Report from Dagstuhl Seminar 16191

Fresh Approaches to Business Process Modeling

Edited by

Richard Hull[1], Agnes Koschmider[2], Hajo A. Reijers[3], and William Wong[4]

1 **IBM TJ Watson Research Center – Yorktown Heights, US,** hull@us.ibm.com
2 **KIT – Karlsruher Institut für Technologie, DE,** agnes.koschmider@kit.edu
3 **VU University Amsterdam, NL,** h.a.reijers@vu.nl
4 **Middlesex University – London, GB,** w.wong@mdx.ac.uk

Abstract

Business Process Management (BPM) has significantly advanced and gained high popularity in industry. However, it remains an open issue why tools frequently are used for business process modeling that are not mainly implemented for this purpose. Often, macros for Microsoft Visio or Microsoft Excel form the first choice to capture the flow of business activities. One reason why these tools might be used is the low training effort and the fast creation of a quick model, which can be generated with these tools. Another reason for the "lower" preference of BPM software tools might be their inability to respond to changes in technology and working styles, e.g. the shift towards "agile" processes and the "flattening" of workforce hierarchies that bring more stakeholders into contact with a much broader array of processing steps than before.

A central question is whether the BPM community should create an entirely new paradigm for process modeling. One can think of more intuitive drawing conventions that laymen would use, and of models of an entirely different kind (i.e. not process-centric and not data- or case-centric) that still bear the possibility to support modern and future business process.

The purpose of this seminar was to bring together a cross-disciplinary group of academic and industrial researchers to foster a better understanding of how to ease the access to, and applicability of, business process modeling. We discussed business process modeling approaches against emerging trends such as Internet of Things, the need for incremental and agile creation of new processes, and the need for workers to understand and participate in multiple contextual levels (e.g. transactional, business goals, strategic directions) while performing processes. The seminar also considered how new technologies, such as modern tools for UI design (e.g. D3, node.js) could be applied to support fundamentally shifts in how processes are modeled and how humans are involved with their execution.

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1 Executive Summary

Richard Hull
Agnes Koschmider
Hajo A. Reijers
William Wong

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3 Seminar Structure and Schedule

The seminar was mainly structured in a working group mode. The schedule of the seminar was as follows:

- *Monday:* intro by participants, panel discussion and working groups
- *Tuesday:* working groups
- *Wednesday:* new group assignment and working groups
- *Thursday:* working groups
- *Friday:* reflection of the seminar

The panel discussion stimulated the participants on the subject of the seminar. The panelists pointed to different views on the seminar's topic. Based on the discussion several working groups were formed discussing the following questions:

- What are purposes of process modeling?
- What are user perspectives in process modeling?
- How is visualization of process models distinct from visualization in general?
- How to implement a purpose-driven visualization of (business) process models?
- What are characteristics of knowledge-intensive processes?
- Are existing BPM methodologies adequate for Agile BPM?
- What can BPM bring to Internet of Things?
- What are technologies supporting collaborative business processes for mutually untrusting partners?

4 Working groups

4.1 How to implement a purpose-driven visualization of (business) process models?

Banu Aysolmaz (VU University Amsterdam, NL), Fernanda Baião (Federal University – Rio de Janeiro, BR), Artur Caetano (INESC-ID – Lisboa, PT), Kathrin Figl (Wirtschaftsuniversität Wien, AT), Jens Gulden (Universität Duisburg-Essen, DE), Julius Köpke (Alpen-Adria-Universität Klagenfurt, AT), Ralf Laue (Westsächsische Hochschule Zwickau, DE), Chris Snijders (TU Eindhoven, NL), Minseok Song (POSTECH – Pohang, KR), and Michael zur Muehlen (Stevens Institute of Technology, US)

We discussed the existence of a gap between the actual process model, made by some creator, and the users of the model who are supposed to derive some benefits from it in order to achieve goals. The main idea we want to emphasize is that there is a need to consider how to best communicate or connect the underlying model to the user, and that this is not a trivial exercise. We also want to emphasize that the same model may need to be communicated in contrasting but consistent ways to different users according to their specific set of concerns and purposes. Measuring the performance of the communication mechanisms is therefore paramount to assess the effectiveness of a model with regards to the purposes of its users. An example might help clarify the issue: the process of checks before liftoff of an airplane would undoubtedly generate a complex process model if represented as a flow of activities, but pilots are instead given checklists and, in principle, see nothing but a simple transformation (view) of the underlying model. In this case, there is an artefact the checklist in between the actual model (process?) and the user. One could argue about whether the checklist is the best way to get pilots to make sure that an airplane can liftoff safely, but the key issues are the following:

- what is the purpose of the visualization: what kind of message or insight or task support should be given to the user,
- what are the relevant perspectives (data, roles, control-flow, time, ...) to be included in the visualization,
- what are the relevant characteristics of the user: different users may have different prior knowledge, cognitive abilities, preferences and even emotional states that affect their performance when using a particular visualization / representation,
- how to best convey the task support or message or insight that needs to be sent to the user, and
- that the best way to convey this message might not be a standard notated process model (e.g. represented with BPMN, EPC).

Creating a process model with another purpose in mind, but then handing it over to the user with another purpose is certainly not always the best solution, and optimal solutions depend on the model, the goal/purpose, the message, and the user. We argue that more attention should be paid to the model user, and how well a visualization fits the intended use/user. A more systematic approach to creating an appropriate message and to evaluate the performance of different ways of creating this message is needed.

Messages a model may convey to users

Depending on the situation, users might need to receive different messages from a model. Not only the user has a purpose, but most often the "sender" has a purpose in mind the user should use the process model for. Without being complete, we could at least discern that a model can be used as:

1. An imperative: "do this"
2. An advice: "it might be a good idea to do this"
3. A goal: "make sure to accomplish this (in whichever way you see fit)"
4. An insight or explanation: "you now see that in our case A always precedes B"
5. A reason: "(you have to wait a bit,) because x steps have to be carried out by others first"

Obviously, combinations of the above could form new message categories as well. The views on a model can be classified according to multiple dimensions (Steen et al. 2004). We can use, for instance, a dimension to classify a model according to its purpose, e.g. designing, deciding, informing, and another dimension to classify the content of the view, e.g. providing the details of a model, focusing on the coherence between the constructs, or just providing an overview of the model. From (Steen et al. 2004) For the BPM community, our guess is that it is most natural to show (variants of the) actual process models (say, a flowchart of some kind) to users, or perhaps parts or condensed versions of them. However, there are many other ways to get a message across. We can borrow from communication sciences and research in human factors to categorize these: the most natural way for a user to receive messages is visually and sometimes through audio, with touch a more remote possibility and smell as a rarity. We easily came up with a large list of mainly visuals:

- Flat text
- Comics
- Checklists
- Decision trees
- Dashboards
- Calendars
- Gantt chart
- Augmented Reality (e.g. Google Glass)
- 3D virtual world
- Maps (e.g. scatter maps)
- Scientific graphs (e.g. histograms, line charts, bar charts)
- Flowcharts
- Controlflow-based models (e.g. BPMN, EPC)
- Goal models
- Organizational models
- Video and animations (visual, possibly with audio)
- Beeps / ticks (audio)

Given different kinds of messages the next question is how they are transported to the user: on paper, on a phone, on a computer screen, as a sticker on the wall, encapsulated in more general tools that are known to the user (such as Excel or Powerpoint), or in still other ways. Some questions that relate to this issue are:
1. Which modes of transportation are more appropriate for which kinds of messages?
2. Which modes of transportation are more appropriate for which kinds of users?
3. How can we transform the underlying model to an artefact (as a vehicle and as a message), depending on the kind of message we want to get across, and how does this depend on the kind of user, and the kind of model?
4. Which kinds of artefacts do users actually use?
5. Which kinds of artefacts have users created for themselves?

What is important to realize is that these issues, although perhaps not yet very well elaborated in the BPM context, are more or less standard in disciplines such as Human Computer Interaction and Communication Sciences. Applying the tricks of their trade to the BPM context in a systematic way would be a good way to proceed. Maybe it would also be an appropriate approach to clarify which user + tasks a process model is suited for and leave other purposes (which are still related to the "process") to other disciplines, to avoid "inventing the wheel" again. In some sense "everything is a process", but the BPM field cannot answer all research questions related to selecting appropriate visualizations, but should concentrate on its main purposes and users. Indeed, the logical next step would then be to consider whether the appropriate goal or purpose of the user (comprehension, compliance, advice, insight/understanding, etc) has been met given the artefact that has been used, and how to measure or compare the usefulness of different artefacts to get this message across, depending on user and model characteristics, and purposes. We now focus in more detail on visualizations.

