Adopting Workflow Patterns for Modelling the Allocation of Data in Multi-Organizational Collaborations

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Abstract: Currently, many organizations need to collaborate to achieve their common objectives. An important aspect hereby is the data required for making decisions at anyone organization may be distributed over the different organizations involved in the collaboration. The data objects and the activities in which they are generated or used are typically represented using business process models. Unfortunately, the existing business process modeling approaches are limited in representing the complex data allocation dimensions that occur in the context of multi-organization collaboration. In this paper we provide a systematic approach that adopts *workflow data patterns* to explicitly model data allocations in multi-organization collaboration. To this end we propose a design viewpoint that integrates business process models with well-known data allocation problem-solution pairs defined as workflow data patterns. We illustrate the viewpoint using a case study of a collaboration research project.

1 INTRODUCTION

Many organizations depend heavily on their collaboration partners and have to align their objectives with those of their partners. For instance, companies collaborate in supply chains to bring their products to end consumers (Lambert and Cooper 2000). Product attributes such as cost, quality and timeliness are common objectives of all collaborating partners (SCC 2012). In projects, likewise, organizations have to collaborate to deliver the products and services pledged in the project contract (PMI 2013). An important aspect of collaboration across multiple organizations is that the data needed for making decisions along the collaboration process might be distributed over the different organizations involved. Having access to the required data is, therefore, crucial.

Collaboration across organizations is typically designed as a set of business processes. A business process model (BPM) primarily specifies the flow of activities (Davenport 1993; Van der Aalst et al. 2003; Aguilar-Savén 2004) and is usually designed by a domain expert (also called a business analyst, domain consultant, *etc*.)

In designing a BPM a domain expert specifies not only the flow of activities but also the data objects produced or required by the activities of the BPM. However, the scope of visibility of the data objects, how the data objects are transferred from activity to activity, how the visibility changes as the data objects are transferred, and how the data objects are used in making decisions usually remain implicit or undefined. Within the context of individual organizations this is less of a concern since data are usually centrally managed. But, in multi-organizational collaboration leaving the information on the generation, usage, transfer and storage of data implicit may render data unavailable and hamper the execution and control of business processes. We refer to these concerns *data allocation concerns*. To support the understanding, communication and analysis of data management in collaboration business process models a data allocation design abstractions are needed.

In this paper we provide an approach to explicitly specify the allocation of data in multi-organization collaboration based on workflow data patterns. To this end we propose a design viewpoint that integrates business process models with workflow data patterns to address data allocation concerns. The design viewpoint helps to understand the data allocation concerns, supports the communication among stakeholders, and help design data allocation solutions.

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The remainder of this paper is organized as follows. Section 2 provides background information on workflow data patterns. Section 3 presents an industrial case study that demonstrates the data allocation design viewpoint. Section 4 presents the data allocation design viewpoint. In section 5 the viewpoint is applied to the case. In section 6 the related work is presented and in section 7 concluding remarks are made.

2 WORKFLOW DATA PATTERNS

Workflow patterns are problem-solution pairs that frequently occur in business process modeling (Russell et al. 2006). Originally, workflow patterns have been proposed to access the suitability of workflow systems used in the context of individual organizations. For that purpose more than a hundred workflow patterns have been identified, categorized and cataloged (van der Aalst and ter Hofstede 2011). Workflow data patterns are well-known and recurring data allocation concerns and the corresponding solutions. Table 1 lists the forty workflow data patterns identified by van der Aalst and ter Hofstede.

The workflow data patterns of van der Aalst and ter Hofstede are categorized into four groups: *data visibility*, *data interaction*, *data transfer* and *data-based routing*. These groups are used in this paper as the four dimensions of the data allocation concerns.

