, MYSQL for the database and PHP enabled apache web server effected the connection between the databases and the web browser.
6.2 Home Page

The home page provides a login screen for the system as shown below.

![Login Section](image)

Figure 6.1: Login Section
6.3 Welcome Page

The welcome page provides buttons that link the administrator to the various pages, in regard to what the administrator wants to accomplish. The user just has to click on the button which he / she needs, as shown below.

![Welcome Screen with buttons to the various options](image)

Figure 6.2: Welcome Screen with buttons to the various options
6.4 Customer Page

When a new customer is ordering for products from the industry his details are taken down this is to enable easy allocation of which orders and to know where they will be delivered upon completion of production.

Figure 6.3: Customer Page for inputting the customer details
6.4.1 Report of Customer Details

The screen shot below shows the addresses of the customers and their contact details.

![Screen shot of Registered customers](image)

Figure 6.4: Screen shot of Registered customers
6.5 Employee Page

The details of all employees are inserted into the employee table as shown below.

![Employee screen shot](image)

Figure 6.5: Employee screen shot
6.5.1 Report of Employee details

The screen shot belows shows a sample of the employees details, their departments and positions.

![Screen Shot of Employees](image)

Figure 6.6: Screen Shot of Employees
6.6 Department

This form shows the department form.

Figure 6.7: Department Page screen shot
6.7 Machine Page

Figure 6.8: Machine Page
6.8 Production Allocation Page

Figure 6.9: Production Allocation Form
6.9 Product Page

Figure 6.10: Product Details Entry Page
6.10 View Products Detail Page

The screen shot shows some of the products that the firm produces in their sizes, unit prices and product categories under which they fall.

![Screen Shot of Product Details](image)

Figure 6.11: Screen Shot of Product Details
6.11 Schedule

Figure 6.12: Production Scheduling Page
6.12 Raw Material Page

![A Decision Support Tool for Production Scheduling - Microsoft Internet Explorer](image)

Figure 6.13: Raw Material Page Screen Shot
6.13 Supplier Page

Figure 6.14: Screenshot of the Supplier Page
6.13.1 Reports of Supplier Details

The screen shot below shows the details of the various suppliers who supply products to the firm.

Figure 6.15: Screenshot of the Supplier details
6.14 Order Details Page

Figure 6.16: Screenshot of the Order Details Page
6.14.1 Screen shot of order Details

The screen shot below shows the various orders that have been received by the firm and
which customer placed which order.

![Screenshot of Order Details Page]

Figure 6.17: Screenshot of the Order Details Page
6.15 Screen shot of orders to be Scheduled

The screen shot below shows a printout of orders that have been received and when the orders are expected to be complete. The screen shot shows the customer, the earliest completion date, the quantity of the product ordered for, and the status of the order whether scheduled or not. Furthermore it also allows for the scheduling of orders. From this you can check for the availability of raw materials to complete an order and make a schedule for a customer order.

Figure 6.18: Screenshot of the Order to be scheduled
6.16 Screen shot of Material Availability

The screen shot below show what happens when an order is placed and the raw materials in the store are less than what is required to fulfill a particular order.

Figure 6.19: Screenshot of material availability
Chapter 7

DISCUSSIONS, CONCLUSION AND RECOMMENDATIONS

This chapter discusses the work carried in this project. It examines how the objectives of the project were met using a pharmaceutical industry as a case study, the design, implementation, conclusion, recommendations and areas for further research are discussed.

7.1 Discussions

The purpose of the study was to develop a decision support tool for production scheduling that will be used to schedule production in industries or similar service providing organizations that require decision support when scheduling production tasks. The case study used was a pharmaceutical industry.

The discussion of the project was organised in accordance with the objectives that the study set out to accomplish. It was organised under the broad heading of analysis, design and development of a decision support tool for production scheduling. As a result appropriate scheduling is a key to effectiveness and efficiency in any industry.

The tool is a web-based tool of a three tier client-server architecture, in which, the first
tier is a client layer; that provides feedback, interfaces and simple validation functionality. In the design of a decision support production scheduler, the client layer is a web browser which staff can access from anywhere within the organisation's intranet depending on their access levels and rights. The second tier is a business logic layer, which in this study is scheduler. The third tier is database layer, that provides data access between second tier and the database server.

