Articulation of Subject-oriented Business Process Models
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ABSTRACT
Business process elicitation needs to capture, document, and share the expertise and experiences developed over time by the involved workers. This paper presents an approach for elicitation of subject-oriented business process models from operatively involved people, who are not expert modelers. The approach facilitates individual articulation and collaborative consolidation of work knowledge. An instrument based on physical structure elaboration techniques is introduced to represent procedural knowledge in conceptual models of collaborative work. These physical models are captured digitally and transformed to syntactically correct S-BPM models. Capturing is supported by interactive tools, which allow to correct syntactic errors. Semantic completeness of the models is archived by interactive refinement during simulated enactment using a process validation engine. The paper shows the feasibility of the approach in two case studies and identifies requirements on interactive guidance during model capturing and interpretation.

Categories and Subject Descriptors
D.2.2 [Software Engineering]: Design Tools and Techniques – Evolutionary prototyping.
H.5.3 [Information Interfaces and Presentation]: Group and Organization Interfaces – Organizational Design, synchronous interaction.

General Terms
Management, Design, Human Factors

Keywords
Articulation work, interactive model transformation, model refinement, case study

1. INTRODUCTION
Changes to business processes have impact on how people work and collaborate within organizations. Being able to quickly adapt business processes to influencing factors from within or outside an organization is crucial in today’s ever-changing business environments. Remaining competitive in such environments, which are characterized by highly dynamic market requirements and increased employee mobility, is dependent on being able to capture knowledge about both, work processes and their context from experienced workers [1] and represent it in a way that makes it accessible for and adaptable to future work situations and new employees [2].

External influencing factors such as operational or technical requirements imposed by business partners or legal requirements constrain business processes. These external influence factors shape how an organization can implement a business process. Designing the actual implementation of a business process within these constraints in an effective and efficient way is a key asset and competitive advantage of a successful business [2].

Traditional approaches to business process management [3] provide means to design and maintain standard operating procedures that workers are bound to during implementation. These approaches allow guiding work procedures spanning different actors and areas of expertise in a dependable and documentable way. They, however, ignore the expertise workers develop over time or are able to contribute from their individual background [4]. With rising experience, workers „interpret“ prescribed business processes in a way that adapts them appropriately to the work context at hand [5]. Context here not only consists of external factors, e.g., such as different customers or market situations, but also of internal factors, such as the ensemble of actors that is involved in a specific instance of a process (e.g., preparing a business decision to be made by a member of the board of directors might be different depending on which board member is involved) [6].

Capturing information about how people collaborate in an organization and how they implement their individual contributions to a business process allows to form a knowledge base about work practices that can guide the implementation of business processes in both, known and novel situations [7]. Having access to this knowledge is crucial to avoid ineffective or even counter-productive work practices especially when working in changing or one-off actor constellations.

This paper proposes a method to capture business process information in conceptual models from people not accommodated to this form of representation and the act of conceptual modeling. The aim of the method is twofold. First, it should lead to a comprehensive representation of the overall business process, taking into account all individual contributions and facilitate identifying and making visible different assumptions of how the collaborative aspects are implemented. Second, it should ultimately produce syntactically correct and semantically complete S-BPM models of the business process to allow for further refinement and processing of the model information.

In the following section, we describe the modeling approach that facilitates the development of the business process model. It lead to a model agreed-upon by all involved people using a low-
threshold, semantically simplified modeling method relying on physical cards for model representation. The next section reports on a tool that has been developed to derive digital conceptual models from the collaboratively created card-based models. The approach of transforming these digitized models to syntactically correct S-BPM models is described in the following section. The last section presents two case studies that demonstrate the feasibility and potential of the proposed approach.

2. Model Elicitation using card-based modeling

In this section, an instrument is introduced that allows capturing subject-oriented process models from operatively experienced people without the need for any background in business process modeling. The aim of the instrument is to methodologically and technically allow for modeling whenever the need arises, especially directly situated in the actual work context. The approach follows a physical card placement paradigm e.g. as proposed for structure elaboration techniques in the field of mental model externalization and alignment [8] and, e.g., adopted in the field of BPM by [9]. The semantics of the used cards as well as their spatial arrangement is predetermined to be interpretable as subject-oriented business processes.

A modeling approach, which serves the goal of capturing a comprehensive representation of the overall business process, needs to take into account all individual contributions and facilitate identifying and making visible different mental models of how the collaborative aspects are performed [10].

In order to be able to identify different perceptions of how collaborative work is carried out, the individual mental models of the collaborating contributors need to be made accessible for alignment [11]. Consequently, an approach for collaborative modeling of work should profit from a stage during which the participants individually externalize their mental model of the business process in the form of a conceptual model.

