Handling Uncertainties and Preparing for the Unexpected in Real-life Project Scheduling

Ripon Kumar Chakrabortty*, Alireza Abbasi and Michael J. Ryan

UNSW Australia Canberra

Never Stand Still

*Email: r.chakrabortty@student.adfa.edu.au

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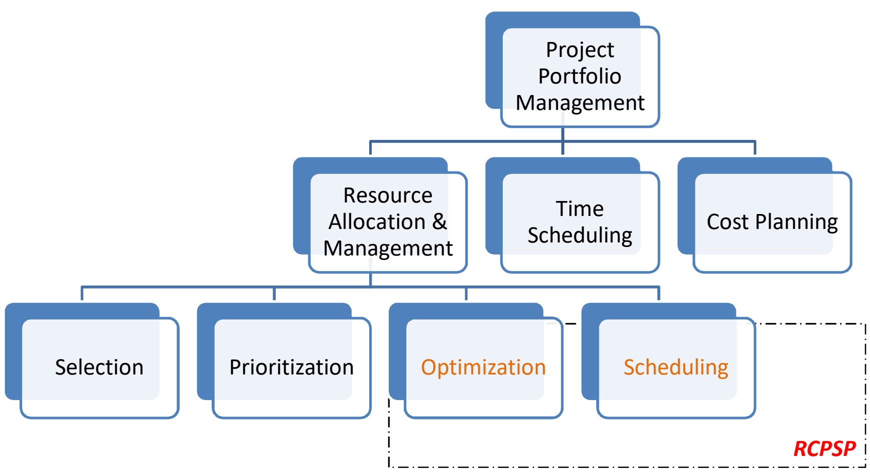
PPM Vs RCPSP



**PPM: Project Portfolio Management*

RCPSP: Resource Constrained Project Scheduling Problem

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The RCPSP*

Project

- A project is a collection of tasks that must be completed in minimum time or at minimal cost.

Resource-Constrained Project

– Is one in which the level of resources available cannot be exceeded.

– Resources are fixed, time is flexible: inadequate resources will delay the project.

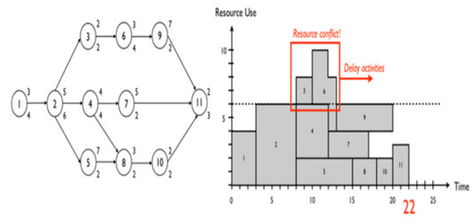

Fig 1: Basic RCPSP Example

**RCPSP: Resource Constrained Project Scheduling Problem*

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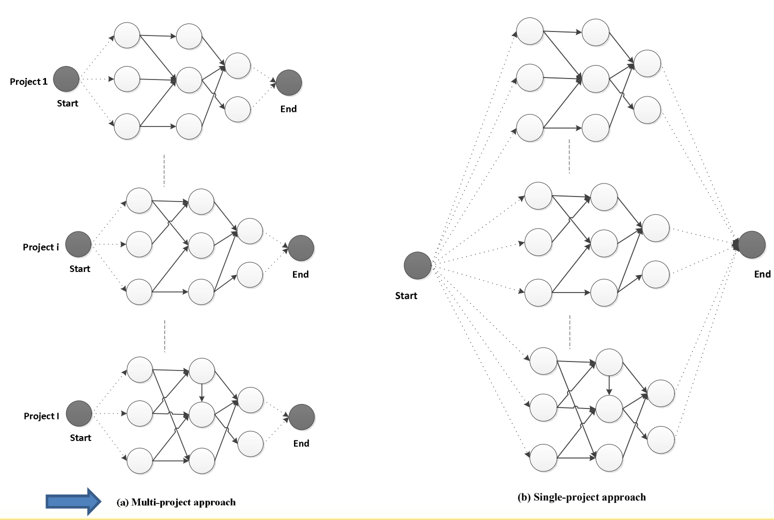
Portfolio of Projects



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Introduction

Research Motivation and Gaps

- Research on RCPSP has mostly considered fixed resource capacities and deterministic activity durations. In real-world environments, however, it is impracticable to obtain only deterministic information.
- Moreover, in real world applications, resource requests and capacities can vary over time (i.e., dynamic) along with the activity processing times or durations.
- Though appealing, this sort of extension has never gained any attention in the scientific literature

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Research Objective

- Aiming to investigate and show the effectiveness of RCPSP techniques over traditional methods by considering one real-life scheduling problem
- Assessing impacts of dynamic resource usage and availability along with stochastic activity durations, on the actual project completion time.
- Outlining important guidelines or propositions for the practitioners, which will help them to handle this kind of adverse situations by predicting the project completion time under dynamic situations.