User interfaces were HTML forms developed using a Linux environment, as is reflected in the prototype of the system. The database was developed using MySQL, a relational database management system.

A client/server architecture was chosen for designing a decision support tool for production scheduling because subsystems can be optimized for a particular set of applications, the tool can grow modularly as different applications grow and more powerful subsystems can be installed without wasting resources on other applications.

7.2 Conclusion

From the implemented system for the users, not only were all user requirements fulfilled, extra functions were achieved. Therefore, it can be said that this decision support tool for production scheduling system project was a success. The staff could access the system locally, conflict of interest could be resolved by the system accepting only certain number of products to schedule for production at a time.

7.3 Recommendations

A decision support tool for production scheduling could be used in large production industries. This is because, the tool is web-based and therefore can be accessed anywhere within the intranet. Being a knowledge base, the system can resolve conflict of interest by allowing only a certain products to be scheduled.
7.4 Limitation of the Study

There was a problem in regards to completion of the study in time although the proposal was approved in June the researcher happened to get a case study industry in September. The study was also limited to the scheduling of only one product although the pharmaceutical industry in the case study has over 60 products. Furthermore, the study was also limited to the scheduling of machine in the production of a product yet the industry had many other machines used during the production process.

7.5 Areas for Further Studies

The researcher has demonstrated the use of the current system prototype in the context of production scheduling. The tool could be expanded to include the followings:

To work as an expert system that can schedule the production of a product based on the raw material requirements and thus can be scheduled more efficiently and plan for future schedules.

Other tools that will allow data to be validated, cross-referenced and other, in a way that support decision-making can be included.

The system’s search capabilities to support arrange of automated and semi-automated (user focused) scheduling mode.

To deepen the system’s domain model to incorporate all relevant resource and planning constraints.

To investigate issues of collaborative schedule and plan development by multiple user’s and
in dynamic configuration of planning and scheduling service to fit particular mobile decision making circumstances.
REFERENCES


APPENDICES

Appendix I: Interview Guide

This guide is part of the research project title "A Decision Support Tool for Production Scheduling" has been prepared by Okullu Andrew Robert from Makerere University as part of his masters project. The aim is to study the existing scheduling system and to establish the requirements for the new system. The information will be analyzed and used to develop a decision support tool for production scheduling.

Interview with the Production Supervisor.

1. What is the name of this institution?

2. What type of production schedule do you use?

3. Does the organisation use any scheduling software?

4. If yes, what scheduling techniques are applied by the organisation?
   (a) Manual
   (b) Automatic
   (c) Both

5. How many departments do you have?

6. What products does the organisation manufacture?
7. How are products produced?
   (a) Make to order
   (b) Make to stock
   (c) Make to inventory

8. What factors determine the amount of products produced?
   (a) Season
   (b) Customer Orders
   (c) Reduced Product Inventory
   (d) Others please specify...........................................

