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# Towards an Architecture for Assistive Process Execution Environments

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**Abstract:** Flexibility in Business Processes is still a challenging issue in research and practice. Performing tasks outside a predefined control flow gains importance in times of dynamic environments, higher employer autonomy, and value-oriented process management. We believe that data science and machine learning can support flexible processes' execution and design by providing assistance. This article sketches an architecture that supports this approach based on a short review of current and past approaches to process modeling and execution.

**Keywords:** Process Execution, Business Process Management, Adaptive Case Management, Recommender, CMMN

## 1 Problem Description

Workflow execution environments provide automated process execution along with Business Process Management capabilities. Large ERP software vendors like SAP, Oracle, and IBM offer such functionalities. Furthermore, specialized platforms focusing on Business Process Management, IT-Service management, or Robotic Process Automation are on the market. Examples are Camunda, ServiceNow, and Kissflow. Though low code and no-code development of executable workflows is intended to support adaptation and creation of workflows by domain experts, this provides only design-time flexibility. However, there are several reasons to adapt process execution at run-time:

- Workflows usually describe the common process execution flow; exceptions from that need to be handled manually.
- In knowledge-intensive business processes, humans decide autonomously what to do next at the run-time of a process.

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- Process execution requires resources. Considering human capital as an example, self-management activities of employees to preserve their resources (e.g., skills, motivation, health) have to be intertwined with direct process activities.
- On a more general level, organizational goals go beyond the process goals, but their achievement is connected with process-related activities like knowledge acquisition or relationship management.

Consequently, many activities are executed in connection with a process instance depending on the run-time context and are not part of the designed workflow. Workflow execution environments barely address these activities. As a result, there is no automated support for these activities, and furthermore, they are not in the control of Business Process Management (BPM). Thus, there is a blind spot concerning essential process knowledge and created value.

Adaptive Case Management (ACM, see, e.g. [HKM15]) is a BPM-paradigm that addresses these issues. Still, the focus is on knowledge-intensive processes only, coming with a high degree of ad-hoc decisions and employer autonomy. Research in that area revealed that processes generally have structured and unstructured parts with, e.g., ad-hoc decisions [Hi16], [ZSJ14]. Approaches to model and support the unstructured part in process execution environments have not been successful on a broad scale. An example is CMMN[4] which has been supported by the Camunda process execution platform. Following a blogpost[5] by Camunda in August 2020 that declared CMMN as failed, the platform no longer supports that notation by now. Research [La18] pointed at two significant drawbacks of the approach – (1) Problems with the understandability for domain experts, (2) Missing concepts to accurately define processes. Thus, addressing the complexity of flexibility in the processes is still a big issue. There are approaches (e.g. [NK16]) that reduce the use of CMMN to models that define sets of activities where each set of activities is bound to a small set of common preconditions for execution. Selecting appropriate activities within such a set is left to the human actor. Again, there is a blind spot for BPM, and human actors in the process have to face the complexity of selecting appropriate activities. There are also approaches like KMDL [GMK05] that add knowledge activities to process models, which again focuses just on knowledge-intensive processes and poses problems with complexity.

Summing up the discussion, there are many activities connected with process execution that are not addressed by "traditional" BPM and Process Execution Environments. Approaches to flexibility and variability have problems dealing with complexity, especially regarding the execution rules in data-driven approaches like ACM.

We believe that data science and machine learning can aid the implementation of *Assistive Process Execution Environments* (APEE) that firstly assist human actors in selecting appropriate activities in less structured process parts or contexts that require out of flow

[4] https://www.omg.org/spec/CMMN/
[5] https://camunda.com/blog/2020/08/how-cmmn-never-lived-up-to-its-potential/

activities at run-time in addition to "traditional" structured workflow definitions and business rules. Secondly, this new Process Execution Environments class allows and requires addressing the aforementioned blind-spot of BPM.

The following second section describes the requirements that we see for the envisioned APEEs. Section three then sketches a general architecture that fits these requirements. In the last section, we provide a summary and an outlook on the next steps.

## 2 Requirements of Assistive Process Execution Environments

Based on the problem description, we can derive requirements for the design-time and run-time environment. Another important aspect is the integration of design-time and run-time and the integration of external data sources.

**Design-Time.** First of all, process modeling must be able to specify structured and less structured parts of a process. Appropriate methods, notations, and tools for that are required. This has been shown, for example, by research on ACM. Since out-of-flow activities could be relevant at any time, there are also mechanisms required to specify what kind of activity this can be and to what extent this is accepted during process execution. This goes along with keeping track of organizational goals and created values that are not part of the main, process-specific goals and values.

Since complexity is an issue, mechanisms that help to handle the complexity need to be implemented. Approaches in the area of visual notations can be found in Moody's "Physics of Notations" [Mo09]. Different types of activities have different relevance for processes and process phases. Thus, a taxonomy for activities that can be adapted and extended depending on the domain is required. This would also help to handle the complexity. Data used and created by the data-driven run-time assistance needs to be considered in process analysis for process design to allow a BPM that also controls these aspects of process execution.

Analyzing and designing processes requires stakeholder involvement. By adding new elements to Design-Time new method(-components) for stakeholder involvement need to be developed. Design-Time tools have to support these.

