A TOOL FOR A FLEXIBLE POSTERIOR ANALYSIS OF SIMULATION EXPERIMENTS

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ABSTRACT

Business processes of modern companies are characterized by a huge complexity which is caused for example by quickly changing markets, short product life cycles or dynamic interactions between particular subsystems of a company. Business process management is intended to implement efficient and customer-oriented processes whereby the simulation of business processes can be used to evaluate the quality of processes and to identify areas of improvements. For modeling of business processes as an event driven simulation model Rump(1999), Scheer(2000) we use the Epc-Simulator (Figure 1) as simulation system (Müller 2012), (Müller 2014a). Extensions of Epc-Simulator are discussed in (Steglich and Müller 2013) and (Müller 2014)

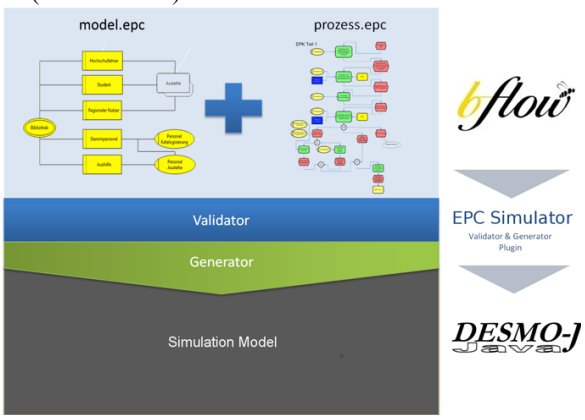

Figure 1: Epc- Simulator concept image

For analysis, the Epc-Analyzer (Müller and Krüger 2015), is presented and compared with the classical analysis approach. The functionality and use of Epc-Analyzer is demonstrated in a case study of Wildau University Library.

CREATING A SIMULATION MODEL USING EPC-SIMULATOR

For generating a simulation model with Epc-Simulator all required business processes must modeled as event process chains (EPC) in Bflow (Bflow 2014), (Kern et. al. 2010). Bflow is an EPC modeling system and runs as Eclipse plugin under (Eclipse License 2004) .

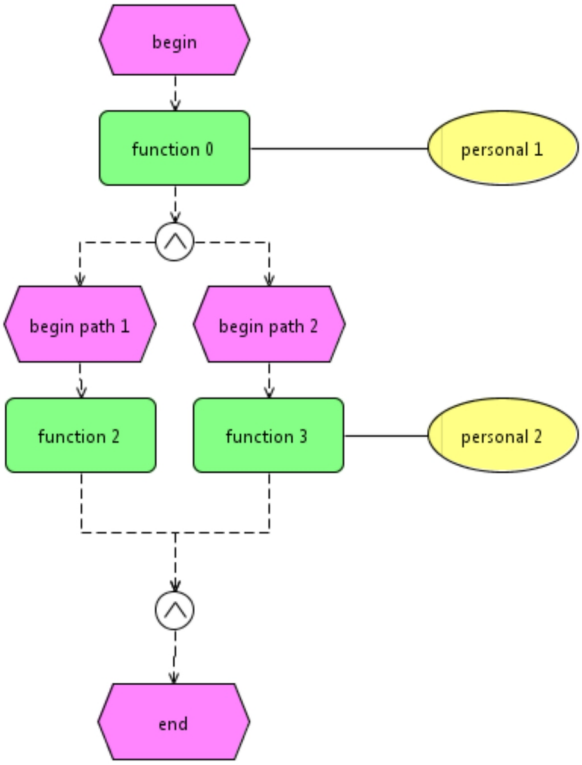

Figure 2: Sample Process

Beside the EPC diagrams, the available resource entities and the frequencies of master entities, that are running through the process chains, are described in a separate model diagram. The Epc-Simulator checks the validity of process chains and the model diagram. When all diagrams are valid the simulation model is generated as

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a Java program. The simulation model uses the DesmoJ simulation frame-work (DesmoJ 2014), (Page 2005). DesmoJ runs with Apache 2 License (Apache License 2004). This concept is painted in the Epc-Simulator concept image (Figure 1).