9. Does the organisation produce finished products before receiving orders?
   (a) Yes.... (b) No......

10. Does the organisation have any production tracking software in place?
    (a) Yes..... (b) No....... 

11. If yes, what does it track?

12. How many production centres does the organisation have?

13. How many products are produced in a production line?

14. What is the duration of the production process?

15. How many stages does each product have?

16. How long does each product stage take?

17. What type of jobs require immediate attention?

18. Do you use any information on which to base during production scheduling?
    (a) Yes ...... (b) No......

19. If yes, what type of information?
20. If no, why?

21. How long does it take to make a production schedule?

22. What are your views, if production scheduling is automated?

23. How do you find scheduling production?

24. Who are supposed to view the production schedules and plans?

25. What are your views if scheduling is automated?

26. How do you know the material stock levels that are available in the stores?

27. What problems do you face when making the current production schedules?

28. Is there a department which submits a production order for a product? (a) Yes........ (b) No......

29. If Yes which department?
Appendix III: Selected Sections of Code at Implementation

```php
<? include "db.php"; ?>
<?php $strPagename = 'main'; include "config.php"; include "header.php";

<head>
<meta name="GENERATOR" content="Arachnophilia 4.0">
<meta name="FORMATTER" content="Arachnophilia 4.0">
<style type="text/css">
  div.menubar{
    color :#000000;
    background-color :lightblue;
    width :100%;
    padding :5px }
  a.menu{
    width :100px;
    text-align : center;
    font-family: Verdana;
    font-style : normal ;
    font-size : 9pt;
    font-weight :bold;
    color :#000000;
    text-decoration : none;
    background-color :#F5D996;
    padding :3px;
    border-style : outset ;border-color :#F5D996 ;border-width : medium }
```
a.menu:hover{
  color :#6F6F6F;
  background-color :#8C1F13;
  border-style :inset ;border-color :#F5D996 ;border-width :medium }
</style>
</head>

<?

$connection = @mysql_connect("localhost", "root", "pass")
or die(mysql_error());

$db_name = "aokullu";
$table_name1 = "product";
$table_name2 = "rawMaterial";

//connect to server and select database

?>
$db = @mysql_select_db($db_name, $connection) or die(mysql_error());

//build and issue query
$sql1 = "SELECT productID, productName, productCategory FROM $table_name1 ORDER BY productID";
$result = @mysql_query($sql1,$connection) or die(mysql_error());

//check the number of results
$num = @mysql_num_rows($result);

if ($num < 1) {
    //if there are no results, display message
    $display_block = "<P><em>Sorry! No results.</em></p>";
} else {

    //if results are found, loop through them
    //and make a form selection block
    while ($row = mysql_fetch_array($result)) {
        $productID = $row["productID"];
        $productName = $row["productName"];
        $productCategory = $row["productCategory"];
        $option_block1 .= "<option value="$productID">$productID</option>";
    }

    $sql2 = "SELECT rawMaterialID FROM $table_name2 ORDER BY rawMaterialID";
$result = @mysql_query($sql2,$connection);// or //die(mysql_error());
//echo"
//query not successful;

//check the number of results
$num = @mysql_num_rows($result);

if ($num < 1) {
    //if there are no results, display message
    $display_block = "<P><em>Sorry! No Raw Material in the store results.</em></p>";
    $display_block = $num;
} else {
    //if results are found, loop through them
    //and make a form selection block
    while ($row = mysql_fetch_array($result)) {
        $rawMaterialID = $row['rawMaterialID'];
        //productName = $row['productName'];
        //productCategory = $row['productCategory'];
        $option_block2 .= "<option value="$rawMaterialID">$rawMaterialID</option>";
    }

    //create the entire form block
    $display_block = "
    <center>
    <table border="0" cellspacing="1" cellpadding="4" bgcolor="#CCCCCC">
    <form name="productAllocation" id="productAllocation" action="productAllocate.php"
    <p>
    <input type="hidden" name="a_add" value="A"

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Product ID</strong></td>
<td>$option_block1</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Raw Material</strong></td>
<td>$option_block2</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Unit Quantity</strong></td>
<td>&lt;input type=&quot;text&quot; name=&quot;unitQuantity&quot; id=&quot;unitQuantity&quot; size=&quot;30&quot; maxlength=&quot;100&quot;&gt;</td>
</tr>
</tbody>
</table>

<input type="submit" name="Action" value="Submit">
<input type="reset" name="Action" value="RESET">

</form>

<? echo "$display_block"; ?>

</center>

<hr>

<? include "footer.php"; ?>

<? include "db.php"; ?>

<?PHP $strPagename = 'main'; include "config.php"; include "header.php"; ?>

(Category ="select product.productCategory from product where productID=$productID"

function determine_UnitTime($category)
{
if ($category="Tablets")
{
$Time =40;
}
else if ($category="Dry Syrup")
{
$Time =50;
}
else if ($category=="Liquid Syrup")
{
	$Time =60;
}
else $Time= 70;
}

function determine_maxCapacity($Category)
{
if ($category=="Tablets")
{
	$maxCapacity =100;
}
else if ($category=="Dry Syrup")
{
	$maxCapacity =200;
}
else if ($category=="Liquid Syrup")
{
	$maxCapacity =300;
}
else $maxCapacity= 400;
}

