Introduction to LEKIN

Gareth Beddoe

LEKIN®

Flexible Job Shop Scheduling System

STERN

Leonard N. Stern School of Business
New York University

Introduction to LEKIN

- What is LEKIN?
- Machine Environments
- Methods Employed
- Graphical User Interface
- Setting up the Environment
- 2 Examples
  - Single Machine Environment
  - Flow Shop Environment

What is LEKIN?

- Interactive scheduling system for machine environments
- Ideal for research and teaching
  - Graphical Interface
  - Built in dispatching rules and simple heuristic methods
  - User-defined algorithms can be added
- Educational Version:
  - 50 jobs, 20 work-centres maximum
  - Windows 98 or NT

Who wrote LEKIN?

- Stern School of Business, NYU
  - Michael Pinedo et. al.
    - http://www.stern.nyu.edu/om/pinedo/
- Download (educational version):
  - http://www.stern.nyu.edu/om/pinedo/lekin
- Reference:

  Pinedo M, *Scheduling: Theory, Algorithms, and Systems (2nd Edition)*, Prentice Hall 2002: pp 493-499

Machine Environments

- Single Machine
- Parallel Machines

- Flow Shop
- Job Shop

- Flexible Flow Shop
- Flexible Job Shop

} Generalisations: more than one machine of each type

Methods: Dispatching Rules

- EDD, MS, LPT, SPT, WSPT
- FCFS: (F)irst (C)ome (F)irst (S)erve
- ATCS: Apparent Tardiness Cost (with Setups).
  - Optimizes the Total Weighted Tardiness.
  - Trade-off between MS and WSPT
- CR: Critical Ratio rule.
  - Schedules jobs according to the ratio of the time left until the due date and the remaining processing time.
  - Trade-off between EDD and LPT.

Methods: Built-in Heuristics

- Shifting Bottle-neck Heuristics
  - General SB Routine (most objectives)
  - Objective Specific routines:
    - SB/sum wT: Total Weighted Tardiness
    - SB/Tmax: Maximum Tardiness, Makespan
- Local Search Heuristic
  - For all objectives
- Hybrid Method:
  - SB-LS: Combination of Shifting Bottle-neck and Local Search heuristics

Methods: User-defined Heuristics

- Users can write new heuristics methods and use the “plug-in” feature
- Operation as external executables with standardised input and ouput parameters
- Allows researchers to test and develop new algorithms in an interactive environment.
- Facilitates comparison between various methods

Objectives

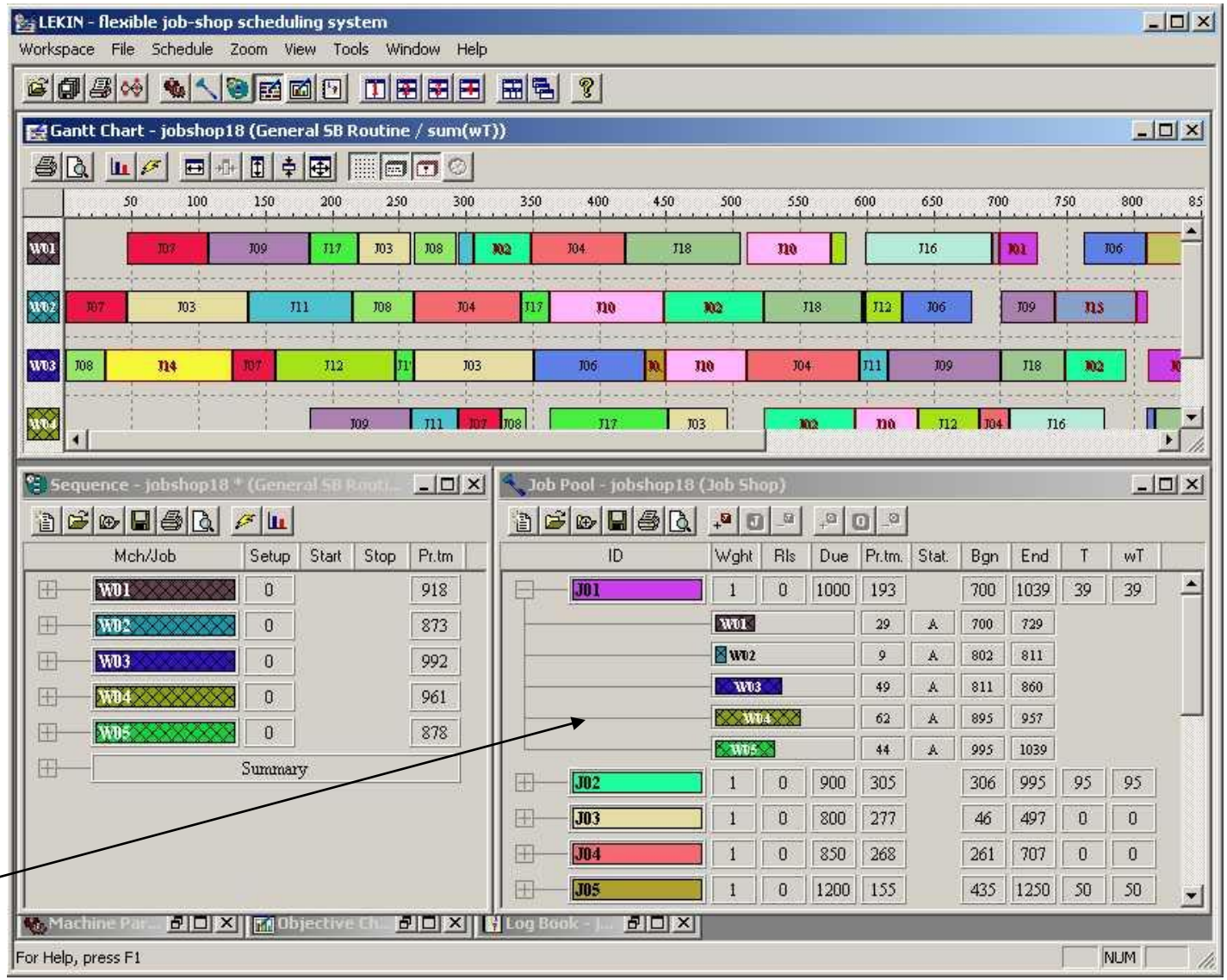
- Makespan $C_{\max}$
- The Maximum Tardiness $T_{\max}$
- The Total Number of Late Jobs $\sum U_j$
- The Total Flow Time $\sum C_j$
- The Total Tardiness $\sum T_j$
- The Total Weighted Flow Time $\sum w_j C_j$
- The Total Weighted Tardiness $\sum w_j T_j$