The results of these individual modeling activities provide a foundation for argumentative co-construction of a shared understanding about the business process. Argumentative co-construction can be facilitated by conceptual models that serve as a shared artifact [10]. A conceptual modeling approach supporting this process should allow expressing individual claims and collaboratively putting them in the context of other claims for referral in the argumentative chain.

The method described in the following thus comprises an individual and a collaborative modeling phase that both use a consistent modeling notation. It ultimately allows for deriving a S-BPM compliant model from the modeling result. Following this multi-step approach puts the proposed method in the tradition of Mullery’s viewpoint-centric requirement specification approach [13]. This approach was already adopted for process modeling in the Plural-method [13, 15], which proposes to use a EPC-oriented notation for letting individuals describe their own processes and couple them using the artifacts they share. The authors claim that the diagrams used in Plural were cognitively challenging in some cases due to their complexity, although the participants in their studies were skilled in process modeling. As the present approach explicitly aims at non-skilled modelers, we follow Herrmann et al.’s findings to use a simpler notation with a reduced set of elements [12] and adapt it to fit the subject-oriented modeling paradigm.

2.1 Actor-centric articulation

The modeling approach has to comprise a phase where models of the actors’ own perceived work contributions are articulated individually. These models then can be consolidated in a common model in the second phase.

Individual modeling and the ability to consolidate to a common model is thus an inherent property of the proposed modeling approach. Models are structured along the entities that are involved in collaborative work (cf. figure 2). Therefore, the participants in the first phase can independently of each other describe

- WHAT they do to contribute to the work process - i.e. their own activities,
- with WHOM they EXCHANGE information or artifacts - i.e. the actors or organizational entities they are interacting with and how this interaction manifests in information or artifact exchange

Figure 1 gives an overview of how these modeling elements are spatially arranged in the individual modeling phase.

![Figure 1: Layout template for individual modeling](image)

The exact semantics of the modeling elements in the stage of individual modeling is hard to be determined upfront. People involved in modeling are not necessarily accommodated to explicitly follow specific semantics when describing work. As long as they use the fundamental modeling elements (WHO, WHAT, EXCHANGE), a common level of conceptual abstraction can be achieved in the next, collaborative phase. The semantics of the modeling elements in individual articulation should, however, be as follows to allow for easier consolidation in the collaborative phase:

- WHO-items indicate the role represented by the modeler herself/himself and those roles the modeler perceives to directly interact with
- WHAT-items describe own activities, their sequence indicates causal and/or temporal relationship
- EXCHANGE-items incoming to the own stream of activities indicate information or artifacts expected from others
- EXCHANGE-items outgoing from the own stream of activities indicate information or artifacts offered to others

Figure 2 shows a sample model that follows the layout rules described above.
2.2 Collaborative Consolidation and Interaction Matching

The individual models are merged and aligned according to the following scheme for consolidation in the phase of collaborative consolidation according to the following procedure (cf. figure 3):

One of the actors starts with placing the WHO-items on the upper border of the shared modeling surface. The actor responsible for starting the real-world work process (if known a-priori) consequently also should start modeling.

The same actor continues with describing the own contribution to the work process by placing WHAT-items below the own WHO-item. Others do not intervene during this stage.

As soon as the actor encounters the first EXCHANGE-item or shared WHAT-item, the targeted communication partner (acting as the source or the sink of the exchange) steps in and starts to match the own perception of the work process with the already externalized model. The following cases can occur here:

- the communication partner has a matching EXCHANGE-item (i.e. an expected exchange that matches an provided exchange or vice versa). In this case, the matching elements are merged and modeling continues (see below)

- the communication partner has no WHO-item for the original communication partner (i.e. has not perceived any collaboration with the original actor at all). In this case, a fundamental difference in work perception has been identified, which needs to be resolved (see resolution strategies below).

- the communication partner has no matching EXCHANGE-item (i.e. did not share the perception of collaboration or did not consider it relevant). In this case, a difference in work perception has been identified, which needs to be resolved (see resolution strategies below).

- the communication partner considers one of the own EXCHANGE-items to match, the involved actors, however, have a different understanding of its content or nature of the exchanged information or artifact (i.e. share the perception of the need for collaboration but do not share a common view of how it is implemented or - alternatively - have chosen different levels of granularity to describe exchanges). In this case, a difference in collaboration perception has been identified, which needs to be resolved (see resolution strategies below).

If a match has been identified or different understandings have been resolved to ultimately form a match, the modeler responsible for the targeted entity continues to complete the model with the elements describing how he contributed to the work process until the agreed upon coupling point (i.e. the EXCHANGE element or shared WHAT element). This includes adding the own WHO elements.

Consolidation continues in this way until all coupling points are agreed upon. If one actor has completed his or her contribution, others with remaining elements not yet incorporated in the common model take over and provide further input the consolidation process.