A sample process is shown in Figure 2. Every master entity that runs through this process is splitted at the first gateway into two parallel running siblings. At the second gateway both siblings are waiting together for synchronization and running afterwards into the next step as one integrated entity. For processing of function 0 and 3 resources are required. Before a master entity can pass this function it must wait for an available resource entity.

For classical statistical analysis by Epc Simulator the data for all master and resource entities are registered. For master entities these are:

- the process times inside a function,
- the waiting time before entering a function,
- the synchronization time inside a join gateway,
- the lifetime and there
- key performance indices.

And for resource entities these are:

- the process times inside a function,
- there utilization and there
- key performance indices.

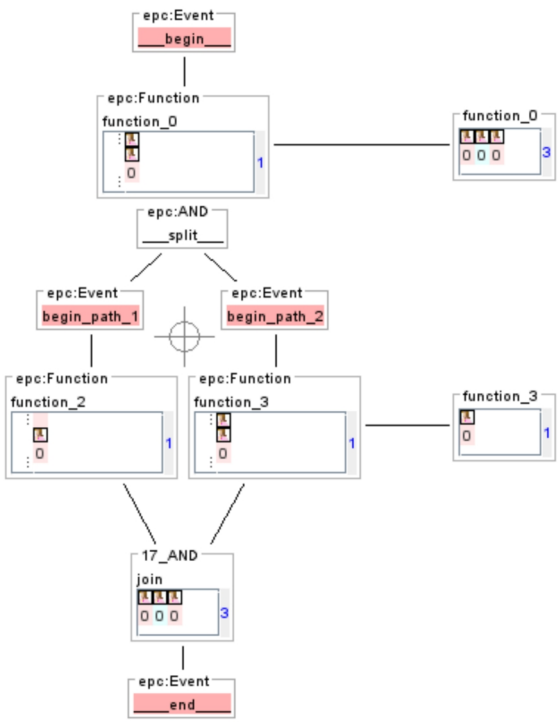

Figure 3: Animation of sample process

This data are stored in dependency of the observed entity and partially of the passed function or join gateway. For statistical representation the data are reported unchanged or aggregated as entity groups or function or join gateway groups.

With an animation viewer application every simulation run can be animated in posterior. For this all changes of states of animated entities are stored during the simulation run in a file, named cmds file (Figure 4). The animation viewer reads the cmds file afterwards. The viewer can pause, restart and repeat the animation. It is also possible to have an detailed look on every entity. The writing of cmds file by simulation model increase its running time by a factor between 1.4 and 4.0. This is a result of some internal investigations.

Figure 3 shows an animated simulation run of the example model. In the function nodes are some master entities processed together with there associated resource entities. In front of some function nodes are waiting master entities for processing. Inside the join gateway (17_AND) some paralleled siblings and there parent are waiting on synchronization.

EPC-ANALYZER

In the Area of "Enterprise manufacturing intelligence (EMI)" (Davidson 2014) are some tools to analyze production data in an enterprise manufacturing process. Normally these tools collect data from production entities, like robots, normalize their data to a unique format for analyzing. The target of EMI Systems is to improve the interaction of different production entities in a production process.

The Epc-Analyzer adapts the idea of an EMI Tool for analyzing simulation data. The Epc-Analyzer stores all data from the cmds file, that build for animation purposes, in a database (Figure 4).

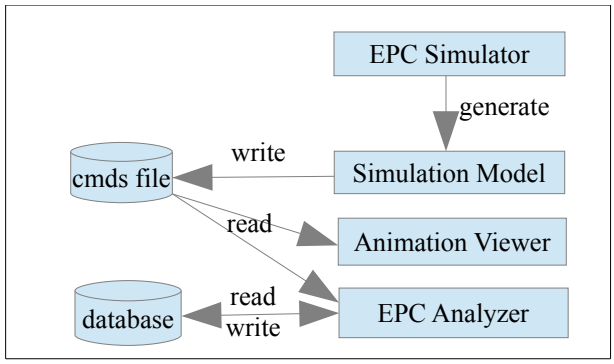

Figure 4: Communication between Simulation Model and Animation Viewer and Epc-Analyzer

The Epc-Analyzer supports a detailed study of the behavior of all master and resource entities inside of the simulation model. This includes views from the different perspectives on the simulation model:

- The master entity view draws a different image about the behavior of every master entity (Figure 5) with all its process-, waiting- and synchronization- times. It supports also a aggregated view on its master group.

