On the Interoperability Contributions of S-BPM

Georg Weichhart[1,2] and Dominik Wachholder[2]

[1] Metasonic AG, Pfaffenhofen, Germany
Georg.Weichhart@metasonic.de
[2] Communications Engineering - Dept. of Business Information Systems,
Kepler University Linz, Austria
{Georg.Weichhart,Dominik.Wachholder}@jku.at

Abstract. Research in *enterprise interoperability* analyzes, describes, and improves the interaction of parts of enterprise systems. Non-interoperability is a situation where either parts of enterprises do not work together at all, or are fully integrated to an extend where the individual parts may not be separated any more. To allow enterprise systems to produce business value its parts need to be interoperable. The S-BPM approach is analyzed with respect to contributions to support interoperability in enterprise systems. Missing support is identified and requirements for tools are derived.

Keywords: Enterprise Interoperability, S-BPM.

1 Introduction

Today's competitive business environment requires sustainable collaboration that is based on the exchange of meaningful information and knowledge. For this reason, interoperability between systems is considered highly relevant as any degree of non-interoperability is likely to lead to problems. Systems which are not compatible on the one hand will not allow interaction among themselves. On the other hand, systems which are fully integrated show lower resilience due to higher probability of overall system failure when an integrated part fails. Research in the domain of "interoperability of systems" in general and "enterprise interoperability" in particular is focusing on identifying and bringing down barriers where systems or system parts are not able to interact [17,8]. The Subject-oriented Business Management Framework and the Subject-oriented Business Modelling Language hold the potential to support interoperability between organizations. Existing S-BPM Tools facilitate information exchange between organizations, humans, and technical systems.

In this paper we analyze the (potential) contributions of the S-BP Management Framework, the S-BP Modelling Language, and existing S-BPM tools to facilitate interoperability. We will also identify further areas of development that are required to be considered in order to facilitate bridging interoperability gaps using the S-BPM framework and/or tools.

The paper is organized as follows. First a framework for interoperability is discussed which is especially tailored to the context of enterprise systems. This

A. Nanopoulos and W. Schmidt (Eds.): S-BPM ONE 2014, LNBIP 170, pp. 3–19, 2014.

discussion is followed by, first, aligning the S-BPM Framework with the interoperability framework, and then aligning existing tools and prototypes with the interoperability framework. This approach allows the identification of gaps that are analyzed and the required further research for fully supporting interoperability is discussed.

2 Interoperability Framework

The concept of interoperability of systems is of importance for sustainable development, and is an ongoing concern for meeting the demands of sustainability. "In today's globally networked environment, one cannot achieve environmental, social/ethical or economic sustainability of any artifact (be it physical or virtual, e.g. enterprise, project, information system (IS), policy, etc.) without achieving ubiquitous ability of the artifact and its creators and users to exchange and understand shared information and if necessary perform processes on behalf of each other in other words, interoperate. Thus, sustainability relies on interoperability, while, conversely, interoperability as an ongoing concern relies on [...] sustainability" [6, p.2].

In the following we discuss (enterprise) systems, followed by systems interoperability in general and continue later with the enterprise interoperability framework [17,8]. The dimensions of the framework will be used for discussing S-BPM support.

2.1 Systems Theory and Enterprise Systems

General System Theory (GST) [4] intends to support the identification of principles that are valid to different scientific disciplines. This is done using abstracting objects to form a *system*. GST builds upon the notion that a system is an organization of connected parts, where each part and the overall system exhibits some behavior. A system is placed in an environment and may have a function and produce some outcome according to a system's objectives [1]. The parts of a system are themselves systems.

Enterprise Systems are organizational systems which may be observed on different levels, ranging from humans undertaking an collaborative enterprise, departments of a single organization to companies being part of supply networks [24].

2.2 Interoperability Approaches

With respect to interoperability approaches, it is important to differentiate between the integration and interoperability of systems as "integration is generally considered to go beyond mere interoperability to involve some degree of functional dependence" [19, p.731]. This functional dependence, however, implies less flexibility and less resilience since it combines the involved systems in order

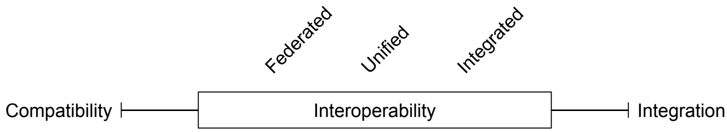

Fig. 1. Compatibility-Integration Continuum

to form a single whole [6]. Integrated systems are sensitive to failures or modifications in individual parts. Small local functional or structural changes may impact distant parts of an integrated system in an unpredictable manner. Interoperability, by contrast, fosters a more loosely coupled approach, where systems remain independent but are coordinated insofar as some collaboration is possible to take place. Functional or structural changes are less crucial as long as the interfaces defined for collaboration are not changed.