The whole process of consolidation per-se is an act of collaborative co-construction of a shared understanding about the collaborative work process. The situations identified above, where mismatches in the individual models are explicitly made visible, are triggers for argumentative co-construction. The mental models of all involved people are refined and/or altered to converge to an extent that allows them to reach common ground on how to collaborate [16].

In all these cases, the model - as visualized in figure 4 - does not play an active role, but serves as a shared artifact for reference and clarification purposes [17][18]. After reaching consensus, the model should represent an agreed upon perception of the respective part of the collaborative work. The immediate visibility of fundamentally different viewpoints in the model prevents quick
consensus building were necessary and requires actors to use more elaborate strategies like integration- or conflict-oriented consensus building [19].

Figure 4: Sample model after collaborative consolidation

3. Capturing and Digitalization

The card-based models need to be converted into digital model representations for further processing. Manual transformation is time-consuming and error-prone. It prevents fast turn-over-times and thus hampers the validation and use of the created models.

An IT-supported tool has been developed to overcome this barrier and bridge the gap between the card-based and the digital model representation, which is directly processable in a workflow engine. The operative design goal for this tool is to avoid the need of splitting an articulation workshop into two parts because of the need for manual model transformation.

The bridge between the card-based model and the digital model is designed to work as transparently for the user as possible. User interaction should only be necessary if model information derived from the card-based model is ambivalent or incomplete and requires refinement. As little technical infrastructure as possible should be required to use the toolchain. The current prototypical implementation is outlined in figure 5.

The toolchain comprises six distinct steps from initial capturing of the model information from the card-based model to the model being available in the S-BPM-based execution environment (cf. dashed circles in figure 5). The following paragraphs describe those steps in more detail and outline the current status of development.

3.1 Initial capturing

The card-based model is captured as a digital image in the first step via taking a picture with a mobile phone (cf. step 1 in figure 5). Any other digital camera can also be used - the mobile app, which is part of the prototype only makes the necessary upload to the backend infrastructure for image recognition and model information extraction transparent for the user. If the model does not fit on one single image with sufficient resolution, several images can be taken, which are interpreted as a whole by the recognition engine. The best available information is used for further processing in such cases (i.e. information extracted from the images with the highest available resolution).

3.2 Extraction of labels, model layout and connections

The modeling cards hold a visual marker that can be recognized and uniquely identified in an image of the model. The optical marker recognition engine is based upon the ReaCTIVision system [20] and outputs the coordinates of each marker as well as their rotation in relation to the y-axis of the image. Based upon this information, and the knowledge that the marker is printed on the exact same position on each card, the cards contained in the image can be identified and extracted.

Card extraction (cf. step 2 in figure 5) needs to be flexible, as the pictures are not necessarily taken from exactly vertically above the modeling surface. The cards thus can be distorted in the picture. The extraction algorithm searches for the corners of the card and creates a circumscribing quadrangle. The pixels inside this quadrangle are then assumed to represent the card. The quadrangle and its contents then geometrically transformed to a rectangle with a given aspect ratio (which is equivalent to that of the printed cards). The created normalized image parts are then stored as distinct pictures for future reference during further processing.

The extracted information is also used for identification of potential connections that are drawn between cards (cf. step 3 in figure 5). The approach taken here for the identification of connections is to identify drawn lines that start in the surrounding area of the card and creates a circumscribing quadrangle. The pixels inside this quadrangle are then assumed to represent the card. The quadrangle and its contents then geometrically transformed to a rectangle with a given aspect ratio (which is equivalent to that of the printed cards). The created normalized image parts are then stored as distinct pictures for future reference during further processing.

The extracted information is also used for identification of potential connections that are drawn between cards (cf. step 3 in figure 5). The approach taken here for the identification of connections is to identify drawn lines that start in the surrounding area of the card and progress without interruption to the surrounding area of another card. In the current technical implementation, lines must not intersect and must not have multiple endpoints. When following the modeling rules laid out in section 2.2, intersections and line splits are not necessary for model creation. This limitation thus is of no relevance for the current application. Endpoints of connections in addition are
analyzed regarding on whether or not they bear an arrow tip indicating their direction. The detailed algorithms for avoiding false positives and making connection tracing robust follow established image-processing approaches (e.g. [21]) and are out of scope for this paper.

3.3 Assessment of adherence to fundamental layout rules

Information about the model layout and the connections is analyzed in the next step regarding its adherence to the model layout rules (cf. step 4 in Figure 5). Automatic model transformation to export S-BPM models (cf. step 6 in Figure 5) can only be performed, if those rules are not violated.