4.1.1 Visualization of Process Models

Assumptions:
- Models are conceptual abstractions that are constructed from an actual or hypothetical scenario, either tangible or intangible

- Models are designed with a purpose in mind
- Models are typically represented in visual form
- The intended purpose of the model may or may not match the actual use of the model
- Cognitive fit (Vessey) of task and visualization is an important influence factor whether one visualization will outperform another related to relevant performance indicators
- Representations are "not superior in an absolute sense; rather they are good in relation to specific tasks"
- The performance of the visualization of a model must be measurable
- A central criterion for the efficiency of a model is the way it helps to reduce cognitive load that is required for gaining knowledge from it. This can be achieved by appropriately harvesting the capabilities of the human visual perception apparatus for parallel cognitive processing on multiple levels of granularity. The way to determine this appropriateness is to some extent again relative to the purposes and users of the models.
- Different visual representations may show measurable performance differences when applied to the same purpose and to the domain

4.1.2 Purpose-based Visualization

When discussing the user perspective in process modeling, it is important to first reach consensus on three aspects: (1) who is the user, (2) what is the purpose of a process model and (3) What is the current context of the user and the process (how and in which situation is user using the model, how good is the required data to produce the model). Once these aspects are defined, it is possible to reason on what is the best possible visualization of a process model for a given purpose. What do we mean by process model visualization? Visualization is the act or process of interpreting a model in visual terms or of putting it into visible form. It can be expressed as function that transforms a conceptual model into a Sign [cf. Peirce, Semiotics].

Visualization(Model, Domain) $\rightarrow$ Transformed Model

The Transformed Model can contain several artefacts such as text or checklists on paper, animated models, video or augmented reality. The Transformed Model is used by a User to achieve a specific Purpose within a given Domain. The fitness of Transformed Model is assessed/measured with regards to its Purpose using a set of Variables that are measured/-operationalized using Measurement functions. A Transformed Model often uses a different visual representation than the source model used to generate it. The Transformed Model may omit or aggregate content of the source model and it may enhance it with additional domain information, e.g. purpose specific, domain specific knowledge, explanations. The additional information can also relate to the current context of the user (augmented reality/virtual world). The visualization can be in the form of direct (1:1) transformations from the source model, but it can also aggregate, exclude or change the way source model constructs are depicted, and add overlays, annotations, dynamic content, etc. The target model may be based on a different modeling paradigm i.e. imperative vs. declarative.

4.1.3 Relationship between purposes and visualizations

The crucial point required to have a thorough conceptual basis for formulating scientifically justified methodical approaches for visualization use, or even automatic mechanisms that are able to suggest visualizations depending on a formalized notion of purposes, is to gain an understanding of the relation between the purposes of a visualization and the characteristics of a particular visualization. This requires to conceptualize

1. A (formal) description mechanism (metamodel) for specifying purposes
2. A (formal) description mechanism (metamodel) for specifying visualization characteristics
3. A mechanism that relates both
4. A mechanism to measure the performance of a visualization with regards to the purposes using a set of variables

Such a conceptual architecture can be created on diverse levels of ambition and complexity. In a simple case, the metamodel of purposes consists of a list of use case types, which are derived from observing typical actions performed with process models. A large potential for researching about how to conceptualize purposes remains on this side, as described in earlier sections.

The metamodel for describing visualization characteristics might in the first place provide a coarse conceptualization of available visualization widget types on a coarse grained level, such as piecharts, barcharts, and other state of the art dashboard components. If visualizations get conceptualized in a more sophisticated way, their metamodel could refer to more abstract visual impressions such as symbols and structures they appear in, or even incorporate phenomena of human visual perception, such as the perception of patterns, perception of spatial distributions, etc.

Finally, a mapping conceptualization could in the first place be conceptualized as a mere relationship between instances of elements from the purpose metamodel, and elements from the visualization metamodel. A deeper going approach would be to find scientific judgements about the plausibility of possible mappings, e.g., in terms of the expected cognitive load of the use of a visualization type for a given purpose. A mapping conceptualization which takes such criteria into account would provide an actual advance in the way how visualizations are conceptualized today, and how the efficiency and effectiveness of their use can be assessed.

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4.2 What are characteristics of knowledge-intensive processes?

Achim D. Brucker (University of Sheffield, GB), Fernanda Baião (Federal University – Rio de Janeiro, BR), Avigdor Gal (Technion – Haifa, IL), Alexander Herwix (Universität Köln, DE), Richard Hull (IBM TJ Watson Research Center – Yorktown Heights, US), Massimo Mecella (Sapienza University of Rome, IT), Hamid Reza Motahari Nezhad (IBM Almaden Center – San Jose, US), Flávia Maria Santoro (Federal University – Rio de Janeiro, BR), Tijs Slaats (IT University of Copenhagen, DK), and William Wong (Middlesex University, GB)

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Knowledge-intensive processes (KiP's for short) represent a new trend in the world of business process management, which was enabled by the availability of big amount of data and tools to to transform such data into knowledge. KiP's also represent a possible solution to a world where processes are no longer structured, long standing, and carefully designed. To accommodate agile processes, which continuously evolve and have to deal with missing, uncertain and erroneous data, we go back in this work to the basic elements that would allow us to better understand what KiP's are, what can they do for us, what type of technology will be at their basis, and what may a plausible research agenda for KiPs.

4.2.1 Use cases

There are many processes which are not well addressed by state-of-the-art process-aware technologies and support systems. Essentially, they share (to a certain extent) the set of requirements (further detailed in this document), which characterize them as KiP's, as it follows:

- Perform a scientific experiment. Scientific experiments are typical scenarios that explore a hypothesis space, frequently embedding what-if analysis and analytical operations. Typically, the scientist defines a sequence of (automated) steps to validate his/her hypothesis and specifies a (often huge) set of scenarios, varying the input dataset to be considered, the parameters of each step execution, or different resources. There is a need to keep track of all scenario variations, decide on the next new scenario to be experimented – and explain why, collaborate with other scientists from the same research team, or from other teams. Provenance data plays a major role, and may serve as input data from which knowledge may be derived.
- Design a marketing campaign. Marketing is a typical creativity-driven process, meaning that there might be interesting scenarios in which the executor come up with new activities that were never executed before. This surely points to the flexibility requirement, but goes beyond it by ideally deciding on innovations of the process through new activities conducted by the agent intentionally to reach a goal.
- Perform medical diagnosis. Medical diagnosis is a typical goal-driven, decision-making scenario. In several cultures, procedures and protocols are very well-regulated and, to a certain level of granularity, well-defined. However, there are relevant scenarios (such as "Doctors without borders" or emergency treatments) in which those pre-defined routines are not effective or the required resources are not available during execution. In these situations, collaborating with different partners so as to decide upon the treatment or searching for new external data/knowledge are frequent actions doctors intentionally do to reach their goal. Moreover, they would be happy to share their new experiences and explain their decision-making process on both successful and unsuccessful cases.
- Air traffic control. Air traffic control scenarios are typically procedure-based, but frequently require context-based adaptations, thus requiring decision-making and a flexible execution environment, so as to cope with real-time adaptations.

4.2.2 Requirements

A KiP is a type of process that comprises sequences of activities based on intensive acquisition, sharing, storage, and (re)use of knowledge, so that the value added to the organization depends on knowledge. One of the main characteristic or requirement of those processes is having an unpredictable flow of activities, i.e., changes might occur from one instance to another. They should be flexible enough so that the next step is typically defined by decisions made after the completion of the previous activity. We consider the following requirements essential to knowledge intensive processes:

- goal oriented, knowledge about the domain available or learned along a specific instance;
- flexibility; adaptiveness;
- possibility to make the rationale for decisions made explicit;
- and collaboration among actors (human or machines).
- No apriori-defined process: The activities to be performed might not be known in advance as well as the flow to be followed. Activities could be defined in real time as a result of a decision. In the case of flows (the set of interrelated activities), the definition could be supported by templates already known or existing best practices. That is why adaptations should be possible and this also requires that the process should be continuously monitored.

