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THE IMPLEMENTATION OF

CRP (CAPACITY REQUIREMENTS PLANNING) MODULE

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ABSTRACT

ERP (Enterprise Resource Planning) was originated as a management concept based on the supply chain to provide a solution to balance the planning of production within an enterprise. This article focuses on the CRP module in ERP, describes in detail the concept, content and modularization of CRP as well as its usefulness and application in the production process. The function of CRP module is to expand orders to production process to calculate production time, then to adjust the load or accumulative load of each center or machine accordingly. The function described in the article tries to load production time used as load to an unlimited extend, then to use auto-balance or normal adjustment to determine the feasibility of the production order planning.

PREFACE

I would like to thank Prof. Yu Chang Yun for letting me work on this topic although I study computer science. I have to thank for her patience, support and many answers to my questions.

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LIST OF ABBREVIATIONS

Enterprise Resource Planning	ERP
Materials Requirements Planning	MRP
Capacity Requirements Planning	CRP
Finite Capacity Scheduling	FCS
Object-Oriented	OO
Bills of Materials	BOM
Management Information Systems	MIS
Work In Progress	WIP
Master Production Schedule	MPS
Just in Time	JIT
Advanced Planning and Scheduling	APS
Graphical User Interface	GUI
Relational Database Management System	RDBMS
Fourth-Generation Language	4GL
Computer-Aided Software Engineering	CASE
Supply Chain Management	SCM
Customer Relationship Management	CRM
Product Data Management	PDM

Manufacturing Executions Systems	MES
Latest Finish Time	LFT
Earliest Start Time	EST
Unified Modeling Language	UML

INTRODUCTION

The CRP module discussed in this paper is the sub-module of the ERP system ZRERP version 1.1 developed by ZhuRi Software Co., Ltd. The version 1.0 of ZRERP is delivered at October 2000. But it did not include the CRP module. According to the user's feedback, version 1.0 is not completely fit the requirement of the modern production. An overused work center creates obvious problems: backup and delays, unanticipated and costly overtime, and loss of quality due to production pressures. After analyzing the load across work centers, complex functions analyze the MRP schedule and compare it against the current capacity of each work center. Using these inquiries, ZRERP version 1.1 is decided to add the CRP module. This is the motivation of my thesis.

This CRP module uses the output of the MRP system as the input data. It will deploy the manufacturing order into the manufacturing process, then to calculate the operation time of the process. This module can process two kinds of the plan unit for the load calculation: work centre or work machine. The measure unit of the plan can be day or week. When we calculate the load of the plan unit, we also use the planned orders outputted by the posterior plan function (Finite Capacity Scheduling –FCS) with the manufacturing orders, so that this load calculation is more accurate. After adding the load to the plan unit, we can the auto-balance operation or the manual adjust operation to verify the feasibility of the plan of the tentative orders. If the plan is feasible, the module will output the manufacturing orders and produce the job orders. If the plan is not feasible, it will output the useful information to the anterior function to review the tentative orders.

In ZRERP version 1.0, the database design is completed. In my papers, I don't care with this issue.

Through this CRP module is the sub-module of the ZRERP system, it can also be run independently. Following are the base knowledge and software tools used in my thesis.

1. The Development Environment

The hardware environment is:

Personal Computer with the frequency of 2G Hz, 512MB Memory, 80GB hard disk.

The Software environment is:

Windows 2K/XP, JBuilder 9.0, Oracle 8i.

2. Object-oriented method and approach

The object-oriented ("OO", for short) concept and approach have been used in many areas and for a myriad of applications, including software engineering, to name but one. OO approaches are now specifically considered as a useful alternative to the traditional approaches. The traditional approach models scheduling problems from two different points of view, namely functional decomposition and related information (data-oriented). The OO approach, however, unifies functional decomposition with related information. Its principal aim is to blend together the functional approach and the data approach through the use of messages between objects; to divide real-world entities into classes and objects, et cetera; to represent classes and objects and their relationships and to describe the interconnectedness between abstraction and reality. The main advantages of the OO approach are realism, flexibility, re-usability and extensibility.

In this thesis, the design of the software is based on the principles of Object Oriented Programming (OOP). This allows for the development and testing of various parts of the code to be done independently. OOP also allows the code to be easily extended.

3. Java

Java is designed to meet the challenges of application development in the context of heterogeneous, network-wide distributed environments. Paramount among these challenges is secure delivery of applications that consume the minimum of system resources, can run on any hardware and software platform, and can be extended dynamically.

Java originated as part of a research project to develop advanced software for a wide variety of networked devices and embedded systems. The goal was to develop a small, reliable, portable, distributed, real-time operating environment. When the project started, C++ was the language of choice. But over time the difficulties encountered with C++ grew to the point where the problems could best be addressed by creating an entirely new language environment. Design and architecture decisions drew from a variety of languages such as Eiffel, SmallTalk, Objective C, and Cedar/Mesa. The result is a language environment that has proven ideal for developing secure, distributed, network-based end-user applications in environments ranging from networked-embedded devices to the World-Wide Web and the desktop.

The Java system that emerged to meet these needs is simple, so it can be easily programmed by most developers; familiar, so that current developers can easily learn Java; object oriented, to take advantage of modern software development methodologies and to fit into distributed client-server applications; multithreaded, for high performance in applications that need to perform multiple concurrent activities, such as multimedia; and interpreted, for maximum portability and dynamic capabilities

4. Oracle

An Oracle database is a collection of data treated as a unit. The purpose of a database is to store and retrieve related information. A database server is the key to solving the problems of information management. In general, a server reliably manages a large amount of data in a multiuser environment so that many users can concurrently access the same data. All this is accomplished while delivering high performance. A database server also prevents unauthorized access and provides efficient solutions for failure recovery.

Oracle Database is the first database designed for enterprise grid computing, the most flexible and cost effective way to manage information and applications. Enterprise grid computing creates large pools of industry-standard, modular storage and servers. With this architecture, each new system can be rapidly provisioned from the pool of components. There is no need for peak workloads, because capacity can be easily added or reallocated from the resource pools as needed.

The database has logical structures and physical structures. Because the physical and logical structures are separate, the physical storage of data can be managed without affecting the access to logical storage structures.

5. JBuilder

JBuilder is a programming compilation tool dedicated to Java which through it's extensive Component Palette contains many of the pre-coded classes emanating from the original Java Language but in a "drag and drop format". Unlike some other Visual Programming tools, not only does it support the reuse of library classes, it retains the ability, at the lowest level, to be amended by the introduction of Java source code as a means of constructing bespoke packages.

6. Structure of the thesis

Because the CRP part is a sub-module of the ERP system, knowing the history and evolution of ERP is essential to understanding its current application and its future developments. For this reason, Chapter 1 describes the evolution of ERP. Chapter 2 will discuss the requirement analysis and system design. In the chapter 3, I describe the most important classes of this module. The implementation of this module is shortly described in chapter 4 then followed by conclusion. The Appendices contain source code of some important classes developed for this thesis.

CHAPTER 1

REVIEW THE EVOLUTION OF ERP

Integrated enterprise resource planning (ERP) software solutions have become synonymous with competitive advantage, particularly throughout the 1990's. ERP systems integrate all traditional enterprise management functions like financials, human resources, and manufacturing & logistics. Knowing the history and evolution of ERP is essential to completing my thesis.

The history of ERP can be traced back to the first inventory control (IC) and manufacturing management applications of 1960s (Chung and Snyder, 1999, Gumaer, 1996). These first applications for the manufacturing were generally limited to IC and purchasing, which was due to the origins of these applications in the accounting software (Gumaer, 1996). The accounting, with its definition based around generally accepted standards, had been one of the first business functions to be computerized and the first applications for the manufacturing were created as by-products of accounting software driven by the desire of the accountants to know the value of the inventory (Gumaer, 1996). IC refers to the effort of maintaining inventory levels and costs within acceptable limits but includes also models for determining how much inventory to order and when to order as well as systems for monitoring inventory levels for management evaluation and decision making (Vonderembse and White, 1996, pp. 751-752). IC applications were the starting point in the evolution process that led to the development of modern ERP applications (Kumar and Hillegersberg, 2000).

The next stage in the evolution of ERP following the IC and manufacturing management applications was the introduction of the concept of Material Requirements Planning (MRP) (Kumar and Hillegersberg, 2000). The concept of MRP, first introduced by Orlicky (1975), is based on an idea of a process that uses Bills of Materials (BOM), inventory records and the master schedule to determine when orders must be released to replenish inventories of parts or raw materials (Vonderembse and White, 1996, pp. 567). MRP system can be defined as a collection of logical procedures for managing, at the most detailed level, inventories of component assemblies, parts and raw materials in manufacturing environment and as an information system and simulation tool that generates proposals for production schedules that managers can evaluate in terms of their feasibility and cost effectiveness (Gass and Harris, 1996, pp. 380). MRP applications were introduced as a scheduling, priority and capacity management systems for the use of plant managers and their supervisory staff (Chung and Snyder, 1999) and typically included features for demand-based planning and algorithms for consumption-based planning (Klaus et al., 2000). The main benefits that enterprises sought with the implementation of MRP applications were the reduction of inventories, lead times, and costs and improvement of market responsiveness, control, organizational communication (Light et al., 2000) and customer service (Chung and Snyder, 1999).

During the 1970s, MRP packages were extended with further applications in order to offer complete support for the entire production planning and control cycle (Klaus et al., 2000). This led to the next stage in the evolution of ERP, which was the introduction of the concept of Manufacturing Resource Planning (MRPII). The concept of MRPII, introduced by Wight (1984), emerged as a logical consequence of the development in earlier approaches to material control (Yusuf and Little, 1998). MRPII seeks to improve the efficiency of manufacturing enterprises through integration of the application of information and manufacturing technologies (Chung and Snyder, 1999). MRPII is an integrated decision support system that ties together departments such as engineering, finance, personnel, manufacturing and marketing via a computer-based dynamic simulation model, which works within the limits of an organization's present production system and with known orders and demand forecast (Vonderembse and White, 1996, pp. 67).

The mainstream of the literature on the evolution of ERP, however, regard ERP as an extension of MRPII with enhanced and added functionality (Yusuf and Little, 1998, Gumaer, 1996, Kumar and Hillegersberg, 2000), encompassing functions that are not within the traditional focus of MRPII, such as human resource planning, decision support, supply chain management, maintenance support, quality, regulatory control, and health and safety compliance (Yusuf and Little, 1998). In the age of customized products and services, long-term forecasts are much less useful and production and distribution far too dynamic and unpredictable to be addressed solely through periodic planning approach of MRPII. However, despite of these shortcomings of MRPII, most ERP vendors still use the same basic model of MRPII for the manufacturing-planning portion of their systems (Gumaer, 1996).

During the last three years, the functional perimeter of ERP systems began an expansion into its adjacent markets, such as supply chain management (SCM), customer relationship management (CRM), product data management (PDM), manufacturing executions systems (MES), business intelligence/data warehousing, and e-Business. The major ERP vendors have been busy developing, acquiring, or bundling new functionality so that their packages go beyond the traditional realms of finance, materials planning, and human resources.

To circumvent MRPII's capacity planning limitations, planners turned to various ways of off-line capacity planning: either manually, with the help of spreadsheet programs, or with the help of new advanced planning and scheduling (APS) systems. APS systems are designed as bolt-ons with the idea of plugging into an ERP system's database to download information and then create a feasible schedule within identified constraints. The new schedule can then be uploaded into the ERP system thereby replacing the original MRP results. These APS systems typically offer simulation ("what if") capabilities that allow the planner to analyze the results of an action before committing to that action through the ERP system. Some of these systems go one step further by offering optimization capabilities. They automatically create multiple simulations and recommend changes in the supply chain within the existing constraints.

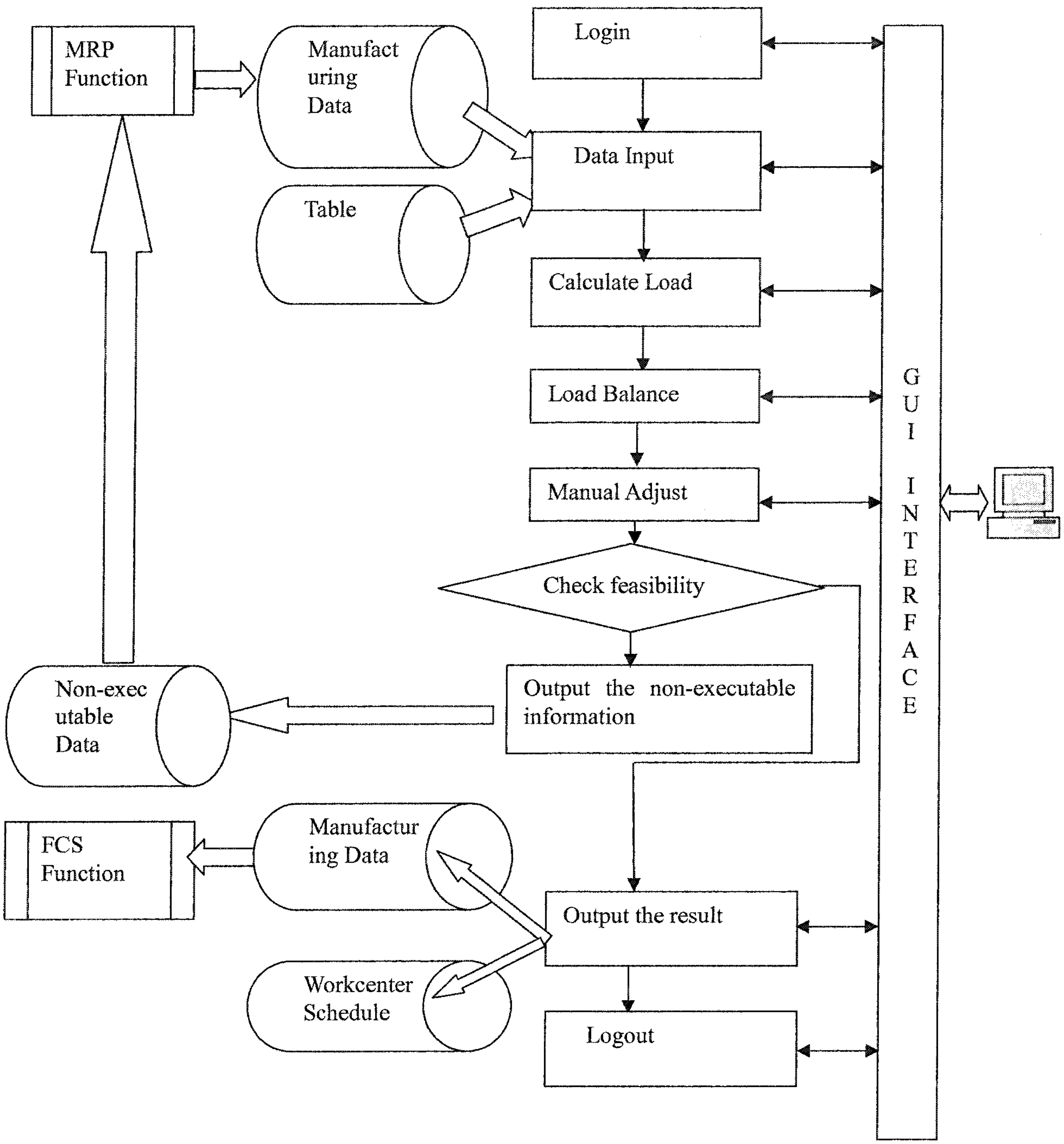
CHAPTER 2

THE REQUIREMENT ANALYSIS AND SYSTEM DESIGN

This CRP module uses the output of the MRP system as the input data. It will deploy the manufacturing order into the manufacturing process, then to calculate the operation time of the process. This module can dispose two kinds of the plan unit for the load calculation: work centre or work machine. The measure unit of the plan can be day or week. When we calculate the load of the plan unit, we also use the planned orders outputted by the posterior plan function (Finite Capacity Scheduling –FCS) together with the manufacturing orders, so that this load calculation is more accurate. After adding the load to the plan unit, we can do the auto-balance operation or the manual adjust operation to verify the feasibility of the plan of the tentative orders. If the plan is feasible, the module will output the manufacturing orders and produce the job orders. If the plan is not feasible, it will output the useful information to the anterior function to review the tentative orders.