The spatial arrangement of the cards is analyzed based on the layout information extracted in the former steps. The first step is to identify the WHO-elements (represented as blue cards in Figure 4), as they are the point of reference for interpreting the remainder of the model. The WHAT-elements (represented as yellow cards in Figure 4) belonging to every single WHO-element are searched for in the second step. WHAT-elements need to be placed vertically underneath the WHO-element they belong to. The sequence of the WHAT-elements is traced starting from directly underneath the WHO-element progressing down until no further WHAT-element is found within given distance and inside a given horizontal tolerance, which is adaptively determined based on the overall geometry of the currently traced sequence. If WHAT-elements remain unassigned to any WHO-element or if their assignment is ambiguous, the layout rules are violated and automatic transformation cannot be performed.

In the third step, the EXCHANGE-elements are assigned to their issuing and receiving WHAT-elements based on the connection information that was extracted from the original picture. EXCHANGE-elements must be connected to WHAT-elements to adhere to the modeling rules. If connections exist among EXCHANGE-elements or to WHO-elements, automatic transformation cannot be performed. Missing connections between EXCHANGE- and WHAT-elements are not considered a fundamental violation, as the connection recognition algorithm is configured conservatively to avoid false positives. The same is true for missing or conflicting direction information derived from arrow tips. Missing connections or direction information needs to be interactively added or adapted to the model representation in the next step.

3.4 Interactive refinement of recognized models

The result of image analysis is displayed for review by the user on a web-based platform in the current implementation (cf. step 5 in figure 5). Users can trigger model transformation and S-BPM model export from there. The platform in addition allows interactive refinement of the recognized model information to a limited extent: Information about card labels can be added as text, replacing the pixel image that holds this information initially. Text-based labels are included in the export and reduce the required effort for detailing the model in the S-BPM modeling environment. In addition, syntactic information about connections between EXCHANGE-elements and WHAT-elements can be added or altered manually. The process of syntactic refinement is currently not supported interactively in terms of visualizations of potential inconsistencies, syntactic errors, or underspecified model parts. The case studies presented in section 5 will show the potential for this interactive guidance.

Model transformation and export can be triggered (cf. step 6 in Figure 5), as soon as review and refinement is completed. The transformation process and the subsequent refinement of the S-BPM model (cf. step 7 in Figure 5) is described in more detail in the next section.

4. Transformation to S-BPM

The modeling approach described above has been designed to lead to models that are transformable to models created with role-aware, communication-oriented business process modeling languages such as S-BPM or BPMN [22]. The mapping from the card-based model to the target S-BPM business process model is a homomorphism (i.e., fully represents the structure of the case-based model in the target S-BPM model). By applying specific transformation rules, the S-BPM model is syntactically correct. Syntactic correctness allows to further process the model with tools designed for S-BPM. The mapping rules are described in the following. Figure 6 shows a mapping from a card-based model to a S-BPM model and presents examples of the application of rules given below at the locations of the dashed-outline circles.

4.1 Transformation Rules

Syntactically valid and semantically equivalent S-BPM models can be derived from card-based models by applying the following set of rules. Creating the behavior diagrams for each identified WHO-element is performed by applying the following rules in the given sequence (cf. numbers in dashed circles in figure 6):

1. WHO-items map to S-BPM subjects. For each WHO-item, a behavior diagram is created.
2. WHAT-items map to S-BPM function states. For each WHAT-item, a S-BPM function state of the same name is created in the according S-BPM subject. The according S-BPM subject is identified by tracing the imaginary line running vertically through the activity card up to the upper border of the model, where the heading WHO-item corresponds to the according S-BPM subject.
3. Causal relationships between S-BPM function states are identified in the original model by tracing the imaginary line running from heading WHO-item vertically down through the WHAT-items. Two vertically adjacent WHAT-items map to a S-BPM state
transition from S-BPM function state mapping to the upper WHAT-item to the S-BPM function state mapping to the lower WHAT-item.

4. The top-most WHAT-item placed below a WHO-item maps to the S-BPM start function state of the according S-BPM subject.

5. The lower-most WHAT-item placed below a WHO-item maps to the S-BPM end function state of the according S-BPM subject, except if the WHAT-item is the origin of a connection to a EXCHANGE-item (see next rule).

6. EXCHANGE-items connected to a WHAT-item by a directed connection originating from the WHAT-item are mapped to a S-BPM send state in the S-BPM subject mapping to the WHO-item the WHAT-item belongs to. The S-BPM send state is inserted after the S-BPM function state representing the originating WHAT-item. The S-BPM send state is named „sending <name of EXCHANGE-item>“. The S-BPM send state is connected with an outgoing state transition to the S-BPM state that maps to the WHAT-item placed below the originating WHAT-item.

7. If the originating WHAT-item is the last element in its sequence of WHAT-items, an additional S-BPM function state is inserted in the according S-BPM subject as a dummy end function state (as send states cannot terminate the internal behavior of an S-BPM subject).

