Project Scheduling Problem for Software Development Library - PSPSWDLIB

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Abstract

A Project Scheduling Problem for Software Development is a variant of Project Scheduling Problem where the software development model can be presented as a set of software activities, a set of developer skills and a set of resources specified on money and the total time divided on time per activity. This paper presents an instance set of Project Scheduling Problem for Software Development for projects of software development.

Keywords: SWPSPLIB, Project Scheduling Problem, PSP, software development.

Resumo

Um Problema de Gestão de Projetos de Desenvolvimento de Software é uma variante do Problemas Gestão de Projetos onde o modelo de desenvolvimento de software pode ser apresentado como um conjunto de actividades de software a realizar, um conjunto de recursos humanos, um conjunto de recursos financeiros e o variável tempo dividida por actividade. Este artigo apresenta um exemplo do Problema de Gestão de Projetos de Desenvolvimento de Software para projectos de desenvolvimento de software.

Palavras-chave: Problema de gestão de projetos, desenvolvimento de software

1. Introduction

The Project Scheduling Problem (PSP) is a generic name given to a whole class of problems in which it is necessary to schedule in an optimal way, the time, cost and resources of projects [Ruiz-Vanoye et al., 2010]. The application areas are usually are defined in terms of: technical elements (development of software, pharmaceutical drugs or civil engineering, planning of production systems), elements of the administration (project scheduling problems, manufacturing management, technology management, contracts with the government or development of new products), and groups of industry (industrial engineering, automobiles, chemicals or financial services).

The general parameters of PSP are [Ruiz-Vanoye et al., 2010]:
a) Resources (machines and tools; workers and their skills; raw materials and semi-finished products; information; money; natural resources as energy, water, land and others).
b) Activities (resource requirement: resource demand, resource request; processing model: activity processing time and activity processing rate; precedence constraints with other activities; time parameters: a ready time or release date, a due date or a deadline; weights parameters: cost or reward for executing an activity; setup times: sequence-independent and sequence-dependent; preemptibility: preemptable or non-preemptable).

The Project Scheduling Problem for Software Development is a variant of PSP where the software development model can be presented as a set of software activities, a set of developer skills and a set of resources specified on money and a total time divided on time per activity. The PSP for Software Development has different variants or applications: fuzzy project scheduling system for software development [Hapke et al. 1994], time-dependent software project scheduling problem [Möhring 2002], project scheduling problem with labour constraints and time-dependent activities requirements [Drezet 2007], project scheduling problem for software development with random fuzzy activity duration times [Huang 2009], and fuzzy resource-constrained project scheduling problem for software development [Wang and Huang 2010].

This paper presents a library of instances for the Project Scheduling Problem for Software Development. Section 2 presents the model formulation of the PSP for Software Development, section 3, the Project Scheduling Problem for Software Development Library (PSPSWDLIB), and the last section, the conclusions.

2. Project Scheduling Problem for Software Development

A project is a temporary and unique effort that, with a set of resources, looks for to satisfy specific objectives within a certain period (Kimms, 2001). [Huang et al 2009] defines a software project as a directed acyclic graph $G = (V, A, S, E)$, where $V = (1, 2, \ldots, n)$ is the set of nodes representing the events (figure 1), A, the set of arcs representing the activities, $(i, j) \in A$, the arc from node i to j in the acyclic graph G with only one directed arc (i, j) from i to j, $S \in V$, the start node and $E \in V$, the end node with each activity duration time being a stochastic variable denoted by $\xi = \{\xi_{(i,j)} \in A\}$.The capital cost of an activity through (i, j) is denoted by C_{ij} while the resource cost of an activity through (i, j) is denoted by r_{ij}.

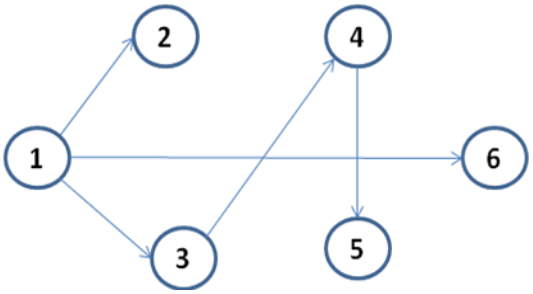

Figure 1 - Project Software representation.