Considering this differentiation, interacting systems may be arranged along a continuum that goes from the compatibility to the integration of systems (cf. Figure 1). The concept of interoperability is located in between these two ends. Interoperability may be further distinguished in federated, unified, and integrated interoperability. Here it is important to consider that integrated interoperability and integration is not identical as interoperability merely requires a predefined way of interaction. The separate manifestations are explained in the following in more detail.

Compatibility According to the Oxford dictionary, the term compatible refers to (two) things that are able to coexist without problems or conflict[1]. Two compatible systems therefore do not interfere with each other's functioning, but might not be able to collaborate with each other so as to, for example, exchange information [19].

Interoperability Interoperability lies in the middle of not interoperable (compatible) and fully integrated [8]. Different approaches (federate, unified, and integrated) describe the characteristics of interoperability with respect to the extent of a standardized format available for interaction.

- **Federated approach** Interoperability is established "on the fly" meaning that neither interfaces nor a common formats on a meta-level exist that enable the collaboration of systems. Involved systems are required to identify and adapt to requirements during runtime [8].
- **Unified approach** A common format exists but merely describes the interaction of systems on a meta-level. Diverging concepts are mapped on a semantical level that allows the translation between multiple systems. This approach might encounter some loss of information as the systems' individual needs are not able to be represented directly.
- **Integrated approach** There is a common format which is used by all involved parties. The individual parties, however, are not integrated them-

[1] `http://oxforddictionaries.com/definition/english/compatible`

selves but exist independent of each other. Only the interface is standardized according to the aligned systems.

Integrated system Integration refers to systems that are combined with each other to form a single whole[2]. As a consequence, the modification of one part will have direct effect on other parts. Malfunction of one (sub)system will lead to a breakdown of the entire system with a higher probability than with loosely coupled systems being interoperable.

2.3 Enterprise Interoperability

Enterprise Interoperability may not be considered as unidimensional in terms of underlying issues, but rather involves a problem space composed of two dimensions that are orthogonally aligned to each other [5]. The first dimension is concerned with interoperability barriers that obstruct the collaboration of enterprise systems with respect to their conceptual, technological, as well as organizational disparities. The second dimension addresses the fact that the collaboration can take place at various different levels within an enterprise including data, service, process, and business concerns. The consideration of both dimensions as orthogonal matrix therefore allows to view the different barriers from the perspectives of the separate concerns and vice versa (cf. Figure 2). For instance, conceptual barriers are relevant as such but require to be considered from the viewpoints of the separate concerns separately. The same principle applies to the interoperability concerns, as for example the service level might involve conceptual, technological, as well as organizational interoperability barriers. A more detailed discourse on the problems space and exemplary samples to the separate points of intersection of barriers and concerns are given later in this section.

The third dimension incorporates interoperability approaches and forms, together with the other two dimensions, the solution space (cf. Figure 2). The intersection of all three dimensions therefore gives a set of solutions that encounters interoperability barriers considering a given concern.

2.4 Enterprise Interoperability Barriers

The interoperability of enterprise systems presumes their ability to communicate information that is mutually understood. In this regard, systems encounter different challenges that range from a consistent way of representing relevant information (*information problems*) to transmission principles (*machine problems*) and organizational aspects (*human problems*) as for instance access priviledges. A classification by means of conceptual, technological, and organizational barriers is specified in the following [5].

- *Conceptual Barriers.* Conceptual barriers emerge once the information to be exchanged among enterprise systems is represented in different ways. Consensus upon the syntactic representation of information as well as semantic

[2] `http://oxforddictionaries.com/definition/english/integrate?q=integrability%25255C#integrate__14`

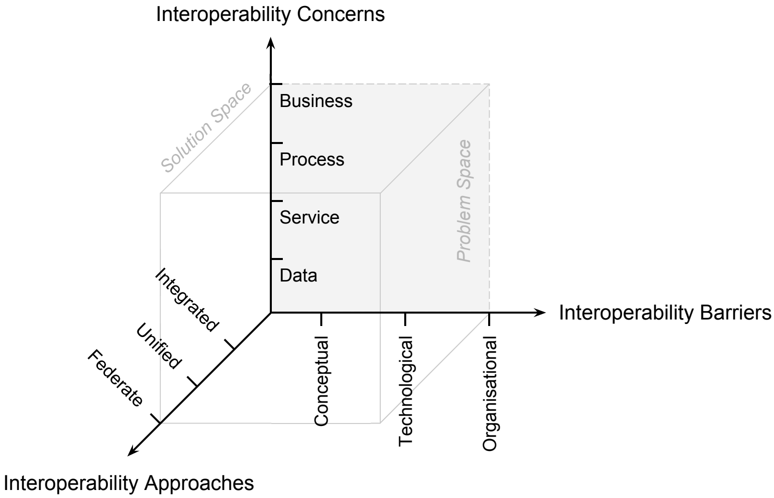

Fig. 2. Dimensions of Enterprise Interoperability [23]

