The Potential of a Network-Centric Solution for Sustainability in Business Processes

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Abstract Due to an increasing pressure from international regulation, customers and other stakeholders, companies are increasingly experiencing the need to incorporate sustainability considerations in their core business processes and daily operations. For this purpose they require software solutions that simplify the collection, analysis, and incorporation of sustainability indicators at the right processes across their operations. However, prevailing systems are enterprise-centric in the sense that they are owned and used by one focal company collecting the data from different sources and using it for its internal decision making. This paper will describe three example use cases in which sustainability plays a key role and will provide an overview of major problems with the current state of the art. In the second part of the paper, a new approach for sharing sustainability indicators is introduced that enables many providers and consumers of environmental data to connect to and leverage a common platform. Finally, the paper analyzes the potential risks and benefits of introducing such a network platform, using the three business use cases to illustrate the opportunities resulting from it.

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1 Introduction

Driven by governmental regulation, market demand and strategic considerations (Amacher, Koskela, & Ollikainen, 2004; Yalabik & Fairchild, 2011), companies are increasingly taking action to improve their sustainability records. For example, most large enterprises regularly assess their emission inventories, set reduction targets, and report on their improvements to various stakeholders (Seuring & Müller, 2008). Leading enterprises are even going beyond static sustainability reporting by incorporating environmental and social indicators into their core business operations, e.g. in product life-cycle management, material sourcing, and supplier management (Koplin, Seuring, & Mesterharm, 2007; Lobendahn Wood, Mathieux, Brissaud, & Evrard, 2010). Such companies have in particular understood the value of improving their processes to achieve environmental excellence; the same way they collaborate with others to improve their supply chains with respect to time, quality, and total cost (Handfield, Sroufe, & Walton, 2005; Sharfman, Shaft, & Anex, 2009).

Information systems are not "keeping up" with the above sustainability trends in business. First, most of the current IT solutions do not provide the needed sustainability indicators and related support in the daily business tasks; instead they mostly aim at supporting a separate environmental role in monitoring, improving, and reporting on sustainability targets (Matt, 2010). As discussed above, this is not enough because there is a high leverage in incorporating environmental indicators with the daily business operations and respective decisions. Second, most of the current solutions that provide support for inter-organizational data collection and considerations do that in a one-to-many, enterprise-centric approach that is difficult to scale. In this approach, each client independently requests data from many providers (e.g. its suppliers). Another client would do the same; therefore one supplier may need to respond to slightly different requests several times. This gives rise to, among others, cost and scalability problems (Linthicum, 2001).

This paper introduces a many-to-many, network-centric solution that companies can use, particularly in inter-organizational scenarios, to easily share and use environmental performance indicators (EPIs) in their business processes. The main idea of this new approach is that many data providers, for example suppliers in a supply chain, publish their requested EPIs on a common platform while many clients use this information in their business operations. Having a common platform for sharing the EPIs in a many-to-many approach eliminates the need for data providers to enter the data multiple times and saves the requesters the time and effort of collecting the EPIs.

The core contribution of the paper is to analyze the potential benefits and risks of providing such a solution. The next section summarizes the research methodology, followed by a literature research. The use cases are described in the fourth section, followed by a summary of the challenges of the status quo that were identified. Then the proposed network architecture is introduced and the benefits and risks are illustrated. The research concludes with a short summary and outlook.

2 Research Methodology

For collecting the requirements of a potential network-centric architecture and investigating potential benefits and risks of such a solution, the case study research approach as suggested by Yin (2003) and Eisenhardt (1989) was followed as illustrated by Fig. 1.