The following figure 2.1 shows the entire work flow the CRP module.

Figure 2.1 The workflow of the CRP module.



As showing in the figure 2.1, the CRP module is composed of 9 parts:

1. Login function

2. Data input function

3. Load calculation function

4. Load auto-balance function

5. Manual adjust function

6. Check the feasibility function

7. Output the non-executable information function

8. Data output function

9. Logout function

2.1 LOGIN FUNCTION

User must input user's ID and password for login the CRP function.

2.1.1 Input

Table 2.1 The following table shows the login input items.

Input Item	Explain
User's ID	The ID of the login user
Password	The password of the login user
Login mode	The mode of user's login.
Cipher File	The list of user and password
Plant table	According to the range of charge table, set the exclusive status in this table.

Workcenter table	According to the range of charge table, set the exclusive status in this table.
Charge table	Get the responsible range of work center from this table.
Data source type	Specify the type of the data source

2.1.2 Output

Table 2.2 The following table shows the login output message.

Output Item	Explain
Login success or not	Return the result of the login.
Type of the error	The number of the login error.

2.1.3 Detail Process

The process logic of the login function is described as :

The fields of user ID and password must be inputted.

Reading in the Cipher file, verify the user ID and password being correct or not.

If the user ID or password is not correct, the error occurs, return the type of error.

If the user ID and password are correct, then reading in the facility table and work center table and charge table from the specified data source.

From the charge table, get all responsible work centers of the user.

Verify the responsible work centers being used by other user. If it is the case, return an error.

If there is no the responsible work center being used by other user, set the status of the work center to exclusive.

According to the user's login mode, we can restrict the CRP functions which user can be used. The following table shows this limit.

Table 2.3 Login mode

Login mode	Usable Functions
Planning	Data Input Function, Calculate Load Function, Load Balance Function , Manual Adjust Function , Non-Executable Information Output Function, Confirm the Planning Function, Data Output Function.
Simulation	Data Input Function, Calculate Load Function, Load Balance Function , Manual Adjust Function , Non-Executable Information Output Function, Confirm the Planning Function.
Reference	Data Output Function.

2.2 DATA INPUT FUNCTION

This module reads the manufacturing orders produced by MRP from the data source into memory. At the same time, it completes the same operation with the part table, work center table, Calendar table etc.

2.2.1 Input

Table 2.4 Input items of the data input function

Input Item	Note
Manufacturing Order Table	Read into memory
Manufacturing Divided Order	Read into memory

Table	
Working Order Tale	Read into memory
Part Table	Read into memory
Device Table	Read into memory
Process Table	Read into memory
Process Sequence Table	Read into memory
Valid Process Sequence Table	Read into memory
Calendar Table	Read into memory
Working Shift Table	Read into memory
Working Shift Type Table	Read into memory
Non-work Period Table	Read into memory
Producible Work center Table	Read into memory

2.2.2 Output

The following table shows the data input result.

Table 2.5 Output items of the data input function

Output Item	Explain
Data input success or not	Return the result of the Data input.
Type of the error	The number of the Data Input error.

2.2.3 Detail Process

Because the work center table and the responsible work center table are already read into memory when user logged into this module, all the rest tables are got into memory from the specified data source. Verifying the correctness of the tables must be processed at the time of reading of the tables. Database is as the default data source, if the user wants to read data from the other data source, it must be specified in the parameter file.

2.3 CALCULATE LOAD FUNCTION

The load calculation of the measure unit is taken by using the data read from the data source. There are two kinds of the work area for the load calculation: the work center and the work machine. We use the manufacturing time of each process deployed by the manufacturing order to calculate the workload. This function also uses the information of the process of the planned order in the posterior function (FCS) in order to achieve the high accurate calculation of the load.

2.3.1 Input

Table 2.6 Input items of the calculate load function

Input Item	Note
Manufacturing order table	Used for deploying the manufacturing process
Process sequence table	The object of the load
Work center table	Used for getting the calculational methods of Job Time
Producible work center table	Used for calculating the Job Time
Calendar table	Used for determining the unit of measure of the load object
Unit of measure	Used for calculating the load
Base time point of the planning	Used for calculating the load
The period of the planning	Used for calculating the load

2.3.2 Output

Table 2.7 Output items of the calculate load function

Output Item	Note
Information of the calculated load and the report of the load	The load information of every unit of the measure (each work center or each

	machine).
The result of this function	If this function runs successfully, return success, else return an error.
The type of the error	Return the number of the error to indicate its type.

2.3.3 Detail process

First of all, we check the input manufacturing orders whether they are the object to calculate the load or not. If they are the object to calculate, then deploy the process of this manufacturing order and calculate the job time of each process according to the unit of measure. We assume that infinite capacity exists at each of these work centers to satisfy this calculated. We use the processes that are determined by FCS function for the high precision load calculation.

2.3.3.1 Verification of the manufacturing order

The LFT (Latest Finish Time) of the manufacturing order must be later than the base time point of the planning. The EST (Earliest Start Time) of the manufacturing order must be in the period time of the planning. The table of 2.8 shows the detail.

Table 2.8 The object to calculate load

The range of the manufacturing order	The object to calculate load
The LFT (Latest Finish Time) of the manufacturing order < the base time point of the planning	No

The base time point of the planning <= the EST (Earliest Start Time) of the manufacturing order < (the base time point of the planning+ the period of the planning)	Yes
(The base time point of the planning+ the period of the planning) <= the EST (Earliest Start Time) of the manufacturing order	No

2.3.3.2 Deploying the manufacturing process

By using the process sequence table, the manufacturing process is deployed from the manufacturing order of the component. The EST and LFT of each process are generated according to the production time of the process. The following tables figure out the method of this calculation.

Table 2.9 The calculation of LFT (Backward scheduling logic)

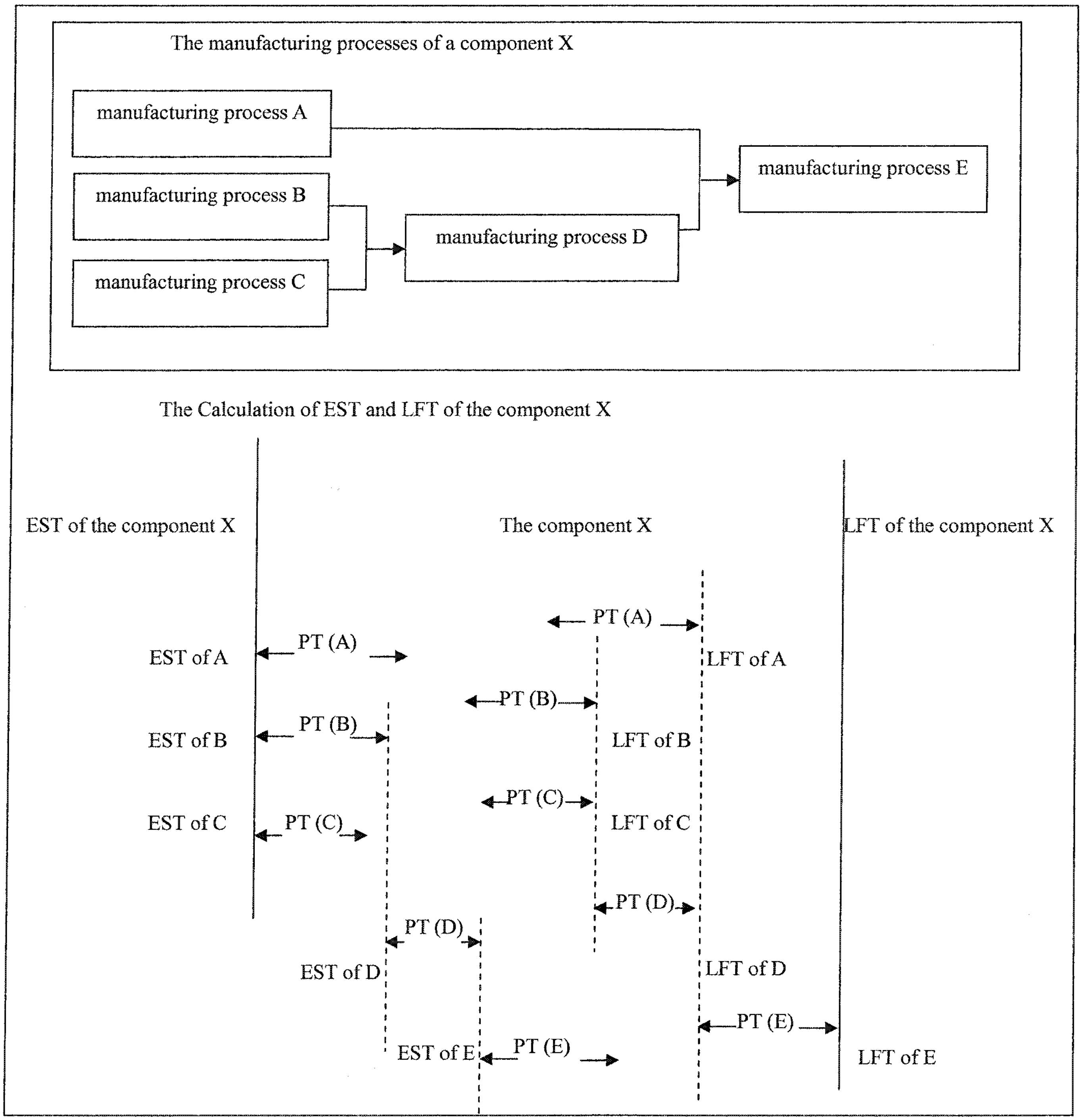
The manufacturing process	The calculation of LFT
The last manufacturing process	The LFT of the last process
The rest manufacturing process	The LFT of the rest process is earliest time among all the subtraction of LFT with its production time (LFT - production time) .

Table 2.10 The calculation of EST (Backward scheduling logic)

The manufacturing process	The calculation of EST
The earliest manufacturing process	The earliest start time of the first manufacturing process.
The rest manufacturing process	The EST of the rest manufacturing process is latest time among all the subtraction of EST with its production time (EST - production time) .

The concrete demonstration of the calculation of EST and LFT is shown in figure 2.3. In this figure PT means Production Time.

Figure 2.2 The calculation of EST and LFT.



2.3.3.3 The calculation of production time of the manufacturing process

The production time of the manufacturing process equals the sum of the product of rated production time of the process and the mount of components and the prepare time. The formulation is:

The production time = (rated production time of the process)*(the mount of components) + the prepare time.

2.3.3.4 The different capacities and loads

The object to be calculated the load can be work center or work machine of the manufacturing area, at the same time, the measure unit of the load can be hour or day, this can be set in the parameter file. In the case of work center, the calculation of load is completed according to the measure unit defined in the process sequence table. In the case of work machine, the rules of selection the work machine to load must be followed are:

Select the machine in the top-priority work center.

In the same work center, select the top-priority machine. If it is overload, then select the next top-priority machine.

If all machines of the center are overload, then select the top-priority machine.

2.3.3.5 The calculation of the standard capacity

Using the following method to calculate the standard capacity of the different machines:

The standard capacity of the current measure unit = The sum of production time of every day according to the measure unit.

The production time of the current day = (∑(the shift production time of the current day of the machine) + append production time)* capacity coefficient

The standard capacity of the different work centers is shown as the formula:

The standard capacity of the current measure unit = ∑(the standard capacities of all machines that are belong to the current center).

2.3.3.6 The discrimination of manufacturing area

If the object to be calculated the load is work center, the load of different machines can not be identified. Whereas in the case of the calculation load of the machine, the load of every work center can be discriminated, because the load of the center equals to the sum of the loads of all machines that are belong to the current center.

2.3.3.7 Getting the information from the function of the posterior planning (FCS)

This calculation load function also gets the information from the function of the posterior planning (FCS). It uses the confirmed production orders of the posterior planning to calculate the load so that this calculation is more accurate. The table 2.11 shows the detail.