concepts used in this context therefore is crucial in order to achieve conceptual interoperability. UEML [21], for example, provides an approach to align diverging enterprise models by allowing to map their different syntaxes in use. Differences on a semantic level are possible to be tackled by using ontologies.

– *Technological Barriers.* As the collaboration of enterprise systems requires their communication and the exchange of information, technological barriers are crucial to be considered so as to achieve interoperability. In this case, not the representation of information is addressed but the way of how this information is processed and finally distributed among enterprise systems. Typical barriers are, for example, different IT architectures & platforms, operating systems, encodings, transmission protocols, and standards. In spite of the attempt of standardization, technological barriers still exists as for instance different versions of a standard or protocol are incompatible with each other.
– *Organizational Barriers.* As compared to conceptual and technological barriers, organizational barriers are less technical oriented but address disparities in organizational structures and management techniques of collaborating enterprises. It is for example crucial to consider differences in implemented responsibility and authority concepts that govern who is responsible for what (e.g., data, service, etc.) and who is authorized to perform which tasks (create, modify, and maintain data, processes, etc.).

2.5 Enterprise Interoperability Concerns

In order to achieve interoperability among enterprise systems it is not sufficient to consider the abovementioned barriers only. Orthogonal to these barriers, interoperability concerns are crucial since they describe where interoperability actually takes places. Chen [5] therefore distinguishes between interoperability concerns on a data, service, process, and business level.

- *Data.* The interoperability of data, both analog and digital, plays an important part in the context of collaborating enterprise systems. It not only facilitates the mere exchange of data (technological barriers) but also the comprehensibility in terms of its representation (conceptual barriers) as well as its handling on an organizational level (organizational barriers). Thus, the existence of diverse data structures, query languages, right up to incompatible security and permission policies might negatively affect the interoperability on a data level. The ability of systems to collaborate on a data level provides the basis for the remaining concerns.
- *Service.* The interoperability of service addresses the proficiency of enterprise systems to collaborate with each other on a functional level. In this context, the term *service* is understood in a more broader sense with respect to any function that is provided by the collaborating partners within an enterprise. It is therefore not limited to just the technical part of, for instance, a service-oriented system architecture. Challenges so as to achieve interoperability arise once services are described differently (conceptual barriers), exhibit different granularities (technological barriers), or underlie diverging policies as related to the management of services (organizational barriers).
- *Process.* A process defines the arrangement of separate services (functions) that in collaboration serve a common business need. Typically, an organization has several of such processes in place which are described using (different) process description languages. Process interoperability intends to eliminate barriers that emerge when composing processes in order to perform verification, simulation, and execution tasks collaboratively. Diverging syntactical and semantical constructs (conceptual barriers), process behaviors (technological barriers), and business process behaviors (organizational barriers) are typical examples that obstruct the collaboration of enterprises on this level.
- *Business.* The interoperability of business describes organizations that have a mutual understanding of how business is performed. It refers to an aligned mode of operation among organizations where diverging constructs related to business issues are negotiated and mapped among each other. Barriers to interoperability of business might range from diverse visions and strategies (conceptual barriers) and different support by means of ICT infrastructure (technological barriers) to issues as related to incompatible organization structures and decision-making processes (organizational barriers).

2.6 Problem Space of Enterprise Interoperability

Ducq et al. give a more detailed discourse on the problem space of interoperability barriers and concerns in their paper by attributing non-exclusive examples to each point of intersection [7]. Table 1 summarizes these findings. Interoperability barriers are given in the columns and interoperability concerns are in rows respectively.

Table 1. Problem Space of Enterprise Interoperability [7]

Barriers / Concerns	Conceptual	Technological	Organizational
Business	Visions, strategies and culture; Business semantics; Business syntax	IT requirement fulfilment; Degree of computerization	Methods of work; Organization structure; Legislation
Process	Process semantics; Process syntax; Process content	Process behavior	Business process behavior;
Service	Service semantics; Service syntax; Service content	Service granularity	Service management
Data	Data semantics; Data syntax; Data content	Exchange format	Classified information; Information ownership

In addition to the two orthogonally aligned dimensions of interoperability barriers and concerns, the timing of the envisioned solution is of relevance when seeking to support the creation of such an solution. Solution timings refer to the circumstances when interoperability problems are tackled. A-priori solutions are approaches that allow to anticipate problems and to overcome barriers before systems are build. A-posteriori solutions are approaches that allow to identify and correct problems after they occur in the running system [16].