Based on an in-depth literature research, the requirement was deduced that a network-centric architecture for the inter-organizational exchange of environmental data will be beneficial for environmental management in terms of costs reduction and data quality improvement. Furthermore, an initial concept for such a platform was developed. Then an industry workshop involving environmental and technical employees of five European companies and three universities was conducted to select appropriate use cases. One conclusion of the workshop was that due to the large amount of data that is considered in sustainability supporting applications, the problems are particular eminent for large enterprises (LEs) and complex products. Furthermore, proposed use cases were ranked and the most prominent three of them were selected as being representative for current problems in inter-company cooperation related to sustainability matters. The data to be collected was identified as a combination of tacit expert knowledge and explicit knowledge contained in existing processes and software. Thus, expert interviews with environmental and technical staff were chosen as an appropriate data collection mechanism in conjunction with an examination of the software in use at the particular case companies. In each company, the status quo for the three use cases was identified and analyzed. Since the results proved extremely consistent despite the differences in industry and geographical region, no additional case studies were planned. Finally cross-case conclusions were drawn, the requirements for a

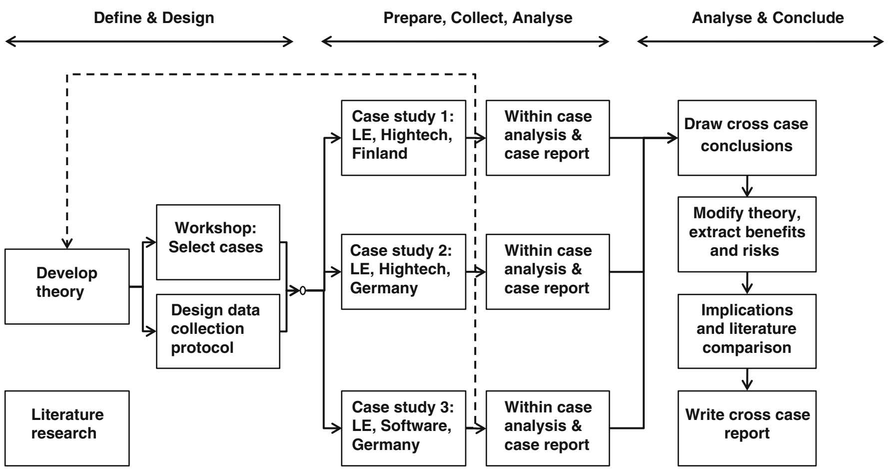

Fig. 1 Research methodology (Based on Yin 2003)

network-centric architecture were modified accordingly and implications were drawn. This was done together with the case companies leveraging two rounds of workshops. In a first round the proposed initial concept of the platform was refined. A second round served to identify potential benefits and risks related to a potential introduction of the platform. The results were furthermore compared with the body of knowledge from the literature review before the case report was written.

3 Related Work

In this section the body of knowledge related to this research in terms of processes (environmental supply chain management), supporting information systems (Green IS) and the underlying network-enabling systems and technologies will be presented. The literature was found using the academic databases Proquest (ABI/INFORM) and Elsevier (Science Direct) since they contain the journals and conference proceedings that were classified as most important for the research area. Complementary research in the university catalogue of the University of St. Gallen and Google Scholar completed the first body of knowledge, which was later enriched by forward and backward search. The literature presented is selective, thus only illustrates the most relevant research concisely.

3.1 Environmental Supply Chain Management

Environmental management (EM) comprises all efforts by a company to reduce the negative environmental impact of its products and operations across their life cycle (Klassen & McLaughlin, 1996). Papers already in the mid-1990s observed the need for a close interaction between environmental and operations management. For example, Gupta (1995) referred to prominent EM examples for including environmentally-friendly product design and waste minimization, e.g. source reduction and recycling. His thesis was that operations management must be directly involved in any of these, and in the setup of the overall environmental management system. The environment has also been suggested as an additional performance criterion for operations, in addition to traditional ones such as cost, quality, time and service (Burgos Jimenez & Cespedes Lorente, 2001). There are various environmental management topics, each with a vast body of research. Since the focus of the research presented in the paper at hand is on cross-organizational improvements, the most significant EM area to consider is the supply chain. Therefore, the rest of this subsection will address the topic of Environmental Supply Chain Management (ESCM).