Graphical User Interface

Solution Schedule

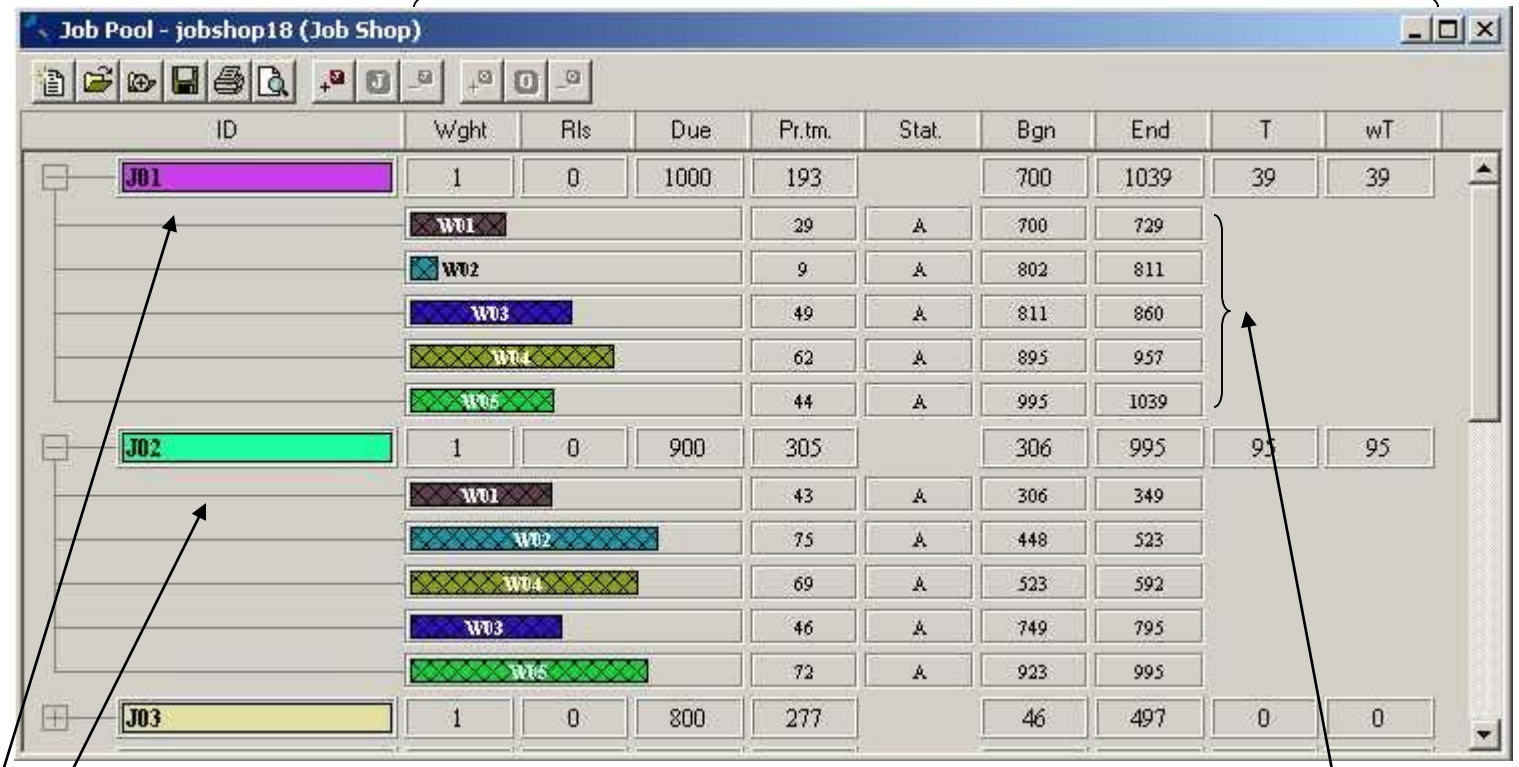
Machine Information

Job Information



Job Pool Window

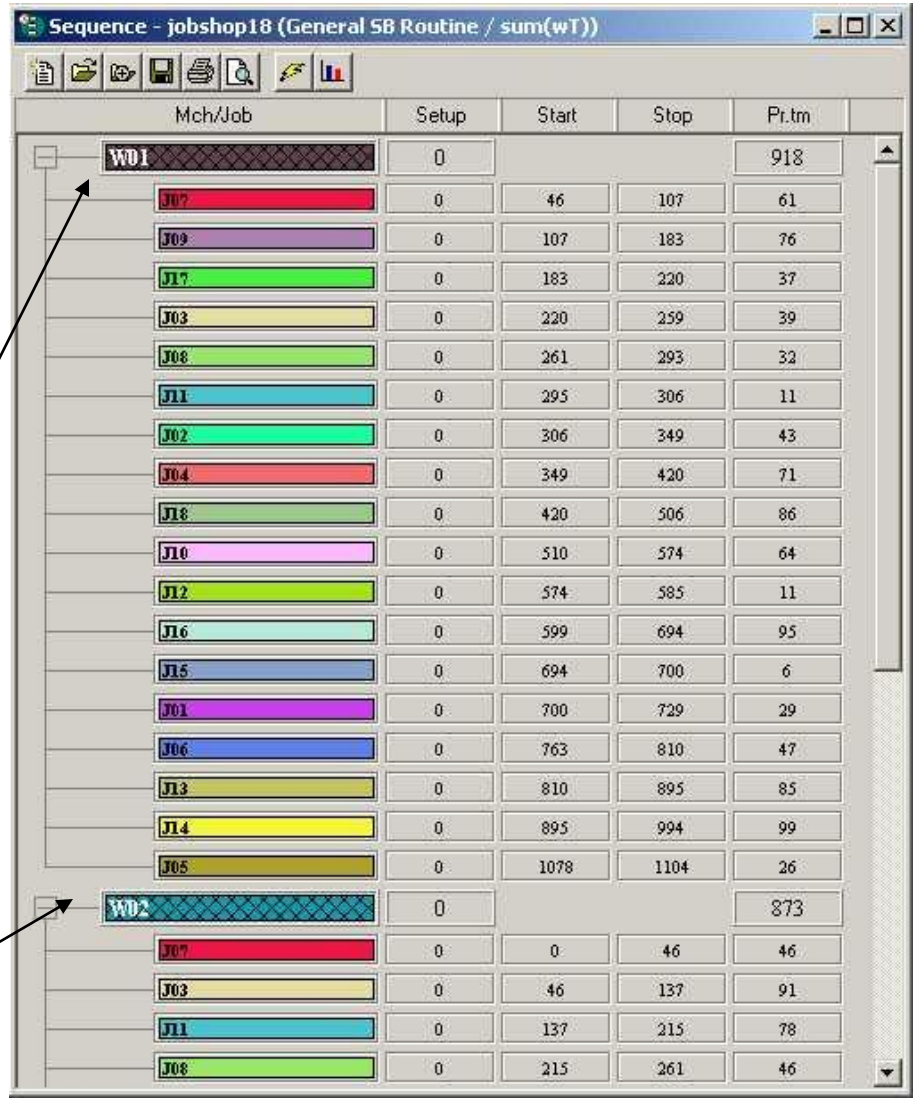
Job statistics and settings



Jobs

Sequence through machines and start and end times for each machine