8. EXCHANGE-items connected to a WHAT-item by a directed connection originating from the EXCHANGE-item are mapped to a S-BPM receive state in the S-BPM subject mapping to the WHO-item the WHAT-item belongs to. The S-BPM receive state is inserted before the S-BPM function state representing the targeted WHAT-item. The S-BPM receive state is named „receiving <name of EXCHANGE-item>“. The S-BPM receive state is connected with an incoming state transition to the S-BPM state that maps to the WHAT-item placed above the targeted WHAT-item.

The subject interaction diagram is created based on the following two rules:

9. WHO-items map to S-BPM subjects. For each WHO-item, a S-BPM subject of the same name is created.

10. EXCHANGE-items map to S-BPM message elements. For each EXCHANGE-item connecting two WHAT-items assigned to two different WHO-items, a S-BPM message of the same name is created between the according S-BPM subject elements.

The application of these rules introduces additional elements to the S-BPM model, which have not been present in the original card-based model. Rules 6 and 8 add send- and receive-states to the S-BPM model. These model elements are only contained implicitly in the card-based model and are derived from the connection points between EXCHANGE- and WHAT-elements. Rule 7 introduces a dummy function state for internal behaviors that would end with a send state. This is necessary as in S-BPM models the outgoing message information is not attached to the send-state itself but to the following transition.

Conditional execution of process parts in internal behavior is not considered during transformation, as the card-based models with their case-based approach do not support modeling of decisions at all. This semantic limitation is addressed after transformation to an S-BPM model by refining it via simulated enactment. This approach is described in the next section.

4.2 S-BPM Model Refinement via Enactment

Working with the method described above leads to models that are semantically incomplete representations of a business process. Most notably, these models do not account for different variants of a business process that are represented using decision elements in other business process modeling languages. The present work deliberately follows a case-based approach to reduce model complexity for the targeted lay modelers [4]. As such the depicted case follows a linear flow of activities and communications and does not require any control flow elements beyond sequence indicators (i.e. arrows connecting two elements).

A comprehensive model of the business process is still required for further processing, e.g., in a workflow engine. Comprehensiveness here refers to representing all potential variants of a case in the model. The present work here takes the approach to refine case-based models interactively using process simulation tools. These tools allow to play through the work process step-by-step and alter and extend the model whenever the simulation is incorrect or incomplete with regard to the perceived real-world work process. This most notably includes introducing conditional model parts that represent different variants of the process. Altering a business process model during its execution is not a common feature of workflow engines. For the present research, a commercial workflow engine has been extended to provide this functionality [23].

Case-based models are mapped to a syntactically correct S-BPM model during the transformation. S-BPM models without syntactic errors can be directly used for simulated enactment in the workflow engine. Simulated enactment is carried out in a distributed manner. Each involved actor is provided with a user interface that presents all currently available tasks. The task list summarizes the current function states of the running process instances the actor’s subjects are involved in. The workflow engine also enables sending and receiving actual information to and from other actors as defined by the send and receive states of the currently executed process model.

For refinement during simulation, an instance of the S-BPM process derived from the original model is started. As stated above, this model initially only reflects one single variant of the process, omitting more sophisticated control flow constructs such as decisions or loops as well as the content and form of the exchanged information. The aim of refinement through simulated enactment is to create a semantically correct and complete representation of the work process in all its variations as perceived by the involved actors. During simulation, the actors enact the process step by step. For each step the responsible actor assesses, whether:

- the step is described correctly and in sufficient detail
- the next step is the only possible way to progress or if there are alternative ways of continuing with the work process. This can refer to alternative options of progressing, optional activities or activities that have been omitted in the original model.
If any of these assessments lead to the need for changes in the process, these changes are made in the modeling environment.

The workflow engine uses model representations, which can be altered during execution. This feature enables changing a process while an instance of it is currently being executed. Changes can have different effects that might trigger the need for further changes in the behavior of other subjects or the overall process. Those cascaded changes require further refinement support, which is not present in the currently implemented prototype and requires further research, which is beyond the scope of this paper.

Refinement through simulation is a means to complete a process description without the need to create comprehensive formal process models by traditional conceptual modeling. Separation of models and model changes along the different involved subjects reduces complexity and allows focusing on one subject’s behavior at a time. Using the execution engine allows to simulate complex decision processes by incrementally adding process variants to the model as the simulation continues. Complex models of collaborative work processes are developed in this way without the need to ever translate an actor’s perceptions of a work process to abstract process descriptions. As the model is refined, it still permanently maintains a syntactically valid state that allows for further processing. This enables live validation of dead- or life-locks or mathematical simulation of capacities. These aspects, however, also have not yet been addressed in the current prototype and are subject to future research.

