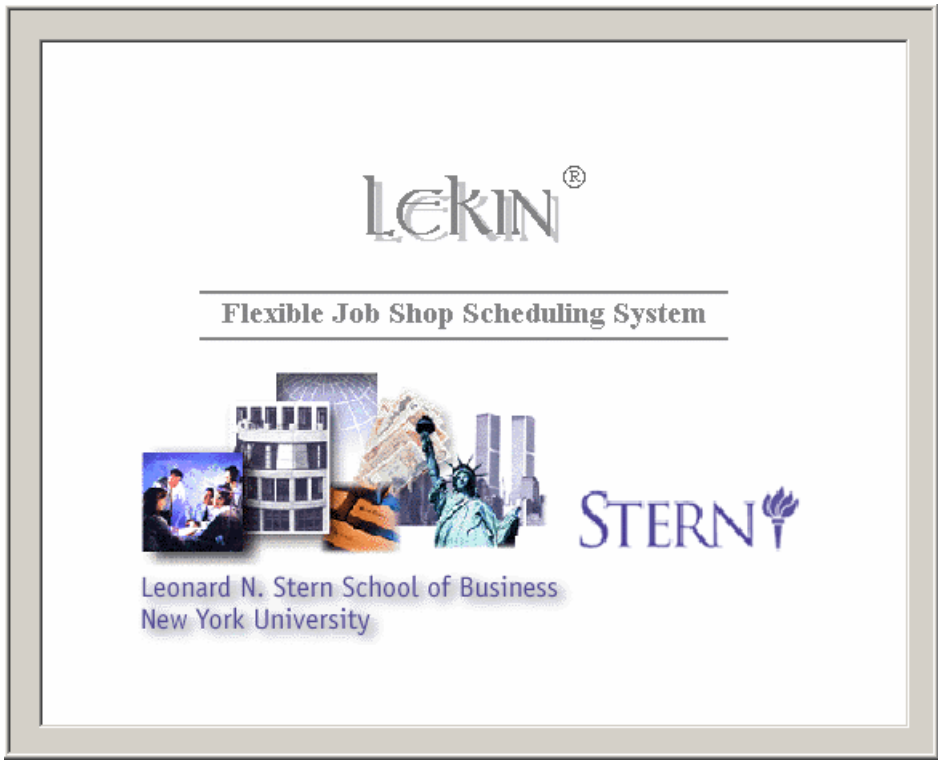
Basic notes for scheduling with the LEKIN software



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1. Introduction

LEKIN is educational software for production scheduling developed by Prof. Michael Pinedo (New York University), among others. The demo version that is explained here can be freely distributed and has some limitations regarding the number of jobs and machines of the problem. LEKIN can be downloaded from http://www.stern.nyu.edu/om/software/lekin/

This handout does not intend to be a comprehensive description of the software, but briefly outline the basic steps for using it. Therefore, many of the features of the software are not described here. LEKIN is described in detail in the Help files accompanying the software.

2. Main menu and toolbar

The main menu and toolbar of LEKIN is shown in figure 1.

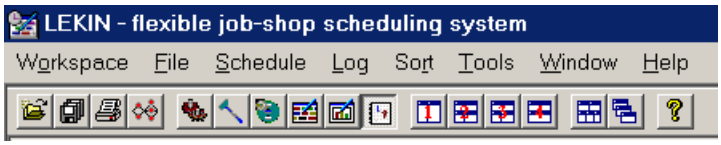

Figure 1. Main menu and toolbar

The description of the main buttons of the toolbar is given in table 1.

	Open a new problem
	Save problem data
	Print all data
	Select the workspace type (see Subsection 3.1. 'Entering a framework')
	Show/focus the Machine Park window (see Subsection 3.2. 'Entering the jobs and machines')
	Show/focus the Job Pool window (see Subsection 3.2. 'Entering the jobs and machines')
	Show/focus the sequence window (see Subsection 4.4. 'Examining the schedules')
	Show/focus the Gantt chart window (see Subsection 4.3. ‘Gantt charts')
	Show/focus the objective window (see Section 5 ‘Measuring the schedules’)
	Several options regarding the number of windows to simultaneously show
	Tile/cascade arrangement of windows
	Help

Table 1. Buttons in the main toolbar

3. Basic steps for entering the data of a scheduling problem

3.1. Entering a framework

Once you enter the program, you are prompted to create a new framework or opening an existing one (see figure *2.*). The framework defines the type of scheduling problem (e.g. flow shop, job shop, etc.) that is to be entered.