Most of the software developed in the world uses various classic methods of development: classic Waterfall Model, Spiral Model, Capability Maturity Model Integration (CMMI), Team Software Process (TSP) and the Personal Software Process (PSP). But none of them allows for scheduling in an optimal way the resources of a software project.

The Project Scheduling Problem for Software Development (PSP for software development) consists of the human resource allocation to the various tasks in a software development project according to their skills, to produce higher quality software, while keeping effort expenditures and scheduling time to a minimum [Gonsalves and Itoh 2010].

The mathematical model of PSP for software development [Gonsalves and Itoh 2010] consists of equations (1-5), where the equation (1) is the objective function of the software PSP, the equation (2) contains the aspects related to project development cost, the equation (3) contains the aspects related to the duration of the software project development, the equation (4) contains the aspects related to the task precedence relations of two consecutive tasks of the software development project, and the equation (5) contains the aspects related to the availability of manpower:

$$\min imize\ f(x) = f_1 + f_2 \tag{1}$$

$$f_1 = \sum_{j=1}^{m} Pc_j \tag{2}$$

$$f_2 = \sum_{j=1}^{m} \left(Q_{Tj} + P_{Tj} \right) \tag{3}$$

$$F_{T(j-1)} < S_{Tj} \quad \forall j \tag{4}$$

$$P_j(t) \Rightarrow \tau_i(t) \neq P_j(t) \Rightarrow \tau_k(t) \quad \forall i, j, k \tag{5}$$

where P_c is the cost per unit time of the j^{th} manpower, m, the total number of manpower allocated to the project development, f_1, the total development cost, P_{Tj}, the processing time of the j^{th} task in the project, Q_{Tj}, the queuing time of the j^{th} task in the project for resource availability, f_2, the actual duration of the project, S_{Tj}, the starting time of the j^{th} task and F_{Tj}, the finish time of the j^{th} task.

The PSP for software development scenario is presented in figure 2, where the example of a software project has a set of events *V= {1,2,3,4,5,6}* and a set of tasks or activities $A = \{a_1, a_2, a_3, a_4, a_5, a_6\}$. The sequence of tasks represented by the arc (i, j) is Arc = $\{(a_1, a_2), (a_1, a_3), (a_1, a_6), (a_3, a_4), (a_4, a_5)\}$. Each element of the arc (i, j) has a resource cost and a capital cost associated.

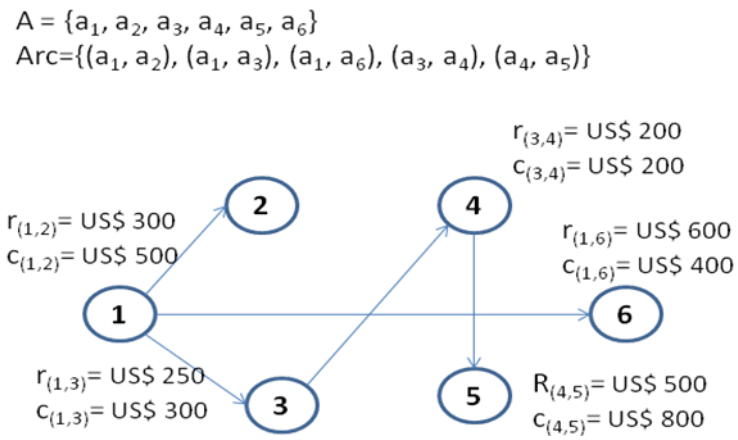

Figure 2- PSP for software development scenario.

In software development, the project managers attempt to improve the way of assigning activities and their costs to a sequence to optimize the use of resources. In this case, adding tasks to a schedule, can represent the actual improvements needed for project software development, but the project managers cannot ensure that the time assigned to the sequence will be enough or optimal to develop the software project.

The common problems on software development are:
- Working backward with a deadline that cannot be changed.
- The Work Breakdown Structure is not defined.
- There are misunderstings regarding the sequence and importance of the activities.
- The resources are not defined well at the beginning of the project software development.

