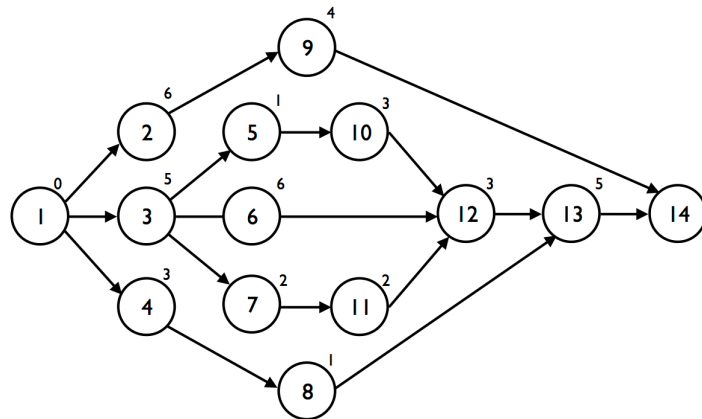


# MSRCPSP Data files: The Patterson format

The datasets with instances for the **multi-skilled resource constrained project scheduling problem** (MSRCPSP) make use of the .msrcp format to represent an activity-on-the-node network with renewable multi-skilled resource use. This is an extension of the well-known Patterson format. The format is a simple text file and its structure is explained on the illustrative project network of figure 1. Each integer above the node is assumed to be the activity duration.

**Figure 1. An illustrative activity-on-the-node network**



(Source: Figure 7.1 of the book "Project Management with Dynamic Scheduling: Baseline Scheduling, Risk Analysis and Project Control")

The network of figure 1 has two dummy activities, i.e. dummy start node 1 and dummy end node 14, and hence, the network contains 14 activities in total, dummies inclusive. The format also makes use of start and end dummy nodes and is structured as follows:

## Project Module

Line 1:

- Number of activities (starting with node 1 and two dummy nodes inclusive)
- Number of renewable multi-skilled resources
- Number of skill types
- Number of skill levels

Line 2:

- Deadline for the MSRCPSP  
(found by solving the MSRCPSP with CPLEX with a time limit of 60 seconds, if no solution was found within the time limit a naive method was used to find a solution)  
(This value can be multiplied with a random value from the range [1,1.2] to get a satisfactory deadline)

Line 3:

- Deadline for the MSRCPSP with skill level requirements (Problems: Cost, HRU, Q)  
(found by solving the MSRCPSP with resource level flexibility (RLF) with CPLEX with a time limit of 60 seconds, if no solution was found within the time limit a naive method was used to find a solution)  
(This value can be multiplied with a random value from the range [1,1.2] to get a satisfactory deadline)

The next block represents the activities with their characteristics (one line for each activity, starting with a dummy start activity and ending with a dummy end activity).

Line 1 (= Activity 1 (dummy)):

- Activity duration
- Number of successors
- Activity ID for each successor

Line 2 (= Activity 2):

- Activity duration
- Number of successors
- Activity ID for each successor

Line 3: ...

## Workforce Module

The next block represents the complete multi-skilled workforce with all its resources (one line per multi-skilled resource and one number for each skill type).

Line 1 (= Resource 1):

- 1, if the resource masters skill type 1. 0, otherwise.
- 1, if the resource masters skill type 2. 0, otherwise.
- 1, if the resource masters skill type 3. 0, otherwise.
- ...

Line 2 (= Resource 2):

- 1, if the resource masters skill type 1. 0, otherwise.
- ...

Line 3: ...

#### Workforce Module with Skill Levels

This block represents the multi-skilled workforce, if hierarchical skill levels are part of the problem at hand, with all its resources (one line per multi-skilled resource and one number for each skill type, which specifies the mastered level).

Line 1 (= Resource 1):

- Level at which the resource masters skill type 1. 0, otherwise.
- Level at which the resource masters skill type 2. 0, otherwise.
- Level at which the resource masters skill type 3. 0, otherwise.
- ...

Line 2 (= Resource 2):

- Level at which the resource masters skill type 1. 0, otherwise.
- ...

Line 3: ...

#### Skill Requirements Module

The next module represents the skill requirements of the activities (one line per activity and one number for each skill type).

Line 1 (= Activity 1):

- Number of resources that the activity requires of skill type 1. 0, otherwise.
- Number of resources that the activity requires of skill type 2. 0, otherwise.
- Number of resources that the activity requires of skill type 3. 0, otherwise.
- ...

Line 2 (= Activity 2):

- Number of resources that the activity requires of skill type 1. 0, otherwise.
- ...

Line 3: ...

#### Skill Level Requirements Module

This module represents the skill level requirements of the activities (one line per activity and one number for each requirement).

Line 1 (= Activity 1):

- Required level of the first skill requirement.
- Required level of the second skill requirement.
- Required level of the third skill requirement.
- ...

Line 2 (= Activity 2):

- Required level of the first skill requirement.
- ...

Line 3: ...

#### Cost Module

This module shows the values of the cost parameters of the resources for the scheduling problem.