Table 2.11 The information introduced from the posterior planning (FCS)

Information
The ID of process sequence of the current process
The ID of manufacturing order which includes the current process
The start time of the process
The end time of the process
The ID of the machine of the current process

The ID of planned order introduced from the function of the posterior planning must be same as the ID of current manufacturing order. The ID of process sequence of the planned order must be the same as the ID of process sequence of the current manufacturing process deployed from the current manufacturing order. The following table shows the information:

Table 2.12 The information deployed from the planned order

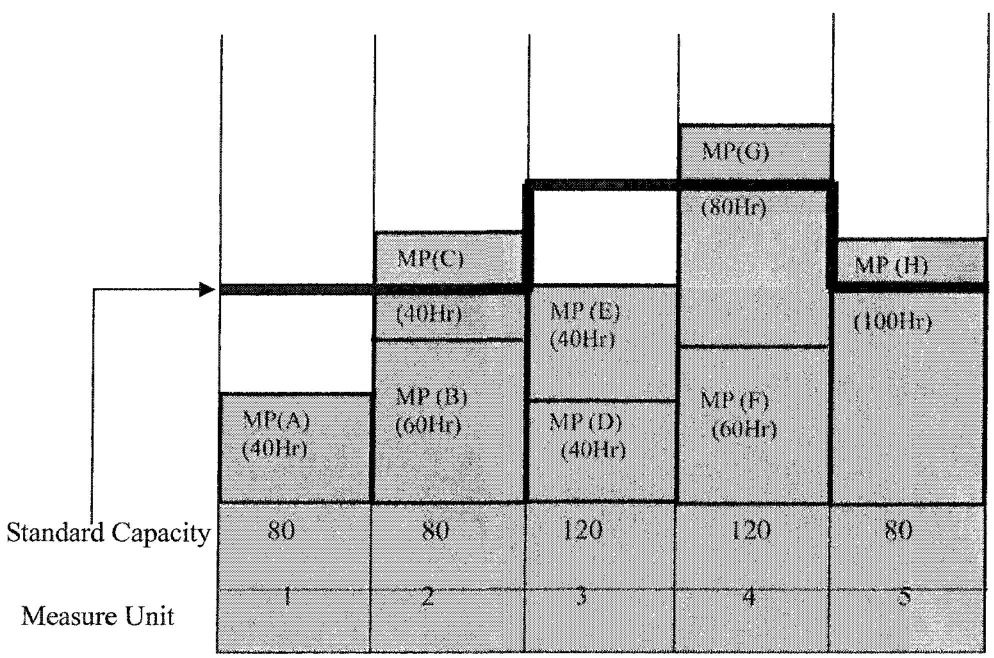
Information of the process	Setting information
Earliest start time	The start time of the process of the planned order
Latest finish time	The finish time of the process of the planned order

Production time	The finish time of the process of the planned order- the start time of the process of the planned order
The object to calculate the load	The machine which its ID is uniform to the ID of the machine of the current manufacturing order. Or the work center that the machine of the planned order belongs to. The ID of the machine is uniform to the ID of the machine of the current manufacturing order

2.3.3.8 The example of the loads

The figure 2.3 shows an example of the loads. Here MP means Manufacturing Process.

Figure 2.3 An example of the load.



2.4 AUTO-BALANCE FUNCTION

For the calculated load, the auto-balance function of the load is processed at the base of the standard capacity. The result of the adjustment of the manufacturing process of this auto-balance function can not be as the output of the CRP module.

2.4.1 Input

Table 2.13 The input items of the Auto-balance function.

Input Item	Note
The information of Calculate Load Function	Load information of the work center
Work Center Table	To get the calculate measure of the job time

2.4.2 Output

Table 2.14 The output items of the Auto-balance function.

Output Item	Note
Information of the calculated load and the report of the load	The load information after auto-balance function
The result of this function	If this function runs successfully, return success, else return an error.
The type of the error	Return the number of the error to indicate its type.

2.4.3 Detail process

This auto-balance load function will process and reschedule all open and planned manufacturing orders using backward scheduling. Backward scheduling logic will calculate each operation backwards from the manufacturing order or planned order.

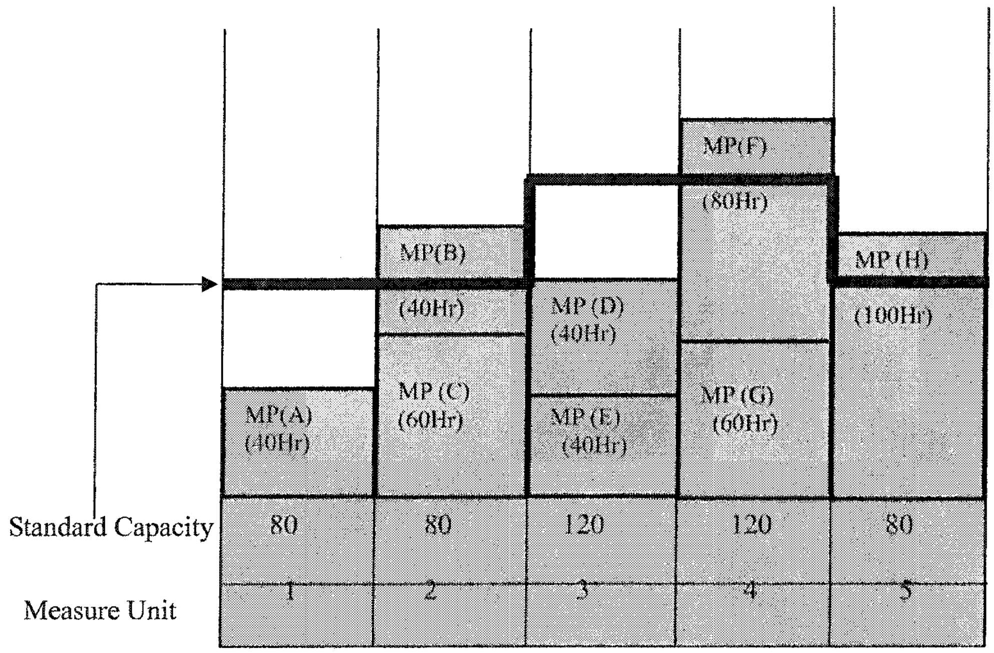
The algorithm of the auto-balance load function we used is simple. In the case of calculation of work center, the auto-balance load function is processed with the work center as measure unit. Whereas in the case of calculation of work machine, the auto-balance load function is processed with the work machine as measure unit. The loads can only be transferred between the machines in the same work center. For the complicate auto-load function, such as the transference of loads between machines in different work centers, we don't take into account.

The detail algorithm of auto-balance load function is illustrated by two examples shown in Figure 2.4-2.7.

These two examples are based on the assumption that the sequence of EST of every manufacturing process is the same as the sequence of the English letters used to express the process. So the EST of the manufacturing process A is the earliest, and that the EST of the process H is the latest. Moreover, The EST of each manufacturing process is earlier than the base point of the planning.

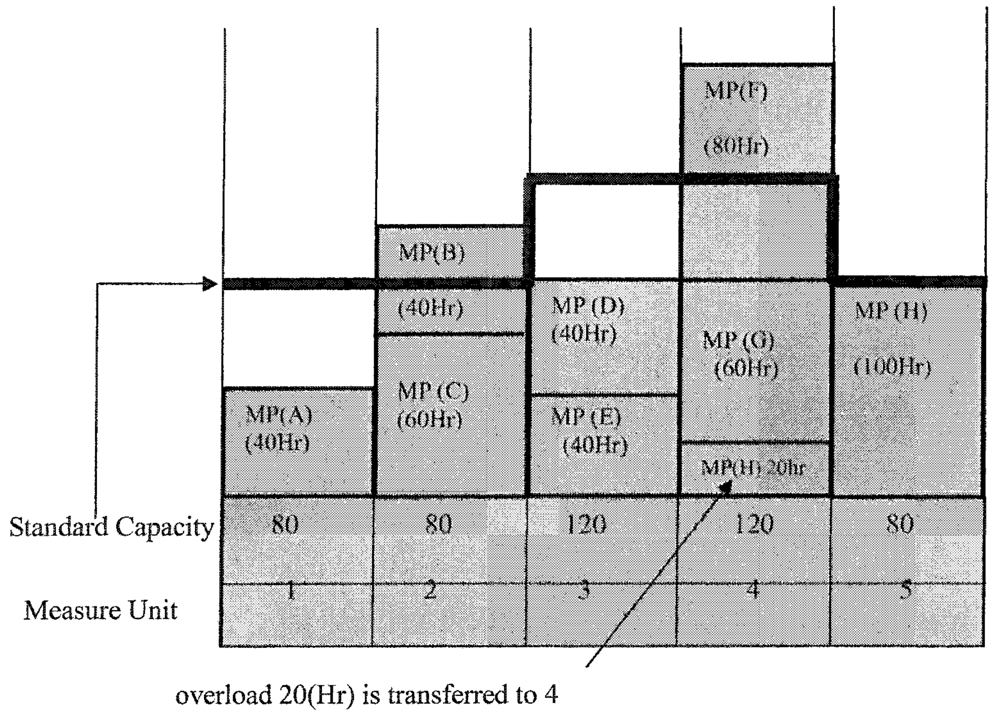
Example 1 of the Auto-balance, here MP means Manufacturing Process.

Figure 2.4 The load of the each measure unit.



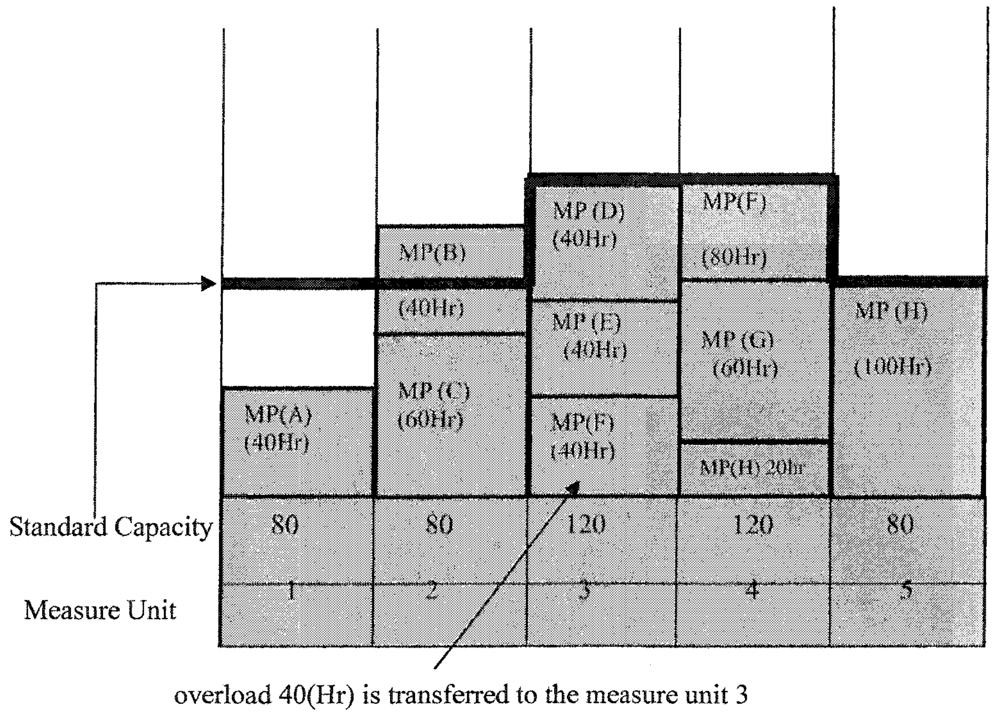
As showing in the figure, because the capacity of the measure unit is over load compared with the standard capacity, it must be taken the auto-balance process of the load. Taking the latest measure unit 5 as the first object to be treated with, the over load 20(Hours) of the manufacturing process of the measure unit 4, as showing in the following figure.

Figure 2.5 The overload 20(Hr) is transferred to measure unit 4.



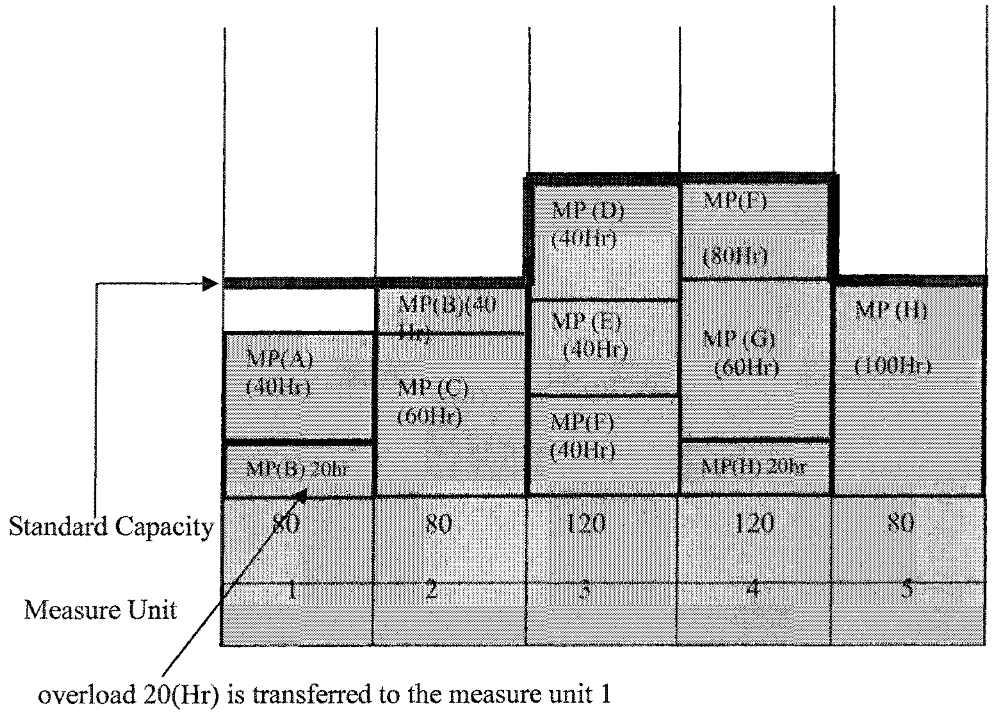
After this transference to the measure unit 4, the loads of the measure unit 5 is under the standard capacity, but the load of the measure unit 4 is over the standard capacity. So the transference of load begins from the earliest EFT of the manufacturing process F, the over load of 40 Hours moves ahead. This is shown in the following figure.

Figure 2.6 The overload 40(Hr) is transferred to the measure unit 3.



Because the load of the measure unit 3 is not over the standard capacity, the measure unit 2 is treated directly. The over load of the measure unit 2 is 20 hours. So the transference of load begins from the earliest EFT of the manufacturing process B. Figure shows this case.

Figure 2.7 The overload 20(Hr) is transferred to the measure unit 1.

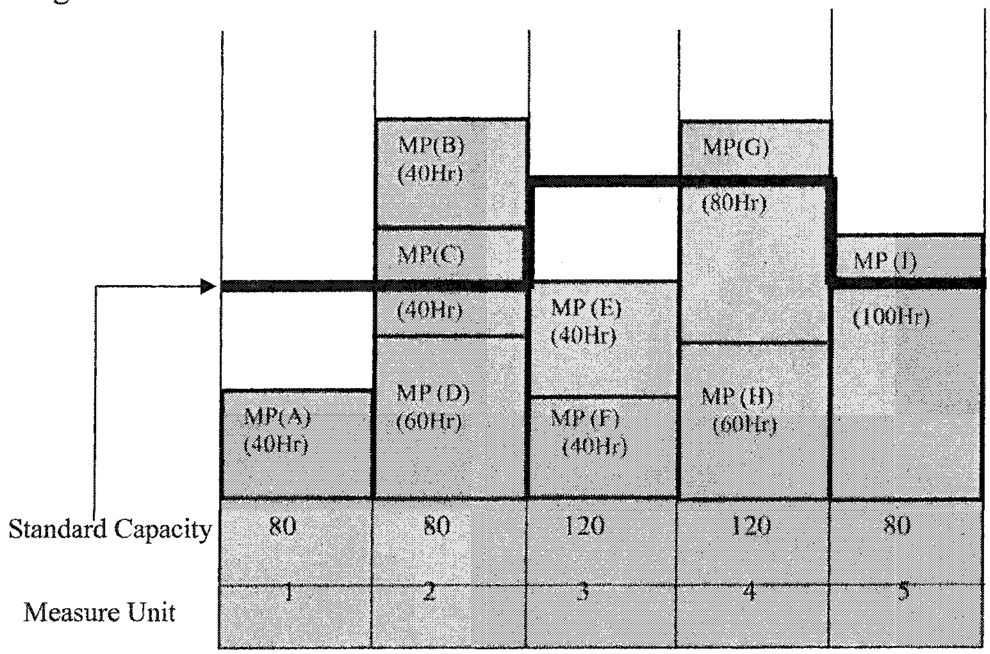


There is not measure unit ahead of the measure unit 1, so the auto-balance process finish.