3 S-BPM

The acronym “S-BPM” is used for [11]:

- Subject-oriented Business Process *Management Framework*,
- Subject-oriented Business Process *Modeling Language*, and
- Subject-oriented Business Process *Modeling Activity.*

For the discussion on the support of interoperability, these manifestations will be distinguished. The Management Framework defines a set of activity bundles (or phases) for organizational development and business process management. These activity bundles are typically “carried out along a feedback control cycle composed out of the phases: analysis, modeling, validation, optimization,

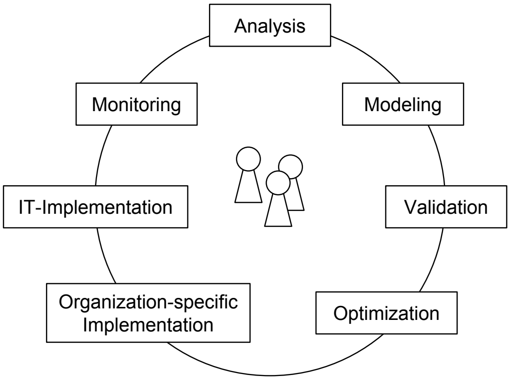

Fig. 3. S-BP Management Framework Activity Bundles

organization-specific implementation, IT-implementation, monitoring" [11, p.30] (cf. Figure 3). S-BP Modeling thereby is considered as an integral part of these phases. However, modeling is only one activity within the framework which (naturally) has a larger scope.

3.1 S-BPM Framework Contributions to Interoperability

In the following discussion we will focus on contributions of the Subject-oriented Management Framework [11] to interoperability. This is done, by using the interoperability framework described above. Support by the Management Framework and S-BPM Tools in general will be identified and mapped to the problem space of interoperability. Subject-oriented Business Process Modeling will be used to refer to the *activity of modeling* and not the modeling environment neither the modeling language itself.

Conceptual Barriers. The following list shows S-BPM Framework support for interoperability concerns regarding conceptual barriers. As mentioned above, conceptual interoperability refers very much to the semantics and syntax of the different concerns (cf. Table 2).

– *Conceptual/Business.* Per-se no support for (e.g. cross-organizational) business interoperability on conceptual level is given directly.
  However, S-BPM Framework distinguishes multiple types of stakeholders which are addressed explicitly and collaboratively work on conceptual interoperability on business level may be realized indirectly through the work of these stakeholders.
– *Conceptual/Process.* The analysis and modeling activities require stakeholders and actors (the process participants) to provide coherent models of their tasks. By using a common language (S-BPM) conceptual interoperability is

facilitated. Validation activities check the process and might uncover conceptual process interoperability problems.
- *Conceptual/Service.* During the validation phase, stakeholders are in charge of checking processes, to see if these realize the desired service. This implies that in S-BPM the service is realized through the underlying processes. Service execution may additionally be monitored through Key Performance Indicators. Establishing key performance indicators in the company, provide additional conceptualizations in terms of what is important, and how performance is measured [11].
- *Conceptual/Data.* No explicit support for overcoming data syntax and semantics issues is provided by the framework. However, data issues are addressed to a limited extend in the IT-Implementation phase of S-BPM.

Technological Barriers. The following list shows S-BPM Framework support for interoperability concerns regarding technological barriers. Interoperability with respect to technology is addressed mainly in S-BPM Framework's IT-Implementation phase.

- *Technological/Business.* Using the framework will result in models that describe manual and automated tasks. Interoperability issues by technology in business will be addressed when applying the framework.
- *Technological/Process.* Explicit process models help to communicate an exchange information about processes. The IT-Implementation phase will result in technological support for processes.
- *Technological/Service.* No explicit support for determining or providing technical services (eg. web services) is given by S-BPM. In S-BPM software services may be called from within subject's states but the framework leaves this to be supported by tools.
- *Technological/Data.* No explicit support for modeling Business Objects is provided by the S-BPM framework. It leaves this to be supported by tools.

Organizational Barriers. The following list shows S-BPM Framework support for interoperability concerns regarding organizational barriers:

- *Organizational/Business.* Organizational structures are not part of the S-BP Models per-se. To some limited extend organizational structures are mapped using "Subject carrier groups" [11] to implement functional roles in S-BPM. Support for organizational change (management) and cross- organizational business issues is missing.
- *Organizational/Process.* S-BPM models do make processes transparent by definition.
- *Organizational/Service.* Service management has to be described in separate S-BPM models. The monitoring phase facilitates management of the quality with which a service is provided [11].
- *Organizational/Data.* Organizational management of data is not explicitly supported by S-BPM.