Zsidisin and Siferd (2001) define ESCM for a firm as “the set of supply chain management policies held, actions taken, and relationships formed in response to concerns related to the natural environment with regard to the design, acquisition, production, distribution, use, reuse, and disposal of the firm's goods and services." Walker, Di Sisto and McBain (2008) provided a literature review of drivers and barriers for ESCM and grouped each by its category. For example, drivers can be internal (e.g. desire to reduce costs, quality improvement, pressure from investors) or external (e.g. regulations, customers, competition, society). Barriers can also be internal (e.g. costs, lack of training) or external (e.g. poor supplier commitment). Many studies took a case study approach to show how companies consider ESCM in practice (Bowen, Cousins, Lamming, & Faruk, 2006; Koplin et al., 2007; Lamming & Hampson, 1996; Lobendahn Wood et al., 2010). Prominent sustainability considerations included supplier management using indicators such as the implementation and certification of an environmental management system (Lamming & Hampson) and product stewardship such as procuring recycled materials (Bowen et al.). Also many authors relied on mathematical modeling techniques to derive formalized decision-making methods in ESCM. One of the main application areas is supplier selection (Handfield, Walton, Sroufe, & Melnyk, 2002; Humphreys, Wong, & Chan, 2003; Kuo, Wang, & Tien, 2010). For example, Handfield et al. constructed a decision-support model based on the Analytical Hierarchy Process to help companies evaluate the environmental performance of suppliers. They used a wide range of environmental indicators that included internal supplier programs, product-level considerations, and third party certification. Another application area of formal models in ESCM is in green product design (Dangelico & Pontrandolfo, 2010; Vinodh & Rathod, 2010). These papers aim to provide companies with formal methods to integrate environmental aspects in design issues, often taking a life cycle approach in the impact assessment.

As seen in this sub-section, there are many examples from research and industry on the importance and adoption of environmental indicators in various supply chain decision areas. This paper will provide more detailed examples of three prominent business scenarios, but first the state of the art information systems that address EM needs is investigated.

3.2 Green IS: Solutions for Environmental Sustainability

Companies generally follow one of four solution approaches to account for and manage their environmental performance indicators (EPIs) (Dada, Staake, & Fleisch, 2010):

- Spreadsheet-based home grown solutions are widely used, especially when companies are still in an early learning phase.
- Some companies are customizing traditional enterprise costing tools to fit the new need of environmental accounting.
- Specialized Life Cycle Assessment LCA tools are widely used for product-level impact analyses.
- Finally, special purpose EPI management tools are gaining in popularity.

- Fulfilling an environmental management task is the common end of all these approaches, however they generally do not allow traditional business solutions (e.g. for purchasing) to compare the environmental impact of alternative decisions. The following paragraph gives an overview of existing solutions pertaining to the last categories above, since they represent the state of the art in IT tools.

The relevance of carbon, energy, and waste management to businesses in the recent years led to a surge in business software designed to aid companies in this area. EPI management has become a common, voluntary practice for many companies, generating demand for dedicated, easy-to-use software. Traditional Environment, Health and Safety EH&S vendors in addition to niche market players are responding with extended or completely new functionalities to support this need (Jacobson, 2010). Some of the most prominent EPI management tools and their providers are (Dada, 2011):

- Enablon GHG-MS[1] (Enablon)
- GHG Management and Carbon Accounting[2] (Enviance)
- Hara Environmental and Energy Management[3] (Hara)
- IHS GHG and Energy Management Solution[4] (IHS)
- SAP Carbon Impact[5] (SAP)

The solutions offer a wide range of capabilities that support companies in their EPI management including data collection, EPI calculation, target management, what-if scenario modeling, emission reduction, and reporting. Most of them focus on the organizational level but some offer support over the product life cycle. However, these tools are meant to be used by environmental roles, instead of operational personnel that perform the business tasks of the firm. Also, the solutions are not designed as many-to-many network solutions that allow inter-organizational collection and leverage of EPIs.