Data visibility dimension defines the scope of data accessibility. In multi-organization collaboration context the scope of the activity have to match with the scope of the data needed to perform the activity at hand or the decision to be made in the BPM. For instance, data in the *task* scope are accessed only within the execution of the given activity in the given BPM instance, while data in the *case* scope can be accessed by all activities of the particular BPM instance. (Note: *task* refers to an instance of an activity; and *case* refers to an instance of a BPM.) The patterns are defined from the most restrictive scope (*task*) to the least restrictive scope (*environment*).

Data interaction dimension defines how the visibility of data changes as they are passed from one activity to another. For instance, *block task to sub-process* interaction means that the data passed from the block task instance to the sub process instance are shared by all activities of the sub process instance; likewise *task to task* interaction means that data is passed from one particular activity instance to another activity instance only.

Data transfer dimension defines the mechanisms of *data interaction*. Data transfer can be by value, by reference, two-way copy (copy in/copy out), *etc*. Not all data transfer mechanisms may apply to all interactions.

Data-based routing dimension defines how data are used to control the start and completion of activity instances or how data are used as conditions to influence the flow of activities.

In designing BPMs, domain experts must take these four dimensions of data allocation into consideration.

Table 1: Workflow data patterns.*

Categories	Patterns
Data Visibility	Task (1), Block (2), Scope (3), Multiple Instance (4), Case (5), Folder (6), Workflow (7), Environment (8)
Data Interaction	
Internal Data Interaction	Task to Task (9), Block Task to Sub-Process (10), Sub-Process to Block Task (11), To Multiple Instance Task (12), From Multiple Instance Task (13), Case to Case (14)
External Data Interaction	Push from Task (15), Pull to Task (16), Push to Task (17), Pull from Task (18), Push from Case (19), Pull to Case (20), Push to Case (21), Pull from Case (22), Push from Workflow (23), Pull to Workflow (24), Push to Workflow (25), Pull from Workflow (26)
Data Transfer	Incoming By Value (27), Outgoing by Value (28), Copy In/Copy Out (29), By Unlocked Reference (30), By Locked Reference (31), Input Transformation (32), Output Transformation (33)
Data-based Routing	Existence as Task Precondition (34), Value as Task Precondition (35), Existence as Task Postcondition (36), Value as Task Postcondition (37), Event-based Task Trigger (38), Data-based Task Trigger (39), Data-based Routing (40)

* The pattern names used by an der Aalst and ter Hofstede are shorted for the sake of readability; the pattern ID's (given insides brackets) are, however, the same as those used by the authors.

3 AN ILLUSTRATIVE CASE AND PROBLEM STATEMENT

In this section we use a multidisciplinary collaboration research case study to illustrative data collaboration concerns.

3.1 Multi-Organisational Collaboration in Research

Collaboration in a research project involves a number of research organizations. The collaboration often takes place as a temporary undertaking wherein one of the collaborating organizations assumes the project leadership responsibility. Projects are defined by project plans which are often long running business processes marked by milestones. Projects have a number of deliverables. The process that leads to a particular deliverable can be perceived as a business process. A conceptual model of data sharing in such a business process is depicted in Figure 1. Business processes in research (and in many knowledge intensive works in general) depend heavily on data sharing, and thus, data allocation is a major concern.

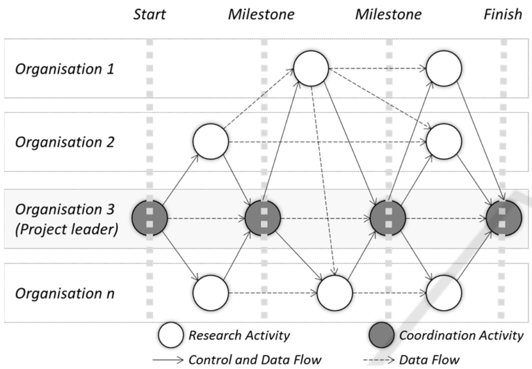


Figure 1: A conceptual model of a project collaboration.