//determine the product unit time and the products maximum machine input

// select AOKULLU as the current db

//checking if there is any order in the database

$Time=determine_unitTime($Category);
$totalTime=$Time*$quantityOrder;
$sql1 = "SELECT orderID FROM orderdetails ORDER BY orderID";

$result = @mysql_query($sql1);
//,$connection) or die(mysql_error());

//check the number of results
$num = @mysql_num_rows($result);
echo $num;
if ($num < 1) {
    $year=2006;
    $month=1;
    $day=31;

    // run the query
    // Build our query here and check each variable with mysql_real_escape_string
    $query1 = sprintf("INSERT INTO orderdetails (orderDate, customerID, productID, quantityOrder, dueDate)
    values(now(),'$customerID','$productID','$quantityOrder',date_add(now(),
    interval 20 minute),'$dueDate')");

    //inserting to the product order table
    // run the query
    if(!mysql_query($query1))
    {
        echo 'Query failed '.mysql_error();
        exit();
    }
}
else
{
$orderId = mysql_insert_id();
$query3 = sprintf("INSERT INTO productOrder ( productID,orderID,quantityOrder)
values('$productId','$orderId','$quantityOrder')");

$query2 = mysql_query($query3);

if(!$query2)
{
    echo 'Query two failed '.mysql_error();
    echo $query2;
    exit();
}
else
{
    echo '<CENTER>Thank you for your submission, <a href = orderdetailsadd.php>ADD ANOTHER</a></CENTER>.
    echo $lateOrder;
    }
}

?>

<br>
<br>
<br>
<hr>
<? include "footer.php"; ?>


## Appendix III: Data Dictionary

### Table 7.1: Entity Description

<table>
<thead>
<tr>
<th>Entity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product</td>
<td>This stores the product details.</td>
</tr>
<tr>
<td>Department</td>
<td>This keeps department details</td>
</tr>
<tr>
<td>Order</td>
<td>This keeps track of all the orders made</td>
</tr>
<tr>
<td>Customer</td>
<td>This keeps track of all the customer details</td>
</tr>
<tr>
<td>Employee</td>
<td>This keep track of the employee details</td>
</tr>
<tr>
<td>Schedule</td>
<td>This keeps track of the production schedules made</td>
</tr>
<tr>
<td>Supplier</td>
<td>This keeps track of the supplier and the materials he has supplied</td>
</tr>
<tr>
<td>Raw Material</td>
<td>This keeps track of the raw materials, their levels and stock</td>
</tr>
</tbody>
</table>
Table 7.2: Table of product details

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Type</th>
<th>Description</th>
<th>Null</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>productID</td>
<td>text</td>
<td>Uniquely identifies a product</td>
<td>No</td>
<td>Alphanumeric</td>
</tr>
<tr>
<td>productName</td>
<td>text</td>
<td>Products Name</td>
<td>No</td>
<td>Alphabets</td>
</tr>
<tr>
<td>productNumber</td>
<td>text</td>
<td>Products Number</td>
<td>No</td>
<td>Alphanumeric</td>
</tr>
<tr>
<td>productOrderDate</td>
<td>Date</td>
<td>Date Product was ordered</td>
<td>No</td>
<td>date</td>
</tr>
<tr>
<td>productOrderBy</td>
<td>text</td>
<td>Employee who made the order</td>
<td>No</td>
<td>Alphabets</td>
</tr>
<tr>
<td>employeeID</td>
<td>text</td>
<td>Foriegn key from Employee</td>
<td>No</td>
<td>Alphanumeric</td>
</tr>
<tr>
<td>productCategory</td>
<td>text</td>
<td>State product Category</td>
<td>No</td>
<td>Alphabets</td>
</tr>
<tr>
<td>productDescription</td>
<td>text</td>
<td>details of a product</td>
<td>No</td>
<td>Alphabets</td>
</tr>
<tr>
<td>productCompletionDate</td>
<td>Date</td>
<td>When production is completed</td>
<td>No</td>
<td>Date</td>
</tr>
<tr>
<td>unitPrice</td>
<td>text</td>
<td>Cost of production</td>
<td>No</td>
<td>Alphanumeric</td>
</tr>
<tr>
<td>orderID</td>
<td>text</td>
<td>Foriegn Key from Order</td>
<td>No</td>
<td>Alphanumeric</td>
</tr>
<tr>
<td>customerID</td>
<td>text</td>
<td>Foriegn Key from Customer</td>
<td>No</td>
<td>Alphanumeric</td>
</tr>
</tbody>
</table>