As opposed to the significant body of EM research, there are only very few IS papers that aim to address the issue with concrete applications in this area. This is due to a bigger emphasis on Green IT (decreasing the environmental impact of IS) rather than Green IS (employing new IS applications to decrease environmental impact across industries) (Boudreau, Watson, & Chen, 2008). Only recently are authors investigating the latter, especially via papers that map out an IS research agenda to address the environmental sustainability challenges (Melville, 2010; Watson, Boudreau, & Chen, 2010). This paper takes account of this gap in Green

[1] http://enablon.com/products/carbon-management.aspx.

[2] http://www.enviance.com/solutions/greenhouse-gas-emissions.aspx.

[3] http://www.hara.com/solutions_overview.html.

[4] http://www.ihs.com/environmental-health-safety-sustainability/.

[5] http://sapcarbonimpact.com/.

IS research, specifically by proposing a network-solution to support scenarios requiring inter-organizational EPI sharing.

3.3 Network-Enabling Systems and Technologies

Authors have discussed various approaches and underlying technologies that enable better support for business networks than the traditional monolithic enterprise applications. Iyer, Freedman, Gaynor and Wyner (2003) argue that traditional information systems do not provide the required flexibility for implementing business network applications. This is due to the dynamic nature and rapid changes of business networks. The authors therefore propose using loosely-coupled web service infrastructure to address these needs. Camarinha-Matos and Afsarmanesh (2005) use the term "collaborative network" for a wider context that comprises various types of entities. Regarding the information system support, the authors refer to different contributing technologies including multi-agent technology, web services, pervasive computing, and location aware environments.

Several papers provided visions and concrete architectures based on web service infrastructures to enable network collaboration (Barros & Dumas, 2006; Boley & Chang, 2007; Heistracher et al., 2004). The vision introduced by Barros and Dumas is that of a marketplace of services offered by a plethora of providers to service consumers. Their high-level architecture for this "web service eco-system" includes various roles in addition to enabling technologies. The concept of cloud computing, delivering computing power, systems software and applications as services over the internet, has been identified as an enabling technologies for B2B networks as it provides the possibility for all partners to access the network using a third trusted entity as provider facilitating scalability and low costs at the same time (Armbrust et al., 2010). Boley and Chang stress the importance of semantic web ontologies and rules for the success of such network.

According to our knowledge, there is no literature that specifically discusses the concept of a business network for sustainability purposes. The next section provides example use cases where environmental considerations play a key role, before introducing a many-to-many network for sustainability.

4 As-is Analysis of Example Use Cases

This section describes three use cases with high sustainability and financial impact thereby illustrating why business processes and EPIs should be aligned more closely in order to improve in both areas. The use case approach was chosen to analyze the business-driven need for new network-centric solutions.

4.1 Sourcing and Procurement

The sourcing and procurement use case outlines the current environmental considerations pertaining to supplier management and operational purchasing. We also articulate the use case goals which follow from the high-level goal of enabling the purchasing organization in benchmarking different suppliers of the same material with regards to specific Environmental Performance Indicators (EPIs).

4.1.1 As-is Process Analysis

Supplier Management

Supplier management includes the evaluation of suppliers against several criteria such as quality, service, and financial aspects. Annual supplier evaluations typically follow an explicit program that includes setting performance categories and their weights, supplier scoring, and improvements. Environmental criteria are also part of this evaluation process, however they mostly comprise binary requirements that have to be fulfilled, e.g. existence of a certified environmental system, energy reduction programs, etc. However, because they are yes/no questions that all accepted suppliers have to meet, different suppliers of the same product are not differentiated in their environmental performance.

Material Compliance

The operational procurement function has the responsibility of carrying out the purchasing activities of a specific division, e.g. product line or business unit. Also, they should ensure that material-level environmental compliance requirements (e.g. WEEE and RoHS-compliance for electronics components) are included in the normal supplier contracts. Because of the compliance-driven nature, these requirements cannot be used to achieve environmental improvements: suppliers either comply or not, and there’s no basis for comparing compliant suppliers.

Environmental Assessments

The environmental management of a company performs two activities relevant for this use case. It is responsible for reporting on enterprise-level emissions; e.g. their greenhouse gas emissions. This sometimes includes emissions caused by suppliers and those due to supplied materials. It also conducts occasional product-based environmental assessments using the life-cycle assessment methodology. This requires data input from first tier suppliers and sometimes even beyond.