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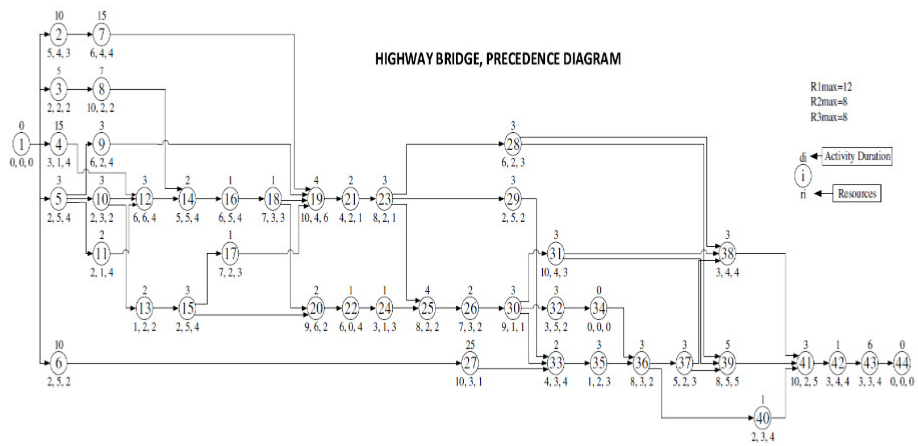
Real-life Scheduling Problem



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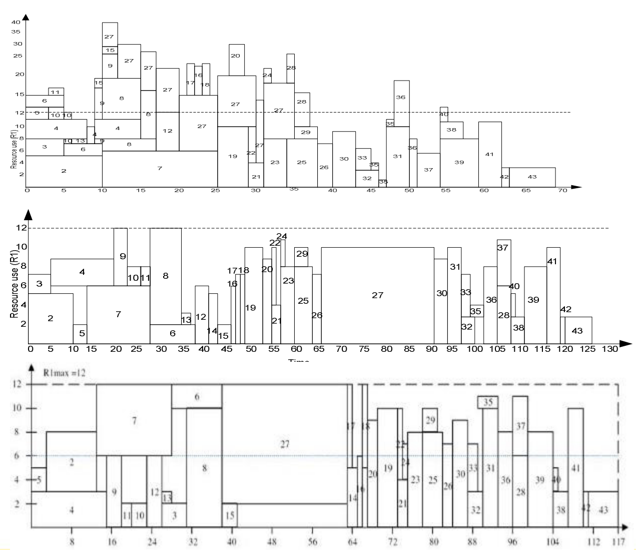
Why RCPSP?



APT* = 69 days

APT = 126 days

APT = 117 days

*Actual Project Completion Time (APT)

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Problem Description

Assumptions and Project Settings:

i. Activities belonging to any particular project have **unique characteristics** and do not depend on other project's activities
ii. There is a **precedence relationship** among the activities that belong to any particular project, and all predecessors must finish before an activity can start
iii. Resources are of **renewable types** only
iv. The activities composing a project have ***stochastic durations***
v. Activities are **non-preemptive** (i.e., cannot be interrupted when in progress)
vi. The parameters (durations, capacities and resource requests) are **non-negative** and integer valued
vii. Resource availability and resource requests are **time-dependent (i.e., dynamic)**

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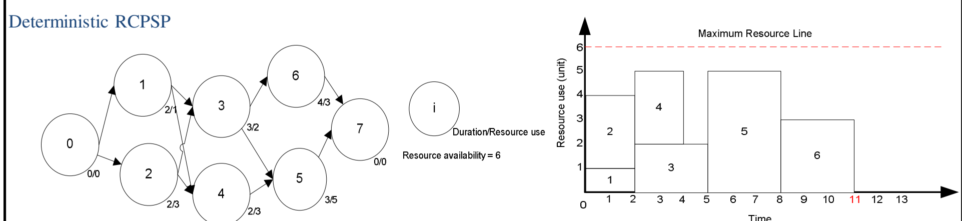
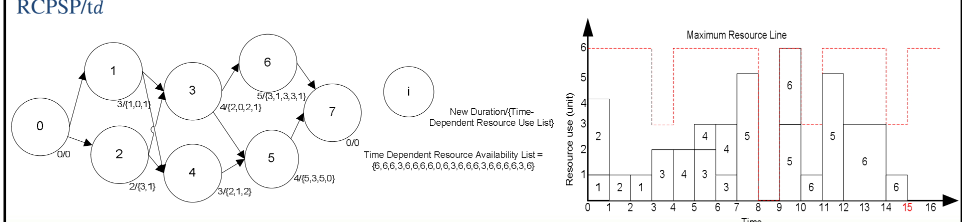
Motivational Example