3.2 Research Collaboration Case Study

In the following we elaborate on the data allocation concern with the help of a specific scenario of a multidisciplinary research project that was conducted from 2004 to 2008. Hereby, four research organizations had to address a water management problem through a participatory process (Pahl-Wostl and Hare 2004). Part of the project's objective was to design a water management planning process that should consist of the following participatory elements: identify the affected actors, with the actors identify water management options and the criteria (called indicators) with which to evaluate the options, provide water management models to the actors with which they gain insight into the impact of the options, and finally let the actors select the most optimum option or options with the help of the models.

A simplified BPM for identifying water-stress mitigation options applied in one study location is shown in

Figure 2. The BPM consisted of four milestones: (1) actors are identified, (2) domain ontologies are defined, (2) options and indicators are elucidated and (4) optimal option(s) are selected. In the first milestone the actors were identified through a survey questionnaire. The survey questions, the responses, as well as the actors are the output data objects. In the second milestone the options, indicators and the ontology that describes the relationships among them were identified by using fuzzy cognitive maps. In the third milestone a virtual interactive model is configured and run a number of times to provide actors a deeper understanding on how the various options impact the study area and how the impacts are reflected as indicator values. Finally, in the four milestones a multi-criteria analysis (MCA) model was used to select the optimum option(s) that most actors agree with. However, many details of how data can be accessed, transferred, how the data transfer affects data accessibility, and how data is used to made decisions remained implicit. Similar data allocation concerns occur also in many other sectors such as food, health care and logistics.

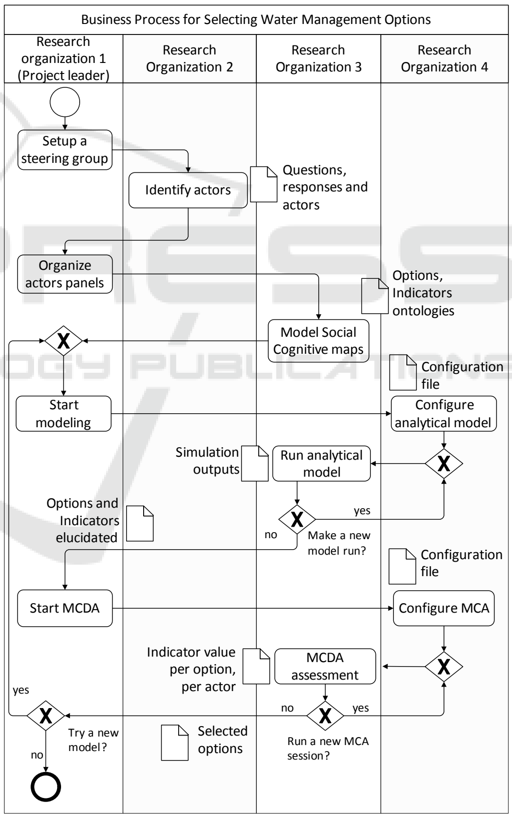


Figure 2: A BPM for selecting options deliverable.

3.3 Problem Statement

A close analysis of the above and many other similar cases shows that the lack of explicit data allocation model is a major concern. In particular, we can identify the following data allocations problems:

- *Difficulty in Defining the Scope of Data*

In BPMs the scope of data required or produced is usually not specified. In the BPM shown in Figure 2, for instance, the options and indicators were required throughout the execution of the BPM, while the results of simulation model runs were needed only with the particular activity instance and for the particular organization. The data allocation was not explicitly defined by domain experts but left to the software engineers who had to deploy the required software system but were not, in many cases, in a position to decide on data allocation.

- *Lack of a Common Data Allocation Model*

Faced with the problem stated above, domain experts and software engineers representing the various project organizations came together to address the problem. However, they lacked models with which they can depict the problems and the solutions.

- *Lack of Models for Redesigning Data Allocations*

Generally, when the design of the current data allocation is not satisfactory, a systematic approach for redesign is required but is lacking.