4.1.2 Use Case Goals

The high-level goal of this use case is to decrease the environmental impact across the product life cycle. This is achieved via including EPIs in the purchasing decisions, in particular for materials with high business and environmental leverage. Three success factors to measure the impact of any approach to include EPIs in the procurement process have been derived together with the industry experts:

- Usage of quantitative supplier-specific material-level EPIs
- Incorporation of EPIs in purchasing operations by the business users
- Percentage of suppliers that provide material EPI data without increase of cost

4.2 Design for Environment

Design for Environment (DfE) is a general concept that refers to a variety of design approaches that attempt to reduce the overall environmental impact of a product, process or service across its life cycle. Based on product and process data, the environmental impacts of different alternatives have to be calculated and compared. Design for environment deals with several topics like environmentally- conscious manufacturing, design for disposal, and packaging related topics. Besides the identification of weak points of a solution and the comparison of alternatives, the tradeoff between decisions in different life cycle phases has to be investigated. The goal is to identify the design alternatives within the product lifecycle that can enable environmental impact reduction at minimal additional costs.

4.2.1 As-is Process Analysis

Life Cycle Assessment (LCA) is conducted by environmental experts. The current process often is characterized by a time-consuming information retrieval from different databases, spreadsheets and other information sources even across organizational boarders. The main process steps applied to LCA are:

- Goal and Scope (Define system boundaries, data quality)
- Data inventory analysis (collecting data, calculation, allocation)
- Life cycle impact assessment
- Life cycle interpretation (weak point, what-if-scenario and sensitivity analysis)

Typical users involved are environmental experts (performing the LCA, setting environmental targets or thresholds), product management (providing input data, defining development directions), in addition to other departments (e.g. procurement, production) that might provide input data

4.2.2 Use Case Goals

The high-level goal of this use case is to decrease the environmental impact of products along their life cycle. This is achieved via *including EPIs in the comparison of design alternatives*. LCA is a part of the comparison and the following processes address two major process steps of LCA:

- Data inventory analysis (collecting data, calculation, allocation)
- What-if-scenarios as part of life cycle interpretation

In order to incorporate EPIs into early design decisions, the data should be presented in a way that non-experts in the environmental domain like product designers can understand it and make meaningful conclusions. On the other hand, the necessary detail level should be provided. For data that is not directly available, meaningful placeholders should be derived through assumptions, comparisons etc. Another use case goal is introducing bottom-up support (support of business users by a community through examples and best practices).

4.3 Preparation of an Environmental Performance Report

The communication of the organization's environmental performance is an integral part of any activity related to environmental sustainability. For efficient communication to a specific target group, different data in different granularity is needed. The goal is to enable an efficient, reliable, and transparent reporting.

4.3.1 As-is Process Analysis

Environmental communication can be divided into two types: Regular communication efforts and ad-hoc communication.

Regular Communication

Regular environmental communication efforts, such as quarterly or annual sustainability reports, have a given structure which only evolves occasionally. This means that the underlying data sources do not change significantly from report to report. Organizations often follow different standards that define the reporting, of which the Global Reporting Initiative (GRI) is the most widely acknowledged guideline for sustainability reporting (Nikolaeva & Bicho, 2010). The main work is related to the collection of the data, which still involves huge manual efforts. In order to retrieve the data, each involved facility or site has to be contacted and the data adapted for system usage. Often there are third parties involved that own the data and/or do the calculations and they too provide the data in formats that also have to be adapted. Environmental data is currently stored in multiple databases within the company, therefore for the creation of a report data has to be retrieved from different information sources.

Ad-hoc Communication

Ad-hoc communication efforts are triggered by a certain event, e.g. a customer request, a criticism to corporate behavior, etc. When an irregular report is created, in a first step the required data and system boundaries have to be determined. After this, the data has to be acquired. This involves accessing many data types in different locations and formats. Since not all data is available in digital format, it also involves finding people and manual work. In the next step, the data has to be transferred to an EPI calculation tool. If the data is incorrect or does not have the desired granularity, the data source and all manual processes have to be tested for correctness. Only then the EPIs for the report can be calculated.

