Interview Guide V1 EN

- **Greeting**

Hello and thank you for taking the time to do this interview with me. [redacted].

- **General introduction**

My research focuses on developing a method to display continuous processes in BPMN and make them executable in a workflow engine. The main reason for this is that I want to use these process models as digital twins. This lies in contrast to a more common data-centric approach of modeling digital twins. My approach is the creation of a digital twin in form of process models which describe the workflows of a system. For this task we worked on BPMN extensions for continuous engineering processes. Why continuous processes? Because discrete processes have already been treated in other research and do not pose the same level of difficulties in correct depiction using BPMN. BPMN is already a widely applied standard in business process management and has found its way into manufacturing. Discrete manufacturing processes can already be modeled using BPMN 2.0. Process execution engines can use these models to execute the process the same way as it is defined in the model. This development has led us to the point at which we want to explore further promising application fields in engineering such as continuous processes.
We basically want to introduce a method to depict such processes in a way which can be understood by any person in a company from engineers to manager. This could be achieved by using this notation. Another advantage is also that there are already a number of workflow engines - applications which allow the execution of these process models based on the logic implemented for each symbol. We work with one that is web-based, extensible and has several communication interfaces implemented. Therefore another benefit is interoperability in this context in comparison to other proprietary, rigid software applications. We want to find out whether this technique can also be applied for implementing digital twins. As digital twins are used to depict a physical system or process in digital form - mostly by using data or mathematical models - we needed to find a way to depict the execution of continuous processes known from chemical engineering. This is why we focused on modeling closed loop control systems.
The process models shall be easily understandable for persons with various backgrounds due to BPMN. The interviews are conducted in order to find out, how process and control engineering and techniques from business process modeling can be combined and how first results are perceived by experts like you. And we also want to find out if there are weaknesses identified by experts and how we can remove them.

- **Introduction of interviewee**

Would you please introduce yourself and tell us a little bit about your connection to either process, chemical or control engineering?

Based on the selection of experts for this interview, it is assumed that you are not familiar with BPMN 2.0 and individual symbols of the workflow engine [redacted]. An introduction document has been given to you for this purpose and questions have been clarified.

- **Unified questions**

- Continuous processes

1) Could you give me an example for a continuous process you may know from your experience in control engineering? (Thermostat)

2) Could you please describe how you would work on implementing a model of this process example/a continuous process if it was your daily work routine?

3) Can you name some features which are relevant when you want to model continuous processes? What do you think is crucial in correctly modeling a continuous process and why? Where do you think lie the challenges of modeling continuous processes?

During my research I identified a set of features which I count as important to depict a continuous process correctly. I'm now listing these features and I want you to tell me:

4) How relevant on a scale from 1 (not relevant at all) to 5 (very relevant) would you rate the following features:

Features	**1 (not relevant at all)**	**2 (less relevant)**	**3 (neither)**	**4 (relevant)**	**5 (very relevant)**
1. Continuity					
2. Conditions to define the end of a continuous process					
3. Time as process parameter					
4. Parallel processing of individual tasks and task sequences					
5. Exception handling					
6. Comprehensiveness in process depiction					

Explanations of properties if requested by interviewee:

Continuity	In continuous processes a variation of different sub-processes or sequences of individual tasks are running as simultaneous iterations. The duration of iterations defines the granularity of the process steps and implies discrete behavior. True continuity with a completely seamless process will be just as unfeasible in a digital representation of a process as it is in reality. However, it must be possible to represent the undisturbed progress of a process flow. The process model shall imply a continuous flow without having to set a limited number of repetitions or a time limit from the beginning. Continuity needs to be presented in form of a loop. BPMN supports loop characteristics for tasks and sub-processes. However, this modeling option is confined to individual tasks and sub-processes and thus may lead to complex, multi-level process flows.
Conditions to define the end of a continuous process	There must be a way to represent the transition from continuous process to sequential and terminating process flows. An example for this transition is the change in operation mode of a system from normal operating state to maintenance or shut down. If these conditions cannot be displayed and changed in the model, the process would continue indefinitely. After the transition the process shall not terminate but the integration of further process steps shall be possible. Break conditions can also be applied to tasks and sub-processes with loop characteristics. In case the break conditions are met, the looping of the defined tasks stops which leaves open the question of where to