In light of the above observations we formulate the following research question: *How to model the allocation of data in multi-organizational collaboration business processes?*

4 DATA ALLOCATION DESIGN VIEWPOINT

In software engineering the ISO/IEC/IEEE (2011) standard provides a meta model and a template for documenting software architecture. According to the standard a design view is defined to represent design concerns and decisions of a particular set of stakeholders. Views addressing the same set of concerns have to conform to a set of common conventions called viewpoints. Based on Business Process Model and Notation (BPMN, OMG 2011), workflow data patterns and software system design approaches we present in this section a *data allocation design viewpoint* to address data allocation concerns. We adopt and adapt the ISO/IEC/IEEE template as shown in Table 2. The elements of the template are described in the following sub sections.

4.1 Stakeholders

The relevant stakeholders in data allocation are domain experts and software engineers that come from the collaborating organizations. Domain experts are concerned with the flow of activities and the data required for executing them. Software engineers are responsible for ensuring the desired data allocation is realized in software systems. The data allocation models are defined collaboratively by these two stakeholders.

4.2 Elements

Three modelling elements are business process models, data objects required in the business process models, and the workflow data patterns. The business process models are represented by a convenient modeling notation (see section 4.4.1); data objects are identified by their names; workflow data patterns are described in detailed in the previously mentioned reference.

4.3 Relations

We identify four relations as shown in Table 2. The four relations are: (1) business process element to organization, (2) business process element to data object, (3) data object to software system, and (4) software system to organization. These relations are further elaborated in section 4.4.3.

4.4 Notations

The notation section provides how the elements and relations are represented graphically. Two modelling notations are used: BPMN and allocation tables. Workflow data patterns are represented by a number of attributes, however, only their ID's are used here. The notations are described below.

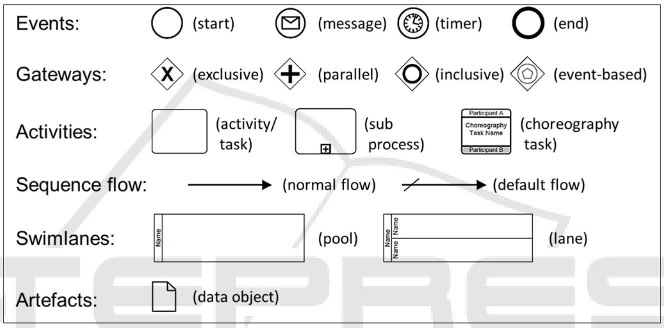
4.4.1 BPMN

To represent business process models we adopt the BPMN (OMG 2011) modeling specification. BPMN is widely used among domain experts, business analysts and managers; it is also used software engineers. BPMN models represent collaboration across business units or organizations. BPMN also a simple *data object* modeling construct. *Messages* and *signals* are also used to represent the flow of data. Data objects are added as annotations to activities. Messages and signals are used indicate exchanges of information and synchronizations. The details of data flow is often left implicit or undefined (von Rosing et al. 2015).

4.4.2 Workflow Data Patterns

The workflow data patterns are originally defined in the context of workflow software. They are described in detail using a number of attributes. When used in the context of multi-organizational collaboration the following attributes are relevant: *name*, *description*, *example*, *motivation*, *overview*, *context*, *issues*, and *animation*. The *implementation*, *solution* and *product evaluation* attributes are not considered relevant here because these attributes represent the properties of centralized (single-organization) workflow systems.

Table 2: Data allocation viewpoint documentation guide.

<table>
<tr><th>Viewpoint Element</th><th>Description</th></tr>
<tr><td>Name</td><td>Data Allocation Viewpoint</td></tr>
<tr><td>Stakeholders</td><td>Domain Experts
Software Architects</td></tr>
<tr><td>Elements</td><td>Elements from OMG's BPMN 2.0 specification
Data objects
Workflow data patterns</td></tr>
<tr><td>Relations</td><td>Data identification – maps the elements of a BPMN model to organizations
Mapping workflow data patterns – maps the elements of a BPMN model to data objects
Data pattern allocation to – maps data objects to software systems
Data management allocation to – maps software systems and data objects to organizations</td></tr>
<tr><td>Notations</td><td>a) BPMN*:


b) Allocation tables:
i) Allocating data to organizations:
<table>
<tr><td>Organizations / BPMN Activities</td><td></td><td></td><td></td><td></td></tr>
<tr><td>…</td><td></td><td></td><td>…</td><td></td></tr>
<tr><td>…</td><td></td><td></td><td>…</td><td></td></tr>
<tr><td>…</td><td></td><td></td><td>…</td><td></td></tr>
</table>
ii) Allocating data to workflow patterns
<table>
<tr><td>Data Object / BPMN Elements</td><td></td><td></td><td></td><td></td></tr>
<tr><td>…</td><td></td><td></td><td></td><td></td></tr>
<tr><td>…</td><td></td><td></td><td></td><td></td></tr>
<tr><td>…</td><td></td><td></td><td></td><td></td></tr>
</table>
iii) Re-allocating workflow data patterns:
<table>
<tr><td></td><td colspan="2">Workflow data patterns</td><td rowspan="2">Software system</td></tr>
<tr><td>Data Object</td><td>From</td><td>To</td></tr>
<tr><td>…</td><td></td><td></td><td></td></tr>
<tr><td>…</td><td></td><td></td><td></td></tr>
<tr><td>…</td><td></td><td></td><td></td></tr>
</table>
iv) Re-allocating data objects:
<table>
<tr><td></td><td colspan="2"></td></tr>
<tr><td>Software system</td><td>Data object</td><td>Organization</td></tr>
<tr><td>…</td><td></td><td></td></tr>
<tr><td>…</td><td></td><td></td></tr>
<tr><td>…</td><td></td><td></td></tr>
</table>
</td></tr>
<tr><td>Properties of Elements</td><td>See section 4.2</td></tr>
<tr><td>Properties of Relations</td><td>See section 4.3</td></tr>
<tr><td>Constraints</td><td>See section 4.4.3</td></tr>
<tr><td>Relation to other viewpoints</td><td>BPMN 2.0 specification and workflow data patterns catalogue</td></tr>
<tr><td>Examples</td><td>See section 5</td></tr>
</table>

* The list only widely used BPMN elements; for a complete list of BPMN elements refer to the OMG BPMN 2.0 specification (OMG 2011).

4.4.3 Allocation Tables

Allocation tables (shown in Table 2b) define how the four relations specified in section 4.3 are represented. The first allocation table is used for identifying data objects generated, used or transformed by organizations. The cells of this table are filled with the names of the data objects. The second allocation table is used for identifying the workflow data patterns that are applicable for the data object of specific activities. The third allocation table is used to allocate data objects to new workflow data patterns and, thereby, also identify the software systems that realize the new allocations. The fourth allocation table is used to identify the organization responsible for the software systems identified in the previous table.

4.5 Constraints

Constraints are aspects of modelling that need to be enforced with respect to elements, relations and notations. The most significant constraint to data allocation viewpoint is that all data objects should at least be associated with one workflow data pattern, a BPMN activity, and an organization.

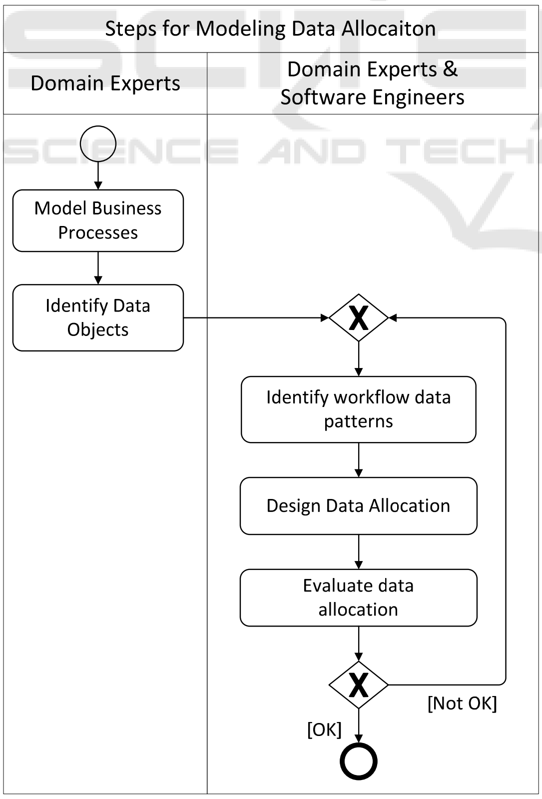


Figure 3: A process diagram representing the process of data allocation modeling.