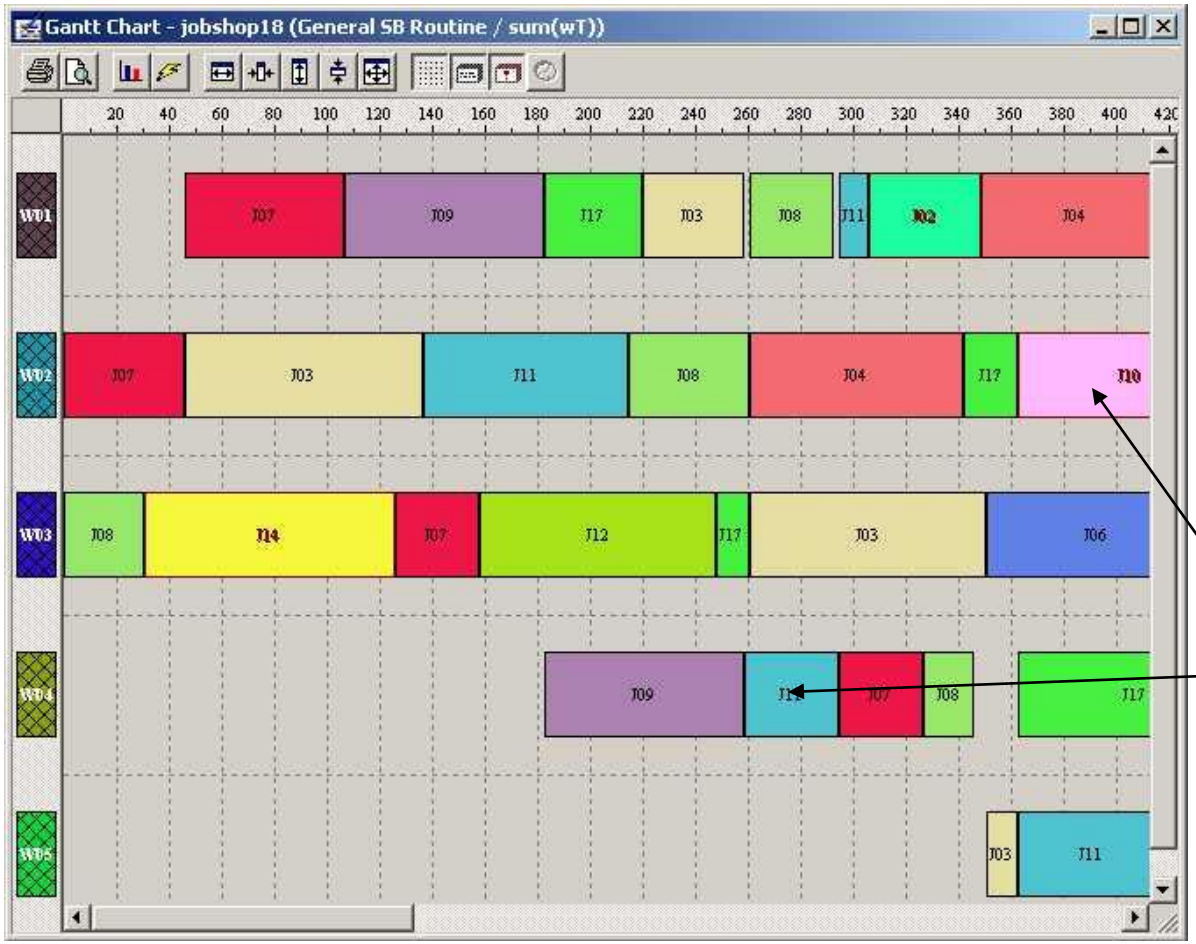
Sequence Window



Machines (Workcenters)

Sequence of jobs through machine and start and end times

Gantt Chart (Schedule) Window

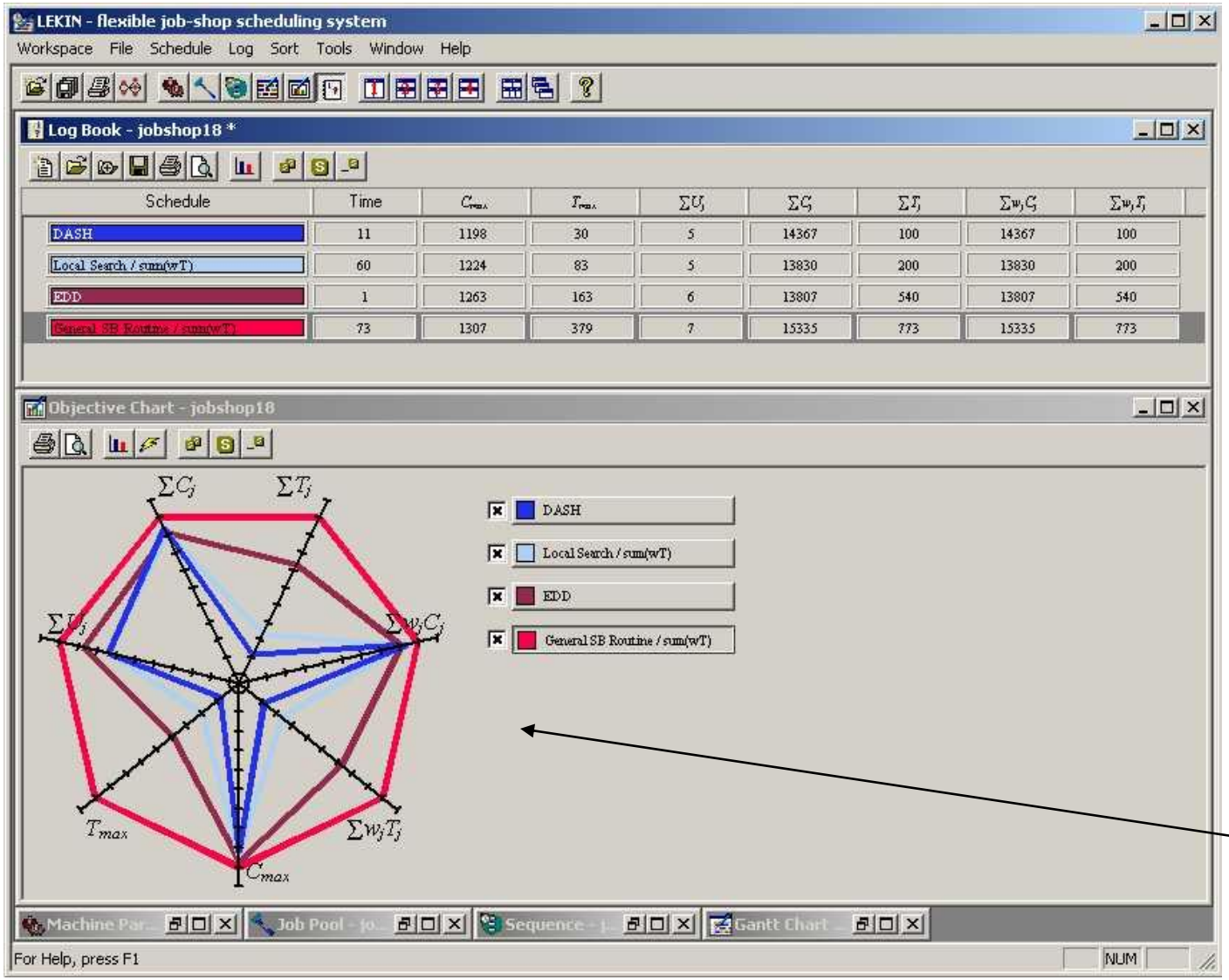


Machines
(Workcenters)