Because the load of the measure unit 1 is under the standard capacity, so the planning of this work center is executable.

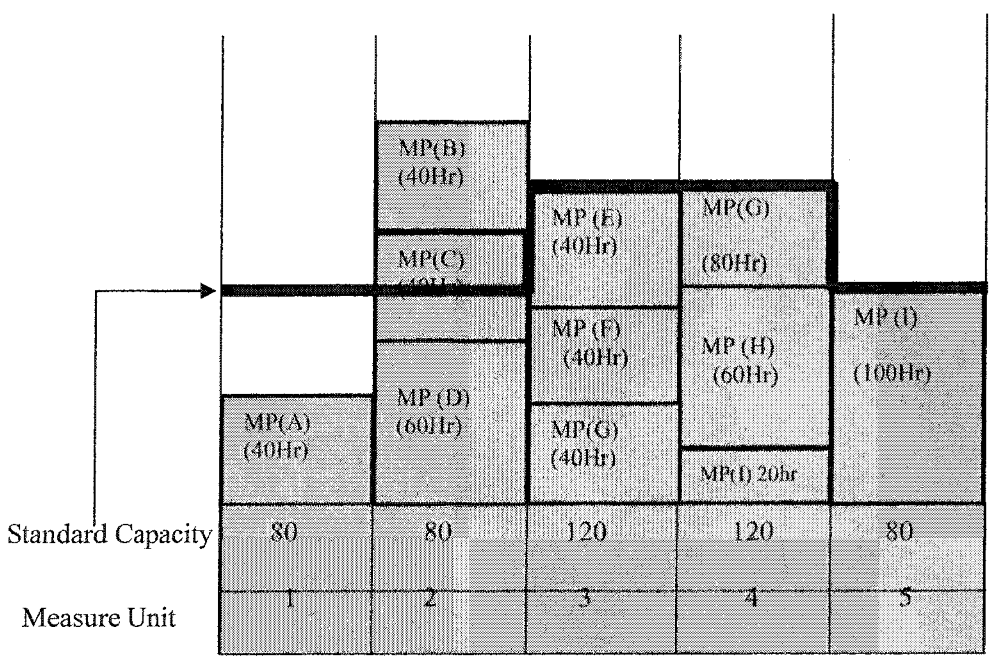
Another example , the case of the planning is not executable.

Figure 2.8 The load of the each measure unit.



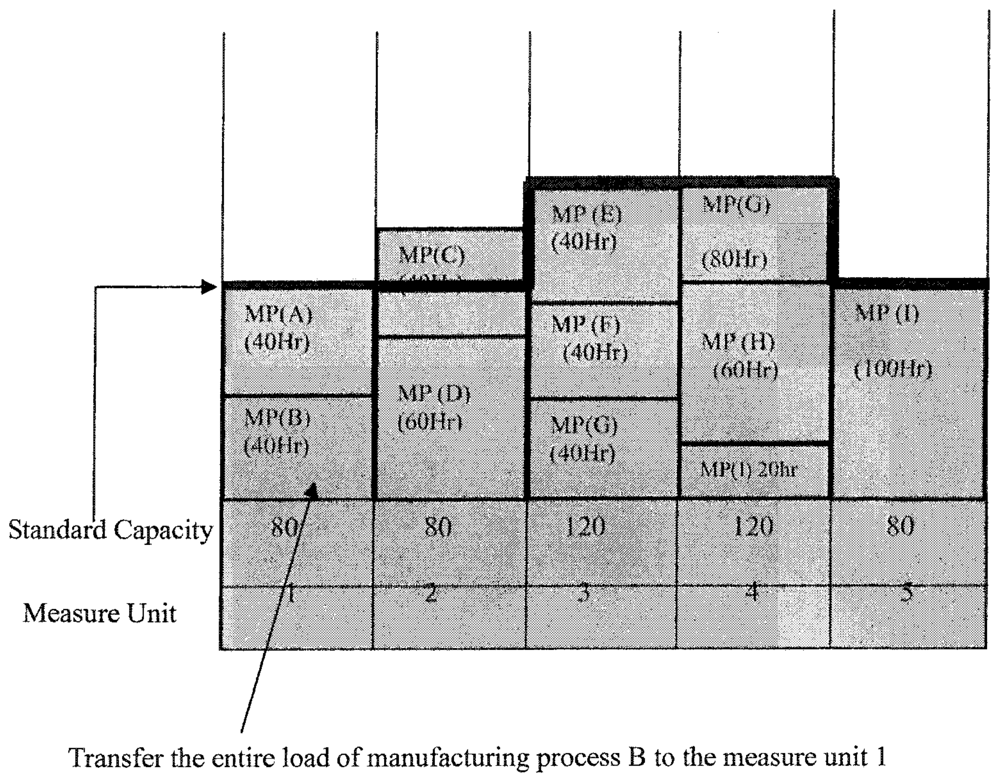
The procedure of auto-balance of the load in this example is similar with that is in the example 1 until the measure unit 2.

Figure 2.9 The load transference until the measure unit 2.



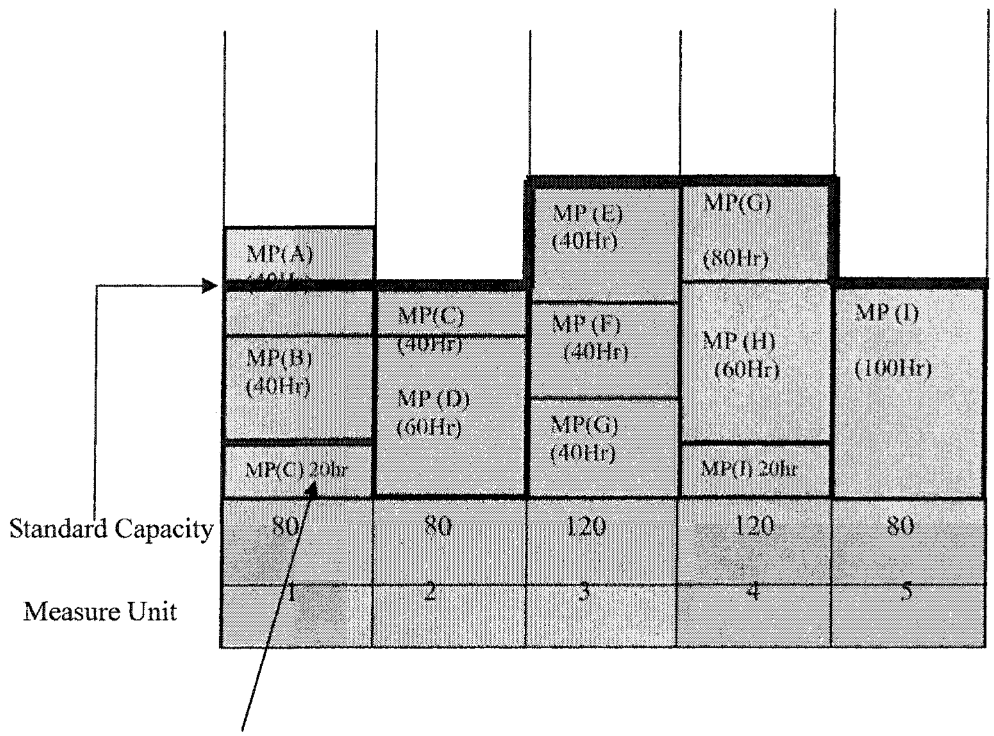
Because the load of the measure unit 2 is over the standard capacity, the transference of load begins from the earliest EFT of the manufacturing process B. In this case, the load of the manufacturing process B is less than the over part of the load of measure unit 2. So the total load of the manufacturing process B is transferred to the measure unit 1. The figure 2.10 shows this case.

Figure 2.10 Transfer the entire load of manufacturing process B to the measure unit 1.



The load of the measure unit 2 is still over load even though the entire load of manufacturing process B is transferred to the measure unit 1. So the over load 20 Hours of the manufacturing process C must be moved to the measure unit 1.

Figure 2.11 Transfer the overload to the measure unit 1.



Transfer the overload to the measure unit 1

There is no measure unit ahead of the measure unit 1, so the auto-balance of the load finishes. Because the load of the measure unit 1 is over the standard capacity, in this case the planning of the work center is non-executable.

2.5 MANUAL ADJUST FUNCTION

It is required to offer the means of manual adjust function after the load calculation. The conceivable operations of the manual adjust function are listed in the following table.

Table 2.15 The operations of the manual adjust function.

Operation	Note
Transfer	Transfer the load from one manufacturing process to an other.
Divide	Divide one manufacturing order into two orders.
Combine	Combine two divided orders to one manufacturing order
Append	Append manufacturing orders. When the manufacturing orders are appended, the validity of MRP is not guaranteed.
Delete	Remove the manufacturing orders. When the manufacturing orders are deleted, the validity of MRP is not guaranteed.
Modify the quantity of the product	Modify the quantity of the product of the manufacturing order. When this amount is modified, the validity of MRP is not guaranteed.
Modify the schedule and the shift type	Modify the day-off or the overtime of the facility to adjust the standard capacity of the work center, so that the load is under the standard capacity.
Undo	Recover the current manual operation.

2.5.1 The transference of the load

The specified load of the manufacturing process is transferred to the appointed plan unit or work center. There are two kinds of the transference.

2.5.1.1 The transference of the load between the work centers

The possible moveable work centers are only those which are corresponding to the current work sequences defined in the producible work center table. This transference can not be performed to the work centers of the other facility. If the moveable status of the facility is set to false, an error will occur.

2.5.1.2 The transference of the load between the work machines

The load calculation is performed using the work machine unit. The possible moveable work machines are only those which are corresponding to the current manufacturing process defined in the producible work center table. This transference can not be performed to the work machines of the work center of the other facility. If the moveable status of the machine is set to false, an error will occur.

2.5.1.3 Input

Table 2.16 The input items of the transference of the load.

Input Item	Note
ID of the manufacturing order	The ID of the manufacturing order which includes the manufacturing process, its load is transferred.
ID of the divided manufacturing order	The ID of the divided manufacturing order which includes the manufacturing process, its load is transferred.
ID of the manufacturing process	The ID of the manufacturing process, its load is transferred.
ID of work center or machine	The ID of the work center or machine to be transferred.
Date	The date of manufacturing process to be transferred.

2.5.1.4 Output

Table 2.17 The output items of the transference of the load.

Output Item	Note
ID of manufacturing process	The ID of the manufacturing process after the transference.
The load information	The load information of the work center or machine after the transference.
The result of this operation	If this function runs successfully, return success, else return an error.
The type of the error	Return the number of the error to indicate its type.

2.5.2 The division of the manufacturing order

The manufacturing order is divided by the specified quantity of the order. At the same time as the manufacturing order is divided, all the manufacturing processes deployed from the current manufacturing order are divided the same quantity. The specified quantity the order must be ranging between 0 < divided quantity < the quantity of the order before division.

After the division, the information of the new manufacturing order is shown in the table.

Table 2.18 The information of the new manufacturing order of the division of the manufacturing order.

Items	The manufacturing order 1 after division	The manufacturing order 2 after division
ID of the manufacturing order	Same as the manufacturing order before division	Same as the manufacturing order before division
ID of the divided manufacturing order	Same as the manufacturing order before division	The minimum value not used of the divided manufacturing order for the same manufacturing order ID.
ID of the component	Same as the manufacturing order before division	Same as the manufacturing order before division
ID of the work center	Same as the manufacturing order before division	Same as the manufacturing order before division
EST	Same as the manufacturing order before division	Same as the manufacturing order before division
LFT	Same as the manufacturing order before division	Same as the manufacturing order before division
Quantity	The specified quantity	The quantity before division – quantity.

2.5.2.1 Input

Table 2.19 The input items of the division of the manufacturing order.

Input Item	Note
ID of he manufacturing order	The ID of the manufacturing order to be divided.
ID of the divided manufacturing order	The ID of the divided manufacturing order to be divided.
Quantity	The quantity of the manufacturing order after division.

2.5.2.2 Output

Table 2.20 The output items of the division of the manufacturing order.

Output Item	Note
Manufacturing order 1	The manufacturing order 1 after division
Manufacturing order 2	The manufacturing order 2 after division.
The load information	The load information of the work center or machine after the division.
The result of this operation	If this function runs successfully, return success, else return an error.
The type of the error	Return the number of the error to indicate its type.

2.5.3 The Combination of the manufacturing order

The combination of the manufacturing order is performed by two specified manufacturing orders. After combination these two manufacturing orders, all the manufacturing processes deployed from these two manufacturing orders must be combined together. The quantity of the manufacturing order after combination is the sum of two combined manufacturing orders. The ID of the divided manufacturing order is the minor value of these two IDs of the divided manufacturing orders. The other information except the quantity and the ID of the divided manufacturing order will inherit the same information of the manufacturing order. The combination can only be performed between the divided manufacturing orders which have the same manufacturing order ID.

2.5.3.1 Input

Table 2.21 The input items of the combination of the manufacturing order.

Input Item	Note
ID of the manufacturing order 1	The ID of the manufacturing order 1 to be combined.
ID of the divided manufacturing order 1	The ID of the divided manufacturing order 1 to be combined.
ID of the manufacturing order 2	The ID of the manufacturing order 2 to be combined.
ID of the divided manufacturing order 2	The ID of the divided manufacturing order 2 to be combined.

2.5.3.2 Output

Table 2.22 The output items of the combination of the manufacturing order.

Output Item	Note
Manufacturing order	The manufacturing order after the combination.
The load information	The load information of the work center or machine after the division.
The result of this operation	If this function runs successfully, return success, else return an error.
The type of the error	Return the number of the error to indicate its type.