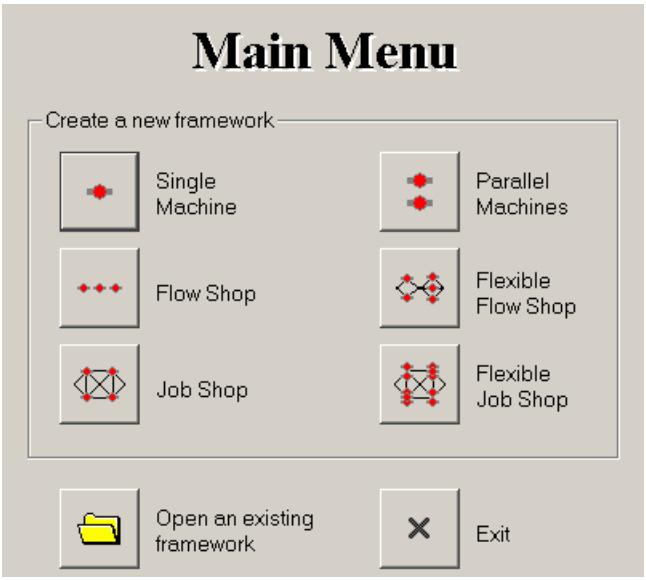

Figure 2. Entering the framework

3.2. Entering the jobs and machines

Once the framework has been selected, the number of machines and jobs is to be specified. A window like the one in figure 3. appears.

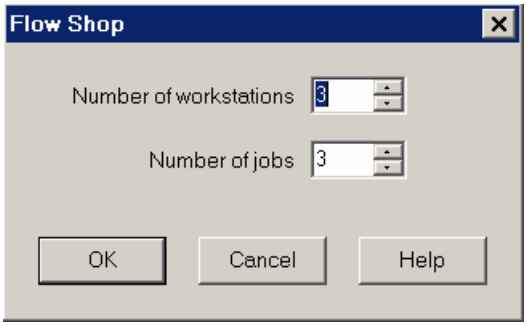

Figure 3. Number of jobs and machines

After entering the number of jobs and machines, a window specifying the main data corresponding to the machines and jobs can be entered (see figure 6.). Alternatively, you can click the “Cancel” button and introduce these data later.

If you click the Cancel button, a screen similar to that in figure 4. may appear. Note the “Machine Park” and the “Job Pool” windows. A description of the menu and main toolbar is given in Section 3.