Jobs

Time

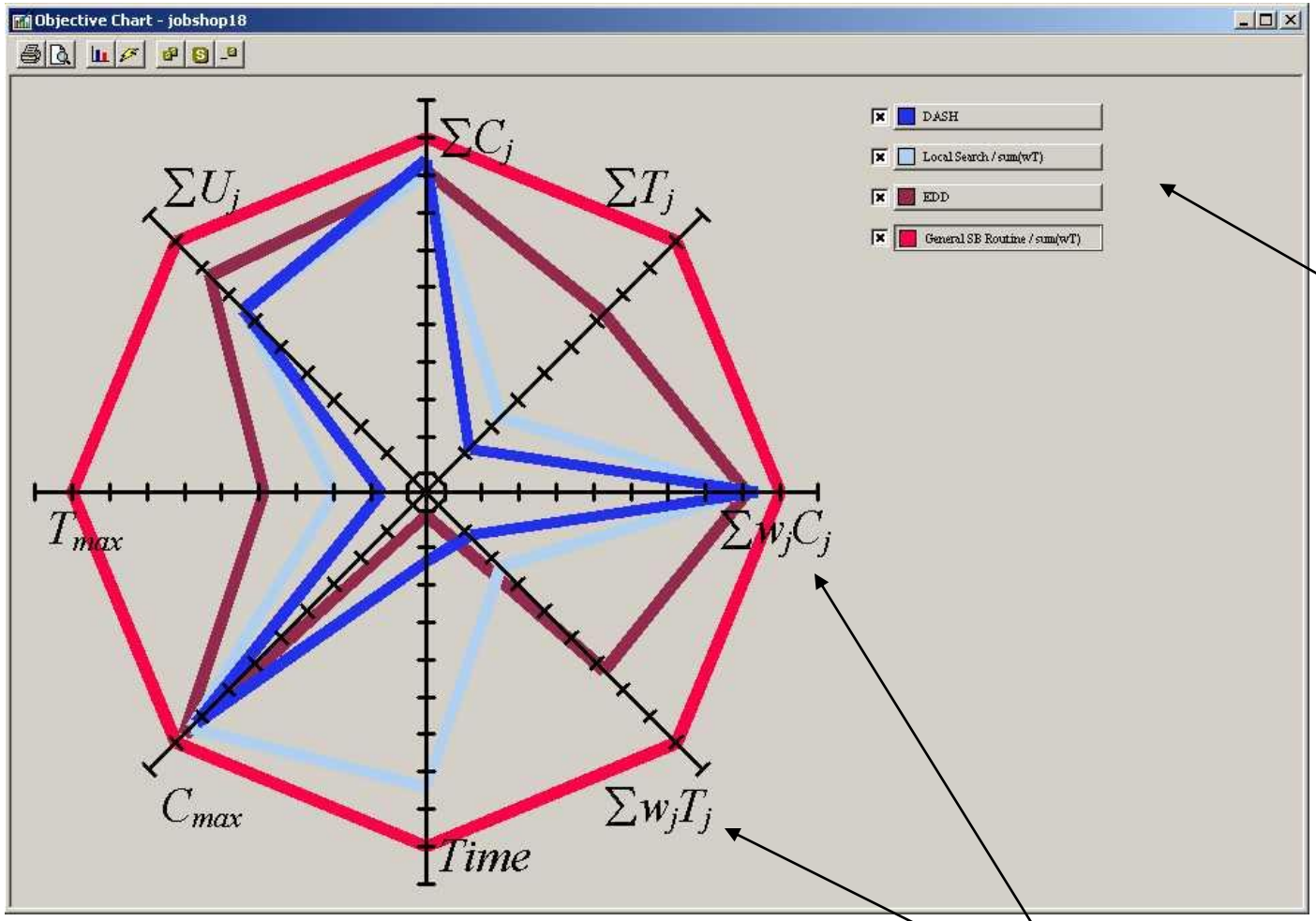
Displaying Results



Log of previous solutions

Objective Performance

Performance Comparisons



Various Solutions

Objectives

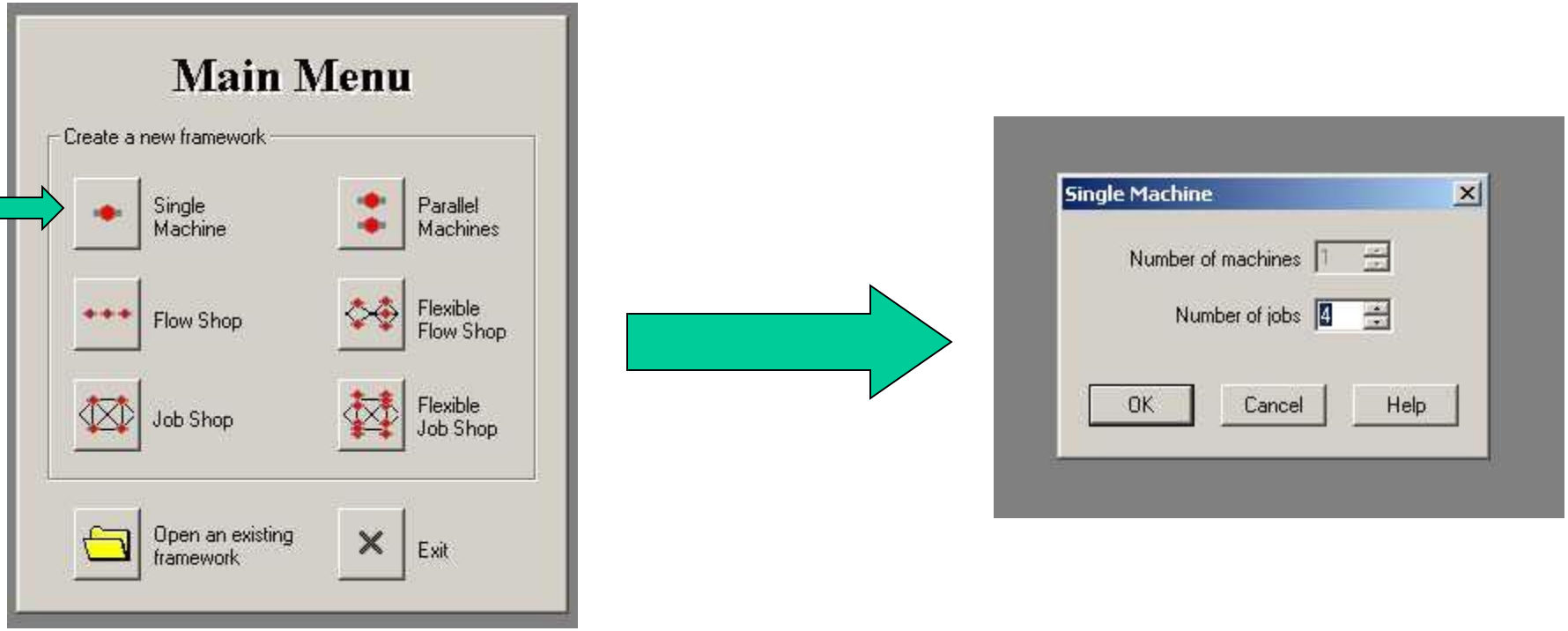
Basic Setup Procedure

1) Enter Machine Information
   - Number of Machines
   - Availability Time
   - Setup Time Information
2) Enter Job Information
   - Number of Jobs
   - Release Dates, Due Dates, Weight, and Route
3) Select a dispatching rule or heuristic and generate schedule

Example 1: Single Machine

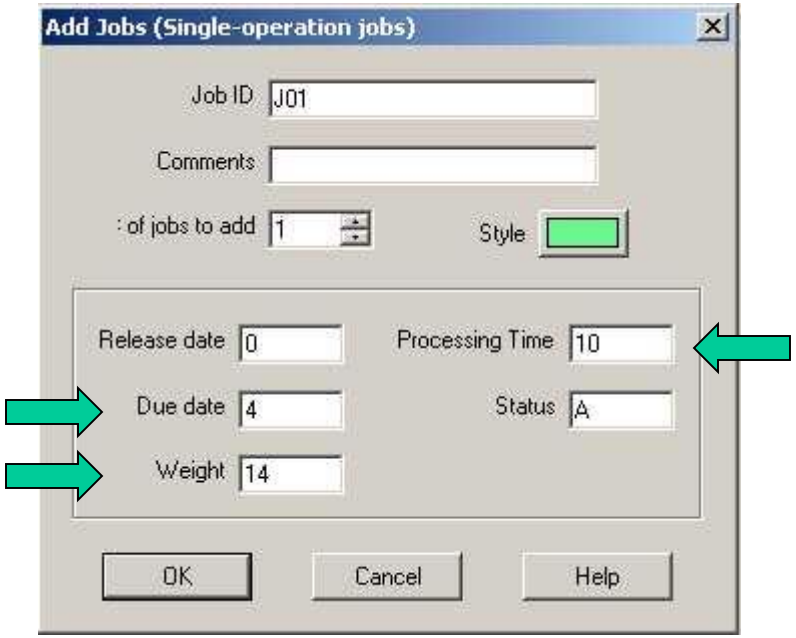
jobs	1	2	3	4
p_j	10	10	13	4
d_j	4	2	1	12
w_j	14	12	1	12