2.5.4 The accession of the manufacturing order

The accession of the new manufacturing order is based on the specified information of the manufacturing order. After the new manufacturing order is created, all the processes of the manufacturing order are generated. At the same time, the load calculation of the manufacturing process is also performed.

2.5.4.1 Input

Table 2.23 The input items of the accession of the manufacturing order.

Input Item	Note
All the necessary information of new manufacturing order	Input the necessary information for creating the new manufacturing order.

2.5.4.2 Output

Table 2.24 The output items of the accession of the manufacturing order.

Output Item	Note
Manufacturing order	The new manufacturing order after the accession.
The load information	The load information of the work center or machine after the accession.
The result of this operation	If this function runs successfully, return success, else return an error.
The type of the error	Return the number of the error to indicate its type.

2.5.5 The deletion of the manufacturing order

Deleting a manufacturing order is performed by specified its ID, at the same time, all manufacturing processes deployed by the current manufacturing order are also removed.

2.5.5.1 Input

Table 2.25 The input items of the deletion of the manufacturing order.

Input Item	Note
ID of the manufacturing order	The ID of the manufacturing order to be removed.
ID of the divided manufacturing order	The ID of the divided manufacturing order to be deleted.

2.5.5.2 Output

Table 2.26 The output items of the deletion of the manufacturing order.

Output Item	Note
Manufacturing order	The manufacturing order to be deleted.
The load information	The load information of the work center or machine after the deletion.
The result of this operation	If this function runs successfully, return success, else return an error.
The type of the error	Return the number of the error to indicate its type.

2.5.6 The modification of the quantity of the manufacturing order

Modifying the quantity of a manufacturing order is performed by specified its new quantity at the same time, all manufacturing processes deployed by the current manufacturing order are also modified.

2.5.6.1 Input

Table 2.27 The input items of the modification of the quantity of the manufacturing order.

Input Item	Note
ID of the manufacturing order	The ID of the manufacturing order to be modified.
ID of the divided manufacturing order	The ID of the divided manufacturing order to be modified.
The Quantity	The new quantity of the manufacturing order.

2.5.6.2 Output

Table 2.28 The output items of the modification of the quantity of the manufacturing order.

Output Item	Note
Manufacturing order	The manufacturing order to be modified its quantity.
The load information	The load information of the work center or machine after the modification.
The result of this operation	If this function runs successfully, return success, else return an error.
The type of the error	Return the number of the error to indicate its type.

2.5.7 The modification of the schedule and the shift type

The objective of modifying the day-off or the overtime of the facility is to adjust the standard capacity of the work center, so that the load is under the standard capacity. There are four types of the modifications listed in the following table.

Table 2.29 The operations of the modification of the shift.

Operation	Note
Modify the shift type	Modify the shift type of the specified work center or machine to the other type of the shift.
Append the overtime	Append the overtime of the work center will change the overtime of all machines of this work center.
Append the day-off	Append the day-off of the work machine.
Delete the day-off	Delete the day-off of the work machine.

5.2.8 Undo operation

For the manual operations, the Undo mechanism is necessary. In one case, if the input parameters of the manual operation are not correct, the Undo operation must be performed. In the other case, when several manual operations are executed, we want to recover the one of them. So the Undo mechanism can satisfy this requirement.

The level of the Undo operation can be set in the parameter file.

2.6 CHECK THE FEASIBILITY OF THE PLANNING

This module is to check the load of the measure unit whether is under the standard capacity or not.

2.6.1 Input

Table 2.30 The input items of the verification of the feasibility of the planning.

Input Item	Note
ID of the work center (machine)	Check the feasibility of planning of the specified work center (machine).
The load information	Use the load information to check the feasibility.

2.6.2 Output

Table 2.31 The output items of the verification of the feasibility of the planning.

Output Item	Note
The result of this operation	If the planning of the work center is executable, return true, else return false.
Arrange the measure unit	General view of the non-executable measure unit.

2.7 OUTPUT THE NON-EXECUTABLE INFORMATION

If the load of the work center is overload, output the non-executable load information.

2.7.1 Input

Table 2.32 The input items of the output of the non-executable information.

Input Item	Note
ID of the work center (machine)	Check the feasibility of planning of the specified work center (machine).
The load information	Use the load information to output.

2.7.2 Output

Table 2.33 The output items of the output of the non-executable information.

Output Item	Note
The non-executable load information	If the planning of the work center is non-executable, save the manufacturing order to local file.
The result of this operation	If this function runs successfully, return success, else return an error.
The type of the error	Return the number of the error to indicate its type.

2.8 DATA OUTPUT

This CRP module finally generates the job order to reflect the result of the load adjustment and the update of the manufacturing order.

2.8.1 Input

None.

2.8.2 Output

Table 2.34 The output items of the data output function.

Output Item	Note
The manufacturing order	Reflect the adjustment of load
The job order	Reflect the adjustment of load
The shift	Reflect the adjustment of load

2.9 LOGOUT

Logout function exits the current CRP module and saves the necessary information. There is no input data and output data involved in this part.

CHAPTER 3

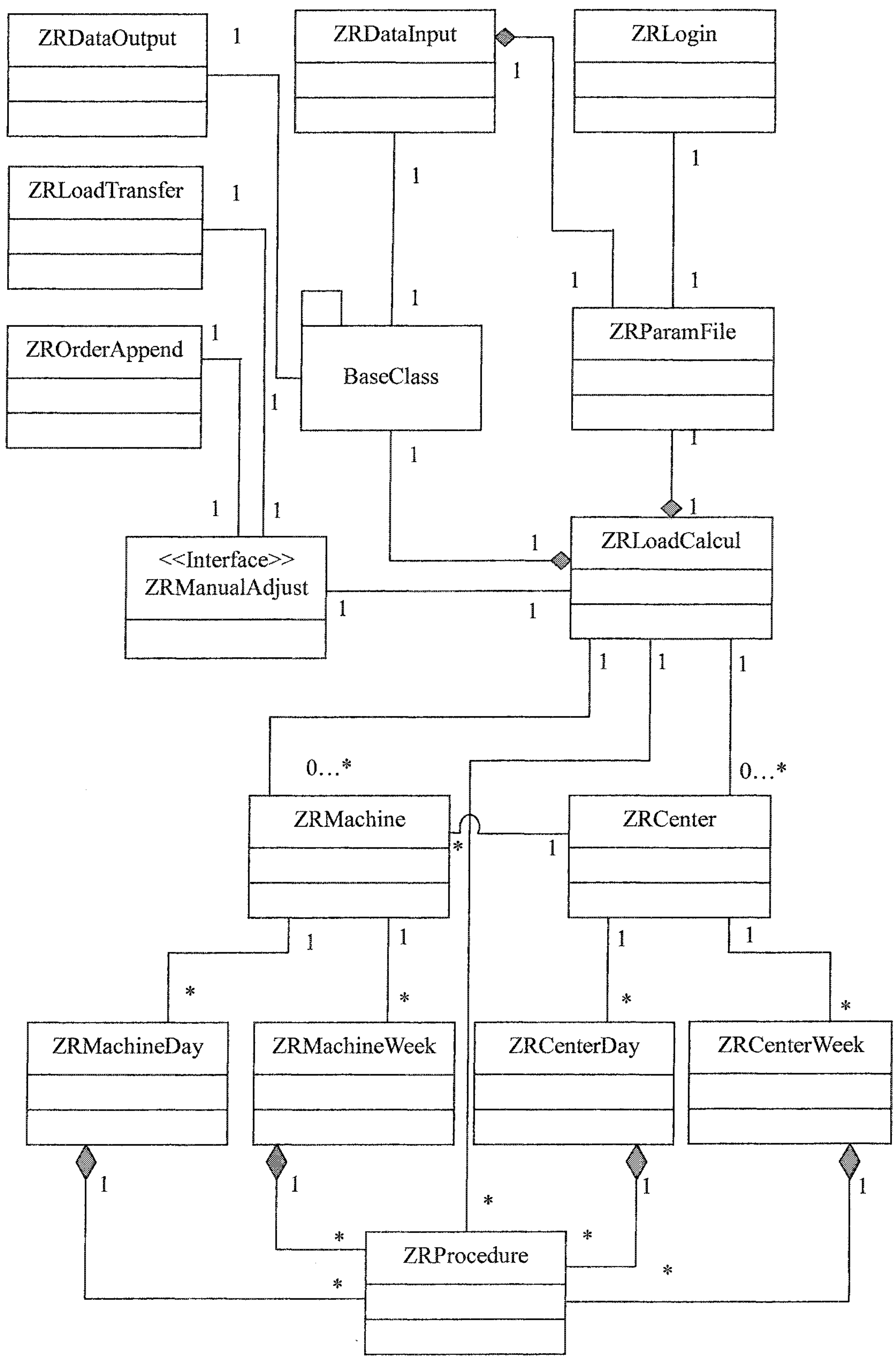
CLASS DESCRIPTIONS

This chapter will discuss the data input, the load calculation and manual adjust parts. Each part contains an associated class for which their behavior and data will describe. The class descriptions will include a statement of purpose and description of both the public and private declarations. The other parts (login, data output and Undo function) will not be discussed.

3.1 THE UML OF THE CRP MODULE

This CRP module contains 9 domains as showing in figure 3.1. Each domain comprises several classes. The Figure 3.1 illustrates the UML of these classes.

The Figure 3.1 The UML of the classes.


ZRDataOutput
ZRDataInput
ZRLogin
ZRLoadTransfer
ZROrderAppend
BaseClass
ZRParamFile
<<Interface>>
ZRManualAdjust
ZRLoadCalcul
ZRMachine
ZRCenter
ZRMachineDay
ZRMachineWeek
ZRCenterDay
ZRCenterWeek
ZRProcedure
1
0…*
*

3.2 THE DATA INPUT CLASS

The data input class will be addressed first because it gets all necessary data into memory from the database for the later use. The corresponding 'ZRDataInput' class allows us to dynamically build all tables in memory. The default data source is database. It also allows the user to read the data from other data source specified in the configuration file. This class contains all of the information needed to calculate the load of the work area.

Table 3.1 describes the private variable declarations in the ZRDataInput class. Private variables are accessible only to member functions of the class.

Table 3.1 The private variable declarations in the ZRDataInput class.

Declaration	Description
Connection conn	The connection with the data source
String logFileName	The file name of the log file
BufferedWriter bufWriter	Used to write file.
Vector vComponent	Data storage vector that holds the records data of the component table.
Vector vWorkingProcedure	Data storage vector that holds the records data of the Manufacturing process table.
Vector vSequence	Data storage vector that holds the records data of the Working Sequence table.
Vector vValidSequence	Data storage vector that holds the records data of the Working Sequence table.
Vector vMachine	Data storage vector that holds the records data of the Work Machine table.
Vector vWorkCenter	Data storage vector that holds the records data of the Work Center table.
Vector vShiftType	Data storage vector that holds the records data of the Shift Type table.
Vector vShift	Data storage vector that holds the records data of the Shift table.
Vector vDayOff	Data storage vector that holds the records data of the Day Off table.

Vector vMnfOrder	Data storage vector that holds the records data of the Manufacturing order table.
Vector vMnfDividedOrder	Data storage vector that holds the records data of the Manufacturing divided order table.
Vector vCalendar	Data storage vector that holds the records data of the Calendar table.
Vector vPlannedOrder	Data storage vector that holds the records data of the Planned Order table.
Vector vFacility	Data storage vector that holds the records data of the Facility table.
Vector vCharge	Data storage vector that holds the records data of the Charge table.
Vector vUserInfo	Data storage vector that holds the records data of the User table.

Each vector contains the records data of the corresponding table. It uses the base class of the record. For example, the Vector vMnfOrder uses the MnfOrderRecord class which is corresponding with one record of the Manufacturing order table.

The following table shows the ZRDataInput public function declarations. These functions are the users interface to the load calculation function.

Table 3.2 The public function declarations in the ZRDataInput class.

Declaration	Description
int getAllTable	Read all record data from the data source into corresponding vector. If the reading operation runs successfully, this function return 0, else return a number to indicate the type of the error.
Vector getVectorComponent	Get the private variable vComponent of the ZRDataInput.
Void setVectorComponent	Set the vector to the private variable vComponent of the ZRDataInput.
The other getVectorXXX, setVectorXXX functions corresponding to the vectors listed in Table 3.1	Get the vXXX vector from ZRDataInput or set the vector to vXXX.

Table 3.3 shows the private function declarations of the ZRDataInput class.

Declaration	Description
int getComponentTable	Read the record data from the Component table into the corresponding vector vComponent. If the reading operation runs successfully, this function return 0, else return a number to indicate the type of the error.
int checkComponentRecord	When this function reads the Component data from the data source, it must be taken the verification of correctness of the Component record.
The other getXXXTable and checkXXXRecord functions corresponding to the vectors listed in Table 3.1	Read the record data from the XXX table into the corresponding vector vXXX. If the reading operation runs successfully, this function return 0, else return a number to indicate the type of the error.

3.3 LOAD CALCULATION CLASS

The ZRLoadCalcul class is the most important class in this module, because it performs not only the load calculation of the work area according to the measure unit, it also takes the task of auto-balance of the load. The load calculation is performed by using the work time of each manufacturing process deployed by the manufacturing order.

The auto-balance load function will process and reschedule all open and planned manufacturing orders using backward scheduling. Backward scheduling logic will calculate each operation backwards from the manufacturing order or planned order.

Table 3.4 shows the private variable declarations in the ZRLoadCalcul class.

Declaration	Description
ZRDataInput dataInput	The data input class
int intCapacityUnit	The unit of the capacity
Date datePlanBase	The base point of the plan
int intPlanDucration	The period of the plan
Date dateBeginTime	The start date of the plan
Hashtable htMachine	Data storage hashtable that holds all machines information.
Hashtable htWorkCenter	Data storage hashtable that holds all Work Centers information.
Hashtable htMachineWeek	Data storage hashtable that holds all machines information. The capacity unit is week.
Hashtable htWorkCenterWeek	Data storage hashtable that holds all work center information. The capacity unit is week.
Hashtable htAllProcedure	Data storage hashtable that holds all manufacturing processes information.

The following table shows the ZRLoadCalcul public function declarations. These functions are the users interface to the load calculation function.

Table 3.5 The public function declarations in the ZRLoadCalcul class.

Declaration	Description
ZRLoadCalcul	Constructor function, in this function the initialization task is done.
loadCalculation	This is the core function in this CRP system, it will devide manufacturing order into manufacturing process, and do load calculation operation.
autoBalance	It is this function that does the auto-balance of the load. It compares the load of the current measure unit with its standard capacity to determine the under load or over load.

getLoadInformation	This function returns all load information of the work center or work machine.
getUnexecutableInformation	This function returns all load information of the measure unit that their capacity are over load

Table 3.6 The private function declarations of the ZRLoadCalcul class.