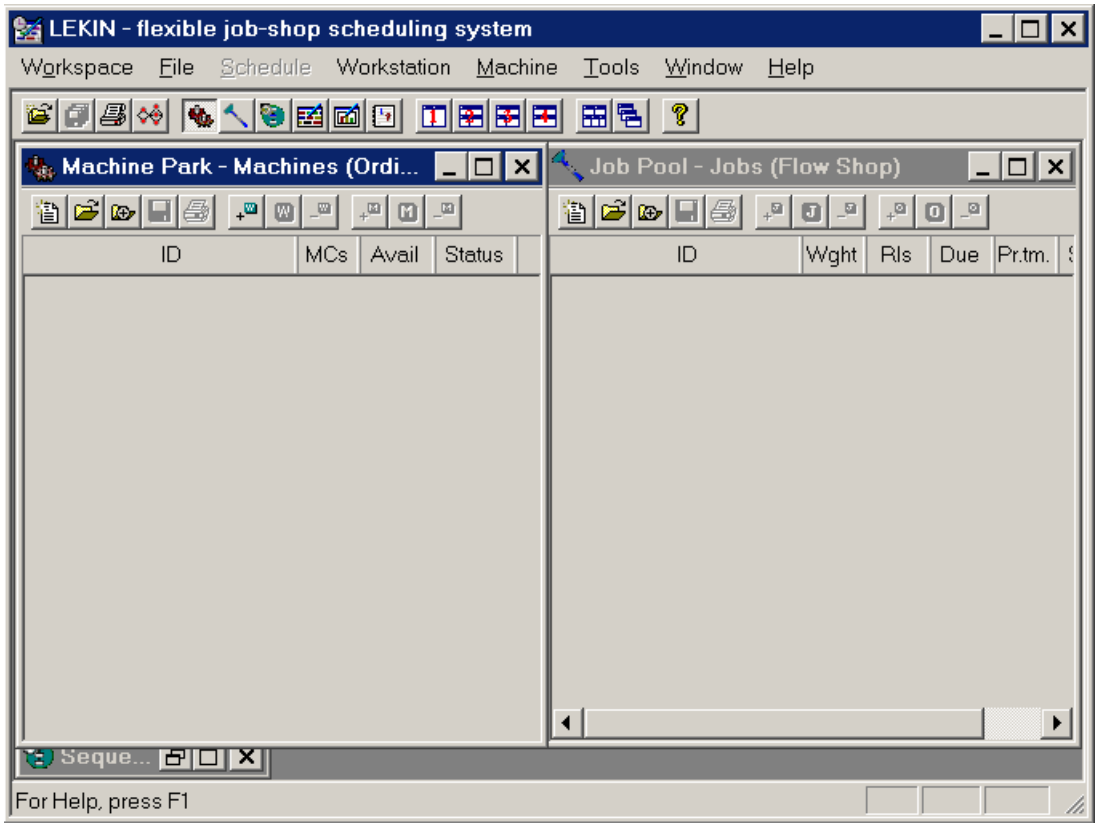

Figure 4. Main LEKIN screen

Next step is entering the machine data. For that, you may focus on the Machine Park window and specify the main data corresponding to the machines. You can do this with the Machine Park toolbar (see figure 5.). The meaning of the main buttons are described in Table 2.

Figure 5. Machine Park toolbar

	Clear machine data
	Open machine file (file *.mch, see Section 0 ‘Data files in LEKIN’)
	Append machines to the existing ones
	Save machine data (see Section 0 ‘Data files in LEKIN’)
	Print machine data
	Add a machine
	Edits a (previously selected) machine – Also by double clicking the machine
	Delete a machine

Table 2. Buttons in the Machine Park toolbar

When adding or editing a machine, several data have to be added/modified (see figure 6.), including the number of machines (only in the case of parallel machines framework), availability date (zero is default), starting status (whether the machine is available, default is yes), and the setup matrix (only for the cases where setup is specified, see section 6).

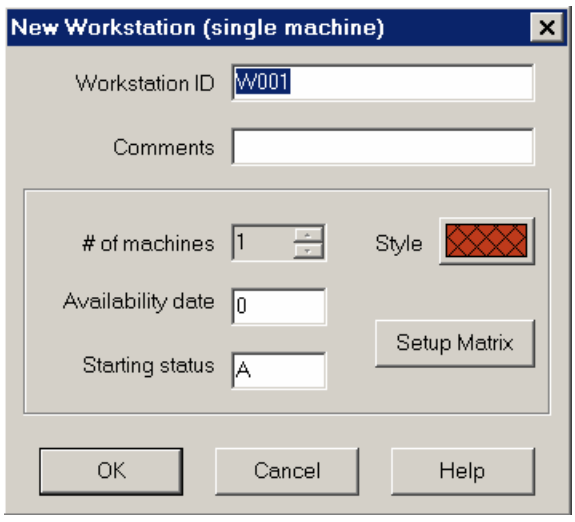

Figure 6. Entering the machine data

After adding the machines, the jobs have to be added. For that, you may focus on the Job Pool window and specify the main data corresponding to the jobs. You can do this with the Job Pool toolbar (see figure 7.). The meaning of the main buttons are described in Table 3.

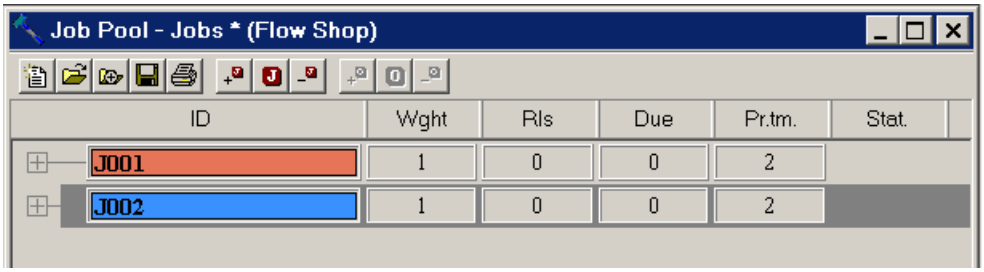

Figure 7. Job Pool toolbar

	Clear job data
	Open job file (see Section 0 ‘Data files in LEKIN’)
	Append jobs to the existing ones
	Save job data (*.job file, see Section 0 ‘Data files in LEKIN’)
	Print job data
	Add a job
	Edits a (previously selected) job – Also by double clicking the job
	Delete a job

Table 3. Buttons in the Job Pool toolbar

When adding or editing a job, several data have to be added/modified (see figure 8.), including the release date, the due date, the weight (relative importance of the job), and the routing matrix. This window may appear slightly different when the framework is a single-machine (see figure 10.).