Deterministic RCPSP



RCPSP/$t\tilde{d}$



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Solving Approach

Evolutionary Local Search Heuristic Approach (ELSH)

- All procedures were coded and solved in Matlab, R2015b, and executed on an Intel core i7 processor with 16.00 GB RAM and a 3.40 GHz CPU
- The maximum iteration number was set as **1000** and the maximum number of algorithm runs was set as **30** with maximum solving time of **500 seconds** for each instance

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Generation of Test Projects

- Considered two different types of statistically distributed duration sets; discrete (i.e., Poisson distribution) and continuous (i.e., uniform distribution).
- Employed two different parameters to control the variation of the resource availabilities and requests. They are: Probabilities (P^A and P^r) and Reduction Factors (F^A and F^r).

Control whether or not a reduction is applied to the availability and the request, respectively

Determine the strength of the reduction for the availability and the request, respectively

For example, P^A=0.2 and F^A=0 represents that the probability for changing resource availability during project span is 20% and the reductions of the resource availabilities will be drastic and becomes 0 at some stage.

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Computational Results

Performance Measures

- Project completion time before occurring duration variance and resource uncertainty (PTb $\widetilde{D}\widetilde{R}$),
- Project completion time after both duration variance and resource uncertainty (PTa $\widetilde{D}\widetilde{R}$) occurs
- Percentage deviations between project completion times before and after variation occurs (%Dev PTa-b)
- Percentage deviation of obtained project completion time from the deterministic lower bound $LB_{det} = 17$ (%Dev PT-LB)

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Computational Results (Continued..)

Table 1: Impacts of dynamic resource usage and availabilities on HB project's performance

$\tilde{d}$	Parameters	$F^A = F^r = 0$			$F^A = F^r = 0.5$		
		$P^A = P^r = 0.05$	$P^A = P^r = 0.1$	$P^A = P^r = 0.2$	$P^A = P^r = 0.05$	$P^A = P^r = 0.1$	$P^A = P^r = 0.2$
Uniform [U (0.75d, 2.85d)]	PTb $\widetilde{D}\widetilde{R}$	149	142	133	152	147	142
	PTa $\widetilde{D}\widetilde{R}$	162	176	201	145	150	160
	%Dev PTa-b	9%	24%	51%	-5%	2%	13%
	%Dev PT-LB	38%	50%	72%	24%	28%	37%
Poisson [$\mu = d$]	PTb $\widetilde{D}\widetilde{R}$	149	142	133	152	147	142
	PTa $\widetilde{D}\widetilde{R}$	186	198	229	171	169	174
	%Dev PTa-b	25%	39%	72%	13%	15%	23%
	%Dev PT-LB	59%	69%	96%	46%	44%	49%

d: activity's planned duration

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Discussion

- Due to dynamic resource availabilities, any project may experience 0 units of resource at a certain period of time, which impedes the generation of active schedules for any schedule generation scheme packages
- For time-dependent resource demands, resource demands may sometimes become lesser than the planned demand, including even zero. Therefore, under this kind of situation, practitioners may experience mixed impacts, given that the project activities also exhibit stochastic nature.

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Discussion (Continued..)

- If for any particular time period t, resource availability and request both become 0, then the effect of time-dependent resource demands and capacities, or even the effect of uncertain durations, is insignificant.
- The impact on project completion time is comparatively lower, when the activity durations follow the Uniform distribution. Therefore, practitioners can better forecast the project completion time and minimise cost, when the project durations are uniformly distributed.

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Conclusion

- The proposed guidelines for RCPSP/$t\tilde{d}$ can meet the requirements of handling *large projects under dynamic environments*, with minimum computational complexity.
- Practitioners can benefit from the proposed approaches, because they can be *easily implemented in generating realized schedules* under varied conditions on a real-time basis.
- Organisations can also *reduce significant financial and time losses* by applying these approaches if any duration uncertainty is experienced.

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Future Works

- Consideration of multiple modes to reflect alternative speeds of the production processes.
- Consideration of multiple projects
- Comparison with other solution approaches (i.e., meta-heuristic).
- Taking into account different objective functions such as the maximization of the net present value.

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