Declaration	Description
initWorkCenterByDay	Initialize the WorkCenter by day,create instances of ZRWorkCenter class and put them into Hashtable variable htWorkCenter
initWorkMachineByDay	Initialize the WorkMachine by day,create instances of ZRWorkMachine class and put them into Hashtable variable htWorkMachine
initWorkCenterByWeek	Initialize the WorkCenter by week,create instances of ZRWorkCenter class and put them into Hashtable variable htWorkCenterWeek
initWorkMachineByWeek	Initialize the Machine by week,create instances of ZRMachine class and put them into Hashtable variable htMachineWeek

3.4 MANUAL ADJUST CLASSES

As discussed in chapter 5, the manual adjust part consists of 8 operations. These operations are base on the interface 'ZRManualAdjust'. Here I will discuss one class for illustration: the class ZRLoadTransfer. The other classes are similar to this class. You can find them in the Index C.

3.4.1 The interface ZRManualAdjust

The following table shows the public functions placed in the interface ZRManualAdjust.

Table 3.7 The public functions placed in the interface ZRManualAdjust.

Declaration	Description
Void setParameter	This interface sets the necessary parameters of the manual operation.
Vector getParameter	This interface gets the input parameters of the manual operation.
Hashtable[] getExistedRecords	This interface gets all necessary existed hashtable to perform the manual operation.
int changeExistedRecords	This interface performs the manual operation.

3.4.2 Load transfer class

ZRLoadTransfer class is corresponding to the load transference operation. There are two kinds of the transference: the load between the work centers and the load between the work machines.

Table 3.8 Shows the private variable declarations in the ZRLoadTransfer class.

Declaration	Description
ZRDataInput zrDataInput	The class instance of class ZRDataInput
ZRLoadCalcul zrLoadCalcul	The class instance of class ZRLoadCalcul
Boolean moveFlag	The flag of the transference operation
Vector vLoadTransferInfo	The vector stores the parameter list.
Hashtable[] existedOrderRecords	The existed manufacturing order hashtable.

Table 3.9 shows the public variable declarations in the ZRLoadTransfer class.

Declaration	Description
OperationObject oo	The class object is prepared for the Undo operation.
UndoList ul	The Undo list used for the Undo operation.

Because the class ZRLoadTransfer extends the interface ZRManualAdjust, the public functions of this class are the same as shown in the table 6.4.1.

3.5 CRP TASK CLASS

I design the ZRCRPTask class to provide the interfaces of all of the tasks described in the previous chapters. This is for two purposes. The first is that the CRP module will work as a whole to integrate to the ZRERP system. The second is that this module can work independently, so we can use this class to interact with the GUI classes.

Table 3.10 shows the private variable declarations in the ZRCRPTask class.

Declaration	Description
ZRConnection crpconn	Open the connection with the data source
ZRDataInput zrDataInput	The class instance of class ZRDataInput
ZRDataOutput zrDataOutput	The class instance of class ZRDataOutput
ZRLogin zrLogin	The class instance of class ZRLogin
ZRLoadCalcul zrLoadCalcul	The class instance of class ZRLoadCalcul
ZRLoadTransfer zrLoadTransfer	The class instance of the class ZRLoadTransfer to perform the load transference operation of manual adjust.
ZROrderDivide zrOrderDivide	The class instance of the class ZROrderDivide to perform the load division operation of manual adjust.
ZROrderAppend zrOrderAppend	The class instance of the class ZROrderAppend to perform the order append operation of manual adjust.

ZROrderUnite zrOrderUnite	The class instance of the class ZROrderUnited to perform the order combination operation of manual adjust.
ZROrderQuantityChg zrOrderQuantityChg	The instance of the class ZROrderQuantityChg to perform the modification of the quantity of the manufacturing order.
ZRShiftChg zrShiftChg	The instance of the class ZRShiftChg to perform the modification the type of the shift.
ZRDayOffAppend zrDayOffAppend	The instance of the class ZRDayOffAppend to append the day-off of the work center or machine.

Table 3.11 shows the public variable declarations in the ZRCRPTask class.

Declaration	Description
UndoList undoList	The list to perform the undo operation.
int undoNum	The number of Undo times.

The table 3.12 shows the public function declarations in the ZRCRPTask class. These functions are used by other modules or by the GUI functions.

Table 3.12 The public function declarations in the ZRCRPTask class.

Declaration	Description
int init()	This function will perform the necessary initialization of the ZRCRPTask class, such as preparing the database connection, reading the configuration file and initializing the private variables. When the initialization operation runs successfully, it returns 0, else an error number occurs.
int login	This function will do the login action as described in chapter 4. When user logs in successfully, it returns 0, else an error number occurs.

int dataInput	This function will read all tables into the memory as described in chapter 4. When it runs successfully, it will return 0, else an error number occurs.
int loadCalculate()	This function will perform the load calculation as described in chapter 4. When it runs successfully, it returns 0, else an error number occurs.
int autoBalance	This function will perform the load auto-balance operation as described in chapter 4. When it runs successfully, it returns 0, else an error number occurs.
Vector getLoadInfo	This function will get the load information of the specified work center or work machine. When it runs successfully, it returns a Vector which contains the load information, else it returns NULL.
int orderDivide	This function will divide a specified manufacturing order into two manufacturing orders as described in chapter 4. When it runs successfully, it returns 0, else an error number occurs.
int orderUnite	This function will combine the specified two manufacturing orders into one manufacturing order as described in chapter 4. When it runs successfully, it returns 0, else an error number occurs.
int orderAppend	This function will append a new manufacturing order as described in chapter 4. When it runs successfully, it returns 0, else an error number occurs.
int orderDelete	This function will delete a specified manufacturing order as described in chapter 4. When it runs successfully, it returns 0, else an error number occurs.
int quantityChange	This function will change the quantity of the specified manufacturing order as described in chapter 4. When it runs successfully, it returns 0, else an error number occurs.

int shiftChange	This function will change the shift type of the specified work center as described in chapter 4. When it runs successfully, it returns 0, else an error number occurs.
int dayOffAppend	This function will append the day-off of the specified work center or machine as described in chapter 4. When it runs successfully, it returns 0, else an error number occurs.
int getNonExecutableInfo	This function will get the non-executable information of the specified work center or machine as described in chapter 4. When it runs successfully, it returns a Vector which contains the load information, else it returns NULL.
int unDo	Calling this function one time to cancel the last operation in the unDoList.
int checkFeasibility	This function will check the feasibility of the planning, i.e. the load of the measure unit is under the standard capacity or not. If the planning is feasible, it returns 0, else either the planning is not feasible 1 or an error number (>1) occurs.
int dataOutput	This function will write back all memory data into the data source, at the same time output the necessary information into the local file. When it runs successfully, it returns 0, else an error number occurs.
int logout	This function will do the logout action to exit this module. When user logs out successfully, it returns 0, else an error number occurs.

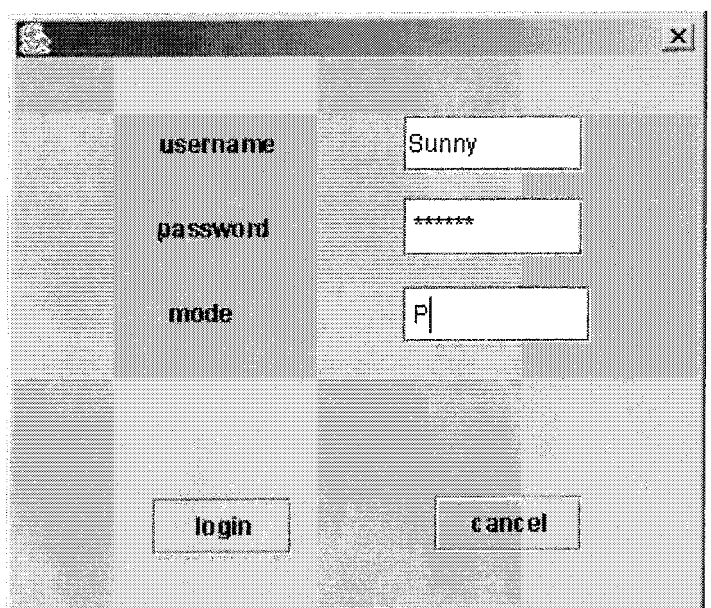
CHAPTER 4

IMPLEMENTATION

The current implementation of this CRP module supports two types of the data source. One is Oracle 8i and another is text format file (Comma Separated Value --CSV). For the text format file, the CsvJDBC driver must be used. It is just like any other JDBC driver. The *csvjdbc.jar* file should be included in the application's classpath.

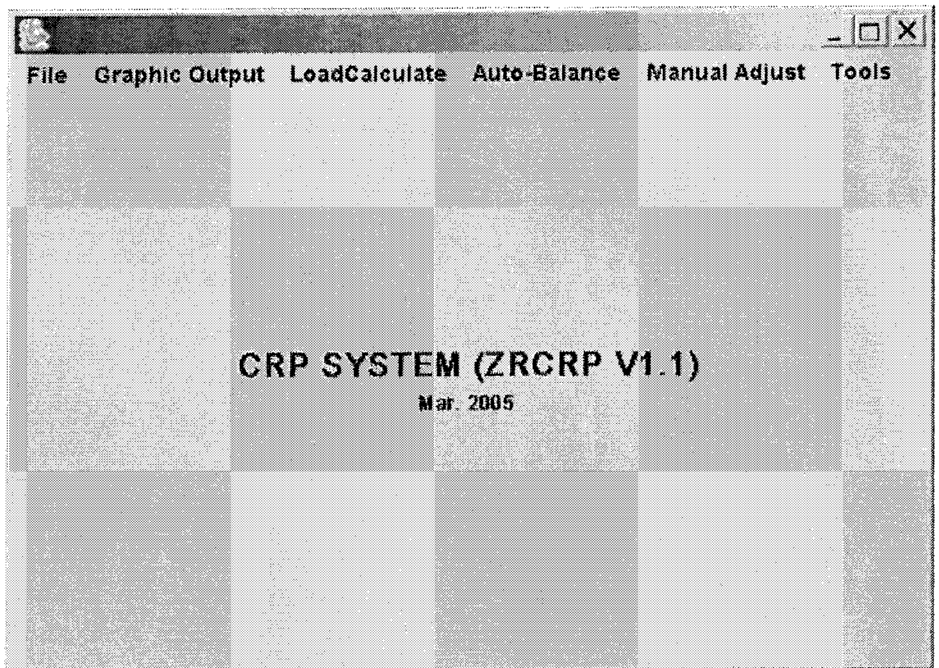
Because Java is the platform independent, so the program is designed to run on any platform. The following figure shows the login window of the CRP module.

Figure 4.1 Login window of the CRP module.



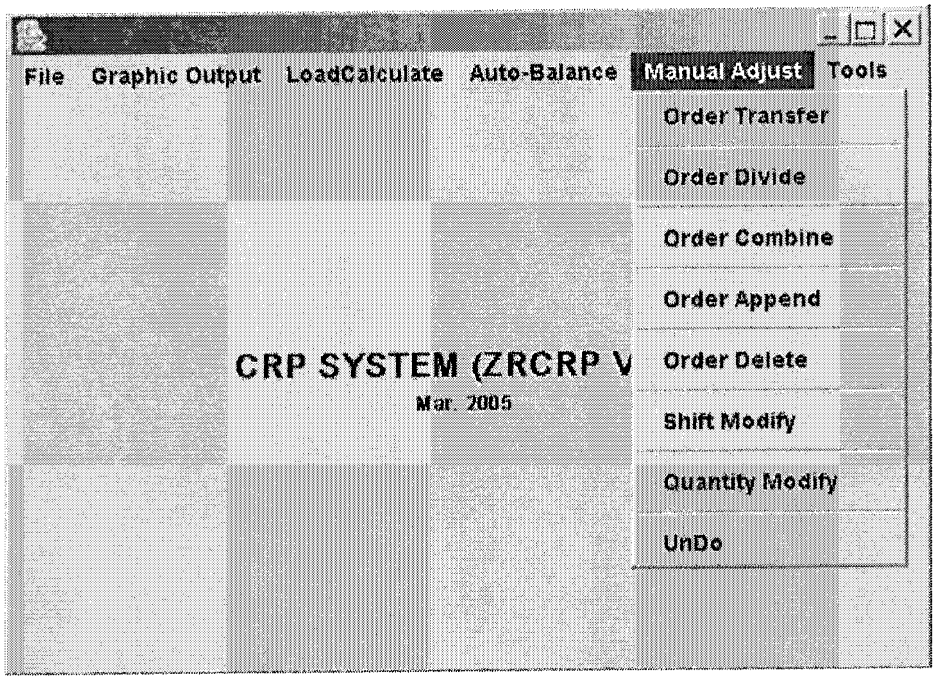
As described in chapter 2, when user logged in correctly, the data input function was performed automatically. So all the data of the data source is read into memory. Then the main frame of the CRP module was shown, as showing in figure 4.2.

Figure 4.2 The main frame of this CRP module.



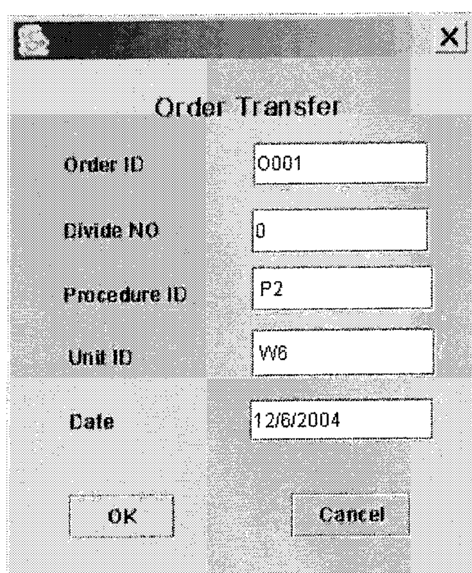
As discussed in chapter 2, this CRP module contains load calculation, auto-balance, manual adjust and data output functions. Each function is corresponding to a menu item in the main frame. The menu items of the manual adjust are displayed in figure 4.3.

Figure 4.3 The menu items of the manual adjust operations.



