pDESy: A Python package for discrete time-event simulation to engineering project

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ABSTRACT

This paper presents pDESy, an open-source Python package for modeling and discrete time-event simulation of the general engineering project. It aims to be the fundamental high-level building block for doing practical, real-world engineering project management by project modeling and simulation. The simulation model consists of four models: Product, Workflow, Workplace, and Team. By using these four models, we can perform an discrete time-event simulation using several types of priority rule. The package can be used to evaluate and design various engineering projects and develop detailed execution plans.

Code metadata

Current code version	v0.5.1
Permanent link to code/repository used for this code version	https://github.com/SoftwareImpacts/SIMPAC-2023-513
Permanent link to Reproducible Capsule	https://codeocean.com/capsule/0368464/tree/v1
Legal Code License	MIT License
Code versioning system used	git
Software code languages, tools, and services used	Python
Compilation requirements, operating environments & dependencies	
If available Link to developer documentation/manual	https://pdesy.github.io/pDESy/
Support email for questions	mitsuyuki-taiga-my@ynu.ac.jp

1. Background and motivation

There are many tools for modeling and simulating engineering projects in the manufacturing industry. However, most of them are for flow-shop manufacturing lanes, and there are only a few modeling and simulation tools for job-shop projects where workers and components move in complex ways. In addition, there are no tools for describing job-shop projects in a generic model that is not specific to a particular process, nor are there any modules that can describe them programmatically.

This paper presents pDESy, an open-source Python package for modeling and discrete time-event simulation of the general engineering project. It aims to be the fundamental high-level building block for doing practical, real-world engineering project management by project modeling and simulation.

2. Modeling and simulation

In the pDESy package, the simulation model consists of four models: Product, Workflow, Workplace, and Team. This paper describes only the critical attributes of each model.

The product model represents the target product to be manufactured or developed. This model defines parts and intermediate components up to the final target product in a tree structure. The workflow model is composed of the tasks to generate a target product. Each task node has "task name", "planned workload", and "dependency between tasks" as attributes. The "dependency between tasks" is expressed by joining task nodes with directed links in the direction of execution. The team model consists of the workers who can perform each task in the workflow model. Each worker has the main attributes of "name", "skill", and

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‘‘available facilities’’. The attribute of skill is defined by each task in the workflow model. For example, a skill value of 1.0 means it takes 1.0 [time] to complete a target task with a workload of 1.0 [worker · time]. We can consider skill differences between workers by using skill values. The ‘‘available facilities’’ is defined as which facilities are available to this worker. The workplace model defines facilities and size. Each facility has main attributes of ‘‘name’’ and ‘‘skill’’. These attributes have the same meaning as those of the same name in workers.

By using these four models, we can perform an discrete time-event simulation. The task execution is represented by reducing the remaining workload and updating the state based on the assigned facilities and the skill values of the workers. The developed process simulation repeats the following operation until the all tasks are ended;

- Extract of tasks in READY or WORKING state;
- Place the products depending on the extracted tasks and workplace priority rule;
- Extract available workers and facilities;
- Allocate workers and facilities based on the resource priority rule;
- Execute the task based on the task priority rule;

One of the features of this simulation is the use of three priority rules: Task priority rules are generally referred to as dispatching rules. This package provides multiple task priority rules, such as TSLACK [1] which prioritizes tasks close to the critical path, FIFO (first in, first out) and others. Multiple options are also provided for resource priority rule and workplace priority rule. Setting appropriate priority rules during simulation makes it possible to reproduce the actual allocation and behavior in the target project.

3. Impact on real engineering projects

The old version of this package was developed as an engineering project design tool with the interface of defining project architecture and the function of discrete event simulation. This package focuses only on the function of discrete time-event simulation, which has been reconstructed as a Python package. Therefore, it can be linked to various corporate project design and production planning tools. The package can be used to evaluate and design various engineering projects and develop detailed execution plans. In Ref. [2], this package was applied to evaluating project architecture in software development mixing waterfall and agile. In Ref. [1], this package applied to designing production strategy considering the cutting peak electricity demand in the shipbuilding process. In Ref. [3], this package evaluated the installation of new production facilities. Recently, we have applied this package to create a detailed production plan for shipbuilding assembly processes [4,5].

4. Conclusions and further development

In this paper, we developed a Python package for discrete time-event simulation. This package enables us to simulate engineering projects by defining Product, Workflow, Team and Workplace models. We can apply this package to evaluate and design various engineering projects and develop detailed execution plans. However, as the size and complexity of the target project increase, ensuring the integrity of the simulation model becomes more problematic. In the future, it will be necessary to develop a function to propose model modifications to ensure consistency and a function to automatically generate the structure of the Workflow model from the Product model.

CRediT authorship contribution statement

Taiga Mitsuyuki: Writing – original draft, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Yui Okubo:** Writing – review & editing, Visualization, Validation, Software, Data curation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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