5. Case Studies

The method described above was deployed in a series of 14 workshops as a part of an international vocational training program to establish process modeling as a means for articulation and reflection about work processes on all organizational levels. In the present paper, a multi-case research design [24] has been chosen. It was used to uncover different approaches of modeling using the proposed method and to explore the potential for interactive guidance during interpretation of the modeling results as S-BPM models. Two contrasting results have been selected from the available data to reach these aims. Both cases are taken from workshops, which have met the goal of creating a shared understanding about the work process using the proposed modeling method. They, however, show contrasting results in terms of the extent the modeling rules were adhered to and consequently their automatic transformability to S-BPM.

The first case presents a model that was created following to the modeling- and layout-rules described in section 2. In the following, we discuss the ambiguities that are still present in these models and hamper automatic transformation. The second case presents a model, which was created following the fundamental modeling approach but violating the layout rules described in section 2.2. Here, we discuss, which information still can be derived from the model automatically and how it needs to be refined to be transformable to a S-BPM model.

The purpose of these cases is to demonstrate the variety of models that are created by lay modelers, who are following a seemingly clearly defined set of modeling rules. It becomes visible that rules were not violated because of ignorance but deliberately when the modelers deemed it appropriate to represent their knowledge about the work environment. Support tools aiming at facilitating the elicitation of actually present knowledge consequently have to be capable of dealing with those ambiguities. Such tools must not force lay modelers in a syntactic framework that does not allow them to express their perception of the actual implementation of the business process.

The models that resulted from the case studies have been encoded following at consistent scheme for structured review and discussion (cf. figures 7 and 8). As the actual content of the model is of no relevance here, the labels have been replaced by codes allowing to identify the model elements that conceptually belong together. WHO-elements were assigned a unique number (e.g. 1, 2, 3, etc.). WHAT-elements were designated with the number of the WHO-elements they belong to and augmented with a sequential number (e.g. 1.1, 1.2, 2.1, etc.) indicating their temporal order. EXCHANGE-elements were encoded with a combination of the numbers of the WHO-elements they connect and again a sequential number (e.g. 1-2.1, 2-3.2, etc.). The layout of the original model was preserved. This encoding allows distinctly referencing different model parts and directly addressing elements that violate the transformation rules.

5.1 Case Study 1 - production-floor logistics

The method was applied in a school for technical and vocational training in industrial production in Slovenia. The school offers 3- and 4-year educational programs for students between the age of 15 to 18. A central part of the curriculum in the second school year is training on organization of work. The aim is to facilitate understanding of the overall work process and contributions by different departments and roles that are necessary to be able to perform the actual production process on the shop-floor. The method was used as part of a three-day workshop on industrial work organization and documentation as a means to support information flow. 20 male students participated in the workshop. The sample work process used throughout the whole workshop was the production of a custom tool holder for a flexible manufacturing cell.

The case presented here focuses the production process only without assembly and quality control. The relevant forms and detailed information flows have been part of the scenario but are omitted here as they are not considered in the modeling activities.

The following departments and/or organizational roles were involved in the present case:

- Order processing - acting as the frontend to the customer and triggering the production process
- Technical engineer - responsible for detailing the work plan for producing the custom order
- Operational manager - responsible for organizing the work in the production workshop
- Factory logistics - responsible for transporting materials and products within the factory
- Warehouse - responsible for storing and handing out raw materials and products
- Production worker - producing the parts necessary for the final product

First, the participants carried out process described in the scenario in a role-play, conducting the work steps as close to reality as possible, including the actual production steps. In the role play, 2-3 students took over one of the roles described above. They then reflected individually and collaboratively about the work process using the modeling method presented in this paper.
Video recordings of the collaborative consolidation sessions were made to document the consensus-building process and reasons for modeling decisions. The resulting models were photographed for later analysis. The individual models could not be documented as the model elements were not laid out physically due to space restrictions in the area of the production workshop, where the reflection activities took place.

Figure 7 shows the resulting model that was created during collaborative consolidation. The model basically follows the layout-rules and to a large extent can be automatically transformed to a S-BPM model. Four modeling constructs, however, violate the layout rules and are reviewed in the following. They are marked with dashed circles in figure 7.

![Figure 7: Modeling result of case 1](image)

Layout violation 1 was made because the participants wanted to express close, co-located collaboration between the two actors, during which no explicit exchange can be identified. Direct transformation fails here, as explicit modeling of collaborative activities is not possible in S-BPM. This problem could also not be resolved satisfactorily for the participants during interactive transformation using workarounds such as creating send and receive state cycles in the behavior of subject 2 for consultation of subject 1. The information about the possibility to collaborate eventually was added as an annotation to the behavior of subject 2. This was feasible, because subject 1 was not involved any further in the whole process.