- The resource entity view shows the behavior of every resource entity with its process- and waiting times. It supports also a aggregated view on its resource group.
- The queue resource view analyzes the queue where the resources are waiting on there next tasks.
- The function and the queue function view describe all activities inside of a function and there waiting queue.
- The event view give information when which master entity is passing this event.
- The connector view describes all activities inside of a join gateway (of OR or AND type) and there synchronization times.
- The route view give an overview about all used ways through the simulation model.

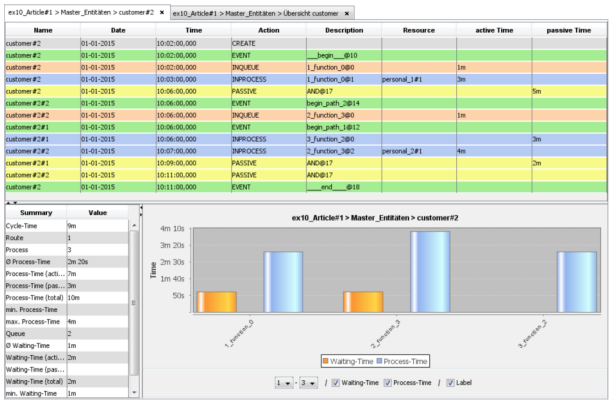

Figure 5: Epc-Analyzer

For a classical statistical analysis of a simulation run, the simulation must prepared with data observers at points of interest in the model. During the analysis process these points of interest may be changed. In this case new observation points must integrated in the simulation model and the simulations must run again. By using Epc-Analyzer the analyst must not decide about the required observation points and there aggregations before a simulation run. Because all data, that are visible in the animation are stored in the cmds file, they can be analyzed by Epc-Analyzer without a new simulation run. This is the advantage of Epc-Analyzer against the classical approach in Epc-Simulator. On the other side the generation of cmds files increases the simulation running time by a factor between 1.4 and 4.0. In cases for serial examinations of parametrized simulation models, without animation requirements, remains the classical way still useful.

CASE STUDY: CATALOGING PROCESS AT WILDAU UNIVERSITY LIBRARY

In the last years the business of a university library has changed. New challenges are located in the area of e-books, e-journals and in teaching scientific searching and writing technics for novice students must supported. For this, a reorganization of the business processes in the library are necessary. In this context the Wildau University Library is trying to document, analyze and optimize their processes. With this they want to increase the transparency and flexibility, specialty to manage substitutions in the case of illness and holidays of staff members. With a simulation based what-if analysis they want to have a tool to forecast the consequences of there management decisions. There is a expectation, that the analysis results can be useful in the discussion between library and university management about the evolution of financial and stuff resources in the next years.

For this the actual processes are analyzed. The catalog process of print book titles is one of these library processes. This Process is described in Figure 6.