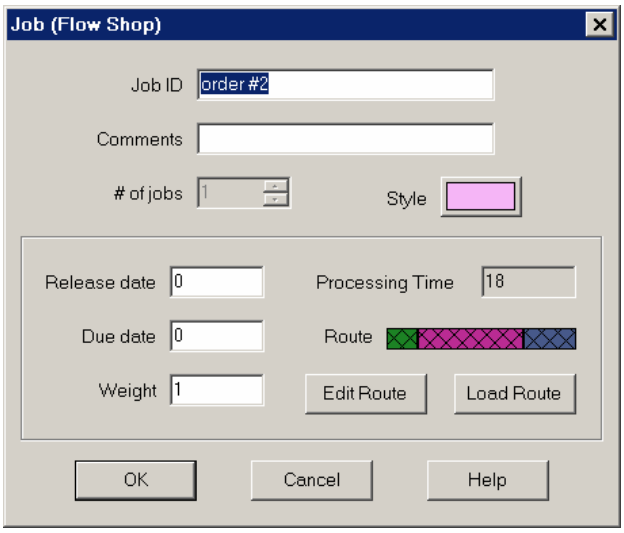

Figure 8. Job Pool toolbar

In order to introduce the data of the routing matrix, you may click the Edit Route button. A window like in figure 9. should appear. In the single-machine case, the processing times are introduced in the job data window as shown in figure 10.