3.2 Tool Contributions to Interoperability

In addition to the above support by the S-BPM framework, a number of tools exist, which provide support, also for interoperability However, for this discussion we do not constrain the discussion to the commercially available tools (e.g., Metasonic Suite[3]) or features, but also include research prototypes. These prototypes may be stand-alone or used in conjunction with the suite.

Conceptual Barriers. The following list shows S-BPM Tool support for interoperability concerns regarding the conceptual barrier:

- *Conceptual/Business.* Bastarz and Halek are using the smart tool with the smart4sense2act [2] to facilitate conceptual clarification of business systems.
- *Conceptual/Process.* Metasonic Build and Proof as S-BPM design system and process validation system respectively, facilitate the clarification of process related concepts.
- *Conceptual/Service.* As services (from the S-BPM point of view) are composed of processes, the clarification of processes (see above) leads to clarification of services. Metasonic Touch which is based on Comprehand [18] facilitates the articulation work of all process participants in order to clarify the work to be done.
- *Conceptual/Data.* No support for clarification of a Business Object's semantics and content is available today.

Table 2. *S-BPM Framework* Support for Interoperability in the Problem Space

Barriers / Concerns	Conceptual	Technological	Organizational
Business		All Framework Activities	
Process	Analysis, Modeling, Validation Framework Activities	IT- and Organization Implementation Framework Activities	All Framework Activities
Service	Validation Framework Activity		Monitoring Framework Activity
Data			

Technological Barriers. The following list shows S-BPM Tool support for interoperability concerns regarding the technological barrier. Since S-BPM focuses on the modeling and implementation of workflows, any S-BPM execution (workflow) engine supports technical interoperability through an integration interoperability approach.

[3] `http://www.metasonic.de/metasonic-suite`

- *Technological/Business.* In the IT-Implementation phase of the S-BPM Framework, the computerization of business processes is realized. The configuration of the workflows will clarify the interface between different tools and human operators on a technology level.
- *Technological/Process.* Metasonic Build and Proof facilitate interoperability of processes with respect to technology through an "integrated interoperability" approach (see above) [11].
- *Technological/Service.* Technical Services like web services may be integrated in S-BPM workflows using refinements in Metasonic Flow.
- *Technological/Data.* Any S-BPM workflow engine may be used as middle layer for establishing interoperability of external tools. By including external data sources in the business process some interoperability between software systems through federation using the process may be realized. This means, that as soon as conceptual/data interoperability is realized, the S-BPM Tools allow to map data to business objects and facilitate data flows from and to other tools.

Organizational Barriers. The following list shows S-BPM Tool support for interoperability concerns regarding organizational barriers:

- *Organizational/Business.* No direct tool support is currently available.
- *Organizational/Process.* The S-BPM design tools naturally support clarification of interaction within processes. Metasonic Touch and Comprehand [18] facilitate the communication and articulation of work related information between process participants beyond pure modeling and design of processes. A research prototype developed in the project jCPEX! [15] enables dynamic routing of business objects to different actors of the same role. The research project results have demonstrated the feasibility of this approach across companies. jCPEX! facilitates standardized interfaces for cross-organizational processes.

  Another research prototype demonstrates the possibility of flexible BPM by making use of ad-hoc process deviations [20]. This allows to maintain interoperability besides changed requirements and allow implementation of process agility [12].
- *Organizational/Service.* KPI management featured in Metasonic Suite, supports monitoring and management of services [11] through supporting the development of performance indicators that clarify goals of a service.
- *Organizational/Data.* No direct support for rights and permissions of access to business objects is given.

3.3 Missing Support

So far, we have analyzed and brought together two existing frameworks. Subject-oriented Business Process Management Framework and existing S-BPM tools and research prototypes do provide support for interoperability in the context of the Enterprise Interoperability Framework. However, as S-BPM has not been designed to address interoperability issues explicitly, a few gaps exist.

Table 3. *S-BPM Tool* Support for Interoperability in the Problem Space

Concerns \ Barriers	Conceptual	Technological	Organizational
Business	smart4sense2act	S-BPM Design Tools	
Process	S-BPM Design and Execution Tools	S-BPM Design and Execution Tools	Metasonic Touch, Comprehand, S-BPM Design Tool, jCPEX!, Ad-hoc Deviations
Service	Metasonic Touch, Comprehand	S-BPM Execution Tool	KPI Management Tool
Data		S-BPM Execution Tool as Enterprise Bus	

Table 4 shows existing support for enterprise interoperability by the S-BPM framework [11], existing tools, and research prototypes respectively [3,15,20,11]. In this table also the solution approach category (integrated, unified, federated) is given. However, the borders between the categories are blurry.