Given the goal-oriented nature of KiPs, and decisions are made about actions in the course of a process, it is fundamental that decisions made could be captured and represented, so that, as a result they could also be converted in new knowledge to be consumed by the process. Finally, although not a strict requirement, collaboration is expected to take place in order to foster the exchange or even the creation of new knowledge within the process.

4.2.3 Main Elements

While the notion of KiP is broad, there is set of building blocks that are common to most of them. This section introduces these core building blocks and describes each of them briefly. The next section places these elements into a conceptual model, with an emphasis on how they relate to each other.

- Goal/Subgoal: A central component of KIP's is the set of goals and subgoals that are to be achieved. We use the term 'goal' to refer both to the overarching goals of a process and to subgoals used along the way. These goals might include concrete, world-affecting goals such as determining how much money should be transferred and to whom, allocating appropriate resources to an activity, or the creation of a document for distribution. They can also include more "intermediate" goals focused on acquiring data or knowledge relevant to the overall process, or the identification of agents (human or machine) that can contribute towards the process. The family of goals typically evolves over time, with goals being achieved, goals being created, and goals being deleted (because they are deemed irrelevant based on other accomplishments.
- Data & Knowledge: A central aspect of KIP's is the accessing of relevant data and knowledge "in the world", and also the creation of new data and knowledge relevant to the goals at hand. Data and Knowledge lie along various dimensions. One dimension ranges from structured data to unstructured content (including text, image, video). Another dimension ranges from factual data to structured knowledge representations (e.g., OWL) to modeling formalisms (e.g., UML) to knowledge captured in documents to tacit knowledge (i.e., in people's minds). The knowledge may be produced through various mechanisms, e.g., asking an expert, ingesting documents manually or by machine, machine learning, etc., and may have varying levels of confidence, precision, etc. Yet another aspect is that some knowledge relates to the actions that might be taken (e.g., pre- and post-conditions), "best practices" that have evolved from previous process executions, and patterns or templates involving combinations of actions. During a KIP some knowledge may be captured into a machine readable form that permits automated reasoning, while other knowledge may be provided for human consumption, with humans making further inferences and conclusions – which may or may not be recorded explicitly.

- Decisions: Because of the prominence of knowledge in KIP's there is an associated prominence attributed to decisions. These decisions might be in the form of choosing to invoke a world-affecting action, such as paying money, allocating resources, or requesting assistance from some agent. The decisions might also be in the form of choosing a single action to be taken as part of the process, or choosing a "pattern" or "template" of actions to be taken, possibly with some parameters assigned. Decisions might also create new goals or determine that some existing goals are no longer relevant.
- Action: In the context of KIP's, actions will include both the types of actions typical of standard business processes, and also actions relating to the acquisition and management of knowledge. The latter category includes actions such as making decisions based on the available knowledge, acquiring additional knowledge, and reasoning about knowledge to create additional knowledge. This knowledge creation might be achieved through a variety of mechanisms, including human thought, automatic reasoning, machine learning, hybrids of the above, etc. Importantly, the family of possible actions may be known to the actors in the system, but it is also quite possible that the full family of actions is not known a priori, and potential actions are discovered along the way.
- (Sub)process Pattern/(Sub)process Template: In many cases it is convenient to classify groups of actions into re-usable, parametrized patterns. This permits a modularity in the process specification, which is useful for both manual and automated reasoning and selection. These patterns might be organized based on existing process management standards or paradigms (e.g., BPMN, CMMN, or declarative ones such as DECLARE, or more informal ones such as Task Lists), or might be more ad hoc in nature.
- Agent/Actor: It is typical of KIP's that multiple agents are involved; these may be human or automated. The agents may have specialized roles, which may be interchangeable. Often the agents may collaborate on achieving goals, or work towards a consensual understanding and agreement about certain information or decisions. In many cases agents will need to communicate with each other in rich ways, including intricate requests (e.g., using "conversational APIs") and transferring rich knowledge. Reasoning about what agents know may be relevant, e.g., if expecting an agent to make a fully informed decision. This is an area where explanation of the activities performed, goals attempted, and decisions made will be very important.
- State/Context/Environment: KIP's typically progress in terms of their internal state and body of goals, plans, and knowledge. KIP's are also operating in an external context of environment. We use the term 'context' to refer to those aspects of the external environment which are relevant or potentially relevant to the process. The context will be evolving, both as a result of KIP actions and due to independent forces. The KIP may pull information from the environment from time to time. In some cases the KIP will include continuous monitoring of the context, with the possibility of actions (including decisions) being triggered by phenomena
- Event: As with most kinds of process, events are a central to KIP's. The events might occur from the environment, including both discrete events and also defined thresholds being exceeded. The events might be internal to the KIP, e.g., when an automated decision process completes its activity and yields a decision value. Events may trigger immediate responses in the KIP, or might lead to the accumulation of knowledge which impacts the KIP later on.
- Exploration/What-if: A particular kind of decision making that arises in KIP's involves the exploration of various possible scenarios, as a component of comparing different alternatives. These comparisons might be short-lived (e.g., minutes) or longer-lived

(e.g., days or months). The information/knowledge obtained about different alternatives contribute to the overall knowledge base of the KIP, and may be used to inform subsequent decisions

4.2.4 Research questions and fresh directions

To support knowledge workers of the future, the state of the art in modeling and executing knowledge-intensive business needs to be advanced in several areas. For example:

- Hybrid manual/automated process models: Knowledge-intensive processes often consist out of small routine tasks or sub-processes that can and should be automated to enable users to concentrate on the parts that need flexibility, creativity as well as "on-the-fly" gathering of information. New approaches are needed for modeling such hybrid models in a uniform way that still allows to specify the overall goals and requirements of a knowledge-intense business process.
- Dynamically evolvable process enactment models. There is a need for defining a rich data model, considering the main elements outlined above, for knowledge-intensive processes to enable both modeling of such processes, as well as enacting them, at run time. Such a modeling approach should allow adding and updating the set of available actions, operations on the model, process flow and fragments, and instantiation from best practices and more abstract processes, in a dynamic manner. In addition, the underlying goals and constraints of the process should be easily adaptable to changes in the context (e.g., changes to laws and business rules) and knowledge (e.g. when new medical treatments are discovered).
- Integration of knowledge information systems: Knowledge-intensive business processes depend, by definition, on a large set of information. The exact amount and type of information might depend on the actual execution of a business process as well as the situational context (e.g., the environment). Thus, new approaches for presenting information, in the context of the business process execution are needed that allow the user to access the situational relevant (i.e., all information that is required to take an informed decision or execute a next step/tasks in the process and, in parallel, avoiding an information overload).
- Compliance analysis of "incomplete" models: Knowledge-intensive business processes need to allow for certain flexibility in their execution to allow users to react on unforeseen events. Thus, they usually cannot be represented by a complete and detailed model that contains all tasks/subtasks. At the same time, knowledge-intensive processes are often needed in domains that are need to fulfill strict audit on compliance regulations or are safety or security critical (e.g., air traffic management, merger and acquisition processes, disaster management processes). How to statically analyze (or reason about) such incomplete models to ensure that they are actually executable and ensure compliance during their execution (respectively, fulfill the basic safety or security requirements) is an open problem. Alternatively, research in enriching models with aspects of run time monitoring (logging) as well as enforcement seem promising to enable a "post-hoc compliance" approach.