Table 7.3: Table of Department details

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Type</th>
<th>Description</th>
<th>Null</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>departmentID</td>
<td>text</td>
<td>Uniquely identifies a department</td>
<td>No</td>
<td>Alphanumeric</td>
</tr>
<tr>
<td>departmentName</td>
<td>text</td>
<td>Name of department</td>
<td>No</td>
<td>Alphabets</td>
</tr>
</tbody>
</table>
Table 7.4: Table of Order details

<table>
<thead>
<tr>
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<th>Type</th>
<th>Description</th>
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<tbody>
<tr>
<td>orderID</td>
<td>text</td>
<td>Uniquely identifies an order</td>
<td>No</td>
<td>Alphanumeric</td>
</tr>
<tr>
<td>orderNumber</td>
<td>text</td>
<td>Number of order</td>
<td>No</td>
<td>Alphanumeric</td>
</tr>
<tr>
<td>orderDate</td>
<td>date</td>
<td>date order was placed</td>
<td>No</td>
<td>date</td>
</tr>
<tr>
<td>customerID</td>
<td>text</td>
<td>Foriegn Key from Customer</td>
<td>No</td>
<td>Alphabets</td>
</tr>
<tr>
<td>customerName</td>
<td>text</td>
<td>Name of customer</td>
<td>No</td>
<td>Alphabets</td>
</tr>
<tr>
<td>quantityOrdered</td>
<td>text</td>
<td>Amount ordered</td>
<td>No</td>
<td>Alphanumeric</td>
</tr>
<tr>
<td>dueDate</td>
<td>text</td>
<td>Name of department</td>
<td>No</td>
<td>Alphabets</td>
</tr>
<tr>
<td>productID</td>
<td>text</td>
<td>foriegn key from product</td>
<td>No</td>
<td>Alphanumeric</td>
</tr>
<tr>
<td>employeeID</td>
<td>text</td>
<td>Foriegn Key from employee</td>
<td>No</td>
<td>Alphabets</td>
</tr>
<tr>
<td>orderPaid</td>
<td>text</td>
<td>whether the product order has been cleared</td>
<td>No</td>
<td>Alphabets</td>
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Table 7.5: Table of Customer details

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<td>Uniquely identifies a customer</td>
<td>No</td>
<td>Alphanumeric</td>
</tr>
<tr>
<td>firstName</td>
<td>text</td>
<td>Name of Customer</td>
<td>No</td>
<td>Alphabets</td>
</tr>
<tr>
<td>lastName</td>
<td>text</td>
<td>Name of customer</td>
<td>No</td>
<td>Alphabets</td>
</tr>
<tr>
<td>customerAddress</td>
<td>text</td>
<td>Address of customer</td>
<td>No</td>
<td>Alphanumeric</td>
</tr>
<tr>
<td>customerPhoneNumber</td>
<td>text</td>
<td>Phone contact of customer</td>
<td>No</td>
<td>Number</td>
</tr>
<tr>
<td>customerOrder</td>
<td>text</td>
<td>Amount ordered</td>
<td>No</td>
<td>Alphanumeric</td>
</tr>
<tr>
<td>orderDate</td>
<td>date</td>
<td>date order was placed</td>
<td>No</td>
<td>date</td>
</tr>
<tr>
<td>productID</td>
<td>text</td>
<td>foriegn key of product</td>
<td>No</td>
<td>Alphanumeric</td>
</tr>
<tr>
<td>productQuantity</td>
<td>text</td>
<td>Foriegn Key from employee</td>
<td>No</td>
<td>Alphabets</td>
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Table 7.6: Table of Employee details