Business Concern: smart4sense2act allows to negotiate a common abstract picture of the business context of processes. — The application of the S-BPM framework provides a common ground for aligning manual and technical tasks.

Process Concern: Using the S-BPM framework and the Tools allow the integration of process related concepts. — For technological barriers support for integration is also provided. — A number of tools exist that allow to overcome organizational barriers by integrating different processes. Tools like Comprehand facilitate the negotiaton of processes among process participants. Metasonic Touch makes use of a common language and hence facilitates unification.

Service Concern: The framework provides through the S-BPM notation a unified language that allows to specify service descriptions. Metasonic Touch and Comprehand allow to negotiate the processes that realise a service. — The uses of the execution environment integrates the different services (services as finer granular process parts). It also allows to provide integrated processes that realise a service. — S-BPM provides a common language to overcome organizational interoperability on service level. Through the use of KPIs the service's outcome and output might be specified in depth.

Data Concern: The S-BPM tools allow to integrate other software systems allowing to exchange data between systems along processes.

It has to be noticed that there is some minor conceptual disagreement between the interoperability framework and S-BPM. In the later, a service is defined by processes which result in delivering value to a customer, the former is more vague in its definition of service. However, the former conceptualization leans toward defining a process as alignment and structuring multiple (more fine-grained) services. For this discussion, however, this disagreement does not lead to interoperability problems between the two frameworks.

Table 4. S-BPM Support for Interoperability in the Problem Space

Concerns \ Barriers	Conceptual	Technological	Organizational
Business	smart4sense2act[3]	Framework (All Activities)[2] S-BPM Design Tools[2]	
Process	Framework (Analysis, Modeling,Validation)[1] S-BPM Design and Execution Tools[1]	Framework (IT-, Organization Implementation)[1] S-BPM Design and Execution Tools[1]	Framework (All Activities)[1] Metasonic Touch[2], Comprehand[3], S-BPM Design Tool[1], jCPEX![1], Ad-hoc Deviations[1]
Service	Framework (Validation)[2] Metasonic Touch[2], Comprehand[3]	S-BPM Execution Tool[1]	Framework (Monitoring)[2] KPI Management Tool[2]
Data		S-BPM Execution Tool as Enterprise Bus[1]	

1 ... integrated; 2 ... unified; 3 ... federated;

For any interoperability support that attempts to fill the gaps, two modes of operation have to be considered. *A-priori* support facilitates the clarification of interoperability issues during design-time of systems. *A-posteriori* support enables negotiation and agreement on appropriate steps of involved parties after an interoperability issue has emerged.

Better support by S-BPM framework and tools is required for overcoming the following barriers:

- *Organizational/Data.* "The structures for assigning rights to data (different rights for different partners); Differences in which an information is to be regarded as classified with respect to the collaboration partner" [8, p.850]. With respect to organizational networking and interoperability on the level of data, trust management, security, and legal issues require further research [22]. This is especially true when considering trust transitivity and determining how to handle permissions once information is passed from one actor to the next which, in turn, further passes the data to another actor. A transparent approach is needed which supports individual actors and applications to not (incidentally) pass classified information to actors who are not authorized to access that data.
- *Conceptual/Data.* "Coverage, i.e. content, of the respective data representation; Heterogeneous data format and structure; Data meaning disagreements" [8, p.850]. Interoperability support for conceptual data interoperability is also a topic of ongoing research. There are ontology and semantic web approaches

(e.g., based on OWL-S) [22] for a-priori mapping of different data types and fields.

- *Organizational/Business.* "The legislative requirements that influence different actors; How enterprises are organized on a high level; High level differences regarding how work is performed in the organizations" [8, p.850]. While business process approaches offer some possibility to overcome organizational issues on process level, a needed high-level overview of organizational differences requires more specific support.

In all cases above, when considering dynamic environments and a-posteriori support the challenge gets even greater. In the case of a need for action because of interoperability issues in running business situations, content and communication needs to be intertwined to support a negotiation of resolution strategies. The dynamics of business needs to be respected by empowering users to act flexible in situations. An organizational learning environment, which facilitates data and knowledge exchange across companies would foster organizational interoperability through supporting communication, negotiation, and providing an organizational memory for interoperability [25].

For example, the SUddEN environment [25] facilitates interoperability on supply-network level, by making use of key performance indicators (KPI) and supporting the collaborative developments of a network-wide performance measurement system (PMS). However, with respect to the enterprise interoperability framework, this environment misses support on process and data concern level.