4.3.2 Use Case Goals

The overall goal of environmental reporting is to provide environmental data to stakeholders within and beyond the organization in an easily digestible way. Until today, environmental reporting often is a one-off process that has no or only rarely connection to the daily business processes. This leads to a situation where environmental reporting is mainly seen as a cost driver and not as an enabler for a sustainable and innovative business. If the environmental reporting is used to make the supply chain more transparent, remove waste and risks and ensure compliance to environmental regulation, the opposite can be the case. Several cases have indeed shown that an increased transparency in environmental performance can also lead to an improved economic performance (Rao & Holt, 2005).

Organizations pursue different goals with environmental reporting. As summarized in the GRI Reporting Guidelines, the main ones are:

- Benchmarking and assessing sustainability performance with respect to laws, norms, codes, performance standards, and voluntary initiatives;
- Demonstrating how the organization influences and is influenced by expectations about sustainable development; and
- Comparing performance within an organization and between different organizations over time.

5 Challenges

This section will give an overview of the challenges identified in the three use cases.

Availability: The main problem in all use cases is the general availability of environmental data. Often, quantitative EPIs are not even in use, and only qualitative questionnaires are common for evaluating suppliers, for example.

Company-related environmental data is scattered within the organization, while product- or supply chain-related data is even scattered across organizational borders. As in the case of Sustainable Sourcing and Procurement, companies have to collect EPIs throughout the whole supply chain and establish connections to all their sub-suppliers for making product assessments. Since usually no direct business connections exist between those companies as well as no standardized processes, the data requests are difficult and response rates extremely low. In the case of design for environment, data from different sources has to be collected. Public databases are often imprecise or lack data for the exact required materials. Differing standards and collection methods complicate the process. This especially holds for data of new products where EPIs have not been calculated yet and the production process has not been established. As a consequence, the EPIs would have to be estimated. Suppliers may not be able or willing to provide EPIs in a very early stage of development. Additionally, some of the data may be confidential and therefore not be provided to other companies.

Lack of comparability: In all use cases, comparability is very limited due to different EPIs, baselines, and reporting standards. Not only is it impossible to compare the sustainability reports, suppliers and materials because of different reporting standards and different data included, but even comparing the EPI of an organization with e.g. the value of the preceding year is difficult. In order to gain a useful comparison, one would need to be sure that both companies use the same measurement methods and assumptions. Also, comparing suppliers from different geographical regions is almost impossible because of different regulations, energy mixes etc. Currently, data is often compared without making these considerations which then leads to less meaningful results. This is particularly eminent in the case of environmental reporting: Because no common standards and EPI implementation guidelines exist, the data of two companies are hardly comparable for the stakeholders. Additional reasons for this are the different organizational structures, product portfolios and geographical regions of operation. Even the reports of the same organization in two different periods may hardly be comparable because of mergers/acquisitions, changing regulation, and changing supplier base and economic growth. As a consequence, the reports are not interpretable by any user without a strong environmental reporting background.

Inflexibility: Due to complex processes and little automation, current approaches are very slow and inflexible. Definition and implementation of EPIs can take up to a year and more, accessing all data required and calculating EPIs up to 6 months. This makes it impossible to quickly react to socio-economic changes or specific crisis situations. If a new indicator that an organization would like to report on does not exist in the company yet, its ease of implementation depends on whether the necessary data has already been collected or measured somewhere.

Lack of process integration: This problem is particularly eminent in the case of sourcing and procurement. Environmental optimizations in purchasing will only take place when environmental indicators are incorporated into the processes, ideally in the procurement, design or reporting tools in use. Currently, the incorporation of material-level EPIs into the company processes and decisions is still not defined and without it, the indicators will not be applicable.