	insert clean up routines. For defining the termination handling of a continuous process and allowing the option to define clean up sequences, Cancel Events can be used. However, for Intermediate Cancelling Events only Boundary Interrupting Events are defined.
Time as process parameter	Due to the critical impact of time regarding continuous processes the role of time needs to be clearly defined. A real-time system reacts to simultaneously occurring process signals in time with a corresponding output. This implies that each task needs to be arrangeable according to the priority level in the timeline of the process in order to guarantee real-time operation of the system. Some control mechanisms are designed to work faster than others. Therefore it must be possible to define and limit the time sequence of tasks and also for complete iterations. BPMN supports Timer Events which need to be applied correctly and comprehensibly in order to understand the implied constraints and display them correctly.
Parallel processing of individual tasks and task sequences	In real-world processes multiple tasks are performed simultaneously. Parallel processing of tasks and task sequences needs to be supported by the chosen modeling environment. In addition, it must be enabled to incorporate specifications defined for continuity and real-time processing. Parallelism can be modeled in a way similar to loops in form of attributes for tasks and sub-processes. The orientation of the attribute marker indicates whether the multiple sequences are processed in parallel or sequentially. Again, increasing complexity of the process leads to an incomprehensible model.
Exception handling	During the execution of tasks, errors may occur which imply a corresponding reaction in the process flow. Mechanisms for exception handling have to be available as assurance for real-time processing and determinism. For exception handling BPMN already implies the usage of Intermediate Events. Timer events can be applied to deal with time restrictions which are fundamental for continuous processes.
Comprehensiveness in process depiction	If all necessary details of a continuous process are included in the model, the level of complexity must not exceed to a point at which users no longer understand the process behind the model. To prevent this drawback, modeling conventions need to compensate complex relations, but still lead to a detailed and comprehensible process models. At any point in the process the user needs to be able to follow the trace of the process flow. If the other mentioned requirements are followed, continuous processes in BPMN quickly become complex and confusing.

- BPMN Extension Model

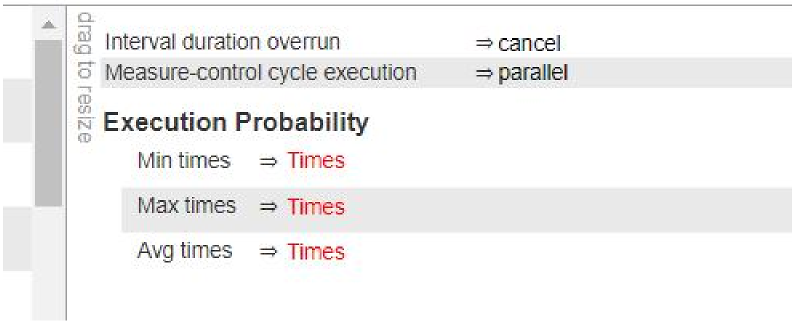
Introduction for extensions

I'm going to show you processes modeled with BPMN 2.0 and with with our custom extensions. The extensions shall on the one hand provide predefined modeling conventions for routines common in process and control engineering and on the other hand help visualize the differences between the parallel paths in the process models. The processes are modeled in [redacted]. For comprehension of the [redacted] models, three additional symbols need to be explained.

Extensions

- Closed-Loop Subsystem Gateway

The Gateway is a combination of an Inclusive and an Event-based Gateway. It contains branches which are triggered for the measuring and control phases of the cycle, as well as branches executed when cancellation events are received. Th Gateway further allows to define the interval duration of each cycle as well as overrun conditions (wait - cancel) as well as the execution order for measuring and control tasks.



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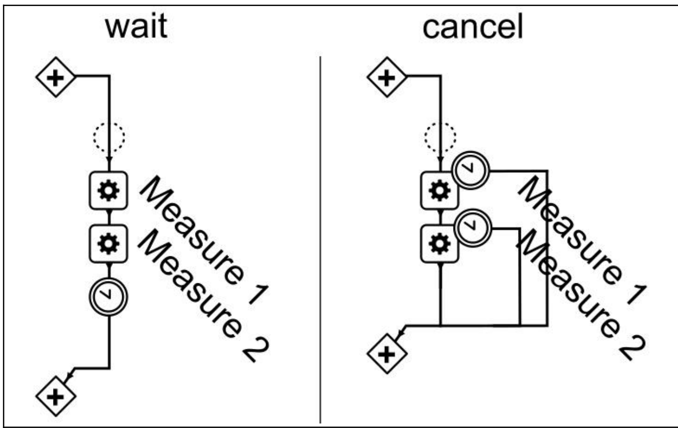
<td>
</td>
<td>When wait, the following iteration starts when all branches are finished and the defined interval duration is reached.
When cancel, the interval duration defines exactly the time each branch takes to finish. If the tasks in a branch are finished early, the branch waits. If not all tasks are finished yet, they are terminated.</td>
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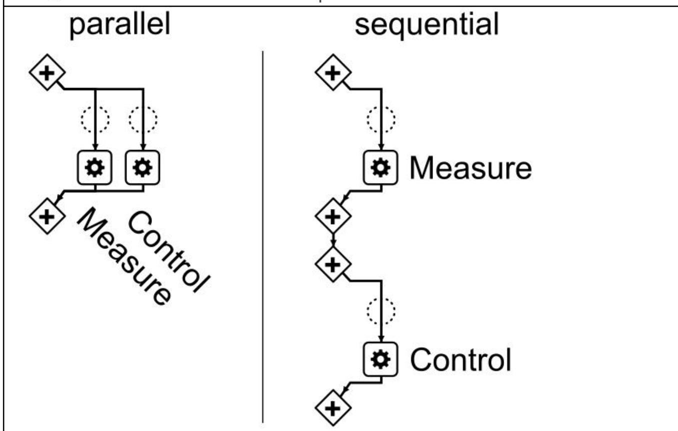
<td>
</td>
<td>When parallel, tasks after Measuring and Control Intermediate Catching Events are performed in parallel.
When sequential, the tasks after Control Intermediate Catching Events are performed only after all tasks after Measuring Intermediate Catching Events are finished.</td>
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- Intermediate Catching Events