An organizational learning environment to support interoperability meeting all concerns, needs, in addition to an organizational point of view, an actor specific view (not only in order to follow the logic of S-BPM). In the actor point of view, it must be assumed that knowledge is distributed within the company or even across companies. This naturally leads to situations where it is not possible to establish a global (over-)view [11]. In order to keep workflow participants (to a large extend) autonomous (but interoperable), advanced support for organizational interoperability is needed on business level. Users may change their processes if required (by them). Giving this freedom is a potential source of non-interoperability and hence comes with great responsibility. The approach to be researched has to enable users to study the impact of changing their behaviors autonomously. A potential technology to do so, but which is not put into use with S-BPM, is agent-based simulation [26,9]. Here autonomous software components (called agents) represent users. For facilitating learning in this context, the agents would be assigned multiple subject-roles [10]. This allows independent interaction of users with a virtual environment which is build on actual process models. Users are enabled to explore the impact of changing a behaviour by allowing individuals to change a subject-behaviour-diagram, and then run an agent-based simulation of the organization in order to identify the impact of the (proposed) changes to other users. Multi-agent simulation has already shown to be useful for planning in distributed environments and providing a high-level overview of supply networks [14].

For making the above described environment useful for a-posteriori organizational interoperability, support for technological interoperability has to be build-in. The technical interoperability needs to address two different, independent aspects. Making existing S-BPM tools interoperable on technical level with the environment allows to extend the learning environment. Comprehand [18] for example, enables knowledge transfer between users on a conceptual level. This tool supports interoperability required in a learning environment for interoperability. The second aspect is to make the learning environment's agents interoperable with existing systems for supporting the agent's decision making during simulation. The first technical interoperability extends the learning environment with other tools to facilitate learning organizational interoperability, the second enables to access information required for decision making during learning.

4 Conclusions

S-BPM, although a process management framework, promises to support interoperability, especially in contrast to integration. Other process frameworks like ARIS [13] aim at providing a global "world-view" based on a global control flow, where IT, actors, and organizational tasks are parts of a fully integrated system. S-BPM uses a different approach as it puts the individual actor in the center of the organizational models [10]. S-BPM assumes independent agents interacting and communicating with each other.

S-BPM does deliver a communication and subject oriented view where process participants are loosely connected through the exchange of business objects and messages. This provides some freedom for the participants, who may optimize their individual task structures. This freedom is a source of non-interoperability and hence requires some additional collaborative effort to support overcoming interoperability barriers.

Overall we have identified three larger areas where the S-BPM Framework should be extended to deliver a full approach to support enterprise interoperability.

- Trust and security needs to be handled for interoperability, especially when considering multiple involved systems which share data.
- Interoperability concerning the enterprise's business requires support, while maintaining S-BPM's autonomous agents world-view.
- Interoperability concerning the data level for different IT systems is currently under developed.

Based on existing works [23,24,14,25], we have additionally described an approach to foster interoperability supporting a-posteriori exploration and learning with respect to organizational interoperability. That approach will make use of agent technology in order to stay close to the S-BPM logic.

Acknowledgement. The research leading to these results has received funding from the European Commission within the Marie Curie Industry and Academia

Partnerships and Pathways (IAPP) programme under grant agreement n^o 286083. For more information on the IANES project see http://www.ianes.eu.