Setting up the problem (1)



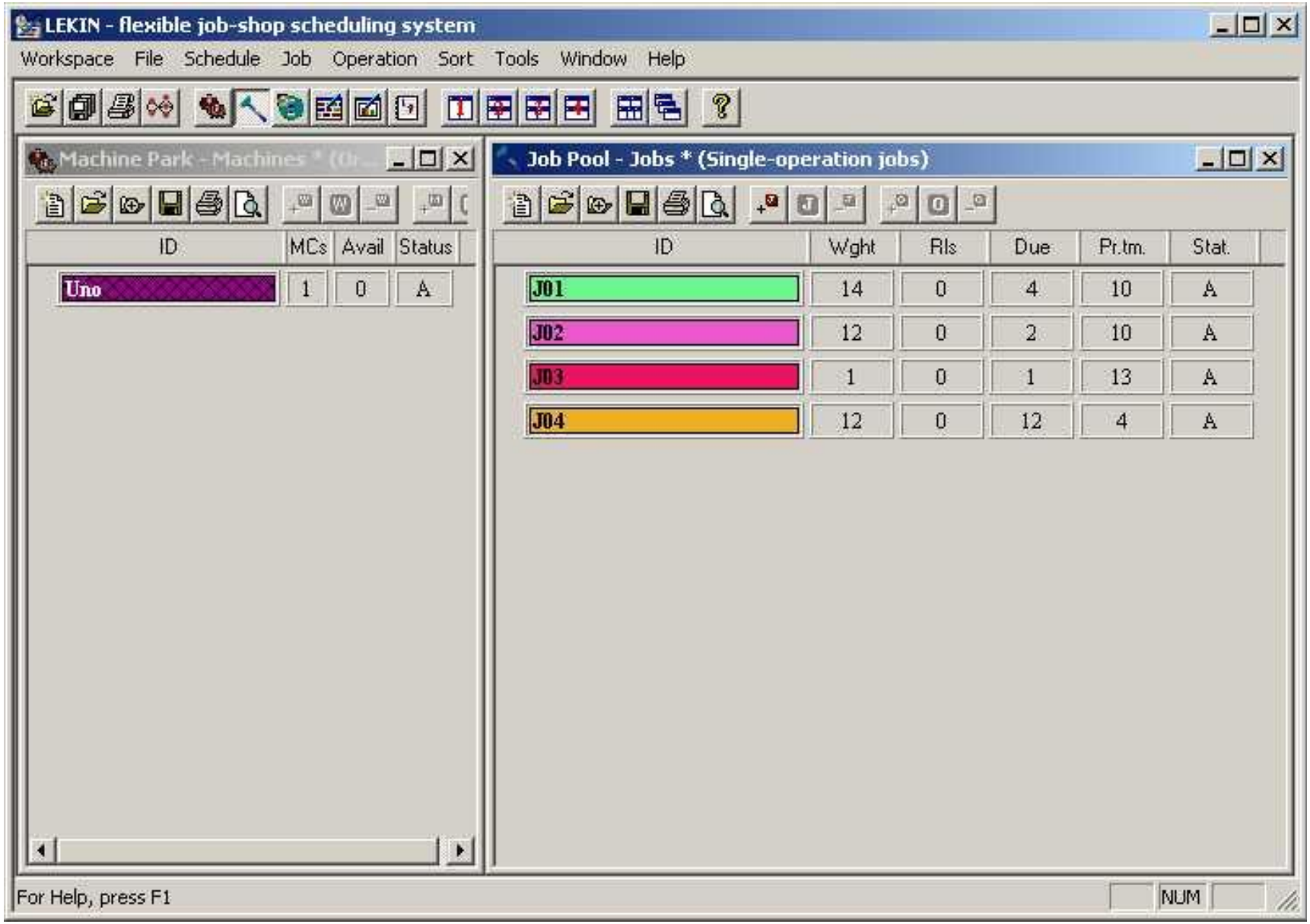
1) Choose Single Machine Environment
2) Number of machines already set (= 1)
3) Choose number of jobs (= 4)

Setting up the problem (2)