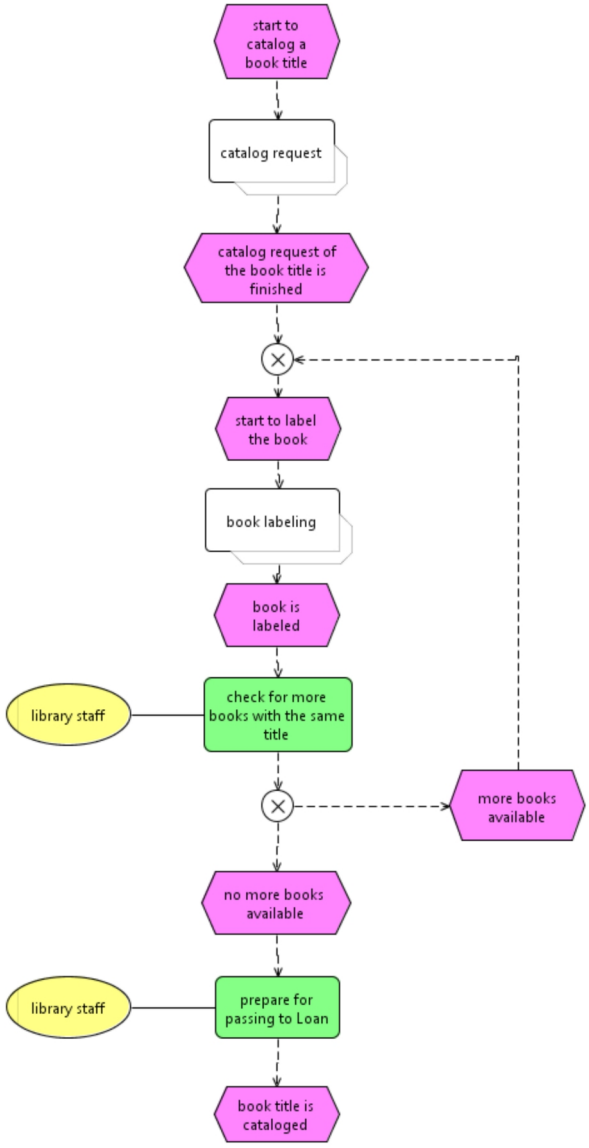

Figure 6: Print Catalog Process

In a first step of the catalog process, the title of new book acquisition must searched and indexed in a library database. This is done with the catalog request process. In a second step the book- and RFID labels of this title are printed and glued in the book. Sometimes the library

buys more than one book of a title. In this case every book must be labeled.

The catalog request process is shown in Figure 7. In a first step the title is searched in a local SISIS database. In 40% this search is successful and the data are correct. In the other case the title must also searched in the union catalog, which based on the integrated library systems ALEPH. Then the SISIS database entry of this title is updated by Aleph and the new acquisition is written in SISIS.

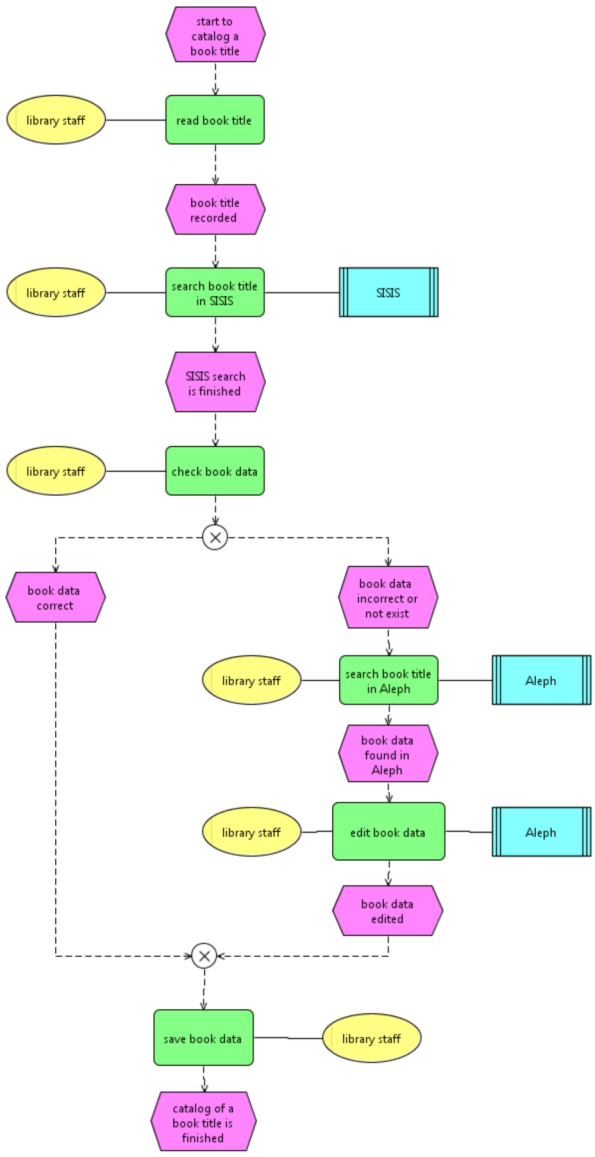

Figure 7: Catalog Request Process

The book labeling process is shown in Figure 8. It is called by the print cataloging process. In this process a back label and RFID label is written and glued in the book. For printing the back label a special back label print device is used.

The duration time of every function is modeled by a triangular distribution. There parameters, the lower-, peak- and upper-time, are subjective estimations of the librarians, based on there daily experience.