References

1. Ackoff, R.L.: Towards a system of systems concepts. Management Science 17(11), 661–671 (1971), http://mansci.journal.informs.org/content/17/11/661.abstract
2. Bastarz, F., Halek, P.: Seeing the wood for the trees again! smart - a holistic way of corporate governance offering a solution ready to use. In: Stephanidis, C. (ed.) Universal Access in HCI, Part IV, HCII 2011. LNCS, vol. 6768, pp. 187–194. Springer, Heidelberg (2011), http://dx.doi.org/10.1007/978-3-642-21657-2_20
3. Bastarz, F., Halek, P.: smart4sense2act: A smart concept for systemic performance management. In: Schmidt, W. (ed.) S-BPM ONE 2011. CCIS, vol. 213, pp. 109–114. Springer, Heidelberg (2011), http://dx.doi.org/10.1007/978-3-642-23471-2_8
4. von Bertalanffy, L.: General System Theory - Foundations, Development, Applications, 17th edn. George Braziller, New York (1969)
5. Chen, D.: Framework for enterprise interoperability. In: Congrès International de Génie Industriel, CIGI 2009 (2009)
6. Dassisti, M., Jardim-Goncalves, R., Molina, A., Noran, O., Panetto, H., Zdravković, M.M.: Sustainability and interoperability: Two facets of the same gold medal. In: Demey, Y.T., Panetto, H. (eds.) OTM 2013 Workshops 2013. LNCS, vol. 8186, pp. 250–261. Springer, Heidelberg (2013)
7. Ducq, Y., Chen, D., Doumeingts, G.: A contribution of system theory to sustainable enterprise interoperability science base. Computers in Industry 63(8), 844–857 (2012), http://www.sciencedirect.com/science/article/pii/S0166361512001248
8. Ducq, Y., Chen, D., Doumeingts, G.: A contribution of system theory to sustainable enterprise interoperability science base. Computers in Industry 63(8), 844–857 (2012); Special Issue on Sustainable Interoperability: The Future of Internet Based Industrial Enterprises
9. Fioretti, G.: Agent-based simulation models in organization science. Organizational Research Methods 16(2), 227–242 (2013)
10. Fleischmann, A., Kannengiesser, U., Schmidt, W., Stary, C.: Subject-oriented modeling and execution of multi-agent business processes. In: The 2013 IEEE/WIC/ACM International Conference on Intelligent Agent Technology (2013)
11. Fleischmann, A., Schmidt, W., Stary, C., Obermeier, S., Börger, E.: Subject-Oriented Business Process Management. Springer (2012)
12. Heininger, R.: Requirements for business process management systems supporting business process agility. In: Oppl, S., Fleischmann, A. (eds.) S-BPM ONE 2012. CCIS, vol. 284, pp. 168–180. Springer, Heidelberg (2012)
13. IDS Scheer AG: Handbuch zur ARIS-Methode - Version 5. Saarbrücken (May 2000)
14. Karageorgos, A., Mehandjiev, N., Weichhart, G., Hämmerle, A.: Agent-based optimisation of logistics and production planning. Engineering Applications of Artificial Intelligence 16(4), 335–348 (2003)
15. Meyer, N., Feiner, T., Radmayr, M., Blei, D., Fleischmann, A.: Dynamic catenation and execution of cross organisational business processes - the jcpex! approach. In: Fleischmann, A., Schmidt, W., Singer, R., Seese, D. (eds.) S-BPM ONE 2010. CCIS, vol. 138, pp. 84–105. Springer, Heidelberg (2011), http://dx.doi.org/10.1007/978-3-642-23135-3_5

16. Naudet, Y., Guedria, W., Chen, D.: Systems Science for Enterprise Interoperability. In: International Conference on Interoperability for Enterprise Software and Applications China, IESA 2009, pp. 107–113 (2009)
17. Naudet, Y., Latour, T., Guedria, W., Chen, D.: Towards a systemic formalisation of interoperability. Computers in Industry 61, 176–185 (2010)
18. Oppl, S., Stary, C.: Facilitating shared understanding of work situations using a tangible tabletop interface. Behaviour & Information Technology, 1–49 (2014)
19. Panetto, H.: Towards a classification framework for interoperability of enterprise applications. International Journal of Computer Integrated Manufacturing 20(8), 727–740 (2007)
20. Rothschädl, T.: Ad-hoc adaption of subject-oriented business processes at runtime to support organizational learning. In: Stary, C. (ed.) S-BPM ONE 2012. LNBIP, vol. 104, pp. 22–32. Springer, Heidelberg (2012), http://dx.doi.org/10.1007/978-3-642-29133-3_2
21. Vernadat, F.B.: UEML: Towards a unified enterprise modelling language. International Journal of Production Research 40(17), 4309–4321 (2002)
22. Vernadat, F.B.: Technical, semantic and organizational issues of enterprise interoperability and networking. Annual Reviews in Control 34(1), 139–144 (2010), http://www.sciencedirect.com/science/article/pii/S1367578810000155
23. Wachholder, D.: Enabling Context-sensitive Behavior Adaptation of Information Resources in Dynamic Environments: Grounding Interoperability on Bigraphical Structures. Master's thesis, Johannes Kepler University Linz, Dept. Communications Engineering - Business Informatics (2013)
24. Weichhart, G.: Supporting interoperability for chaotic and complex adaptive enterprise systems. In: Demey, Y.T., Panetto, H. (eds.) OTM 2013 Workshops 2013. LNCS, vol. 8186, pp. 86–92. Springer, Heidelberg (2013)
25. Weichhart, G., Feiner, T., Stary, C.: Implementing organisational interoperability the sudden approach. Computers in Industry 61(2), 152–160 (2010), http://www.sciencedirect.com/science/article/pii/S0166361509002048
26. Wooldridge, M.J., Jennings, N.R.: Intelligent agents: Theory and practice. The Knowledge Engineering Review 10(2), 115–152 (1995)