Layout violation 2 was made because the participants explicitly wanted to express that the information carried by EXCHANGE-element 2-3.1 is also needed in WHAT-element 3.2 and not only in 3.1. When transforming this construct to its S-BPM equivalent, the connection to element 3.2 is superficial, as in S-BPM information received once is available globally for the whole subject afterwards. When strictly applying the transformation rules described in section 4.1, however, the two incoming connections would be mapped to two distinct receive-states. While this is syntactically still correct, and also should not hamper simulated enactment, the two receive-states are semantically redundant and should be avoided. This could be handled by special case treatment during transformation, as such redundancies can be recognized automatically. In the present case, however, the superficial receive-state was manually removed.

Layout violation 3 was made to save vertical space, as the modeling surface was restricted in height. The participants choose not to draw a continuous line, but rather used an asterisk (cf. figure 7) to indicate the two lines belonging together. This violates the modeling-rules and cannot be recognized automatically by the model recognition engine described in section 3.2. The use of such modeling constructs, however, is rather common in the practical application of the method. Connections spanning across multiple WHO-elements in general are hard to trace and quickly make the model confusing and unclear. Future iterations of the modeling method thus could profit from the introduction of a dedicated connection element, which could be used in pairs to indicate distant connections belonging together. In the present case the violation was resolved manually during interactive model refinement.

Alleged layout violation 4 was made to indicate that the information carried by both EXCHANGE-elements needs to be available, before the activity represented by WHAT-element 4.1 can be started. While the modeling method assumes a maximum of one in- and outgoing connection per element, exceeding this limit is not explicitly prohibited. When applying the transformation rules, the two connections are mapped to two consecutive receive-states that are temporarily arranged before function state 4.1. This construct exactly leads to the intended behavior and thus does not prevent successful transformation. This violation thus is acceptable and can be processed with the current set of rules.

The remainder of the model fully adheres to the layout rules and can be transformed to a S-BPM model without any ambiguities. In the present case, modeling was considered finished here, and no further refinements were deemed necessary. The modeled process already fully represents the flow of activities and communication necessary in that specific organizational setup.

5.2 Case Study 2 - organization of street dance workshops

The method was used in a curriculum for social care workers in the Netherlands. The workshop was carried out with 16 students (5 male, 11 female) aged between 18 and 21 in their second year education. The method was used as a means to reflect about practical experiences from internships, which are an integral part of the curriculum. The students had just returned from their internships, where they had to organize street dance workshops for socially disadvantaged young people. As they did there internships at different institutions, modeling not only served as a reflection exercise but also as a consolidation activity for the different experiences. The task was to identify the activities and interaction with stakeholders necessary to organize a street dance workshop in a publicly funded youth center. The stakeholders to be involved were not prescribed in this case in contrast to the first case study and had to be identified in the course of reflection.

The participants were split into three groups, which each performed the reflection exercise separately. The results of each group subsequently were presented in a plenary session. The case presented here is the result of one of these groups.

In their group work, the participants first discussed the roles they considered relevant. Each of them then took over one of these roles and reflected on the process from this perspective. This was done with the aid of the „actor-centric articulation”-part of the method. In a second, collaborative step, the different
The resulting models were photographed for later analysis. The individual model parts were not laid out physically and thus were not documented separately. Video recordings of the collaborative consolidation sessions were made to document the consensus-building process and reasons for modeling decisions.

The model did not remain underspecified without reason during collaborative consolidation. The participants were able to identify, which information needs to be exchanged between a given set of involved actors. They, however, claimed that, in most cases, it was neither possible to more specifically determine upfront the exact point in time at which information needs to be exchanged, nor that it made sense specifying the EXCHANGE upfront the exact point in time at which information needs to be exchanged, nor that it made sense specifying the EXCHANGE element needs to be made available for interactive refinement of the model. The card labeled „1-4“ can be transformed to a message in the subject-interaction-diagram. It, however, is still lacking direction information, as the card-based model does not unambiguously specify the sender and recipient. EXCHANGE-elements that are placed in a chain between two WHO-elements (e.g., the cards labeled „1-4.1“ and „1-4.2“, or „4-5.1“ and „4-5.2“) fundamentally violate the connection-rules, but still can be uniquely assigned to the two subjects representing the connected WHO-elements (potentially including spatial distance information, if extracted connection information is ambiguous). EXCHANGE-elements without any connection information or with more than two connections that cannot be reduced by spatial interpretation (e.g., for the card labeled „2-3-4.1“) cannot be used for extraction of subject interaction information automatically and need to be interpreted interactively.