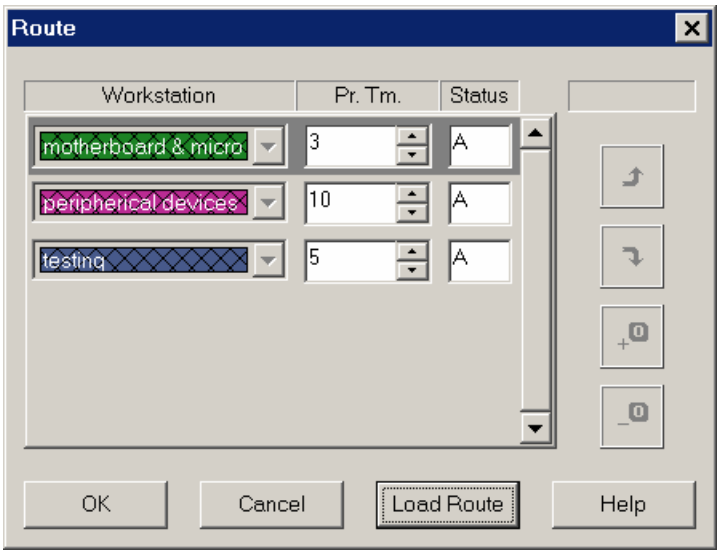

Figure 9. Routing matrix

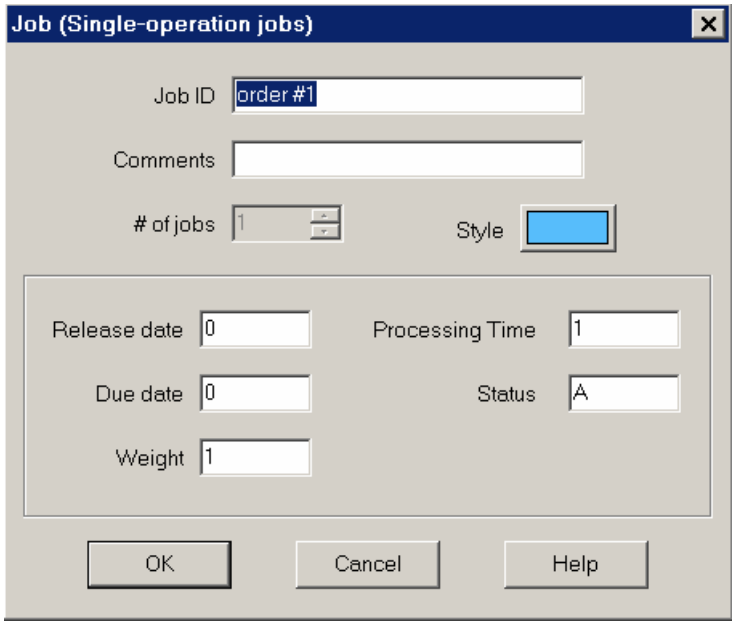

Figure 10. Processing times specification for the single machine case

In the routing matrix, the order in which the job has to visit the different machines can be specified (only for job-shops). Additionally, the processing times (Pr.Tm.) of each job on each machine can be also entered. Finally, the status button is connected to setup considerations, which are addressed in Section 6 ’Introducing setup times in LEKIN’.

4. Scheduling the jobs

4.1. Scheduling rules

Once the relevant data of the problem have been entered (see Section 3), the scheduling process can start. This process is accomplished in LEKIN in the Schedule option in the main menu (see figure 1.). The options are shown in figure 11.

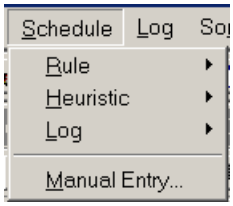

Figure 11. Options in the Schedule menu

- **Rules (Dispatching rule).** The available dispatching rules are:
  - ATCS (a rule similar to WSPT) for the problem of minimizing wT
  - EDD (Earliest Due Date)
  - MS (variation of EDD)
  - FCFS (First Come First Served) – order by release date
  - LPT – Longest Processing Times
  - SPT – Shortest Processing Times
  - WSPT – Weighted Shortest Processing Times

- **Heuristics**

  A number of specific algorithms, including a powerful local search rule that can be used for any objective function.

- **Logs**

  Serves to browse among the schedules generated for the current problem.

- **Manual Entry**

  Allows manually introducing any arbitrary schedule (job by job, machine by machine). The manual entry is described in the next subsection.

4.2. Manual entry of sequences

When the 'Manual Entry' option is selected, a window like the one in figure *12.* may appear.

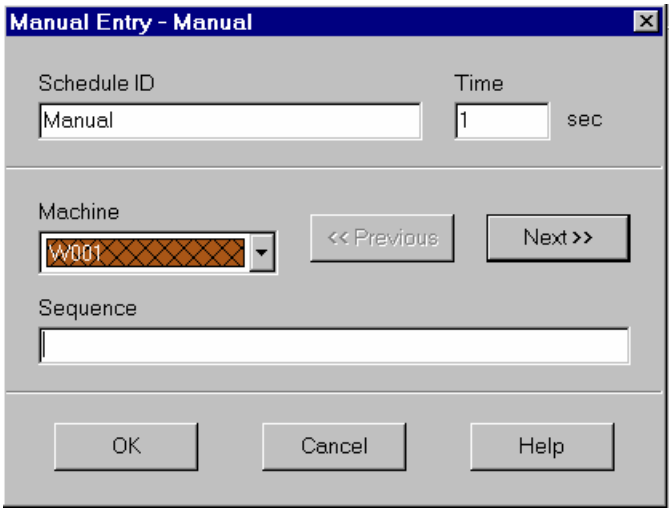

Figure 12. Manual entry window

In this window, the sequence for each machine can be specified by entering the name of the jobs in the field 'Sequence' separated by the character ;. For instance, if the jobs Ids are Job 1, Job 2, and Job 3, a feasible sequence is Job 1;Job 2;Job 3.

Once this is done for the machine selected in the 'Machine' list, the sequence for the next machine can be entered by either selecting a new machine in the 'Machine' list, or by clicking the 'Next' button. The field 'Time' serves to specify the time supposedly taken to obtain the schedule that is manually being entered (this may be useful when a criterion to compare several schedules is the CPU time to get them, see Section 5).

4.3. Gantt charts

Once a schedule has been introduced by any of the above means, the program shows the Gantt chart window corresponding to the schedule (see figure 13.). The meaning of the main buttons of the Gantt chart toolbar is given in table 4.