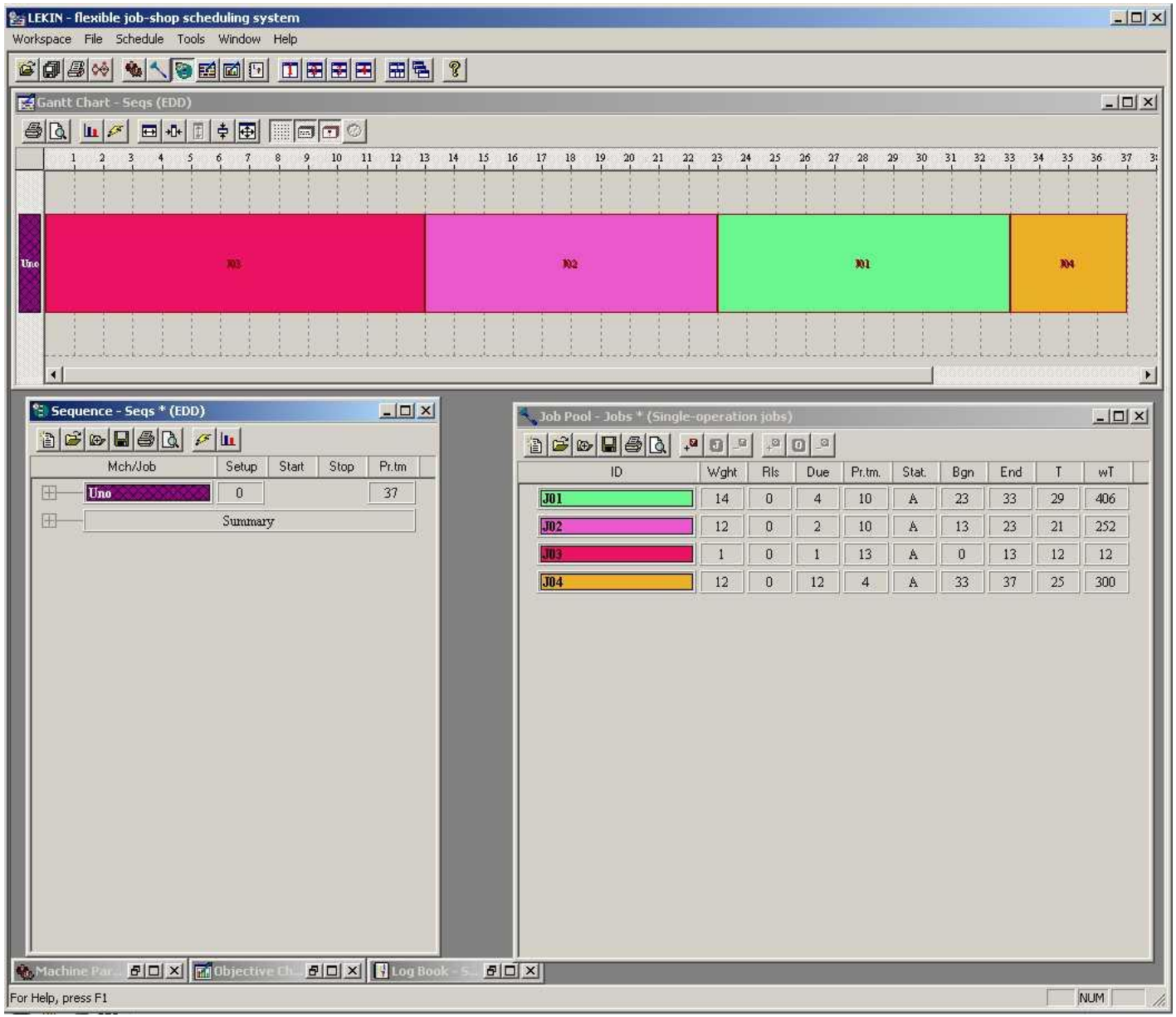


- For each job:
  - Enter Due Date, Processing Time, and Weight
  - Click OK

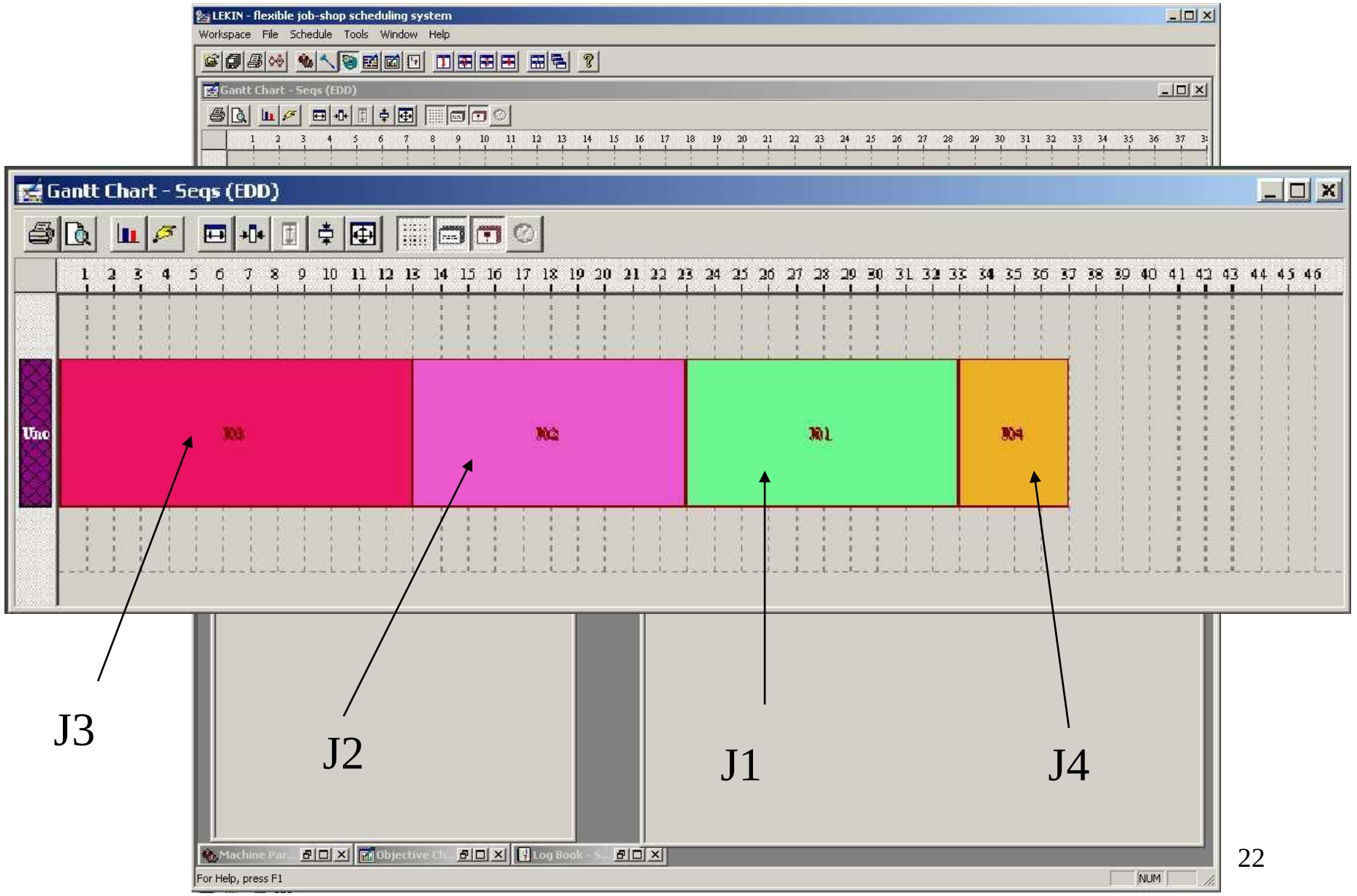
Environment Display



Schedule!


LEKIN - flexible job-shop scheduling system
Workspace File Schedule Tools Window Help
Gantt Chart - Seqs (EDD)
Uno
J03
J02
J01
J04
Sequence - Seqs * (EDD)
Mch/Job Setup Start Stop Pr.tm
Uno 0 37
Summary
Job Pool - Jobs * (Single-operation jobs)
ID Wght Rls Due Pr.tm. Stat. Bgn End T wT
J01 14 0 4 10 A 23 33 29 406
J02 12 0 2 10 A 13 23 21 252
J03 1 0 1 13 A 0 13 12 12
J04 12 0 12 4 A 33 37 25 300
Machine Par...
Objective Ch...
Log Book - S...
For Help, press F1
NUM

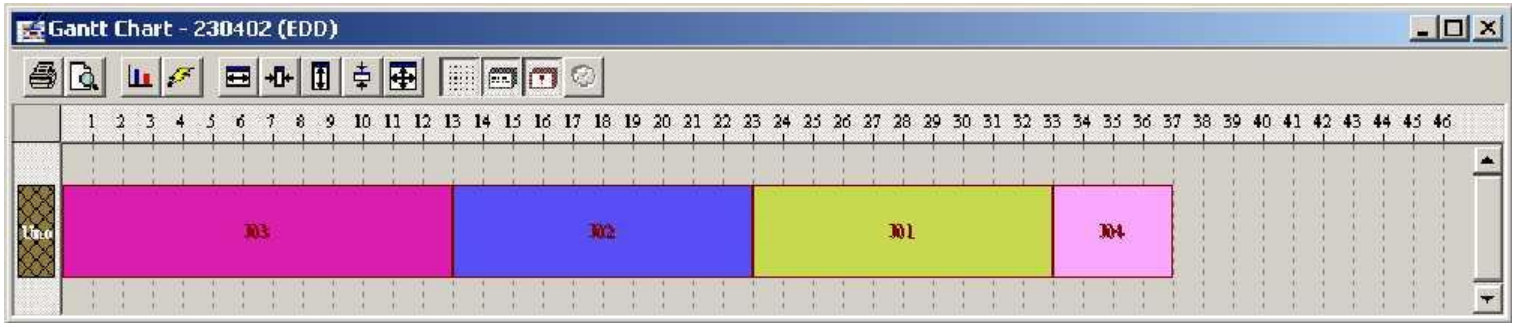
Schedule!