4.6 Method for Applying the Viewpoint

Figure 3 shows the method for applying the allocation viewpoint. The process starts with the domain expert defining the BPM in step 1. In step 2 the domain expert identifies the data objects involved in each activity. In step 3 the domain expert and the software engineers identify the workflow patterns that best represent the present data allocation. In this step they identify data allocation concerns that need to be addressed. In step 4 they select new workflow data patterns that address the data allocation concerns. In this step they identify the software requirements and responsibilities. In step 5 the data allocation is evaluated. If after evaluation the new data allocation seems unrealistic the steps 3, 4 and 5 are done again. It may take a few iterations before an optimal data allocation is achieved.

5 APPLYING THE DATA ALLOCATION VIEWPOINT

In this section we illustrate how the approach shown in Figure 3 is applied in the case study described in section 3.1. The first step of the approach is already presented in
Figure 2.

Table 3: Identifying input and output data objects (*a*=actor(s), *q*=question(s), *r*=response(s), , *o*=options, *i*=indicators, *g*=game configuration, *v*=value).

BPMN Elements \ Organizations	Research organization 2	Research organization 3	Research organization 4
Setup steering group			
Do survey	*a, q, r=f()*		
Organize actor panels			
Model cognitive maps		*o, i=f(q, r)*	
Launch gaming			
Configure model			*c=f(o, i)*
Play games		*f(i, o)*	
Launch MCA			
Configure MCA			
Run MCA			*v = f(i,o)*

In step 2 the data objects of each BPM activity were identified using the first allocation table as shown in Table 3. (For brevity only the most significant data objects are included.) The cells show the mapping of data inputs to data outputs for each activity (row) of each organization (column). Data inputs and outputs are presented as functions (*f*). The arguments of *f* are the data inputs; the return values are data outputs. For instance, the *do survey* activity (which is shown as *identify actors* in Figure 2) required no input data object but results in three output data outputs. For more complex data inputs and outputs data flow diagram (Larsen et al. 2012) can be used instead.

Next, in step 3, the four dimensions of the data allocation concerns which had been implicit in the original BPM were made explicit with the help of the second allocation table as shown in Table 4. Each cell was assigned up to four workflow data pattern slots. Each slot is separated by a vertical bar—one workflow data pattern per slot from the four pattern categories: patterns 1 to 8 for data visibility, 9 to 26 for data interaction, 27 to 33 for data transfer, and 33 to 40 for data routing.

Table 4: Mapping data to workflow data patters (numbers match the workflow data pattern of Table 1: 1=*Task*, 2=*Block*, 5=*Case*, 9=*Task-to-Task*, 13=*From-Multiple-Insatnce*, 27=*By-Value-In*, 28=*By-Value-Out, 40=Data-Based-Routing, config.=configuration*).

Data Object / BPMN Elements	*q*=question	*r*=response	*a*=actor	*o*=option	*i*=indicator	*v*=value	*c*=config.
Setup steering group							
Do survey	*1|9|28*		*5*				
Organize actor panels							
Model cognitive maps			*5*	*1|9|28*			
Launch modeling							
Configure model				*1|9|27*			*2*
Run model			*5*	*1|9|27*		*28*	
New model run?				*1|13|27|40*			
Launch MCA							
Configure MCA				*1|9|27*			*2*
Run MCA			*5*	*1|9|27*		*28*	
New MCA run?				*1|13|27|40*			
Try a new model?			*40*				

Table 4 can be described as follows: researchers often manage data at each activity instance separately (1); share data directly (9); send data by value (28) and receive them by value (27). In some cases the scope of data extends a few activities, as is the case with configuration files (2). In some other cases data is collected from multiple instances when activities are executed in iteration (13). When iterations are done routing at decision points is made based on data stored externally (40).