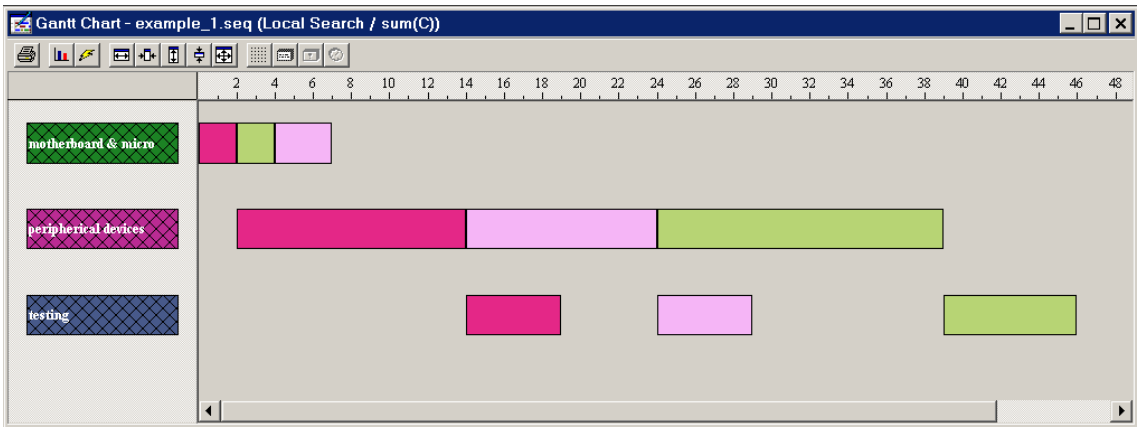

Figure 13. Gantt chart window

	Print Gantt chart
	Opens the multi-objective window in order to open the objective chart window (see Section 5 'Measuring the schedules').
	Show the performance of the schedule with respect to a number of objectives (incl. makespan, tardiness, tardy jobs, etc.)
	Set of buttons to make longer, shorter, wider, thinner, or resize the blocks in the Gantt chart
	Show a grid
	Show the name of the jobs

Table 4. Buttons in the Gantt chart toolbar

4.4. Examining the schedules

The schedule can be also examined in the Sequence Window (see figure 14.), where several relevant data of the schedule are shown. The meaning of the buttons in the toolbar are shown in table 5.

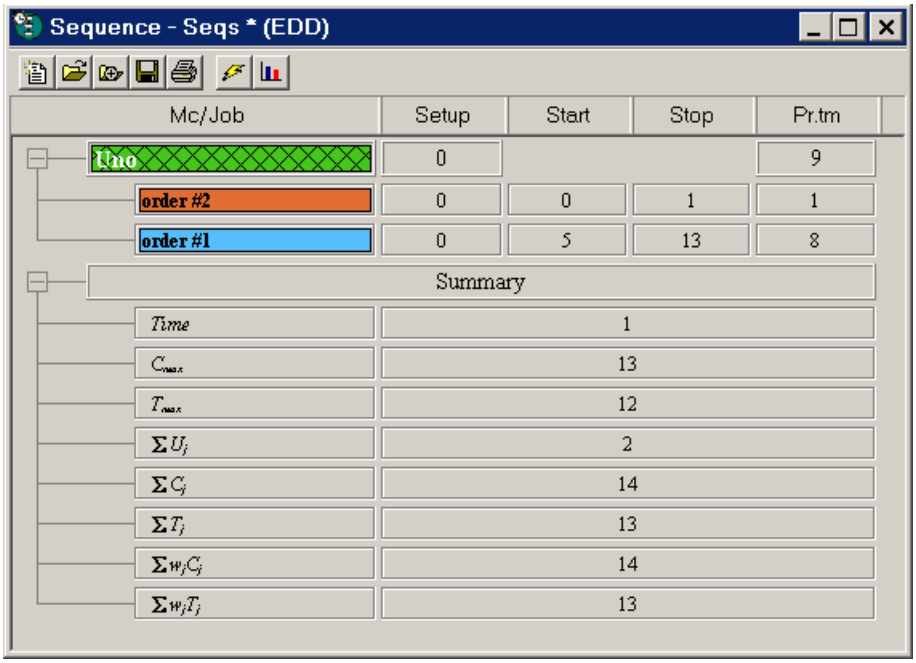

Figure 14. Sequence window

	Clear sequence data
	Open sequence file (see Section 0 'Data files in LEKIN')
	Append sequences to the existing ones
	Save sequence data (*.seq file, see Section 0 'Data files in LEKIN')
	Print sequence data
	Open the multi-objective window in order to select the schedule measures (see Section 5 'Measuring the schedules').
	Show the performance of the schedule with respect to a number of objectives (incl. makespan, tardiness, tardy jobs, etc.)