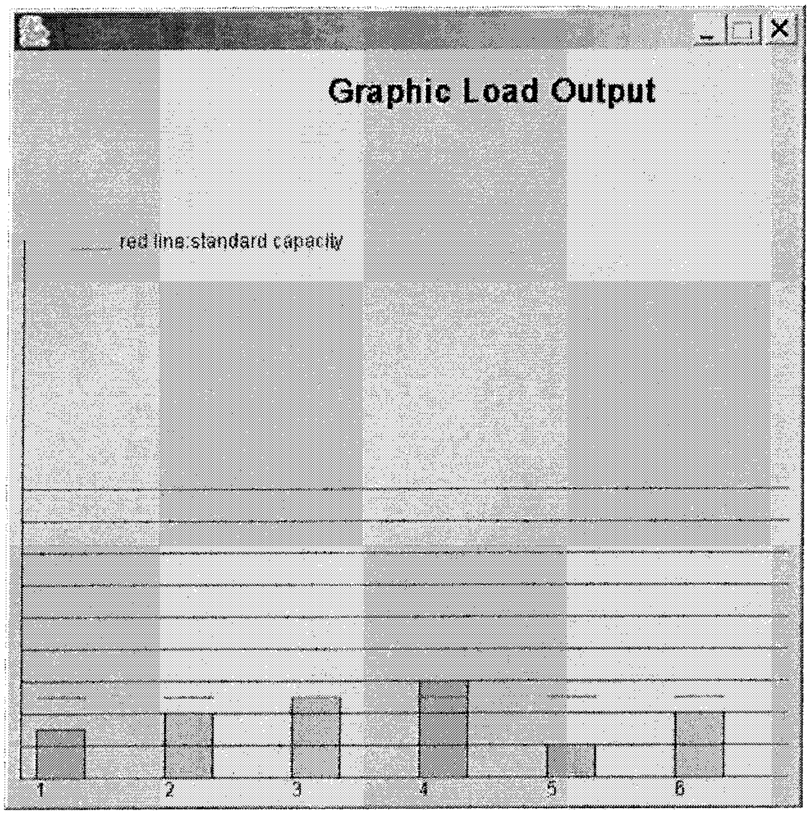
Here we give an example of the order transferring operation for illustration.

Figure 4.4 The order transference operation.



For the load information output, the graphic display is more legible, visual and dynamic. Figure 4.4 is the graphic result of the implementation.

Figure 4.5 The graphic output of the load.



CONCLUSION

Materials Requirements Planning is a new information system program and its rather simple mission was to schedule manufacturing processes to meet customer needs as laid out in a Master Production Schedule (MPS). The MPS come from the individual product forecasts and is intended to ensure that customers get what they want in a timely fashion. A problem arose early on, however, the MPS might not be feasible with available capacity. The MPS might call for more units to be produced in a period than the factory could handle. The simple solution is to move some of the production to an earlier or later time period. This required an understanding of customer requirements and capacity restrictions. Critical customers would have to be moved to earlier periods to avoid a stock-out that could damage important relationships. Capacity Requirements Planning (CRP) is added to further enhance MRP and allow for complete and feasible scheduling of manufacturing lines.

In this paper I introduced the requirements analysis, the detail design and the implementation of the CRP module. The load calculation is performed by taking into account of the planned orders in the posterior planning function (FCS) to achieve the calculation more accurate. The load auto-balance function is designed to enable verifying the feasibility of the planning by the means of comparing the added load with its standard capacity of the measure unit. I used the backward load scheduling (infinite) method to perform the load auto-balance function. As shown in chapter 4, I realized the graphic load displaying. In chapter 2, I also described the manual adjust operations. The purpose of these operations is to offer the manual means to adjust the planning.

The class descriptions in chapter 3 explicitly describe the functions involved in the load calculation, the auto-balance and the manual adjust functions. Class declarations and access are also listed here. Public and private functions and data members ensure that data is not accidentally changed by some outside source.

Design of the CRP module is based on the principles of Object Oriented Design and Object Oriented Programming (OOD/OOP). To further facilitate this all code is written using Java. This language was also chosen based on the ease of extensibility of completed code.

In conclusion I believe this implementation of the CRP module to be a big step in ZRERP system. Many and varied ERP systems may be evaluated to do the same job.

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APPENDIX A

CLASS TABLE

Class Name	Description
ZRCRPTask	The interface class of GUI
ZRConnection	Connecting to data source
ZRLogin	Logging in this Module
ZRDataInput	Reading the data into memory
ZRLoadCalcul	Calculating the load and doing the auto-balance
ZRManualAdjust	The interface to do manual adjust
ZRDataOutput	Output the data
ZRLogout	Logging out
ZROrderDelete	Deleting the specified order
ZRLoadTransfer	Transferring the load
ZRShiftChg	Modifying the shift
ZROrderDivide	Dividing the order
ZROrderUnite	Combining the order
ZROrderAppend	Append the order
ZRDayOffAppend	Append the day-off
CalendarDB	The interface of CalendarDBImpl
CalendarDBImpl	Operating the calendar table
CalendarRecord	Storing the calendar record
ChargeDB	The interface of the ChargeDBImpl
ChargeDBImpl	Operating the charge table
ChargeRecord	Storing the charge record
MachineDB	The interface of MachineDBImpl
MachineDBImpl	Operating the machine table
MachineRecord	Storing the machine record
FactoryDB	The interface of FactoryDBImpl
FactoryDBImpl	Operating the facility table
FactoryRecord	Storing the facility record
MnfOrderDB	The interface of MnfOrderDBImpl
MnfOrderDBImpl	Operating the manufacturing order table

MnfOrderRecord	Storing the manufacturing order record
MnfOrderDivideDB	The interface of MnfOrderDivideDBImpl
MnfOrderDivideDBImpl	Operating the manufacturing order detail table
MnfOrderDivideRecord	Storing the manufacturing order detail record
PartDB	The interface of PartDBImpl
PartDBImpl	Operating the component table
PartRecord	Storing the component table
ProduceableTimeDB	The interface of ProduceableTimeDBImpl
ProduceableTimeDBImpl	Operating the producible time table
ProduceableTimeRecord	Storing the producible time record
SequenceDB	The interface of SequenceDBImpl
SequenceDBImpl	Operating the process sequence table
SequenceRecord	Storing the process sequence record
WorkOrderDB	The interface of WorkOrderDBImpl
WorkOrderDBImpl	Operating the work order table
WorkOrderRecord	Storing the work order record
WorkCenterDB	The interface of WorkCenterDBImpl
WorkCenterDBImpl	Operating the work center table
WorkCenterRecord	Storing the work center record
WorkingProcedureDB	The interface of WorkingProcedureDBImpl
WorkingProcedureDBImpl	Operating the process table
WorkingProcedureRecord	Storing the process record
ValidSequenceDB	The interface of the ValidSequenceDBImpl
ValidSequenceDBImpl	Operating the valid process sequence table
ValidSequenceRecord	Storing the valid process sequence record
WorkCenterDay	Storing the information of the work center by day
WorkCenterWeek	Storing the information of the work center by week
MachineDay	Storing the information of the work machine by day
MachineWeek	Storing the information of the work machine by week
ZRException	The exceptions defined in this module.

CErrorNumber	Contains all errors' number
ZRComm	The common class
ZRMachine	Storing the machine's information
ZRWorkcenter	Storing the center's information
ZRParamFile	Reading the configuration file.
ZRProcess	Storing the information of a process
UndoList	Performing Undo operation.