Information about the elements used in the card-based model needs to be made available for interactive refinement of the model. A complete set of the used elements can be extracted automatically as long as the cards do not overlap (e.g., as is the case for elements „4.1“ and „3-4.2“). While other image recognition approaches might make the algorithm more robust to overlaps, the current implementation of the recognition algorithm relies on the visibility of the visual marker printed on each code. Elements cannot be recognized if it is only partially visible or covered at all.
6. Discussion

Both cases have shown the need for interactive interpretation of the created card-based models. Even if the fundamental modeling rules are known and accounted for during the modeling process, participants consider appropriately representing the agreed-upon view on the work process to be more important. This justifies violations of the modeling rules for them. The participants’ behavior needs to be respected in the present approach. Its primary motivation is to capture knowledge about the procedural and collaborative aspects of business processes from operatively experienced people, and constraining them as little as possible.

The aim of seamlessly transforming the modeling results to S-BPM models thus evidently only can be reached by interactively guiding the participants through the resolution of inconsistencies and ambiguities of the initial card-based model. In the description of the cases, several requirements on the model interpretation process to this respect could be identified:

- Connections that are redundant in an S-BPM model need to be automatically identified and removed (case 1 and case 2).

- EXCHANGE-elements cannot unambiguously integrated in subject behavior models or in the subsection interaction model because of missing or ambiguous connections to WHAT-elements or direct connections to WHO-elements need to be offered for interactive syntactic refinement with as much information about their context in the model as possible (case 2).

- any EXCHANGE-elements that cannot be transformed to according messages in the S-BPM model during interactive refinement because of incomplete or too abstract descriptions need to remain in the S-BPM model as annotations for consideration during semantic refinement during simulated enactment (case 2).

- WHAT-elements need to be assigned to WHO-elements based on distance to the WHO-element itself or already assigned WHAT-elements. Ambiguities in sequence need to be addressable during interactive syntactic refinement and if necessary be carried on as annotations to semantic refinement through simulated enactment (case 2).

In addition to these improvements, interpretation of the extracted conceptual model information, the image recognition engine itself needs to be extended by heuristics for recognizing intersecting connections (case 2) and has to provide a feature to explicitly assign distant connection fragments to each other to allow for uncluttered model layout (case 1).

Given the present research design, these requirements are not necessarily comprehensive. The requirements have been derived from cases that are contrasting in terms of the adherence to the modeling rules and thus provide a valid starting point for the development an interactive refinement tool. Creating syntactically valid S-BPM models with the help of this tool allows for semantic refinement via simulated enactment as described in section 3.3.

7. Conclusions

This paper has presented an approach for elicitation of subject-oriented business process models from operatively involved people by facilitating individual articulation and collaborative consolidation of work knowledge. After introducing the articulation methodology in section 2, focus was put on the instrument developed for transforming the collected conceptual model information to a S-BPM model in sections 3 and 4. Articulation and consolidation is supported by a structure elaboration technique based on modeling with physical cards. The first step towards deriving an executable S-BPM model thus is to capture the physically created models by taking pictures and extract conceptual model information by using image recognition algorithms (cf. section 3.2). In a second step, the conceptual models are interpreted by applying a set of rules that allow transformation to a syntactically correct S-BPM model, if the modelers have followed given layout and modeling rules. In case of violation of these rules, interactive syntactic refinement of the model information is required. The S-BPM models created in this way are semantically incomplete because of the nature of the articulation method. The S-BPM models are thus semantically refined in the final step by identifying and compensating model inconsistencies and gaps via simulated enactment (cf. section 4.2).

Experiences with the deployment of the method in real-worlds settings have shown, that not constraining the models in terms of modeling rules during articulation and consolidation is important for capturing adequate models. Relaxing modeling rules during articulation and consolidation, however, implies the need for correcting syntactical modeling problems in the card-based models before being able to transform them to S-BPM models. Interactive syntactic refinement, i.e., pointing modelers to potential problems and inconsistencies in their models and providing them with information to resolve them, thus plays a crucial role in the toolchain. In section 5, a case study of two contrasting cases has been described and used to derive requirements on tool support in the area of interactive syntactic refinement.

The case study has shown that the proposed approach in general is feasible and meets the aim of enabling articulation and consolidation of knowledge about business processes without the need for a background in modeling. The observed effects on creating a shared understand about a business process fit those described for the Plural-method [14]. The approach presented here maintains the goal of capturing the business process in a well-defined, formal representation that allows for further IT-based processing. The case study furthermore has shown the need for interactive support of the transformation process to S-BPM and has identified requirements on tools in this area. The major limitation of the present research in this respect is the limited number of cases used as a foundation for deriving these requirements. As they have been selected to reflect critical cases for the application of the card-based modeling method, the identified requirements still provide a valid input for a first iteration of tool that assists during interactive refinement.

In future work, the existing prototype will be extended with functionality based upon those requirements. In an iterative development cycle, the tools will be tested further to gain insights in potential areas of functional improvement and in the effectiveness of the overall instrument in terms of avoiding modeling language barriers when capturing business process information from operatively experienced end-users.
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9. REFERENCES