Measure	Control	Cancel
		
Receiving events to perform measuring cycles	Receiving events to perform control cycles	Receiving events to abort closed-loop systems

These symbols indicate the purpose of the following tasks. These tasks are only executed when the events are triggered. This means that the measurement event indicates that the subsequent symbols only indicate measurement sequences. The same applies to control and abort events. For measurement and control events we can define a cycle time. Depending on whether the closed-loop subsystem follows a parallel or sequential or a wait or cancel approach, the execution runs differently. Control events can further be used to define which controller model is used - PID, PI, PD PT1, PT2 - these controllers are represented in their mathematical form. The tasks for them are basically calculations represented in fixed subprocesses. After these calculations, the user can add tasks for further data processing. This can also be done after measurement tasks, which can also be called data acquisition tasks. Measurement and control events should be triggered at regular frequency - termination events, on the other hand, are triggered only by their termination conditions, which can be defined by the user. An example of an abort event would be when something triggers the abort of a cycle, such as a watchdog function to monitor the maximum cycle time, or it could be an emergency stop. After the event is triggered, tasks can be added to the cleanup routine before the cycle ends or the process is completely terminated.

Process model Examples

I will now show you process examples modeled with the extensions presented in our paper. I would like you to take a look at the models and tell me what you can read out of them and whether the models fulfill the necessary information content for modeling the underlying control processes. Beforehand, I will explain to you what is to be modeled for each process. Please give open feedback on the models in BPMN.

5) Evaluate the following model: simple feedback control (PI) temperature control for a heat exchanger based on the example from the MathWorks library[1].

The temperature of a liquid in a stirred tank is controlled by means of a heat exchanger. The heat flow introduced via the heat exchanger is controlled by a valve that controls the steam flow. The disturbing environmental influence to be considered is the fluctuating temperature of the liquid supplied.

Instance in [redacted]: will be shown in the interview

[1] See https://de.mathworks.com/help/control/ug/temperature-control-in-a-heat-exchanger.html, accessed 05/05/2021

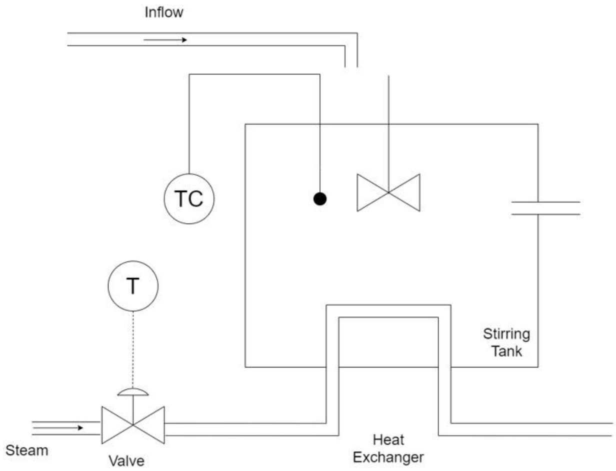

Bild 1: Process flow chart[1]

6) Evaluate the following model: Instance in [redacted]: will be shown in the interview.

The process description for the model was taken from Siemens training materials[2].

This is also a temperature control for a stirred reactor, the control is realized in this example with a PID controller, a manual control and a pulse generator. Furthermore, locking conditions are defined. The detailed descriptions from the training documents for process modeling with SIMATIC PCS7 were used as the basis for the process modeling[2].

7) Based on these extensions would you be willing to introduce this modeling method in your daily work routine when you were developing a model of a continuous process?

8) How well do think do these extensions describe a control system for these examples?

Features	**1 (very bad)**	**2 (not well)**	**3 (neither)**	**4 (well)**	**5 (very well)**
Model 1					
Model 2					

Please give a reasoning for your answers.

9) What is missing for a detailed process description?

10) Talking with experience in control engineering - what would you recommend to add to these extensions to make them more attractive to use for engineers?

11) Did you recognize the continuity in these models? On a scale form 1 to 5, where 5 is the best value.

[2] See https://www.automation.siemens.com/sce-static/learning-training-documents/pcs7/v9-0/p01-06-control-loop-v9-tud-0719-de.pdf, accessed on 05/05/2021

12) How would you imagine a data-centric point of view for such processes? What do you think about displaying continuous processes known from industry from a more process-centric point of view in comparison to a more data-centric point of view?

Thank you for taking time for this!
I'm grateful for feedback on the interview!