After the current data allocations were made explicit, the re-allocation was done in step 4 by assigning data objects to different (better) workflow data patterns using the third allocation table as shown Table 5. Re-allocation is mainly motivated by the availability of new and improved collaboration software systems. As shown in the table the new systems are shared knowledge and database systems. Also in this step the fourth allocation table was used to identify the responsible organizations that had to provide the required software systems (Table 6). The required database systems were made available by two organizations; a new collaboration partner was enlisted to provide the required KB system.

Table 5: Re-allocating workflow data patterns. (5=*Case*, 8=*Enviroment*, 15=*Push-from-Task,* 16=*Pull-to-Task,* 17=*Push-to-Task*, 18=*Pull- from-Task*, 19=*Push-from-Case*, 20=*Pull-to-Case,* 27=*By-Value-In*, 28=*By-Value-Out,* 29=*Copy-In/Copy-Out*).

	Workflow patterns		Software system
Data object	From	To	
q=question	*1|9|27,28*	*1|9|27,28*	
r=response	*1|9|27,28*	*1|9|27,28*	
a=actor	*5*	*8|15,16|29*	KB
o=option		*8|15,16|29*	KB
i=indicator		*8|15,16|29*	KB
v=value		*5|15,16|29*	DB
c=config		*5|19,20|29*	KB

Table 6: Allocating data objects to organisations.

Software system	Data object	Organizations
Project KB	*a, o, i, c*	?
Shared DB1	*v* (model)	3
Shared DB2	*v* (MCA)	4

Last, in step 5, the new allocations were evaluated. It turned out that some data objects required broader scope and visibility. For instance, indicator values (*v*) from model runs have to have *case* (5) visibility; the indicators and options were made public (*environment* visibility 8), *etc*.

6 RELATED WORK

Among business process modelers, BPMN is the de-facto standard for modelling business processes (Decker and Barros 2008; Chinosi and Trombetta 2012). It is also used to model cross-organizational interaction as business process choreography model

(Peltz 2003). Data objects are often added as annotations. However, BPMN provides little modelling support for data allocation.

Data flow diagrams and state charts (Harel 1987) have been the main means of modeling data flow and transformations in business process models. State machines (OMG 2015) are used to model state, and thus data, changes in business processes. Petri-nets and Business Process Execution Language (BPEL) provide modelling constructs for including data aspects into business process models (Hinz et al. 2005). Recently, a fully data-centric business process modeling approach is suggested (Hull 2008). However, none of these approaches address data allocation concerns that occur in a multi-organizational collaboration sufficiently.

In software architectural design that usually accompany business process modelling several design viewpoints are suggested (Woods and Rozanski 2005; Clements et al. 2010). Rozanski and Woods, for instance, propose an architecture framework consisting of seven different viewpoints, namely, *Functional, Information, Concurrency, Development, Deployment* and *Operational,* and *Context* viewpoints. Their work does not, however, include architecture perspective on analyzing data allocation concerns.

7 CONCLUSIONS

Data allocation is an important concern when designing collaboration business processes. It appears that current business process modeling approaches are limited in expressing all the four dimensions of data allocation concerns we identified. We showed how changes in data allocations captured by the four dimensions documented as workflow data patterns can be used data allocation concerns. In future work we will extend apply the design viewpoint to other real-life applications and investigate ways to extend it.

REFERENCES

Aguilar-Savén, R. S. (2004). "Business process modelling: Review and framework." *International Journal of Production Economics* 90(2): 129-149.

Chinosi, M. and A. Trombetta (2012). "BPMN: An introduction to the standard." *Computer Standards & Interfaces* 34(1): 124-134.