4.3 What are user perspectives in process modeling?

Artur Caetano (INESC-ID – Lisboa, PT), Christian Janiesch (Universität Würzburg, DE), Jan Recker (Queensland University of Technology – Brisbane, AU), Chris Snijders (TU Eindhoven, NL), Victoria Torres (Technical University of Valencia, ES), Barbara Weber (Universität Innsbruck, AT), William Wong (Middlesex University, GB), and Michael zur Muehlen (Stevens Institute of Technology, US)

Models are (shared) representations of some actual or desired system created by an individual or a group. Process models capture the behavioral aspects of a system, and are used to explain, predict, design, enact or constrain past, current and/or future situations. It is important to realize that models are constructions by an individual or a group and intended for use by a (different) individual or a (different) group. Sometimes, these individuals might be computerized agents but more often than not they are human agents or a combination thereof. The creation and use of process models are sometimes distinct activities, sometimes not. The goal of some models is to be consumed as they are created (e.g. to create a shared understanding among a group of participants), other models are invariant upon creation (e.g. standards, reference processes or procedure manuals), others are transformed after an initial stable state has been reached (e.g. a model that is re-designed for optimization purposes, a conceptual process model that is subsequently used for the configuration of a workflow system), and yet others are created but are intended to be used only rarely, such as evacuation procedures or the preparation for emergency cases. In each of these scenarios, different people are involved in the creation, validation, and use of the models. Sometimes, not the individual user but a group of users, e.g. a team or a department, is formative to the process. Therefore, better understanding of the different types of users, their perspectives, and how they influence the creation and use of process models may result in better approaches to process modeling and to models that fit better with the users' needs.

4.3.1 Clarifications Required to Understand the User Perspective

When discussing the user perspective in process modeling, it is important to first reach consensus on two aspects: (1) who is the user and (2) what is the purpose of a process model, as described next.

4.3.2 Who is the user?

1. Which roles does the user play in relation to the model?
   Creator (e.g. information provider, modeler), reader (e.g. interpreter, consumer), transformer (e.g. implementer, enactor, redesigner), and so forth.
2. How can the model user be distinguished?
   - What cognitive characteristics does the user have? (e.g., working memory capacity, executive functions, ability to learn, etc.)
   - How experienced is the user? (in understanding the domain and the system of interest being modeled, in understanding the modeling method and supporting modeling tools, in performing the actual modeling process, in understanding the model constructs and semantics).

- Which other static (e.g., personality) or dynamic traits (e.g., knowledge, attitude, user context) are relevant to consider?
- Does the user correspond to a specific archetype (i.e., a persona)?

3. How does a user create, interpret, use, and adapt the model? Possible approaches to answer this question will likely be exploratory in nature, with the objective to discover usage strategies, difficulties, value and importance, as well as concepts and constructs that can inform subsequent measurement, and include:
   - Cognitive Task Analysis (CTA) of users can be conducted while they create the models, use them (concurrent CTA), and also after (retrospective CTA).
   - Observational Studies of users can be carried out by combining various techniques such as Think Aloud methods (Concurrent Protocol Analysis) to determine the issues and difficulties, considerations and strategies they encounter during the creation and use of the models.
   - Neurophysiological methods such as eye tracking, EEG, heart rate monitoring and galvanic skin response measurements, for assessing or identifying and correlating stressors in the model comprehension and creation. This can include identifying difficult or challenging situations, or frustrations with the model understanding and creation, and how they correlate with the performance of the task. Correlates can help to better understand antecedents of (IT) behavior (e.g., stress as an antecedent of an error).
   - Observation Studies and Tracking of user interactions while using or creating the system (e.g., model interactions, mouse events, scrolling, click streams). A longer-term goal of tracking user interactions is to be able to directly map the user behavior to measured variables of interest such as acceptance, userfriendliness, etc.
   - Ethnographic Studies of users interacting with artifacts resulting from the model (systems, policies, procedures, instructions) (e.g., creation of workarounds as opposed to following model(er) intent, time to change existing behavior, contemporaneous commentary on perceptions regarding the new situation).
4. The difference in the fundamental nature of work that information users do will influence the nature of the models that need to be produced to support that work:
   - As clerical workers, they are not informed by the information and their work is dictated by the procedures and policies of the organization, e.g. the completion of forms, the input of data to complete a task;
   - As knowledge workers, their roles focus on the creation and construction of new understandings as a result of being informed by the new information. This new understanding enables the formulation of solutions and problems.
   - This difference suggests that models required to support clerical type of work will necessarily be more transaction-oriented, while models needed to support knowledge workers will need user interfaces in the resulting systems that support the creation of understanding, methods for sense-making, and ways for defining new strategies and tasks.

4.3.3 What is the purpose of a process model?

Can the purpose of modeling be defined concludingly before the start of a business process management project or any other initiative that involves process modeling? If so, in which situations should the purpose be defined a priori or be emergent? Should or can the purpose be derived from the needs/concerns of the users as concerns may be contradictory? The purposes of a process model may include the following:

- Informal purposes, e.g., understanding, communication, brainstorming.
- Semi-formal purposes, e.g., documentation/knowledge management, training.
- Formal purposes, e.g., software development, workflow execution, artifact evolution (transformations).

It is, however, important to consider that there are previously undefined, unanticipated and/or exploratory purposes, e.g., re-purposing, which should not be excluded prematurely in order not to restrict the user's ingenuity with regard to process modeling.

The question of what the modeling purpose is and who the model users are, is closely linked to the question of what defines the utility of a model. Possible constructs to operationalize and measure model utility include understandability, shared understanding, consensus, executability, effectiveness, acceptance, cost/benefit-ratio and task performance.

4.3.4 Future Research on the User Perspective in Process Modeling

Based on our interpretation of the literature on business process management and in particular on process modeling to date, we believe that several questions remain unanswered, incomplete or simply unbeknownst until now. Partly, this may or may not be related to the fact that there are not enough established (and thus universally accepted) research methods in Information Systems to deal with these questions. In the following, we present several of these questions:

1. Are there differences between models that are used or created for groups of users and those that are created or used for and by individuals?
2. How do we better understand the mental model of the users? Which factors influence and/or support model creation and understanding? Can available methods be applied to a single user or also to groups of users? How can we capture and translate user expertise into the models?
3. How, when, and why is a user affected directly or indirectly by a process model? For example, does a user interact with the process model, or does the user interact with a process that is defined by the model, or with a system that is being controlled through the process model? Are there users that have an interest in the process model but neither interact with the model nor the resulting process?
4. What roles does a user play in different process modeling phases, such as information gathering, (re-)designing, using, changing, optimizing, etc.?
5. What are appropriate measures to assess the alignment of model creation and use with the user perspective?
6. How do we observe the impact of using these measures? Which of these have we not considered at all so far? Are the current measures adequate?
7. How can we support/advise organizations to consider and implement a user perspective in their business process management efforts? Can we generalize universal guidelines? Would a "user-perspective process maturity model" be relevant? Do current modeling standards satisfy the needs of users and the needs of organizations? Do they need to be adapted before use? If so, how can this process be guided.
8. What are the differences between process design and process modeling in terms of the activities performed and the user perspectives on the processes and outcomes? Is the user perspective on process modeling different from the user perspective on process design? Could we support both with similar methods, tools and systems? If not, what makes process design different from process modeling?
9. What are the differences between user-centric and use-centric modeling? Often, one fundamental question in design is what we design for? Designs based on user actions and user's mental models can be overly restrictive for a number of reasons, such as users having

a flawed mental model. As such approaches to design that incorporate use as a focus of the design and modeling process have a greater opportunity to capture the affordances, expectations, and factors that constraints the nature of the work and their relationship to higher order goals of the organization. How can business process management incorporate and test the effectiveness of such an approach? How can the outcomes of procedures and processes be understood from the perspective of an organization's higher order goals, such as profitability, efficiency or market competitiveness?

10. What can we learn from other fields that examine human perspectives, such as Human-computer Interaction, Cognitive Systems Engineering, User-centric Design, Technology Appropriation, Human-in-the-loop, Human-Performance Management, Cognitive Psychology, Neuroscience

4.3.5 Emerging principles

In answering these and related questions, we also find that several principles emerge that can govern user perspectives in process modeling. Importantly, depending on the purpose of the model, the type of user and the domain of the system, we may find.

A need to adequately interface the model to the user, i.e. techniques that "translate" the information from the underlying model for a user in a way that is more appropriate for them (e.g. checklists are used in aviation as an interface to a far more complex underlying process model). This implies that

- the representation techniques should be aligned with the concerns of the users of the model
- the same process model can be viewed from multiple perspectives according to the concerns of its users, and
- we would expect different representation techniques to show measurable differences (e.g. different levels of comprehension, different levels of reusability) in constructs that are important to the purpose of the respective user group.

Different types of model usage, such as models defined for executing just once or never (as is the case with evacuation processes which not meant to be used often), models meant for training people, models for ensuring that quality standard levels are reached, or models for building consensus between stakeholders. We would expect that the effort of model creation and consumption can be viewed in relation to the utility derived from the creation and consumption of the model. This may require to define a utility function over time for models with a long "shelf life".