The book titles are delivered by book stores on every working day (MONDAY until FRIDAY) between 8 AM and 5 PM. The inter arrival times between 2 titles are given by exponential distribution with a mean of 45 minutes. In all described processes works one librarian in part time (MONDAY until FRIDAY between 9 AM and 1 PM). For printing the back labels, the back label deceive is working 24 hours daily.

The simulation runs 4 weeks from February, 1st, 2015 00:00 until March, 1st, 2015 00:00.

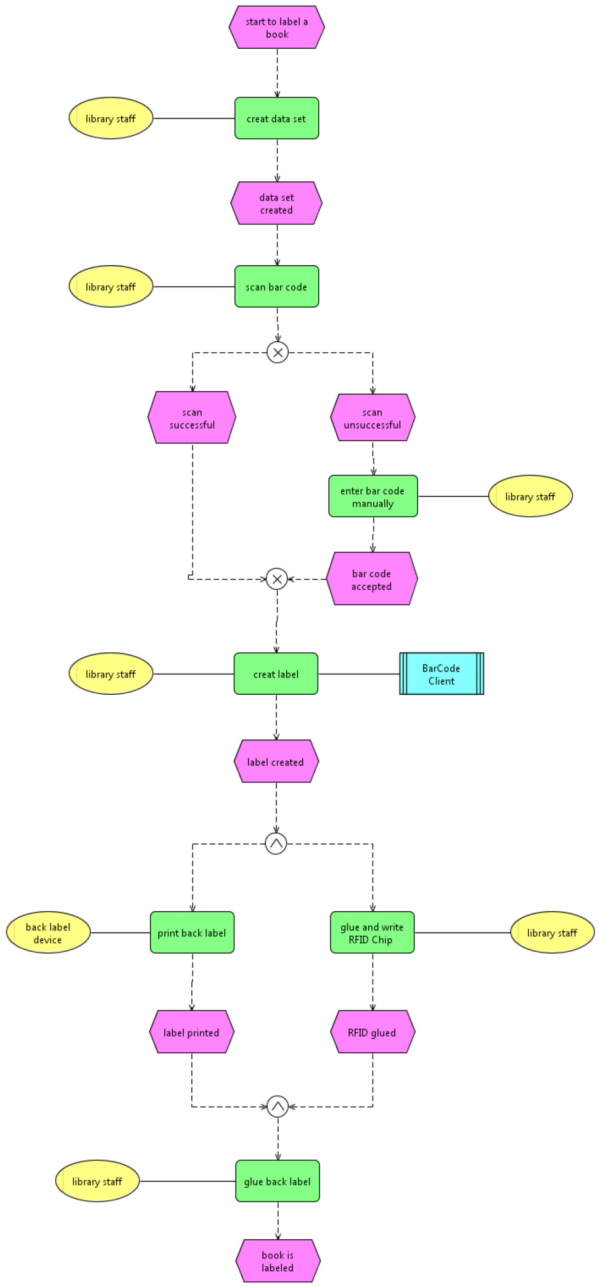

Figure 8: Book Labeling Process

This process is analyzed with classical technics by (Dierking and Wilke 2013). For this they must include a

data observer at every point of interest into the simulation model. In this paper the Epc-Analyzer is used. In opposite to a classical analysis no statistical observation points must included.

In a first step it makes sense to look at the the first event (Figure 9) and last event (Figure 10) of the print catalog process (Figure 6). These diagrams shows the number of entities that passed these events.

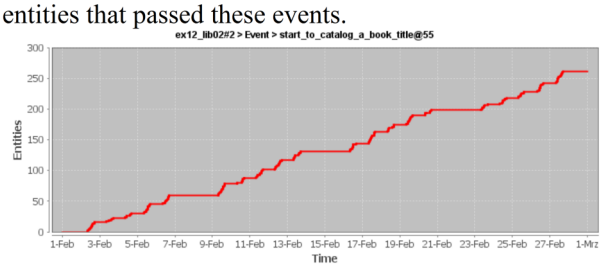

Figure 9: Begin of print catalog

Both diagrams show clearly the weekends, where the number of entities is not changed, because only on working days new entities are generated and processed by the library staff. The difference between both curves describes the number of entities inside the process.