Clements, P., F. Bachmann, L. Bass, D. Garlan, J. Ivers, R. Little, P. Merson, R. Nord and J. Stafford (2010). Documenting software architectures: views and beyond, Addison-Wesley.

Davenport, T. H. (1993). Process Innovation: Reengineering Work Through Information Technology, *Harvard Business School Press*.

Decker, G. and A. Barros (2008). Interaction Modeling Using BPMN. Business Process Management Workshops: BPM 2007 International Workshops, BPI, BPD, CBP, ProHealth, RefMod, semantics4ws, Brisbane, Australia, September 24, 2007, Revised Selected Papers. A. Hofstede, B. Benatallah and H.-Y. Paik. Berlin, Heidelberg, *Springer Berlin Heidelberg:* 208-219.

Harel, D. (1987). "Statecharts: a visual formalism for complex systems." *Science of Computer Programming* 8(3): 231-274.

Hinz, S., K. Schmidt and C. Stahl (2005). Transforming BPEL to Petri Nets. Business Process Management: 3rd International Conference, BPM 2005, Nancy, France, September 5-8, 2005. Proceedings. W. M. P. Aalst, B. Benatallah, F. Casati and F. Curbera. Berlin, Heidelberg, *Springer Berlin Heidelberg:* 220-235.

Hull, R. (2008). Artifact-Centric Business Process Models: Brief Survey of Research Results and Challenges. On the Move to Meaningful Internet Systems: OTM 2008: OTM 2008 Confederated International Conferences, CoopIS, DOA, GADA, IS, and ODBASE 2008, Monterrey, Mexico, November 9-14, 2008, Proceedings, Part II. R. Meersman and Z. Tari. Berlin, Heidelberg, *Springer Berlin Heidelberg:* 1152-1163.

ISO/IEC/IEEE (2011). Systems and software engineering -- Architecture description. *ISO/IEC/IEEE Standard 42010:2011*.

Lambert, D. M. and M. C. Cooper (2000). "Issues in Supply Chain Management." *Industrial Marketing Management* 29(1): 65-83.

Larsen, P. G., N. Plat and H. Toetenel (2012). "A Formal Semantics of Data Flow Diagrams." *Formal Aspects of Computing* 6(6): 586-606.

OMG (2011). Business Process Model and Notation 2.0 (BPMN 2.0).

OMG (2015). OMG Unified Modeling Language (OMG UML): 752.

Pahl-Wostl, C. and M. Hare (2004). "Processes of social learning in integrated resources management." *Journal of Community & Applied Social Psychology* 14(3): 193-206.

Peltz, C. (2003). Web Services Orchestration and Choreography. 36: 46-52.

PMI (2013). A Guide to the Project Management Body of Knowledge *(PMBOK) – Fifth Edition*.

Russell, N., W. M. van der Aalst and N. Mulyar (2006). "Workflow Control-Flow Patterns: A Revised View." *BPM Center Report BPM*-06-22.

SCC (2012). Supply Chain Operations Reference Model (SCOR): Revision 11.0.

van der Aalst, W. M. P. and A. ter Hofstede. (2011). "Workflow Patterns. http://www.workflowpatterns.com/." Retrieved December 23, 2015.

Van der Aalst, W. M. P., A. H. M. Ter Hofstede and M. Weske (2003). Business Process Management: A Survey. BPM 2003, *International Conference on Business Process Management*, June 26-27, 2003, Eindhoven, The Netherlands, Springer.

von Rosing, M., S. White, F. Cummins and H. de Man (2015). Business Process Model and Notation—BPMN A2 - Scheel, Mark von RosingAugust-Wilhelm ScheerHenrik von. *The Complete Business Process Handbook*. Boston, Morgan Kaufmann: 429-453.

Woods, E. and N. Rozanski (2005). Using Architectural Perspectives. Software Architecture, 2005. *WICSA 2005. 5th Working IEEE/IFIP Conference on*.