LEKIN - flexible job-shop scheduling system
Workspace File Schedule Tools Window Help
Gantt Chart - Seqs (EDD)
Gantt Chart - Seqs (EDD)
J3
J2
J1
J4
Machine Par...
Objective Ch...
Log Book - S...
For Help, press F1
NUM

More Solutions

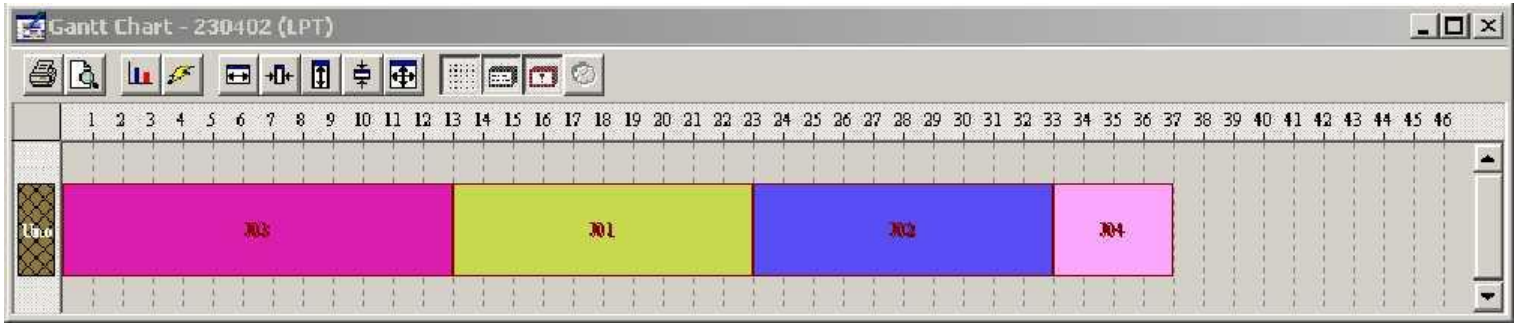
EDD:

(3214)



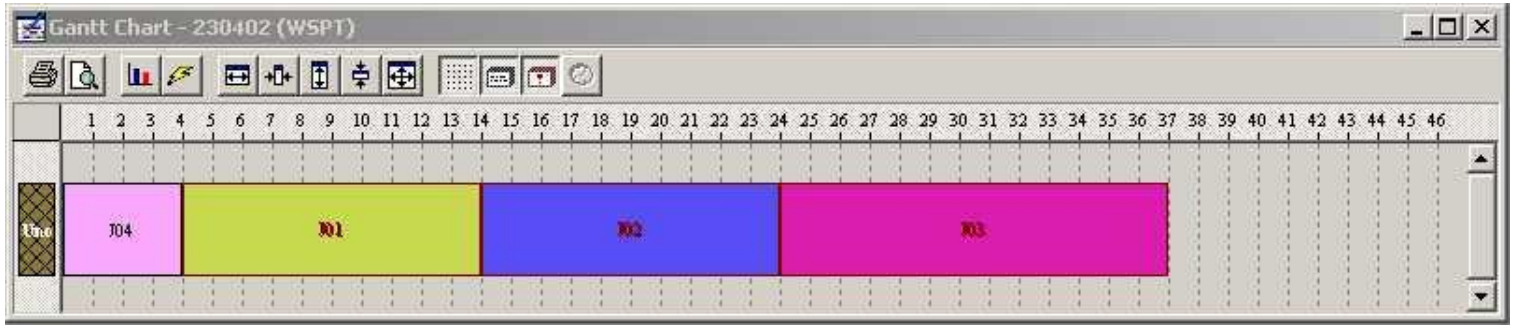
LPT:

(3124)



WSPT:

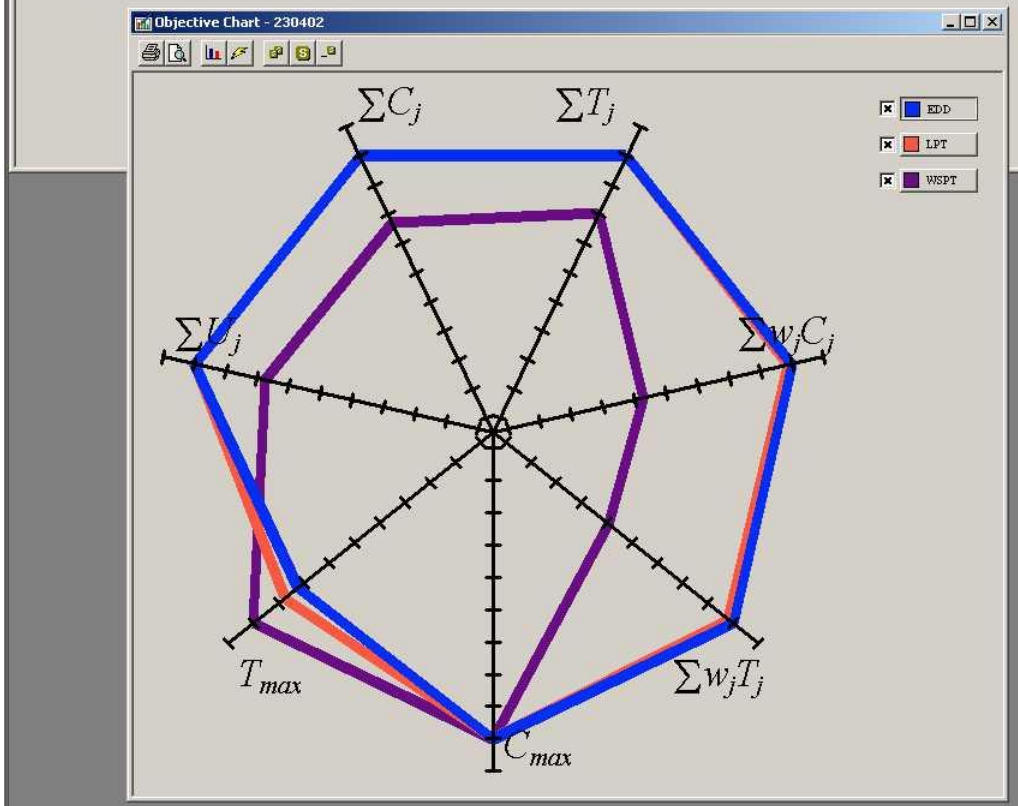
(4123)



Comparison

Log Book - 230402

Schedule	Time	C_{max}	T_{max}	$\sum U_j$	$\sum C_j$	$\sum T_j$	$\sum w_j C_j$	$\sum w_j T_j$
EDD	1	37	29	4	106	87	1195	970
LPT	1	37	31	4	106	87	1175	950
WSPT	1	37	36	3	79	68	569	440