Table 5. Buttons in the sequence toolbar

5. Measuring the schedules

Once one or more schedules are generated, its/their performance with respect to one or more scheduling objectives can be specified. This is done by clicking the  button either from the Gantt chart window (see Subsection 4.3.) or the sequence window (see Subsection 4.4.). By doing this, a window like the one in figure 15. appears.

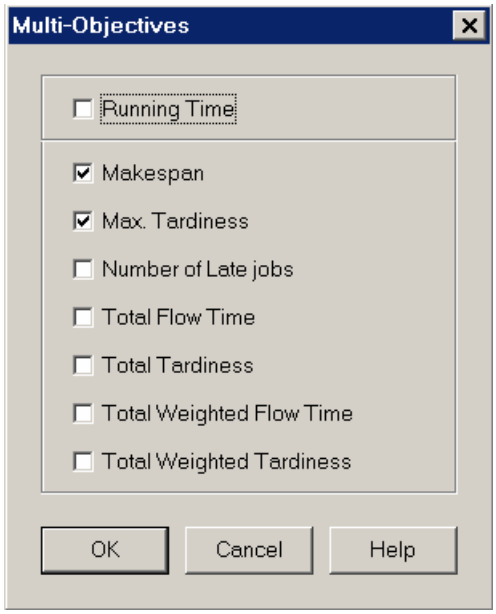

Figure 15. Multi-objective window

In the multi-objective window, one or more scheduling objectives can be specified, including the usual scheduling criteria and the running time to obtain the different sequences (see Subsection 4.2.). The obtained schedules are then represented according to the selected objectives in a chart such as the one in figure 16. Thus, the different schedules can be compared according to several objectives. The meaning of the main buttons of the Objective Chart window are explained in table 6.

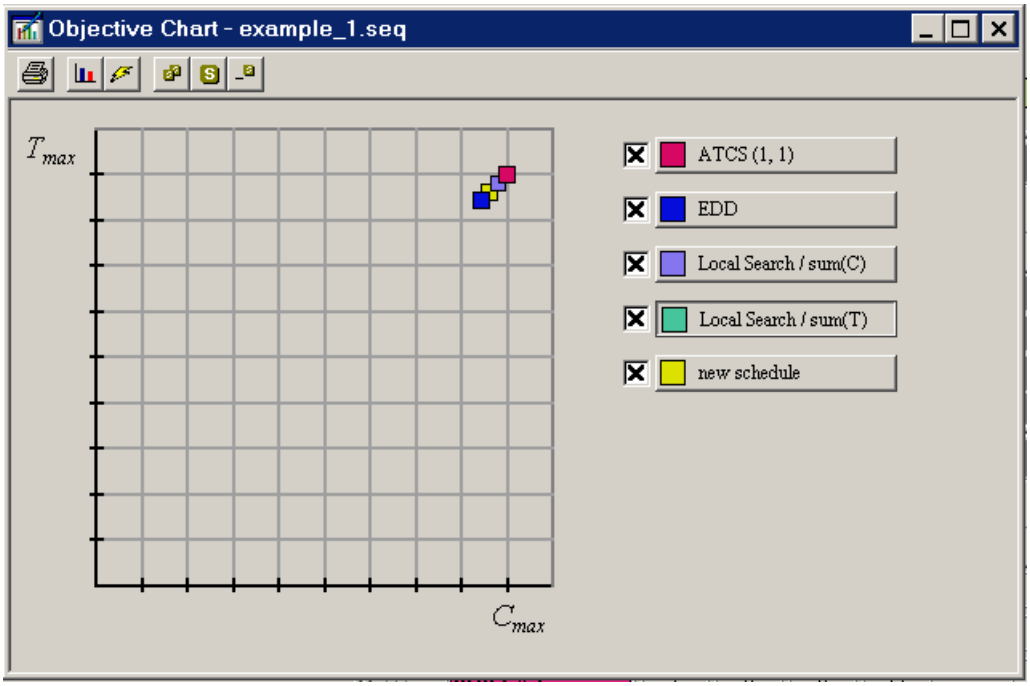

Figure 16. Objective chart

	Print
	Open the multi-objective window in order to select the sequence measures
	Show the performance of the sequence with respect to a number of objectives (incl. makespan, tardiness, tardy jobs, etc.)
	Copy a sequence into a new one
	Edit the appearance of a sequence
	Delete a sequence