3. Project Scheduling Problem for Software Development Library (PSPSWDLIB)

The Project Scheduling Problem for Software Development Library-PSPSWDLIB is a depository of test instances of the Project Scheduling Problem for Software Development. The depository of instances can be downloaded for others researchers to experiment.

In this section, we present the parameters or characterization (Table 1) used to generate the instances of PSP for software development, where NP is the total number of projects of software development, Na, the total number of tasks or activities, NE, the total number of employees allocated to the software development, NS, the total number of skills of the employees, Rel. Date, the Release Date, DD, the Due or Limit date, Penalty Cost, the cost per day that exceeded the limit date, SKL, the Skill level, S-SkL, the month salary, ET, the total time that the employee is available to the project, a, the task number, aT, the task duration time, T(aT), the total time of the tasks, successors, the successor tasks, C_{ij}, the capital cost of the task (i, j), aS_i, the precedence task for aS_j and Rsk, the restriction skill.

Table 1- Parameters of the PSP for Software Development.

Instance name					
NP	Na	NE	NS	Rel.Date	DD
Skill level	**Month Salary**				
SkL_1	$S\text{-}SkL_1$				
…	…				
SkL_a	$S\text{-}SkL_a$				
Employee number	**Skill level**	**Time/hrs**			
E_1	SkL_1	ET_1			
…	…				
E_n	SkL_n	ET_n			
Task number (a_i)	**Task time**	**C_{ij}**	**RSk**	**Successors (a_j)**	
a_1	aT_1	C_1	RSk_1	aS_1	…
…	…	…	…	…	
a_n	aT_n	C_n	RSk_n	aS_n	
	T(aT)				

In Table 2 is an example of one instance for the PSP for software Development, where the software project has 20 different activities and the base time is a week.

Table 2- PSP for software development instance.

Instance name	SWD1-1
PROJECT INFORMATION:	
Number of projects	1
Number of tasks	20
Number of employees	5
Number of skills of the employees	10
Rel. Date	0
Due Date	3711
Penalty Cost	5

Skill level	Month salary	Skills	Time/hrs
1	627	1	2
2	1415	3	4
3	1672	5	6
4	1681	7	8
5	1942	9	10

Employee number	Skill level	Time/hrs
E_1	1	885
E_2	5	674
E_3	1	771
E_4	4	952
E_5	4	528

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Task number	Task time	C_{ij}	Restriction skill	Successors	Total cost
a1	135	1	4	a3, a2, a4	135
a2	65	1	4	a5	65
a3	130	4	4	a6	520
a4	178	3	1	a7, a8	534
a5	81	5	4	a9	405
a6	87	1	1	a16	87
a7	176	4	2	a10, a11	704
a8	73	2	3	a12, a13	146
a9	53	1	5	a15	53
a10	184	4	5	a17	736
a11	158	3	5	a14	474
a12	127	2	2	a14	254
a13	26	5	3	a14	130
a14	108	1	5	a20, a18	108
a15	62	5	4		310
a16	130	4	5		520
a17	138	3	5	a19	414
a18	84	1	3		84
a19	164	2	4		328
a20	91	3	5		273

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We generated 5 instance sets for the PSP for Software Development (Table 3) with each instance set having 25 cases. The instances can be downloaded from the PSPSWDLIB site (http://ruizvanoye.com/pspswdlib).

Table 3- PSPSWDLIB instances set.

Instance Set	Number of Projects	Number of Employees	Number of skills of the employees	Number of Tasks	Instances number
PSPSWD1	1	1 to 5	1 to 10	10 to 30	25
PSPSWD2	1	6 to 10	1 to 10	10 to 30	25
PSPSWD3	1	11 to 15	1 to 10	10 to 30	25
PSPSWD4	1	16 to 20	1 to 10	10 to 30	25
PSPSWD5	1	21 to 25	1 to 10	10 to 30	25

4. Conclusions and future research

The Project Scheduling Problem can be applied to any type of project management, but needs to be adapted on three principal project characteristics: scope, cost and time.

As future work, we plan to generate more instances of this problem on several research directions: the first research will be oriented to generate a variant of PSP oriented to multiple projects for software development and its set of instances; the second research will be oriented to analyze the results of heuristics approaches on solving PSP for software development; and other researches will be oriented to apply PSP to different fields of project management.

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