Differences in assisted/guided versus unassisted processes for process modeling. Developing an assisted process for model creation may lead not only to syntactically correct but also to better models, i.e. models that fulfill the purposes of its users:

- Enabling the user to create models in a guided but generally unrestricted fashion and facilitating the purpose these models may lead to an increased uptake and training of process modeling and improve model use, user satisfaction as well as model quality.
- We would expect that articulating the "meta-process" of framing the modeling purpose prior to modeling leads to a measurable increase in model utility.

Different ways to operationalize and to measure the quality of a process model (e.g. shared understanding, comprehension, etc.). This may lead to the definition of indicators, measures, maturity levels, etc. A framework that may be useful for the user perspective in process modeling may be the emergence of work routines and processes over time. This is because we expect that not only processes and their models evolve but also the types and communities of users that engage with these models. The framework differentiates three distinct stages:

1. Magic: Someone figures out how to do something. The details of the work practice or process are non-transparent to outsiders. So, the model of the work is either unknown, or the result of the work violates the preconceived notions that were built on existing models.
2. Heuristic: Over time, rules/constraints/sequences emerge that achieve the outcome in a more consistent/predictable fashion. The process becomes discernible and repeatable. A model at this stage represents a rough approximation of the work being conducted, but certain aspects as to "why" things work remain hidden. Also, models at this stage may not be generalizable but only cover specific scenarios such as the normal routine that works in most cases.
3. Algorithmic: The process can be described in a formal and systematic fashion, and repeated even by those unfamiliar with the domain or without any human involvement at all. A model developed at this stage is generally detailed and precise, and often fit for machine consumption.

4.3.6 Implications

Two sets of implications flow from our discussion. The first set relates to the way the user perspective is incorporated into research conduct and reporting about process modeling. We suggest a set of recommendations for business process management research conduct and reporting:

- Identify and name the roles of (intended) users or user groups in focus.
- Delineate the specific purpose of the model in focus.
- Identify the relevant study variables of interest that relate to a user or user group, such as purpose, goal, ambition, value, utility, experience and so forth.
- Clarify whether a study is about the model, the process being modeled or the process of modeling itself.
- Separate process design from process modeling. That is, decouple the act of creating a design for a process (what should it do, how should it perform, what options should it encompass) from the act of creating a model that captures this design.

The second set of implications relates to the way research studies are designed and executed to examine user perspectives in process modeling. Specifically, we suggest to encourage presently under-utilized methods of research that are particularly well-suited to developing an understanding of the user (as well as groups thereof). Examples of research methods that suit this purpose, in our view, include

- Ethnography / descriptive field studies
- Inductive field studies
- Qualitative empirical studies
- Development of measurement scales for use in a business process management context to facilitate quantitative analysis
- Usage of multimodal data collection to enable triangulation It is important to state that we do not argue that no such research exists. Our point is merely that we believe more such research should be conducted, and our academic community should dedicate more efforts to encourage, incentivize and appreciate such modes of research.

4.3.7 Conclusion

We found that our engagement in the topic raised several important questions about definitional, procedural, methodological, and theoretical matters. Designing novel, fresh approaches to process modeling will be a consequential action enabled by seeking answers to some of the questions and matters we have raised. Hints at these answers can (perhaps should) also be sought in neighboring disciplines. We believe that drawing attention to the user perspective will (re-)fresh how we approach process modeling in future research.

4.4 What are technologies supporting collaborative business processes for mutually untrusting partners?

Soren Debois (IT University of Copenhagen, DK), Marlon Dumas (University of Tartu, EE), Tijs Slaats (IT University of Copenhagen, DK), Christian Stahl (TWT GmbH – Stuttgart, DE), and Ingo Weber (Data61 / NICTA – Sydney, AU)

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URL http://dx.doi.org/10.1007/978-3-319-45348-4_19

This working group has considered applications of distributed ledger technology (e.g., blockchain) in the context of the execution of distributed, collaborative business processes involving mutually untrusting partners. Distributed ledger technologies solve a variant of the distributed consensus problem in which processes have to achieve consensus on a history of events: "What happened?". The canonical application and example is Bitcoin, where the question of "what happened" amounts to "how was the money spent". Historically, Bitcoin exploited the blockchain distributed ledger to solve the problem of double spending in virtual currencies without a central trusted authority. When every participant is aware of the ledger, no participant can spend digital currency twice, without the other participants discovering this double spending. Contrast this to the functioning of, e.g., credit cards, where credit companies serve as a single trusted party ensuring absence of double spending. Bitcoin, in contrast, relies on no single trusted party. The problem of determining canonically "what happened" is acutely relevant for distributed execution of business processes in a setting of mutually untrusting partners. This problem extends naturally to the one of ensuring that "what happens next" is in accordance with the underlying business process.

4.4.1 Potential Applications

The Working Group envisions three applications of distributed ledgers (DLs) in the context of collaborative business process execution:

1. DL as an audit trail. Since no participant can realistically change the transactions in the DL after it has been accepted by the network, the DL can serve as a trusted audit trail. This audit trail can be consulted in case of disputes, for example if the customer states that they have not accepted a given purchase order for which an invoice has been issued to them, or if they contest the contents of that purchase order. Note that in this case, it is not necessary for the blockchain to store the entire contents of the data objects manipulated in the process hash codes suffice if the parties are able to produce the original objects in case of an audit.

2. DL as a monitoring mechanism : A "smart contract" (i.e. a piece of executable code executed by the DL network) can verify and/or enforce the constraints of the process model. E.g., the smart contract can reject an invoice submitted by a vendor to the DL if no corresponding purchase order exists in the DL.
3. DL as an active coordination mechanism. While "smart contracts" are by definition restricted to acting on data in the DL, they can be connected to outside systems by running "trigger" nodes acting (outside the DL) upon transactions recorded in the DL via a smart contract. E.g., the smart contract asserts a purchase order in the DL, a trigger a the vendor picks this up, and submits a "ship" event back to the smart contract.

4.4.2 Trust and Privacy

DL technologies entail questions linked questions of trust and privacy. There is a spectrum of trust. If the participants are fully mutually untrusting, a public DL should be used. However, a public DL, especially the current Ethereum Smart Contracts implementation, leaks information: The process being executed is itself publicly available in the form of Etherium bytecode. The details of execution of a particular instance are similarly publically available (with the caveat that information that does not form the basis of decisions in the process can of course be encrypted). It the participants would prefer to keep the process execution itself private, they could run a private DL. This approach implies a relatively high degree of trust among participants: all are allowed to see all collaborative process variables, know the account holders, etc. In between, there may be cases where permissioned blockchains could be most appropriate.

4.4.3 Conclusion

The working group contends that the application of distributed blockchain technologies is a fresh avenue of research for BPM research, with the potential to provide practical solutions for achieving trustworthy process executions in collaborative execution of processes between mutually untrusting process participants.

4.5 Are existing BPM methodologies adequate for Agile BPM?

Marlon Dumas (University of Tartu, EE), Udo Kannengiesser (Metasonic GmbH – Pfaffenhofen, DE), Agnes Koschmider (KIT – Karlsruher Institut für Technologie, DE), Ingo Weber (Data61 / NICTA – Sydney, AU), and Liang Zhang (Fudan University – Shanghai, CN)

Business processes, especially knowledge intensive ones, are subject to frequent changes in their environment (e.g. changes in demand or in customer expectations) as well as unforeseen circumstances that may require special treatment. Effectively responding to such changes and special circumstances has become an imperative in modern organizations, calling for agile approaches to Business Process Management (BPM). These approaches depart from traditional "rigid" process management approaches that start from the premise that the process is planned in advance, that the plan is documented in detail, and that the plan is enforced by setting up normative policies and procedures and/or by instrumenting information systems in order to enforce "the plan". We define Agile BPM as the practice of managing business processes in a way that fosters adaptability. In this setting , process adaptability is the ability for a process to adapt to changes in its environment fast and effectively. Adaptations of a process can occur at different levels of granularity, ranging from adaptations of an entire process including all its related (sub) processes and all instances thereof, to adapting parts of a process (e.g. specific subprocesses or activities), down to adapting one instance of the subprocess to requirements arising from a given situation. Arguably, the most adaptable process is the one that can be freely executed in any way by the process performers, such that process workers are allowed (and encouraged) to perform every process instance and every activity in any way they see fit taking into account the circumstances surrounding the case (i.e. in a "casebycase" manner). The least adaptable process on the other hand is the one that is performed always in the way it has been planned and where process workers are encouraged or forced to follow the plan to the letter. A key element to achieve process adaptability is the type of schematization of the process meaning the level to which process workers implicitly or explicitly follow a plan. In this respect, we observe different types of schematization, ranging from the most liberal to the strictest one:

- Entry schematization: The creation of an instance of the process follows a (data) schema – e.g. a form. This is generally the case in an application to approval processes, where the creation of a new instance of a process requires the customer to fill in a specific form, or in an issue to resolution process where the creation of a new instance starts with the creation of a ticket in an issue tracking system.
- Milestone schematization: At this level, the process is divided into phases delimited by milestones. For example, an application may reach a "presubmitted" or "validated" phase before being assessed. An issue on the other hand may reach an "accepted" milestone and later on reach a "closed" milestone.
- Activity schematization: At this level, the set of possible activities of the process are enumerated, scoped, defined, assigned to roles, and possibly grouped according to phases. For example, in an issue to resolution process, one will find activities such as "Investigate issue", "Isolate issue", "Propose resolution", "Discuss resolution with customer", and "Test resolution". Note that in addition to activities also events could be defined e.g. "Issue escalated", "Issue closed", etc.
- Workflow schematization: At this level, dependencies between activities and/or events are visible – e.g. one activity is triggered when another activity is completed or an activity might be triggered following a certain event and if certain conditions are fulfilled. Importantly, schematization may occur even in the absence of an explicit representation of the schema. It may be that in some cases that the schema of a process (e.g. the workflow) is not explicitly captured but simply exists by convention. It is also important to note that there is a tension between agility and other dimensions of business process performance management. Attempts to increase agility may come for example at the expense of quality. For example, in a complaint to resolution, if two complaints from related customers are handled differently despite being essentially identical, this may give rise to customers perceiving a lack of equal treatment. Similarly, agility can come at the expense of transparency if every case is allowed to deviate in an ad hoc manner, we lose the global picture of the entire process.

A central tradeoff of agile BPM is how to determine the right type and degree of schematization for every process, which maximizes adaptability while achieving performance targets with respect to other performance dimensions. In other to strike the above tradeoffs, organizations need to rethink the way they approach business process management. Below we discuss a set of "values" that can be used to guide a transformation from a rigid BPM culture to an agile one.

4.5.1 Values of Agile BPM

An existing framework can be used to define basic values of agile BPM approaches. This framework is called the "manifesto for agile software development" (2001). Its applicability to the development of business processes (or "the process of process modeling") was discussed in a panel session at BPM 2015. The values included in the agile manifesto (adapted to BPM) can be stated as follows:

1. Individuals and interactions are valued more than rigid procedures and tools: This value statement emphasizes the importance of selforganising teams, individual creativity and adhoc communication, in the way carried out in many design thinking approaches. Heavyweight procedures and complex tools and notations are seen as obstacles for creative process development.
2. Executable processes are valued more than comprehensive process diagrams: This value statement stresses the importance of experiencing the results of process modeling: the actual processes as they are executed. The executed process (even if it is only "simulated" through physical or software supported role play) is seen as more effective than analyzing a comprehensive process diagram.
3. Stakeholder collaboration is valued more than upfront process specification: This value statement highlights that all stakeholders including the process participants need to be included in the modeling process. This should ensure that what is modeled correctly represents the stakeholders' needs and perceptions of the process. Upfront specification, in contrast, limits stakeholder participation to a separate, upstream phase of elicitation. What happens in the subsequent phases is then no longer influenced by them and therefore risks losing alignment with their needs.
4. Responding to change is valued more than following a plan: This value statement is about accepting that process changes will occur rather than assuming that everything that was initially modeled remains the same.

4.5.2 Research Questions

In our discussions, we collected a set of research questions through brainstorming and subsequent refinement. The result is the following list:

- Are existing BPM methodologies adequate for Agile BPM? For instance, do existing lifecycle models still hold? If not, what is the best methodology for Agile BPM?
- What are dimensions and important characteristics of agility in BPM? What are the variables that drive the answers to the questions below?
- To what extent should we schematize, when do we have "sufficient" schematization? How do we determine the minimal requirements stemming from, e.g., needs in terms of efficiency and regulatory compliance? How does the purpose influence the appropriate level of schematization?
- How is the schema created and updated? When should we model, and when should we derive schemas from data and observations?
- How to respond to changes or the need for changes?
- How do you learn about the need for change and understand what needs to change?

4.6 How is visualization of process models distinct from visualization in general?

Jens Gulden (Universität Duisburg-Essen, DE), Banu Aysolmaz (VU University Amsterdam, NL), Soren Debois (IT University of Copenhagen, DK), Ralf Laue (Westsächsische Hochschule Zwickau, DE), Tamara Mchedlidze (KIT – Karlsruher Institut für Technologie, DE), and Minseok Song (POSTECH – Pohang, KR)

The working group observes that many contemporary visual process notations only tenuously connects spatial and semantic relations. Many such notations are graphs (sets of nodes and edges), and the visual representation of these graphs exploit spatial relations only in so far that an edge is represented as an arrow from a box representing the source node to a node representing the target node. The relative positioning of, e.g., the nodes themselves often has little or no semantic significance. Practitioners will often compensate by choosing layouts where one axis corresponds, somehow, to causality or the passage of time. This is the situation for, e.g., BPMN, DCR, and DECLARE, The Working Group contends that BPM notations has room for improvement in comprehensibility by a further strengthening of the connection between spatial and semantic relationships.

4.6.1 Visualisation, comprehension, and abstraction

A common complaint of BPM diagrams (in any notation) is the “But this is too complex!” outcry. The Working Group maintains that this complexity is not a property of visualization, but rather a property of the processes we model: Were they not complex, we would not bother to model them. Process models typically serve as an integrating perspective on knowledge that has references to other perspectives. E.g., the specification of a task may reference to accompanying actors and/or resources. As a central integrating perspective, the process model thus inherently is embedded in a multidimensional structure of relationships, for which to provide cognitive access is the main purpose of a process visualization. This complexity manifests itself, e.g., in declarative modeling notations primarily as an implicit need that the visualization consumer having to reason about the ramifications of the rules represented visually. This is unacceptable; computation is for computers. The complexity manifests itself in “imperative” modeling notations primarily as unacceptable growth in (visualized) model size. If this complexity is inherent to the process, then any visualization of that process must contain that complexity. The only way to remove complexity from the visualization is to remove it from the process. Whether or not removing complexity is feasible and reasonable depends on the exact reason the process is being visualized in the first place. The consumer of the visualization will have a goal in looking at the visualization; usually, that goal will not require every last detail of the process model, and so some removal of detail is possible. Being able to provide this ability is a requirement specific toward process visualizations, which is not demanded from visualizations in general. We emphasize that the exact means of removing complexity is immaterial: It may be as simple as filtering certain elements from the visualization, or as complex as performing model transformations before visualizations. Thus, the Working Group contends that the useful visualization of process models is inextricably linked to on the one hand to the questions the visualization is supposed to help answer, on the other our ability to suitably simplify the model before visualization. There can be no useful visualization without abstraction.

4.6.2 Visualization of Process Models

To examine the particulars of process visualization, the Working Group proposes considering the problem from three angles:

1. Use cases.
2. Requirements.
3. Examples.

4.6.3 1. Use Cases

Below is a nonexhaustive list of potential use cases for visualizations. Note the overlap with the purposes of having a process model in the first place. Each visualization is categorized as either static, animation, or interactive:

- A static visualization is a set of fixed diagrams.
- An animation is, well, an animation.
- An interactive visualization can be either of the former types, but additionally allows the user to dynamically alter the parameters or form of the visualization.