**Run-Time.** At run-time, the APEE needs to allow the same flexibility that is expected from ACM-based systems. Additionally, data-driven assistance for selecting the next best activity to execute needs to be provided to human actors. The run-time environment must support different flexibility levels ranging from strict control flow and rules to free choice of even unspecified activities depending on the process specification and the context.

**Integration.** Besides integrating design-time and run-time via the process specification, process knowledge needs to be available at design-time and run-time using a common data lake. This includes the log data from process execution and data from other information systems such as the knowledge management systems when knowledge activities are considered. This requires a common context model that allows data integration as well as appropriate interfaces. Furthermore, it should be possible to integrate already existing taxonomies and conceptual models of the involved domains to support re-use. In order to integrate unstructured data, two aspects need to be covered. Firstly, context information as described in the context model needs to be assigned as meta-data to unstructured data records. Secondly, since collected unstructured data also describes the context, a mapping functionality needs to be provided that maps phenomena detectable in these data to the context model concepts. Thus, unstructured data becomes accessible to process analysis, design, and execution control.

## 3 Architecture for Assistive Process Execution Environments

Figure 1 shows a sketch of the intended architecture for APEEs. Boxes with round corners symbolize active components. Regular boxes stand for models and data. Arrows show information flows. In the following, the main components are lustrated.

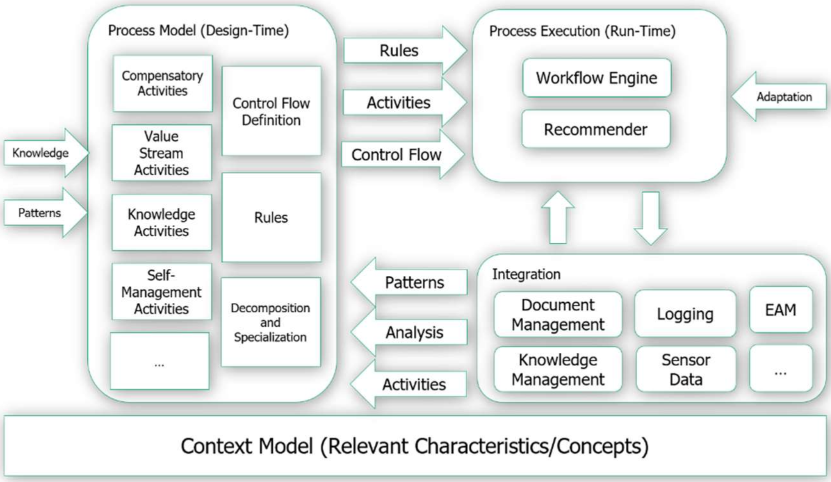


Fig. 1:Assistive Process Execution Environment Architecture

**Design-time.** Process models can be defined using control flow definitions (e.g., in BPMN) combined with rules from declarative approaches for less structured process parts (e.g., using DMN). Rules are also used to define the level of allowed flexibility (e.g., using Flexibility Patterns [LK18]). Several mechanisms are envisioned for complexity handling. While aggregation/decomposition and view generation are common for control-flow specifications, we also see mechanisms like generalization/specialization, classification, and queries. These can also be applied to activities and rules. Since a significant number of activities needs to be considered, taxonomies should be used here. Important categories of activities are shown in Fig. 1 (e.g., Compensatory Activities or Value Stream Activities). However, this is not exhaustive, and it is assumed that single activities may belong to several categories. To provide complexity handling, a repository of process model artifacts that allows querying based on classification and other meta-data based on the context model should be part of the design-time environment.

**Run-time.** The run-time environment consists of a workflow engine that allows workflow execution based on control flow definitions and rules but also run-time adaptation. The recommender component explores the room for flexibility at run-time and recommends possible activities based on context data. There are different approaches to recommender implementation that could be used (see, e.g., [Ag16]).

**Integration/Context Model.** Besides the data that is directly handled by the workflow engine, various context data might be required and to be traceable depending on the domain. When process knowledge lies in unstructured data, document management needs to be integrated. Self-management may require sensor data integration; knowledge activities the integration of knowledge management for assistance and analysis. Other sub-models of the enterprise architecture like data and role models are required for the definition of rules. Integration and knowledge re-use require a context model at an inter-organizational level that can be specialized for a specific organization's needs. Semantic technologies are envisioned as an appropriate means to support this.

Furthermore, new ad-hoc activities need to be registered in the design repository. Execution patterns can be mined in the logs using process discovery approaches (e.g. [Au18]) to support learning for process design from previous process executions.

## 4 Conclusion and Future Work

We have shown that out-of-flow activities are not an issue solely to knowledge-intensive business processes. Adding flexibility to all kinds of processes can be supported by the assistance provided through process execution environments. With our APEE, we sketch an architecture for such environments. It is based on existing approaches (e.g. [Sc08]) but emphasizes still-existing significant problems and is new in its perspective and combination. The following steps would be a more rigorous development of the concept, evaluating implementation alternatives, and creating a prototype. Concretely, experiences from process design and analysis in the domain of personal services (e.g. [LK20], [LSL19], [LWH19]) and self-management ([Lam18], [LF+20]) are going to be used to construct a first proof of concept prototype. The prototype will be evaluated in a case study in order to derive further development steps. The Camunda process execution platform is envisioned as the technical base. It allows ad-hoc activities, the definition of rules and provides run-time access on execution logic for the recommender. Different approaches for recommendation will be compared and selected based on an analysis of the context.

The goal is to generalize findings for a further specification of the APEE approach and method support design.

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