More Comparison

EDD

WSPT

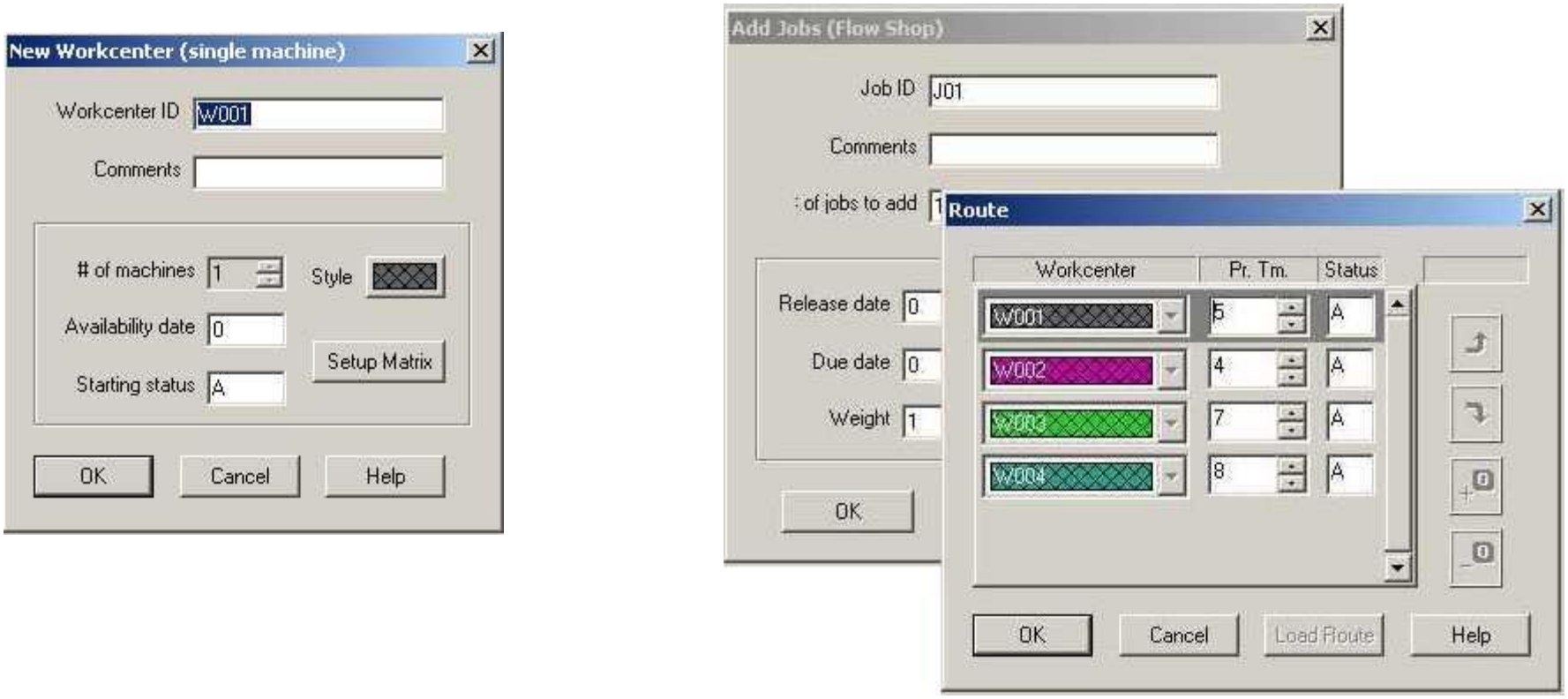
LPT

Example 2: Flow Shop

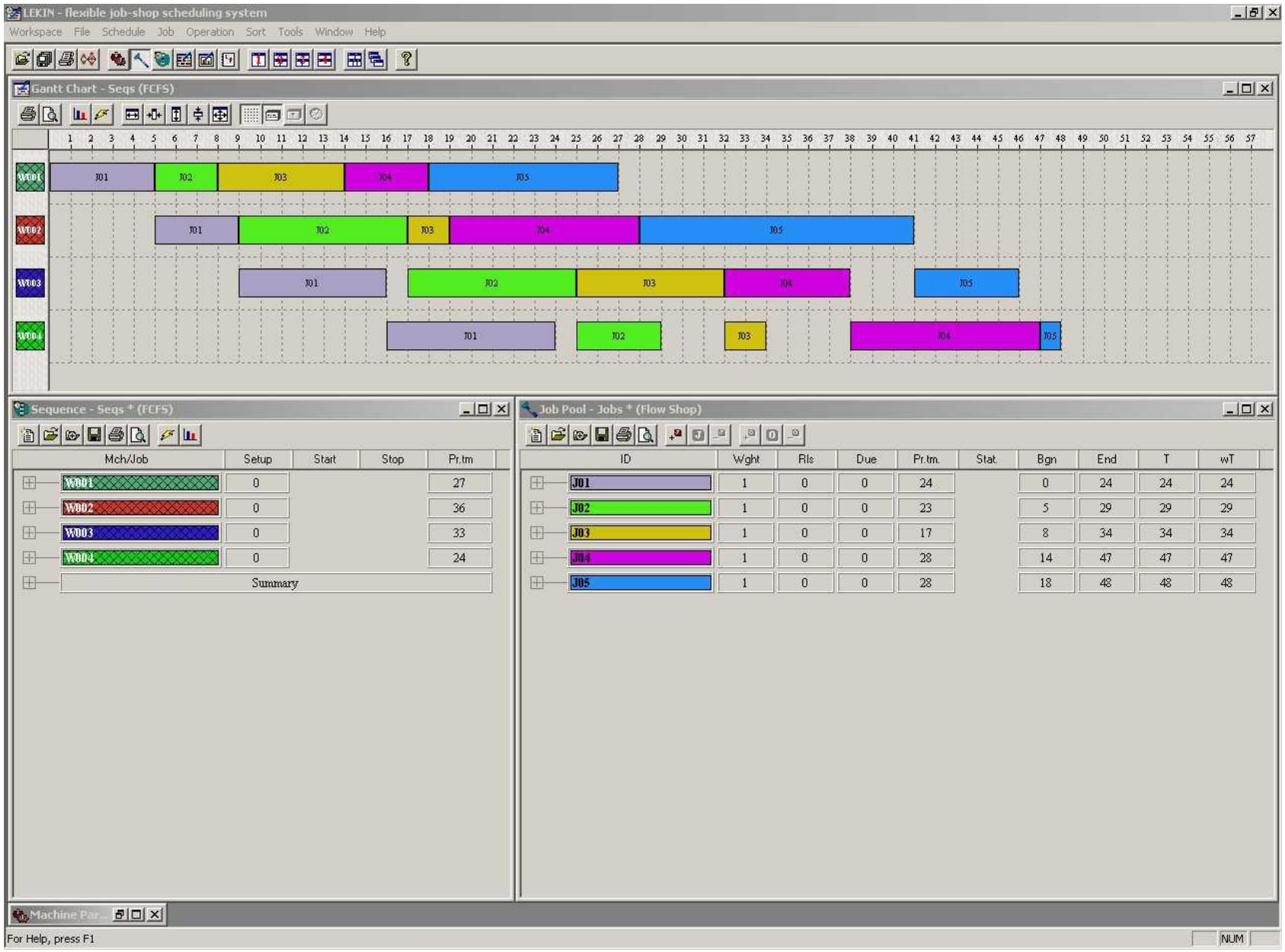
jobs	1	2	3	4	5
p_{1j}	5	3	6	4	9
p_{2j}	4	8	2	9	13
p_{3j}	7	8	7	6	5
p_{4j}	8	4	2	9	1

Setting up the problem

- Machine (Workcenter) setup
- Establishing machine route for jobs



Schedule!


LEKIN - flexible job-shop scheduling system
Workspace File Schedule Job Operation Sort Tools Window Help
Gantt Chart - Seqs (FCFS)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57
W001 J01 J02 J03 J04 J05
W002 J01 J02 J03 J04 J05
W003 J01 J02 J03 J04 J05
W004 J01 J02 J03 J04 J05
Sequence - Seqs * (FCFS)
Mch/Job Setup Start Stop Pr.tm
W001 0 27
W002 0 36
W003 0 33
W004 0 24
Summary
Job Pool - Jobs * (Flow Shop)
ID Wght Rls Due Pr.tm. Stat. Bgn End T wT
J01 1 0 0 24 0 24 24 24
J02 1 0 0 23 5 29 29 29
J03 1 0 0 17 8 34 34 34
J04 1 0 0 28 14 47 47 47
J05 1 0 0 28 18 48 48 48
Machine Par...
For Help, press F1
NUM

Other LEKIN features

- Manual Schedule Adjustment
  - useful for determining neighbourhood definitions in local search development
- Large library of standard problems included in package
- Industrial version currently in development
  - will be able to handle a much larger machine environment
  - will include considerably more dispatching rules and built in heuristics

Summary

- Graphics based interactive machine shop scheduling system
- Ability to schedule a number of different machine environments
- Valuable as an educational and research tool
- Extendible with new heuristic techniques