Nonexhaustive list of use cases:

- Understand what the activities of a process are ("the domain"). [static]
- Understand flow of activities. [static]
- Understand causal relationships among activities (perhaps from different processes). [static interactive]
- Analyze related perspectives (process models inherently multi-perspective: actors, resources, cost, ...). [static]
- Focus into details (zoom, detailing). [interactive]
- Finding similarities and differences among processes. [static]
- Find out bottlenecks. [static]
- See progress of execution. [animation]
- Find violations of rules.

Typically, different stakeholders with different interests are involved.

4.6.4 2. Requirements

In this Section, we list the attributes of visualizations that appears to the Working Group as particular to process model visualizations.

- Visualize fragments/perspectives only (requires conceptualization of the workflow)
- Collapse / filter: abstraction, navigation.
- Uncollapse / enrich with information
- Select which part is shown (e.g. by zooming, or other means [most simple: enter start/end textually])
- Create different views
- Decrease computation needs based on user type
- Guide user in where to start reading, where to read next (e.g. by interactivity)
- Give control over impression of time distances and lengths
- Give control over how to perceive causal relationships
- Exploit spatial relationship to represent semantic relationships (especially because there are so many semantic relationship)
- Enable user controls

4.6.5 3. Examples

As a starting point for investigating the state of the art, this working group proposes collecting example visualizations from Seminar participant's recent research papers. Example visualizations should transcend basic BPMN diagrams. As part of the collection of examples, the Working Group proposes also forming a catalog of non examples: A list of important properties of process models that currently have no visual representation. Examples of such non-examples could be:

- Security properties
- Resource consumption

The working group considers this collection of non-examples the most promising avenue for finding fresh approaches to BPM visualizations.

4.6.6 Conclusions

The working group contends that visualization of process models, while not necessarily distinct from visualization in general, has the property that because of the richness of the underlying process models, no single visualization will fit all purposes. The object is therefore not to find the visualization of a process, but to to find a visualization suitable for the question at hand. The working group proposes:

1. The collection of a library of published example visualizations.
2. The construction of a catalog of non-examples in the above sense: Attributes of process models currently not being visualized.
3. The evaluation of comprehensibility of different visualization approaches (taking into account the background, needs and goals of different visualization consumers).

4.7 What can BPM bring to Internet of Things?

Agnes Koschmider (KIT – Karlsruher Institut für Technologie, DE), Avigdor Gal (Technion – Haifa, IL), Christian Janiesch (Universität Würzburg, DE), Udo Kannengiesser (Metasonic GmbH – Pfaffenhofen, DE), Massimo Mecella (Sapienza University of Rome, IT), Andreas Oberweis (KIT – Karlsruher Institut für Technologie, DE), Jianwen Su (University of California – Santa Barbara, US), Victoria Torres (Technical University of Valencia, ES), Barbara Weber (Universität Innsbruck, AT), and Liang Zhang (Fudan University – Shanghai, CN)

The Internet of Things (IoT) postulates not only the interaction of humans and software systems but also the interaction with "things", objects in the real world that can act as an autonomous agent. These agents execute small business processes that are triggered either through command for authority dependent things or events that signify a particular (complex) situation that the agent recognizes deems important enough to (re) act. The processes may be full-fledged business processes to deliver a good or simple notifications similar to a personal assistant reminding you of your own tasks which are due or close to failing. This is possible because sensor data is available in the large from stationary sensors in smart spaces as well as automated and manually transmitted data human and artificial agents which can be used in an automated fashion. Due to the increase in computing capacity and miniaturization, decisions cannot only be made from a central instance but also locally by the agent in a timely and useful fashion. In the future, even humans may be wired into this event cloud of information.

4.7.1 The promise BPM brings to IoT

BPM brings a process perspective to the way IoT is being used. Just like in traditional process management, the fundamental understanding of process data involves the notion of a process. IoT data may be created in a way that is completely independent of any notion of a process (e.g., by emitting GPS location every 20 seconds). However, once put in the right context (e.g., a process of a bus following a route in the city) such data all of a sudden become correlated (e.g., a bus cannot fly from one place to another). Therefore, BPM can provide an infrastructure for improving the use of IoT, control its quality, and improve its prediction ability.

4.7.2 The promise IoT brings to BPM

IoT is part of a recent trade knows as big data. As such, it provides continuous monitoring by using sensing devices, being wearable devices, positioning beacons, mobile phone sensing, etc. Such data is valuable for process management and mining is multiple ways. IoT data can assist in discovering situational processes or unknown processes. It can also serve in online process compliance. It assists in predicting operational measures such as length of stay, accumulations of queues, etc. Finally, it provides a way for AB testing of newly designed processes.

4.7.3 Process-related Internet of Things scenarios

Ideas about Internet of Things currently have many forms and range from intelligent coffee mugs with a craving for more black gold to sophisticated transport and logistics solutions linking suppliers and customers based on sensor data and their processes. In the following, we detail some examples which require business process modeling in the Internet of Things and present some common characteristics. One scenario would be personal assistant. The emergence of wearables and IoT devices allows to employ raw data coming from sensors to make decisions and then to apply these decisions through actuators, either virtual or physical, or proposed to the final user in the form of suggestions or alerts. Specific tasks can have many different goals, but they are mainly performed according to a set of models representing environmental dynamics and, noteworthy, user habits and desires. These models can be either handmade by experts or automatically extracted (through learning and mining techniques) from previously acquired sensor logs.

4.7.4 Open questions for research

On a more general level there are several broader questions that can be extracted from the scenarios introduced above. We have extracted those and present them in the following in no particular order.

- How to best organize events stemming from different event sources into an event log?
- How to connect low-level events with high-level activities?
- How much process structure is necessary when designing a flexible and mostly autonomous system?

- What part of the system has to be pre-modeled and what is rather discovered? How to combine model execute with discover predict?
- How to link a large amount of autonomous and asynchronous micro processes?
- How does the central role of communication in IoT fit with the control-flow centric view of most BPM approaches?
- How do we model the interaction of reasoning (analytics) and action (process) of things?
- How do we specify and, thus, model the autonomy of agents?
- How to link organizational (business) processes to personal/individual processes?
- How to support online conformance checking?

4.7.5 Conclusion

The Internet of Things provides a massive playground for industry as well as for personal use through the meaningful yet dynamic interaction of man, software, and machine. Due to the inherent size, complexity, and volatility, it may not be possible to model comprehensive business processes but only parts thereof. However, the coordinated effort of planning, executing and measuring systems based on a large amount of smaller and autonomous business processes is still necessary and new technical and technological solutions need to emerge. We have formulated a number of research questions on process modeling that we deem important to be tackled in the near future for an Internet of Things to make benefit of business processes.

4.8 What are purposes of process modeling?

Hajo A. Reijers (VU University Amsterdam, NL), Alexander Herwix (Universität Köln, DE), Thomas Hildebrandt (IT University of Copenhagen, DK), Julius Köpke (Alpen-Adria-Universität Klagenfurt, AT), Henrik Leopold (VU University Amsterdam, NL), and Han van der Aa (VU University of Amsterdam, NL)

The process model is the starting point and central artifact of many scientific contributions in the area of Business Process Management. This includes both empirical as well as technical contributions. Interestingly, most of these works abstract from the actual purpose of the process model. That is, they do not consider why and for whom the process models were created. In this working group, we thus started out with analyzing the range of purposes of process models. Based on this analysis, we identified areas where process models do not live up to the expectations we have about them. Our contribution is threefold. First, we listed the purposes of process models and the main organizational roles that are associated with these purposes. Second, we elaborated on three key areas in more detail and identified potential for new research directions. Third, we elaborated on the problem of integrating the different representations resulting from our proposals.

4.8.1 Purposes of Process Modeling

To determine directions for future improvements of business process modeling, we first identified a number of different purposes for which process models are used in organizations.

As a starting point for a discussion, we used the purposes identified by Reijers (2003). Without claiming completeness, this resulted in the following 10 purposes:

1. Training: Models used to introduce new employees to the business processes they will take part in.
2. Simulation & Analysis: (Executable) specifications of processes used to simulate and analyze the behavior business processes.
3. Costing & Budgeting: The usage of process models to measure and then price out the resources used for activities to generate goods and services for clients.
4. Enterprise Management: The usage of models to control and manage the enterprise or parts of it (spanning multiple business processes)
5. Documentation & Knowledge Management: Models used to capture and preserve tacit knowledge on an organization's business processes
6. Work Guidance: Models or artifacts used to support users (e.g. as a reference) while they are executing a process.
7. Enactment: Models that are used to automatically control & manage the execution of processes, e.g. as implemented in a workflow management system.
8. System Development: Models used to specify functional requirements to be used as input for systems development.
9. Organization Design: Models used as basis for business process improvement activities.
10. Compliance & Security: Models used to ensure compliance of business process-es to regulations or (ISO) standards.
11. Furthermore, we identified the organizational roles that make use these models for the aforementioned purposes in order to identify the stakeholders to which business process models are relevant.