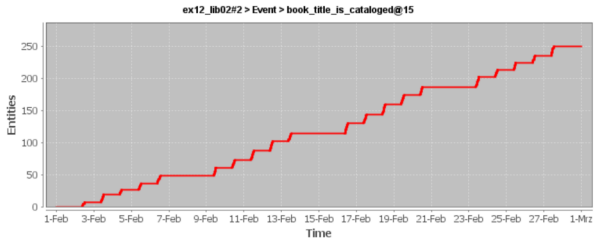

Figure 10: End of print catalog

The function "read book title" is the first function in the print catalog process. In its waiting queue (Figure 11) the unprocessed book titles are waiting. The diagram show clearly the 4 weeks and the single working days. Since the daily working hours of the librarian are shorter than the delivery time of book titles, the number of titles in the queue is increased when book titles are delivered, but not processed by a librarian.

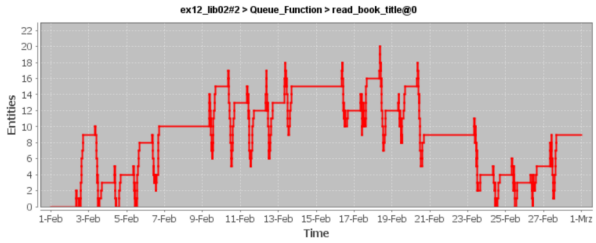

Figure 11: Waiting entities on first function

The inter arrival times between new book titles and the process times of each function is given by a random distribution. The variability of the total process times is shown in Figure 12. These fluctuations are the reason for changing the levels of waiting titles in Figure 11.

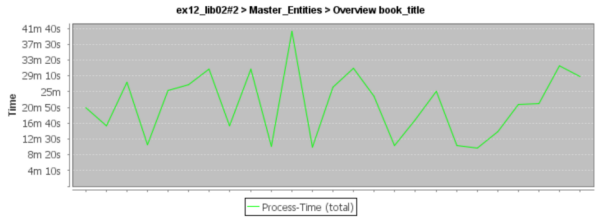

Figure 12: Process times

The resulting passing times is shown in Figure 13. The big outlier are consequences of weekends and the small of the end of every day.

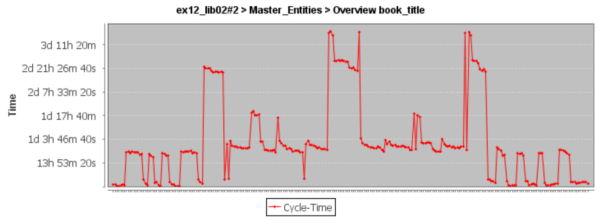

Figure 13: Passing times

The librarian is working 4 hours per day, 5 days per week and 4 weeks. These are 80 hours or 3 days and 8 hours. The librarian is 91.3 % of this time working and 8.7 % waiting on new tasks.

Figure 14: Staff utilization

A detailed view of staff utilization is given by the resource queue (Figure 15), where the librarian is waiting on new tasks. These happens only in the first an d the last week. The waiting in the first week may be caused by attunement of the model.

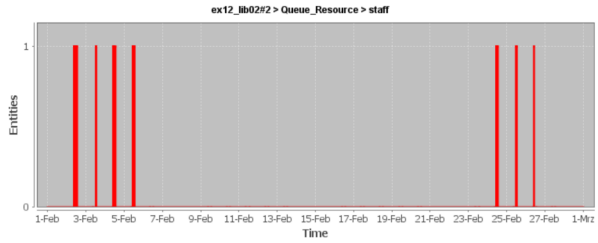

Figure 15: Staff entities out of work

In Figure 11 we have seen that the level of waiting books is changed in the last week to a lower level. This is the reason of the staff waiting time in the 4th week in Figure 15.

CONCLUSION

The presented case study shows the applicability of Epc Analyzer on practical tasks. For animation purposes the

simulation model writes a cmds file. This file is the basis of all investigations of Epc-Analyzer. Hence, the simulation model needs no special preparations for studys made by Epc Analyzer afterwards. The price of this independence is the investment of creating the cmds file. The writing of cmds file by simulation model increase its running time by a factor between 1.4 and 4.0. On the other side, for serial examinations of parametrized simulation models, without animation requirements, remains the classical way still useful.

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