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<th>Type</th>
<th>Description</th>
<th>Null</th>
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</tr>
</thead>
<tbody>
<tr>
<td>employeeID</td>
<td>text</td>
<td>Uniquely identifies an employee</td>
<td>No</td>
<td>Alphanumeric</td>
</tr>
<tr>
<td>firstName</td>
<td>text</td>
<td>First Name of employee</td>
<td>No</td>
<td>Alphabets</td>
</tr>
<tr>
<td>lastName</td>
<td>text</td>
<td>last Name of employee</td>
<td>No</td>
<td>Alphabets</td>
</tr>
<tr>
<td>departmentID</td>
<td>text</td>
<td>foreign Key from Department</td>
<td>No</td>
<td>Alphanumeric</td>
</tr>
<tr>
<td>dateOFBirth</td>
<td>date</td>
<td>when employee was born</td>
<td>No</td>
<td>date</td>
</tr>
<tr>
<td>maritalStatus</td>
<td>text</td>
<td>Employee marital status</td>
<td>No</td>
<td>Alphabets</td>
</tr>
<tr>
<td>position</td>
<td>text</td>
<td>Title of staff</td>
<td>Yes</td>
<td>Alphabets</td>
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</table>

Table 7.7: Table of Schedule details

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<th>Null</th>
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<td>text</td>
<td>Uniquely identifies a schedule</td>
<td>No</td>
<td>Alphanumeric</td>
</tr>
<tr>
<td>productID</td>
<td>text</td>
<td>Foreign Key Of product</td>
<td>No</td>
<td>Alphanumeric</td>
</tr>
<tr>
<td>amountScheduled</td>
<td>text</td>
<td>Amount scheduled</td>
<td>No</td>
<td>Alphabets</td>
</tr>
<tr>
<td>dateScheduled</td>
<td>date</td>
<td>Date of production</td>
<td>No</td>
<td>Alphanumeric</td>
</tr>
<tr>
<td>startTimeOfProduction</td>
<td>date</td>
<td>Start time of production</td>
<td>No</td>
<td>date</td>
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<tr>
<td>endTimeOfProduction</td>
<td>date</td>
<td>End of Production</td>
<td>No</td>
<td>date</td>
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</table>
### Table 7.8: Table of Supplier details

<table>
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<th>Description</th>
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</tr>
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<tbody>
<tr>
<td>supplierID</td>
<td>text</td>
<td>Uniquely identifies a supplier</td>
<td>No</td>
<td>Alphanumeric</td>
</tr>
<tr>
<td>supplierName</td>
<td>text</td>
<td>Name of Supplier</td>
<td>No</td>
<td>Alphanumeric</td>
</tr>
<tr>
<td>supplierAddress</td>
<td>text</td>
<td>Supplier’s address</td>
<td>No</td>
<td>Alphanumeric</td>
</tr>
<tr>
<td>quantitySupplied</td>
<td>text</td>
<td>Quantity supplied</td>
<td>No</td>
<td>Alphanumeric</td>
</tr>
<tr>
<td>rawMaterialID</td>
<td>text</td>
<td>foreign Key from raw material</td>
<td>No</td>
<td>Alphanumeric</td>
</tr>
<tr>
<td>supplyDate</td>
<td>date</td>
<td>date of supply</td>
<td>No</td>
<td>date</td>
</tr>
<tr>
<td>receivedBY</td>
<td>text</td>
<td>Employee who received the supply</td>
<td>No</td>
<td>Alphabets</td>
</tr>
</tbody>
</table>

### Table 7.9: Table of Raw Material details

<table>
<thead>
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<th>Range</th>
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<td>No</td>
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</tr>
<tr>
<td>quantityIn</td>
<td>text</td>
<td>quantity in stock</td>
<td>No</td>
<td>Alphanumeric</td>
</tr>
<tr>
<td>quantityOut</td>
<td>text</td>
<td>quantity taken out</td>
<td>No</td>
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<td>rawMaterialCategory</td>
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<td>Alphanumeric</td>
</tr>
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<td>productID</td>
<td>text</td>
<td>Foreign Key from product</td>
<td>No</td>
<td>Alphanumeric</td>
</tr>
<tr>
<td>supplyID</td>
<td>text</td>
<td>foreign key from supply</td>
<td>No</td>
<td>Alphanumeric</td>
</tr>
</tbody>
</table>