

Investigation on standard discrete event simulation case examples for the manufacturing industry in order to minimize the modeling effort

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1 Introduction

This paper is focused on discrete event simulation (DES) case examples within manufacturing, all be it the discussed topic is applicable also to other DES application areas for example health care [1].

In this paper the terminology of “standard model” is interchangeable with “standard case”, “standard use case”, “standard case example” and “standard example”, the emphasis is on the “standard”. Standard in this context meaning well defined, widely communicated, studied and understood and used by many – thus a (pseudo) “standard”.

Standard (case) examples (or standardized models) are being used for example within the nuclear industry to show failure resilience when licensing new fuel types [2]. As of late in the context of AI (artificial Intelligence) pre-trained models are being made available at no cost to the user, which minimize the user effort to adjust the model to any specific needs [3]. Also standard models/examples are often used in the context of benchmarks [4]. The benefit of standard example models can be seen in the shortcut as to avoid regenerating models from scratch for each type of application use. Finally a well documented and studied case & model give a credibility and minimizes the error risk as well as communication about specific topics is simplified as “the standard case” is well known.

As it appears various DES software has various model data storage (file) formats [5], as there is a competitive situation. However having a standard model definition language and file format will allow to focus on the model application use, thus how the model must/should be adjusted in terms of model change and/or adjusting model data.

As a larger transformation is currently taking place within the scope of Industry 4.0 digitalization and its SmartFactory [6] there is potential to improve the use of DES within the scope of manufacturing support as to for example process optimization, production planning and potentially failure investigation and remedy identification [7]. In the future DES could be used in real time decision making [7].

This investigation will investigate what is being published within the field of standard case models, identify the current state of model data interchange and suggest some features of a standardized model and its application use within the scope of industry 4.0.

Finally an answer will be given to the question if there is a “Hello World” example case for discrete event simulation ?

2 Review of literature

Some clarification of the title has been given above as to “standard model”, however it can be stated once again. By standard model in this paper the meaning is a well communicated & published example case of a discrete event simulation. At its best such a standard model has several papers using and extending it for various aspects.

In order to review “standard models” some evaluation criteria are useful, model evaluation criteria have been discussed previously [8]. However for this investigation only the use of the same manufacturing (model) case example will be investigated.

The investigation was done by searching & reading published papers if possible no older than 2015, thus completeness is not claimed. Specifically Google and its scholar.google.se search page where used as well as the MDH (Mälardalens Högskola) on-line library. The internet was used as a source for published papers.

To keep it simple only the (manufacturing) example cases found are listed below. No claim of completeness is being made.

Used search words:

- discrete event simulation example
- discrete event modeling standards
- discrete event modeling cases
- discrete event simulation json

The above listed search criteria must be understood to represent a starting point, thus based on the findings references and citation links at elsevier, researchgate and others have also been used.

List of found none healthcare example cases in published papers:

- a) Communication networks [9]
- b) Traffic [10]
- c) Fully automated fill pharmacy [11]
- d) Skateboard factory [12]
- e) Warehouse[13],[14]

During the research for publication it became clear that model use case examples seldom are being published separate, most often the example case is given in order to explain some idea or type of application using the paper content topic. Below a short list of representative keywords of papers is given: DevsBench [4],[15], SmartFactory [7], SysML [16], Pattern[17], FMI [18], Cosimulation [19].

3 Reflection

When doing research for this paper it became clear that there are several activities on going, however they are disconnected and have different focus and driving force.

On the one hand there are DES software centric activities developing libraries and other software on support of making DES simple and versatile to use [20],[21]. One of which is the DREAM project funded by the EU (under FP7 ended 2013); which created open source software ERP5 (<https://www.erp5.com>), ManPy [22] with DREAM-GUI (<https://www.manpy-simulation.org>). The ManPy documentation uses a pattern[23] exemplification approach which potentially can simplify modeling and also requires less effort to get a working model.

On the other hand there are published works using DES for investigation on various topics as shown in previous chapter, many times relating to real world manufacturing problems and aspects, among them car manufacturing [24Randell] and electronics parts manufacturing. All of these examples have in common that by applying DES optimization a (commercial) benefit is expected when applying the findings.

A commonly used very simple DES example case is a M7M//1 queue also called single server queue [25], however this is a general simple example which must be adopted to to real world, in the manufacturing context it can be a functional manufacturing operation which has a material buffer and a manufacturing activity, either automated or manual.

Benchmarking can be considered to be one of the reasons why standard example cases have been developed [15], as they allow to compare software and hardware.

Also one of the findings was the skateboard factory example case [12] used for problem based learning (PBL) at universities. This published case represents an opportunity to use the same learning example in many universities thereby creating a common modeling understanding as well problem description and potentially analysis approach. Thus the skateboard factory is one very promising example, however it will needs to be implemented in several common commercial and open source DES software tools.

In support of a wide area of application any future standard example case should model manufacturing examples using various different functionalities in the same example such as batch processes, assembly line and environment variations, etc. Also the standard example documentation must be given in english language and should include graphical case descriptions, making the english language comprehension less

important – potentially even minimizing the risk for misunderstandings as well as use and implementation errors.

The previously mentioned ManPy pattern approach applied correctly has the potential to minimize the effort (time, work effort) to create a DES-model. None the less the knowhow needed may also hinder wider use, as the DES software tools must become simpler to use [26], as many times the time allowed to create a model in support of decision [27] making is short. In this context also data interfaces must be developed which support simple data access/transfer to any ERP, MES and other manufacturing system.

Finally if a pattern based discrete event modeling is being used it will also simplify the use of AI based machine learning (ML) [27], thus improving the correctness of the predictions made based DES, this needs to be developed further. Patterns of DES could be connected to patterns in ML, which has large potential to cut implementation time needed and minimizes the overall credibility of the derived predictions.

Conclusion

To answer the initial question of Hello World”, YES and NO there is not one single example case for discrete event simulation in the context of manufacturing process simulation, thus a complete manufacturing process or production line example. However a commonly used very simple DES example case is a M7M//1 queue which can be found in various real world processes. In the context of production line a single server (M/M1) queue can represent a manufacturing process step using a material buffer and a material processing activity.

Also there are standards (ISA95, FMI) in support of standard use case examples. As Industry 4.0 and its SmartFactory evolve commercial interests will drive the creation of standard pattern based use cases for both teaching and actual hardware implementation.

As the scope of this paper is narrow, the focus has been published papers, thus for future work it is suggested to investigate textbooks (teaching DES) as well as looking at examples provided by commercial and open source discrete event simulation software.

One activity which will greatly support the standard (pattern based) example case would be to model the skateboard factory and its variations in different DES software tools, allowing to benchmark DES software capability and user friendliness.

Reconnecting to the paper topic what makes a good standard example case to minimize the DES effort ?

1. Simple to understand but complex enough to model manufacturing process details.
2. Well documented thus a baseline documentation exists including data, which supports creating a basic DES example case using the software tool of

choice. At best tutorials, examples and detailed explanations exist, however these will evolve over time once the case example is used widely.

3. Extensible depending on the user objective for using the example case
4. Availability of working example case simulations, implemented in both commercial and open source DES tools.
5. The example case is used by many, thus published papers exist and also a good understanding of the example case, including variation in used data.

Finally there is potential in connecting DES pattern based example cases to standard machine learning methodology and other software tools (so called Cosimulation [5]), which could improve the field of DES application, into DES based real time prediction.

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