4.8.2 Topic I: Work Guidance – Process Participant

Process models are being used by process participants to obtain information on how to carry out their work. For example, a process participant may understand a particular step in a process in more depth or needs to understand which steps are to be taken. The current nature of process models is such that they are not optimal to provide this in-sight.

4.8.3 Solution

There are different directions in which process models can be enhanced such that they can better guide workers. The following additional information can be added:

1. Status: the particular status of the work item that a process participant is interested in,
2. Explanation: the reasons why the work item that a process participant is interested in has reached the particular status it is in,
3. Goal: the particular goal for the work item or the overall process,
4. Route: the suggested route to further deal with the work item in question. These different aspects are partially dependent on each other, e.g. there is no route that can be recommended without knowledge about the particular status. Also, the incremental addition of these aspects lead to an increasingly sophisticated artifact. In the end, the most sophisticated manifestation of the artifact may be characterized as a context-sensitive recommendation system for process workers.

4.8.4 Topic II: Training – Process Participant

Problem: Consider the rehearsal of the emergency procedure for an accident at a train bridge (Debois et al., 2016). Today it is carried out using a storyboard for an emergency scenario, describing the anticipated events. Some of the events are initiated by the trainee (e.g., the accident, oil leaking from train, train bursting in fire, passengers falling in the water) other events / activities are omitted and replaced by questions to the participants (What do you do now?). The storyboard reflects the "correct" procedures – and the trainee can help participants doing the right thing, but the rehearsal should also be able to continue if some users do not follow the right procedure. The problem is that current process models typically do not allow for describing re-hearsal storyboards / scenarios nor do tools support simulation of such scenarios as "games". This means that the rehearsal storyboards are created separately from the models of the emergency procedure (which is required to be described by law) and thus they need to be manually aligned. Also, there is very limited support for feedback during simulation.

4.8.5 Solution

A fresh approach to modeling for the purpose of process training would be to integrate the process model required for documenting the procedure with modeling of (good and bad) scenarios/story-boards for training games, i.e. to model the process needed to add gamification elements to the simulation. This could perhaps be done declaratively (Debois et al., 2016), e.g. by modeling the actions and goal of each participant in the game, actions that are preconditions, and responses (likely with deadlines) to actions / events happening during the training, penalties and rewards. The model should also allow for recording feedback to each action / event during the training. Another fresh approach could be to use process mining of both past rehearsals, real process executions and physical rehearsals to suggest scenarios relevant for training, and also to provide feedback on a finished training instance (e.g. how did this training in-stance related to previous ones?). It could even be possible that one could derive the game-model for training automatically based on historical data analyzed using e.g. process mining.

4.8.6 Topic III: Enterprise Management – Top Manager

Problem: Enterprise management is a challenging and knowledge-intensive activity that requires the synthesis of a variety of data sources (e.g., data warehouses or unstructured data about customer needs). Currently, process models used to facilitate this activity include, for example, process architectures and value chains. While these process models already provide a general overview of the enterprise and its processes, they do not facilitate the act of integrating this knowledge in an effective way. For example, current process architectures provide an overview of the existing processes and their relationships within a company. However, the process models themselves are modeled at a level of detail, which makes them difficult to use and interpret for top managers.

4.8.7 Solution

A fresh approach to modeling for the purpose of enterprise management could involve the development of new notations that facilitate the integration of process executions and management relevant objectives. This would allow for the presentation of management relevant perspectives on processes, for example, in the form of smart dashboards that provide managers with the possibility to drill-down into the most appropriate level of abstraction. Moreover, it would be interesting to pursue the development of advanced planning and simulation features that allow top managers to explore the consequences of adjusting management objectives and/or process models based on the historic data of process executions.

4.8.8 Alignment

Process models are used for different purposes and by user groups with different requirements. For example, the IT department needs a very detailed, enactable process model, while the management is typically much less interested in the sequencing of activities, but in the achievement of goals on various levels. The process models applied for training purposes typically only emphasize the typical cases ignoring much of the behavior modeled in the executable models. The compliance department is typically using rule-based modeling. These different requirements on models lead to the use of completely different tools such as Powerpoint for training, Excel for managers, rules for people being in charge of ensuring compliance, and executable BPM models for the IT department. Even on the modeling level, different modeling paradigms are being used by different user groups. For example, declarative models are often the first choice for modeling compliance whereas imperative models are the prominent candidate for modeling a business process. However, these different models actually describe the same real world process. This leads to alignment issues between the different artifacts. For example, a change in the management model or in the compliance rules needs to be reflected in the implementation and also in the training material. Process views have been proposed to support different user-groups with information on the right level of abstraction (Reichert et al., 2012). However, such views only allow abstracting or omitting elements of the process model and do not allow to add missing knowledge about the process (e.g., business goals or more details) and to translate a model to a different representation or modeling paradigm. Consequently, new methods are required:

- Semi-automatic creation of alignments between process models of different user groups and potentially different modeling paradigms by including domain knowledge. For example, mapping an executable process to the management's goal model.
- Deriving one model from another one including abstractions and refinement with the inclusion of domain knowledge. For example, generation of training material from an executable model.
- Automatic identification of parts of a group specific process model that are being affected by another group specific model, for example visualize on the level of a BPMN model for documentation purposes those parts being affected by a compliance rule.

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Participants

- Banu Aysolmaz
VU University Amsterdam, NL
- Fernanda Baião
Federal University – Rio de Janeiro, BR
- Achim D. Brucker
University of Sheffield, GB
- Artur Caetano
INESC-ID – Lisboa, PT
- Soren Debois
IT Univ. of Copenhagen, DK
- Marlon Dumas
University of Tartu, EE
- Kathrin Figl
Wirtschaftsuniversität Wien, AT
- Avigdor Gal
Technion – Haifa, IL
- Jens Gulden
Universität Duisburg-Essen, DE
- Alexander Herwix
Universität Köln, DE
- Thomas Hildebrandt
IT Univ. of Copenhagen, DK
- Richard Hull
IBM TJ Watson Research Center – Yorktown Heights, US
- Christian Janiesch
Universität Würzburg, DE
- Udo Kannengiesser
Metasonic GmbH – Pfaffenhofen, DE
- Julius Köpke
Alpen-Adria-Universität Klagenfurt, AT
- Agnes Koschmider
KIT – Karlsruher Institut für Technologie, DE
- Ralf Laue
Westsächsische Hochschule Zwickau, DE
- Henrik Leopold
VU University Amsterdam, NL
- Tamara Mchedlidze
KIT – Karlsruher Institut für Technologie, DE
- Massimo Mecella
Sapienza University of Rome, IT
- Hamid Reza Motahari Nezhad
IBM Almaden Center – San Jose, US
- Andreas Oberweis
KIT – Karlsruher Institut für Technologie, DE
- Alexander Paar
TWT GmbH – Stuttgart, DE
- Jan Recker
Queensland University of Technology – Brisbane, AU
- Hajo A. Reijers
VU University Amsterdam, NL
- Flávia Maria Santoro
Federal University – Rio de Janeiro, BR
- Tijs Slaats
IT Univ. of Copenhagen, DK
- Chris Snijders
TU Eindhoven, NL
- Minseok Song
POSTECH – Pohang, KR
- Christian Stahl
TWT GmbH – Stuttgart, DE
- Jianwen Su
University of California – Santa Barbara, US
- Victoria Torres
Technical Univ. of Valencia, ES
- Han van der Aa
VU University of Amsterdam, NL
- Barbara Weber
Universität Innsbruck, AT
- Ingo Weber
Data61 / NICTA – Sydney, AU
- William Wong
Middlesex University, GB
- Liang Zhang
Fudan University – Shanghai, CN
- Michael zur Muehlen
Stevens Inst. of Technology, US