Line 1:

- Fixed minimum starting cost
- Variable minimum starting cost

The next two blocks present the fixed and variable skill cost (one line per skill type and one number for each level)

Line 1 (= Skill 1):

- Fixed skill cost if a resource masters skill type 1 at skill level 1.
- Fixed skill cost if a resource masters skill type 1 at skill level 2.
- Fixed skill cost if a resource masters skill type 1 at skill level 3.
- ...

Line 2 (= Skill 2):

- Fixed skill cost if a resource masters skill type 2 at skill level 1.

• ...  
Line 3: ...

Line 1 (= Skill 1):

- Variable skill cost if a resource masters skill type 1 at skill level 1.
- Variable skill cost if a resource masters skill type 1 at skill level 2.
- Variable skill cost if a resource masters skill type 1 at skill level 3.

• ...

Line 2 (= Skill 2):

- Variable skill cost if a resource masters skill type 2 at skill level 1.

• ...

Line 3: ...

#### Common Resource Usage Module

This module depicts the usage cost rate and usage values of a common good

Line 1:

- Usage cost rate of a common good

The next blocks represents the usage of a resource (one line per skill type and one number for each level)

Line 1 (= Skill 1):

- Usage if a resource masters skill type 1 at skill level 1.
- Usage if a resource masters skill type 1 at skill level 2.
- Usage if a resource masters skill type 1 at skill level 3.

• ...

Line 2 (= Skill 2):

- Usage if a resource masters skill type 2 at skill level 1.

• ...

Line 3: ...

#### Rework Module

The next module represents the rework probability of resources (one line per skill type and one number for each level)

Line 1 (= Skill 1):

- Rework probability of a resource that masters skill type 1 at skill level 1.
- Rework probability of a resource that masters skill type 1 at skill level 2.
- Rework probability of a resource that masters skill type 1 at skill level 3.

• ...

Line 2 (= Skill 2):

- Rework probability of a resource that masters skill type 2 at skill level 1.

• ...

Line 3: ...

#### Example

It is assumed that the project network of figure 1 requires 4 skill types and the multi-skilled workforce consists of 8 multi-skilled resources. Consequently, the .msrcp text file for the network of the figure can be as follows:

```
\* Project Module *\
14      8      4      5

25

30

0      3      2      3      4
6      1      9
5      3      5      6      7
3      1      8
1      1      10
3      1      12
2      1      11
1      1      13
```

4	1	14
3	1	12
1	1	12
3	1	13
5	1	14
0	0	

\\* Workforce Module \*\

1	0	1	1
0	1	0	1
0	0	1	0
1	0	0	0
1	0	0	1
0	0	1	1
1	1	1	1
1	1	0	0

\\* Workforce Module with Skill Levels \*\

2	0	1	4
0	5	0	1
0	0	3	0
4	0	0	0
2	0	0	3
0	0	1	5
2	3	2	1
3	4	0	0

\\* Skill Requirements Module \*\

0	0	0	0
2	1	2	1
1	2	1	4
0	3	2	1
0	2	2	0
1	0	0	3
5	0	2	0
2	0	0	4
3	1	1	1
0	1	4	0
1	2	2	0
1	0	0	5
0	1	0	2
0	0	0	0

\\* Skill Level Requirements Module \*\

-1

2	4	5	1	1	3	
4	4	5	3	1	3	5
3	4	5	1	3	4	
3	5	1	1			
4	1	1	5			
2	2	2	3	4	1	3
3	4	1	3	4	5	
2	2	2	5	3	5	
4	1	1	2	3		
2	4	5	1	3		
4	1	1	3	4	5	
5	3	5				

-1

\\* Cost Module

100 1

4	8	12	16	20
3	6	9	12	15
3	6	9	12	15
4	8	12	16	20

0.05	0.1	0.15	0.2	0.25
0.06	0.12	0.18	0.24	0.3
0.09	0.18	0.27	0.36	0.45
0.09	0.18	0.27	0.36	0.45

\\* Common Resource Usage Module \*\

15				
47	40	35	28	22
44	38	31	24	20
47	47	42	29	24
36	35	29	27	23

\\* Rework Module \*\

0.74	0.7	0.65	0.64	0.59
0.76	0.65	0.63	0.62	0.58
0.76	0.65	0.64	0.59	0.59
0.71	0.68	0.6	0.59	0.56

As an example, activity 2 of figure 1 has a duration of 6 and needs 2, 1, 2 and 1 units of skills 1, 2, 3 and 4, respectively. Activity 2 requires skill type 1 at levels 2 and 4, skill type 2 at level 5, skill type 3 requires 2 resources at level 1 and skill type 4 at level 3. The availability of these skill types is maximum 5, 3, 4 and 5 units (from the workforce module). Obviously, we also have to take into account the skill constraints, if we want to assign resources to activity 2. Furthermore, activity 2 has 1 successor: activity 9.

A resource that masters skill type 1 at level 2 will have a fixed skill cost of 8 units and variable skill cost of 0.1 currency units. That same resource will have a usage rate of 40 units and a rework probability of 0.7.