APPENDIX B

LOAD CALCULATION SOURCE CODE

```
/**
    * the load calculation function
    */
public   void     loadCalcul() {

      Enumeration e = this.htMnfOrderNew.keys();

      while(e.hasMoreElements())
      {
        MnfOrderRecord                                    order                                    =
(MnfOrderRecord)(this.htMnfOrderNew.get(e.nextElement()));
        String partID = order.getPartID();

        // get manufacture order details
        String orderID = order.getOrderID();

        MnfOrderDivideRecord                              orderDetail                              =
(MnfOrderDivideRecord)(this.htMnfOrderDivid.get(orderID + "0"));

       if (orderDetail == null) {
           System.out.println(logDate.toString()+":ManufacturingOrder
Table :OrderId="+orderID+":There is no corresponding data in the ManufacturingOrder
Detail Table .\r\n");
       }

        Date orderEst = orderDetail.getEstDate();
        Date orderDeliverDate = orderDetail.getDeliverDate();

        Date      planLastDay      =      new      Date(this.datePlanBase.getTime()      +
this.intPlanDucration*3600*1000*24);


        if(!orderEst.before(this.datePlanBase) && orderEst.before(planLastDay))
        {
        int number = orderDetail.getQuantity();
```

```
        // get sequence and process ID
        TreeSet sequence_s = (TreeSet)this.htAssistSequence.get(partID);
        Iterator i = sequence_s.iterator();

        Vector procedures = new Vector();

        // for each sequence, generate procedure
        while(i.hasNext())
        {
          SequenceRecord sequence = (SequenceRecord) i.next();

          //if the sequence is valid
          boolean isNotValid = true;

          String sequenceid = sequence.getSequenceID();
          TreeSet    validSequenceTS    =    (TreeSet)this.htValidSequence.get(partID    +
sequenceid);
          Vector validSequenceVecotr = new Vector(validSequenceTS);
//          System.out.println(validSequenceVecotr.size());

          Date submitDate = orderDetail.getDeliverDate();
          int num = 0;
          boolean isFind = false;

          while (!isFind && num<validSequenceVecotr.size())
          {
            ValidSequenceRecord                    validSequence                    =
(ValidSequenceRecord)validSequenceVecotr.elementAt(num);
            if(submitDate.after(validSequence.getValidStartDate()))
            {
              if(num == validSequenceVecotr.size() -1)
              {

                isNotValid = validSequence.getIsValid();
                isFind = true;
              }
              else
              {
                ValidSequenceRecord                validSequenceNext                =
(ValidSequenceRecord)validSequenceVecotr.elementAt(num+1);
                if(submitDate.before(validSequenceNext.getValidStartDate()))
                {
                  isNotValid = validSequence.getIsValid();
```

```
                    isFind = true;
                  }
                }//end if reach end

              }//end if after the current date
              num = num + 1;
            }//end while

            if(isNotValid)
            {
             System.out.println(logDate.toString()+":The process is not in the valid
period.\r\n");
            }

            if(!isNotValid)
            {
/*
              //get work procedure infomation
              String workProcedureID = sequence.getWkProcedureID();
              WorkingProcedureRecord wkProcedure =
(WorkingProcedureRecord)this.htWorkProcedure.get(partID + workProcedureID);
              String workcenterID = wkProcedure.getShopID();

              // get produceable table
              String sequenceID = sequence.getSequenceID();
              ProduceableTimeRecord produceable =
(ProduceableTimeRecord)this.htProduceableTime.get(partID + sequenceID +
workcenterID);
*/
              //get produceable table, new
              ProduceableTimeRecord produceable = null;
              String workcenterID = null;

              String sequenceID = sequence.getSequenceID();
              Hashtable produceableWorkcenter =
(Hashtable)this.htProduceableTime.get(partID + sequenceID);
              if(produceableWorkcenter == null)
              {
                 System.out.println(logDate.toString()+":Routing
Table :RoutingId="+sequenceID+":There is no corresponding workcenter in the
ProducibleTime Table .\r\n");
              }
              else
              {
```

```
                    Enumeration workcenters = produceableWorkcenter.keys();
                    boolean isFind2 = false;
                    while(workcenters.hasMoreElements() && !isFind2)
                    {
                      workcenterID = (String)workcenters.nextElement();
                      TreeSet                    workcenterInfo                    =
(TreeSet)produceableWorkcenter.get(workcenterID);
                      Vector vWorkcenterInfo = new Vector(workcenterInfo);

                      int num2 = 0;
                      boolean isInThisShop = false;
                      boolean isNotValid2 = true;

                      while(!isInThisShop && num2<vWorkcenterInfo.size())
                      {
                        ProduceableTimeRecord               currentRecord               =
(ProduceableTimeRecord)vWorkcenterInfo.get(num2);
                        if(num2 == vWorkcenterInfo.size() - 1)
                        {
                          if(!orderDeliverDate.before(currentRecord.getValidStartDate()))
                          {
                            produceable = currentRecord;
                            isNotValid2 = currentRecord.getisValid();
                            isInThisShop = true;
                          }
                          else
                          {
                            isInThisShop = false;
                          }//end if the deliver date is after the last record's begin date
                        }
                        else
                        {
                          ProduceableTimeRecord               nextRecord               =
(ProduceableTimeRecord)vWorkcenterInfo.get(num2 + 1);
                          if(!orderDeliverDate.before(currentRecord.getValidStartDate())   &&
orderDeliverDate.before(nextRecord.getValidStartDate()))
                          {
                            produceable = currentRecord;
                            isNotValid2 = currentRecord.getisValid();
                            isInThisShop = true;
                          }
                          else
                          {
```

```
                        isInThisShop = false;
                      }
                    }//end if reach the last record
                    num2 = num2 + 1;
                  }//end while judge if in this shop
                  if(isInThisShop && !isNotValid2)
                  {
                    isFind2 = true;
                  }
                  else
                  {

                  }
                }//end while all workcenters
                if(!isFind2)
                {
                  produceable = null;
                }
              }//end if produceableWorkcenter == null

              // calculate the procedure's total time
//                                              WorkShopRecord     workcenter     =
(WorkShopRecord)this.htWorkShop.get(workcenterID);
              if(workcenterID == null || produceable == null)
              {
                System.out.println(logDate.toString()+":There     is     no     corresponding
WorkCenter in the WorkCenter Table .\r\n");
              }
              else
              {

                WorkShopRecord                    workcenter                    =
(WorkShopRecord)this.htWorkShop.get(workcenterID);

                char type = (char)workcenter.getCalculateType();
//                System.out.println("flaskjdfasdjfkasdf");
                double totalTime = 0.0;
                if(type == 'L')
                {
                  totalTime = produceable.getLt();
                  totalTime = totalTime + produceable.getAbundantTime();
                }
                else if(type == 'S')
                {
```

```
                    totalTime = produceable.getSt() * number;
                    totalTime = totalTime + produceable.getAbundantTime();
                }
                else
                {
                    //throw                                                              new
ZRException(CErrorNumber.CALCULATE_TYPE_ERROR);
                    System.out.println(logDate.toString()+":Calculate Type error.\r\n");
                }
//                  System.out.println("flaskjdfasdjfkasdf");
                ZRWorkProcedure                 pro                =                 new
ZRWorkProcedure(order.getOrderID(),orderDetail.getDivideNO(),order.getPartID(),orderD
etail.getQuantity(),sequence.getWkProcedureID(),sequence.getSequenceID(),sequence.get
Sequence(),workcenterID,totalTime);
//                  System.out.println("flaskjdfasdjfkasdf");
                procedures.add(pro);
//                  System.out.println("flaskjdfasdjfkasdf");
              }
            }
            else
            {
              //the sequence is not valid
            }
        }//end search in all sequence belong to this order
        //calculate LFT and EST
        Date lft = orderDetail.getLftDate();
        Date est = orderDetail.getEstDate();
        int n = procedures.size();
        if(procedures.size() == 0)
        {
         // throw new ZRException(CErrorNumber.PROCEDURE_SPREAD_FAILED);
         System.out.println(logDate.toString()+":Procedure spread error.\r\n");
        }
        else
        {

          ZRWorkProcedure pro = (ZRWorkProcedure)procedures.get(0);
          pro.setEST(est);
          for (int j = 1; j < n ; j++)
          {
            ZRWorkProcedure pro_prev = (ZRWorkProcedure)procedures.get(j-1);
            ZRWorkProcedure pro_curr = (ZRWorkProcedure)procedures.get(j);
            long prev_time = pro_prev.getEST().getTime();
            prev_time = prev_time + (int)(pro_prev.getTotalTime()*1000);
```

```
            Date curr_date = new Date(prev_time);
            pro_curr.setEST(curr_date);

        }

        pro = (ZRWorkProcedure)procedures.get(n-1);
        pro.setLFT(lft);
        for(int j = n-2; j>=0; j--)
        {
            ZRWorkProcedure pro_next = (ZRWorkProcedure)procedures.get(j+1);
            ZRWorkProcedure pro_curr = (ZRWorkProcedure)procedures.get(j);
            long next_time = pro_next.getLFT().getTime();
            next_time = next_time - (int)(pro_next.getTotalTime()*1000);
            Date curr_date = new Date(next_time);
            pro_curr.setLFT(curr_date);
            }

        //add load process
        String unitID = "";
        Date start = null;
        Date end = null;
        String taskID = "";
        double totalTime = 0;
        String mnfOrderID = "";
        int devideNum = 0;
            for(int j = 0; j < n; j++)
        {
            pro = (ZRWorkProcedure)procedures.get(j);
            this.htAllProcedure.put(pro.getOrderID()     +     pro.getOrderDividNo()     +
pro.getProcID(),pro);
            this.htProForSearch.put(pro.getOrderID()     +     pro.getOrderDividNo()     +
pro.getSequenceID(),pro);
            String workcenterID = pro.getWorkcenter();
                if(this.intCapacityUnit == 1 && this.strPlanUint.equals("R"))
            {
                TreeSet tsMachine = (TreeSet)htAssistMachine.get(workcenterID);
                if (tsMachine == null) {
                    System.out.println(logDate.toString()+":There is no machine in this
workcenter: workcenterID="+workcenterID+" .\r\n");
                }

                int machineNum = tsMachine.size();
                Vector vMachine = new Vector(tsMachine);
                Date     theDate     =     new     Date(pro.getLFT().getTime()     -
```

```
(pro.getLFT().getTime())%(24*3600*1000) - this.TIME_ZONE*3600*1000);
                Date     lastDay     =     new     Date(this.datePlanBase.getTime()     +
this.intPlanDucration*24*3600*1000);
                if(theDate.after(lastDay) || theDate.equals(lastDay))
                {
                  theDate = new Date(lastDay.getTime() - 24*3600*1000);
                }

                //get the latest unit, if standard capacity lower than current load
                EquipmentRecord                         lastMachine                         =
(EquipmentRecord)vMachine.get(machineNum -1);
                String lastMachineID = lastMachine.getEquipmentID();
                ZRMachine                         lastZRMachine                         =
(ZRMachine)this.htMachine.get(lastMachineID);
                MachineDay                         lastMachineDay                         =
(MachineDay)((Hashtable)lastZRMachine.getDayHT()).get(lastMachineID                         +
theDate.toString());

                if(lastMachineDay.getCurrentLoad()                                         >
lastMachineDay.getStandardCapacity())
                {
                  //add the procedure to the first unit
                  EquipmentRecord machine = (EquipmentRecord)vMachine.get(0);
                  String machineID = machine.getEquipmentID();
                  ZRMachine zrMachine = (ZRMachine)this.htMachine.get(machineID);
                  MachineDay                         machineDay                         =
(MachineDay)((Hashtable)zrMachine.getDayHT()).get(machineID + theDate.toString());

                  pro.setMachine(machineID);
                  Integer seq = new Integer(pro.getSequence());
                  String sequence = seq.toString();
                  String temp = "";
                  for(int nu = 0; nu< 5-sequence.length();nu++)
                  {
                    temp = temp + "0";
                  }
                  sequence = temp + sequence;

                  String strTaskID = pro.getPartsID() + "_" + pro.getMachine() + "_" +
ZRComm.date2String(pro.getLFT()) + sequence;
                  pro.setTaskID(strTaskID);

                  machineDay.addLoad(pro);
```

```
        //out put the infomation
       unitID = machineID;
       start = machineDay.getCalDate();
       end = new Date(machineDay.getCalDate().getTime() + 24*3600*1000 -1);
       taskID = "undefined";
       totalTime = pro.getTotalTime();
       mnfOrderID = orderID;
       devideNum = 0;
     }
     else
     {
       boolean flag = true;
       Enumeration eMachine = vMachine.elements();
       while(eMachine.hasMoreElements() && flag)
       {
         EquipmentRecord                    machine                    =
(EquipmentRecord)eMachine.nextElement();
         String machineID = machine.getEquipmentID();
         ZRMachine zrMachine = (ZRMachine)this.htMachine.get(machineID);
         MachineDay                    machineDay                    =
(MachineDay)((Hashtable)zrMachine.getDayHT()).get(machineID + theDate.toString());
         if(machineDay.getStandardCapacity() >= machineDay.getCurrentLoad())
         {

           pro.setMachine(machineID);
         Integer seq = new Integer(pro.getSequence());
         String sequence = seq.toString();
         String temp = "";
         for(int nu = 0; nu< 5-sequence.length();nu++)
         {
           temp = temp + "0";
         }
         sequence = temp + sequence;

         String strTaskID = pro.getPartsID() + "_" + pro.getMachine() + "_" +
ZRComm.date2String(pro.getLFT()) + sequence;
         pro.setTaskID(strTaskID);

           machineDay.addLoad(pro);

           unitID = machineID;
           start = machineDay.getCalDate();
           end = new Date(machineDay.getCalDate().getTime() + 24*3600*1000
- 1);
```

```
                    taskID = "undefined";
                    totalTime = pro.getTotalTime();
                    mnfOrderID = orderID;
                    devideNum = 0;

                    flag = false;
                  }
                  else
                  {
                    flag = true;
                  }
                }
              }
            }
            else if(this.intCapacityUnit == 1 && this.strPlanUint.equals("W"))
            {
              ZRWorkcenter workcenter =
(ZRWorkcenter)this.htWorkCenter.get(workcenterID);
              if ( workcenter == null) {
                System.out.println(logDate.toString()+":There is no corresponding
workcenter.\r\n");
              }
              Date theDate = new Date(pro.getLFT().getTime() -
(pro.getLFT().getTime())%(24*3600*1000) - this.TIME_ZONE*3600*1000);

              Date lastDay = new Date(this.datePlanBase.getTime() +
this.intPlanDucration*24*3600*1000);
              if(theDate.after(lastDay) || theDate.equals(lastDay))
              {
                theDate = new Date(lastDay.getTime() - 24*3600*1000);
              }
//              System.out.println(theDate.toString() + pro.getLFT());
              Hashtable htWorkcenterDay = workcenter.getDayHT();


              Integer seq = new Integer(pro.getSequence());
                  String sequence = seq.toString();
                  String temp = "";
                  for(int nu = 0; nu< 5-sequence.length();nu++)
                  {
                    temp = temp + "0";
                  }
                  sequence = temp + sequence;
```

```
                    String strTaskID = pro.getPartsID() + "_" + pro.getWorkcenter() + "_" +
ZRComm.date2String(pro.getLFT()) + sequence;
                    pro.setTaskID(strTaskID);

                ((WorkcenterDay)htWorkcenterDay.get(workcenterID                      +
theDate.toString())).addLoad(pro);

                //out put the infomation
                  unitID = workcenterID;
                  start     =      ((WorkcenterDay)htWorkcenterDay.get(workcenterID       +
theDate.toString())).getCalDate();
                  end = new Date(start.getTime() + this.intCapacityUnit*24*3600*1000 -1);
                  taskID = "undefined";
                  totalTime = pro.getTotalTime();
                  mnfOrderID = orderID;
                  devideNum = 0;
              }
              else if(this.intCapacityUnit == 7 && this.strPlanUint.equals("R"))
              {
                TreeSet tsMachine = (TreeSet)htAssistMachine.get(workcenterID);
                if (tsMachine == null) {
                 System.out.println(logDate.toString()+":There   is   no   machine   in   this
workcenter: workcenterID="+workcenterID+" .\r\n");
                }
                int machineNum = tsMachine.size();
                Vector vMachine = new Vector(tsMachine);
                long          weekNum          =          (pro.getLFT().getTime()           -
this.datePlanBase.getTime())/(this.intCapacityUnit*24*3600*1000);
                Date  theDate  =  new  Date(this.datePlanBase.getTime()  +  weekNum  *
(this.intCapacityUnit*24*3600*1000));

                Date      lastDay      =      new      Date(this.datePlanBase.getTime()      +
this.intPlanDucration*24*3600*1000);
                if(theDate.after(lastDay))
                {
                  weekNum = this.intPlanDucration/this.intCapacityUnit;
                  theDate  =  new  Date(this.datePlanBase.getTime()  +  weekNum  *
(this.intCapacityUnit*24*3600*1000));
                }

                //get the latest unit, if standard capacity lower than current load
                EquipmentRecord                     lastMachine                          =
(EquipmentRecord)vMachine.get(machineNum -1);
                String lastMachineID = lastMachine.getEquipmentID();
```

```
            ZRMachine                    lastZRMachine                    =
(ZRMachine)this.htMachineWeek.get(lastMachineID);

            MachineWeek                  lastMachineWeek                  =
(MachineWeek)((Hashtable)lastZRMachine.getWeekHT()).get(lastMachineID     +
theDate.toString());

            if(lastMachineWeek.getCurrentLoad()                           >
lastMachineWeek.getStandardCapacity())
            {
              //add the procedure to the first unit
              EquipmentRecord machine = (EquipmentRecord)vMachine.get(0);
              String machineID = machine.getEquipmentID();
              ZRMachine                      zrMachine                    =
(ZRMachine)this.htMachineWeek.get(machineID);
              MachineWeek                    machineWeek                  =
(MachineWeek)((Hashtable)zrMachine.getWeekHT()).get(machineID             +
theDate.toString());

              pro.setMachine(machineID);
                Integer seq = new Integer(pro.getSequence());
                String sequence = seq.toString();
                String temp = "";
                for(int nu = 0; nu< 5-sequence.length();nu++)
                {
                  temp = temp + "0";
                }
                sequence = temp + sequence;

                String strTaskID = pro.getPartsID() + "_" + pro.getMachine() + "_" +
ZRComm.date2String(pro.getLFT()) + sequence;
                pro.setTaskID(strTaskID);

              machineWeek.addLoad(pro);

              //out put the infomation
              unitID = machine.getEquipmentID();
              start = machineWeek.getCalDate();
              end = new Date(start.getTime() + this.intCapacityUnit*24*3600*1000 -1);
              taskID = "undefined";
              totalTime = pro.getTotalTime();
              mnfOrderID = orderID;
              devideNum = 0;
            }
```

```
        else
        {
          boolean flag = true;
          Enumeration eMachine = vMachine.elements();
          while(eMachine.hasMoreElements() && flag)
          {
            EquipmentRecord                    machine                    =
(EquipmentRecord)eMachine.nextElement();

            String machineID = machine.getEquipmentID();
            ZRMachine                          zrMachine                  =
(ZRMachine)this.htMachineWeek.get(machineID);
            MachineWeek                        machineWeek                =
(MachineWeek)((Hashtable)zrMachine.getWeekHT()).get(machineID             +
theDate.toString());
            if(machineWeek.getStandardCapacity()                          >=
machineWeek.getCurrentLoad())
            {
              pro.setMachine(machineID);
            Integer seq = new Integer(pro.getSequence());
            String sequence = seq.toString();
            String temp = "";
            for(int nu = 0; nu< 5-sequence.length();nu++)
            {
              temp = temp + "0";
            }
            sequence = temp + sequence;

            String strTaskID = pro.getPartsID() + "_" + pro.getMachine() + "_" +
ZRComm.date2String(pro.getLFT()) + sequence;
            pro.setTaskID(strTaskID);
              machineWeek.addLoad(pro);
             unitID = machine.getEquipmentID();
            start = machineWeek.getCalDate();
            end = new Date(start.getTime() + this.intCapacityUnit*24*3600*1000
-1);
            taskID = "undefined";
            totalTime = pro.getTotalTime();
            mnfOrderID = orderID;
            devideNum = 0;
              flag = false;
            }
            else
            {
```

```
                flag = true;
            }
        }
    }
}
else if(this.intCapacityUnit == 7 && this.strPlanUint.equals("W"))
{

    ZRWorkcenter workcenter =
(ZRWorkcenter)this.htWorkCenterWeek.get(workcenterID);

    System.out.println(logDate.toString()+":There is no corresponding workcenter.
\r\n");

    long weekNum = (pro.getLFT().getTime() -
this.datePlanBase.getTime())/(this.intCapacityUnit*24*3600*1000);
    Date theDate = new Date(this.datePlanBase.getTime() + weekNum *
(this.intCapacityUnit*24*3600*1000));

    Date lastDay = new Date(this.datePlanBase.getTime() +
this.intPlanDucration*24*3600*1000);
    if(theDate.after(lastDay))
    {
      weekNum = this.intPlanDucration/this.intCapacityUnit;
      theDate = new Date(this.datePlanBase.getTime() + weekNum *
(this.intCapacityUnit*24*3600*1000));
    }

    Hashtable htWorkcenterWeek = workcenter.getWeekHT();
        Integer seq = new Integer(pro.getSequence());
        String sequence = seq.toString();
        String temp = "";
        for(int nu = 0; nu< 5-sequence.length();nu++)
        {
          temp = temp + "0";
        }
        sequence = temp + sequence;

        String strTaskID = pro.getPartsID() + "_" + pro.getWorkcenter() + "_" +
ZRComm.date2String(pro.getLFT()) + sequence;
        pro.setTaskID(strTaskID);
    ((WorkcenterWeek)htWorkcenterWeek.get(workcenterID +
theDate.toString())).addLoad(pro);
```

```
                    unitID = workcenterID;
                    start = theDate;
                    end = new Date(start.getTime() + this.intCapacityUnit*24*3600*1000
-1);
                    taskID = "undefined";
                    totalTime = pro.getTotalTime();
                    mnfOrderID = orderID;
                    devideNum = 0;
                }
                else
                {

                }
            }//end add load process
            }
            }//end if the order is in the term
            else
            {
             //the order is out of range
             System.out.println("The Order is out of range. orderID="+orderID+"\r\n");
            }
        }//end search in all the orders
    }
```