Table 6. Buttons in the objective chart window toolbar

6. Introducing setup times in LEKIN

In LEKIN, setup times are introducing by using a label to denote the status of a machine after processing certain job. The 'status' serves to indicate the state of an specific machine after processing a particular job, and it is labeled by an English capital letter, from 'A' to 'Z'. In general, for each job, one must specify the status of each machine in the route of the job after its processing (see figure *17.*). As it may be seen in figure *17.*, work center 001 is specified to be in state 'A' after its processing, while work centers

002 and 003 are specified to be in states ‘B’ and ‘C’, respectively. With this information, you must be able to define, for each job, the status of each machine in the shop after the processing of this job.

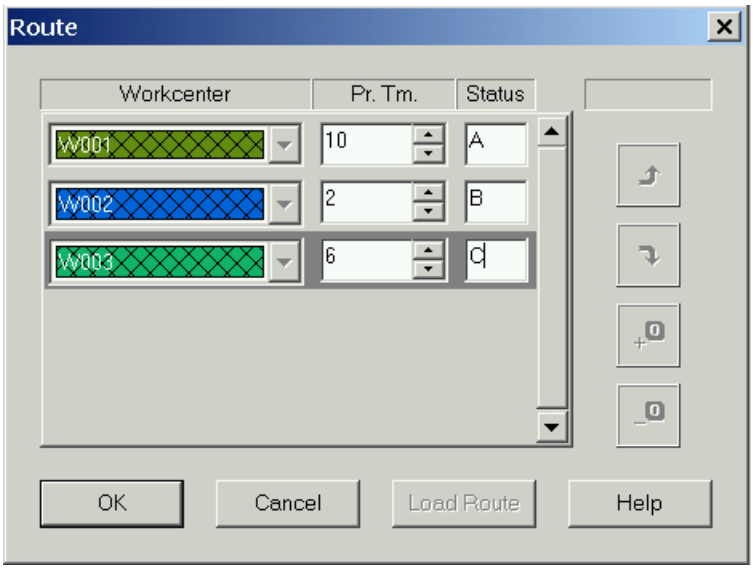

Figure 17. Entering the status of the machines after processing certain job

Once the information of the status for each work center has been entered, you may specify, for each machine, the setup times required to pass from a certain status to another. This is done in the “Setup Matrix” button in figure ***6.*** By clicking in this button, a window like the one in figure may appear.

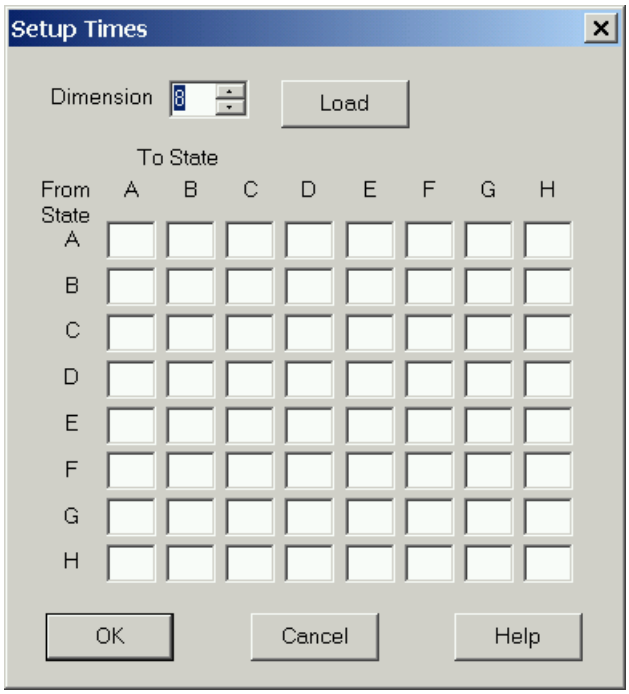

Figure 18. Entering data in the setup matrix

Data files in LEKIN

LEKIN stores the relevant data of a scheduling problem in three different files:

- Machine files (*.mch). Contains the description of the relevant data of the machines

- Job files (*.job). Contains the description of the relevant data of the jobs

- Sequence files (*.seq). Contains the description of the relevant data related to a specific sequence.

The separation of the scheduling data in three sets allows re-using the results or the framework for different problems.