Costs: The current process is often characterized by time-consuming information retrieval from different databases, spreadsheets and other information sources even across organizational boarders. Since the data is scattered within the organization or even across its boarders, a huge number of employees has to be involved. Due to the lack of automation and incompatible formats and processes, the costs of bringing environmental data into the business processes are high. Especially the collection of all required data for environmental reporting is extremely time-consuming. This is not only an issue of data availability and process costs, but also of the critical reaction time to emerging events. In ad-hoc reporting, it is necessary to react to a certain situation and be able to support the argumentation with suitable data. A fast collection of data and computation of EPIs is therefore absolutely required in the context of ad-hoc environmental reporting.

6 Network-Centric EPI-Sharing System

Value creation that incorporates EPIs requires collaboration among different supply chain entities. This especially holds for product-level indicators, since the required resources are scattered along the whole supply chain. Collaboration in supply chains is not a new topic. However, the focus of most of these systems has been on logistics and procurement. The goal of keeping procurement costs and inventories low while keeping cycle times short has motivated partners to work together and reveal data. This has lead to a number of different approaches which support collaboration through the mechanisms of information integration, process and resource coordination and reporting of performance measures (Lee, Kim, Noh, & Lee, 2010). The types of collaboration systems fall into three major categories (McLaren, Head, & Yuan, 2002):

- Message-based systems which enable one-to-one communication between the supply chain partners, using standards such as EDI or XML-based messages,
- Electronic portals or marketplaces which mainly serve for offering and purchasing of products. They are either based on one-to-many or many-to-many communication, depending on the exact specification,
- Shared collaborative SCM systems, such as systems for collaborative planning, forecasting and replenishment (CPFR). Many of these systems are ERP-based. This leads to the fact that in most cases although the principle follows a network-based approach, messages are exchanged one-to-one.

These systems differ in their total costs of operation and their opportunity costs through inflexibility and lock-in as well as in their capabilities for enabling the integration of information and processes.

Although they promise many benefits, the adoption of systems of all three types has fallen short of all expectations. The reasons for this have been discussed controversially. The most mentioned arguments have been the lacking trust of partners to reveal data within the supply chain, supplier resistance, and high costs of implementing the system combined with long periods of amortization. The argument of trust is supported by the fact that during the last years, small private networks in industries with static vendor relationships have been more successful. In contrast to that, open network-based approaches in dynamic industries reveal their true benefits with an increasing number of participants. This leads to a first-mover problem, where nobody wants to take the first step in fear the network may never reach a critical mass to justify investments (McLaren et al., 2002).

Since traditional mechanism are costly and fail to collect all required data with sufficient quality, we propose the concept of a network-centric information system for B2B EPI exchange. This idea is similar to that of Supply Chain Collaboration Information Systems: Through connecting all partners in the supply chain via a central data repository, the ease of sharing and accessing high quality data is improved, and the low response rates of classical one-to-one communication can be avoided.

It is almost impossible to establish business relationships with all necessary organizations by classical means. According to the interviews with industry partners, experience has shown that response rates are in general as low as 5–10%. All other data has to be collected manually, e.g. by material experts and consultants, with the corresponding high costs. One important reason for this is the high costs of implementing one-to-one communication channels with a high number of partner organizations. Electronic Data Interchange (EDI) as the dominant one-to-one communication technology has never accomplished its expectations because the entry costs for small and medium-sized companies without strong IT-department have been too high (Iacovou, Benbasat, & Dexter, 1995). As shown in the use case descriptions, not even commonly accepted standards exist, which means that the companies have to communicate their data using not only one, but many different standards and formats. The network-centric IS approach solves this problem by a number of different means:

- Single source for accessing and sharing EPIs
- An EPI description language for describing EPIs and related data
- Common environmental reports, supplier EPIs etc. provided by the community
- Interface to use case specific backend systems
- Content such as reporting standards, important regulations, etc.
- An EPI community

Organizations only have to join the network once. Since the platform works based on the cloud paradigm on demand, no installation is necessary and implementation costs are kept low. After their identity has been approved by the provider, they can load their EPIs on the platform, share it with stakeholders and request access to other companies' data.

The System supports functionality in three main areas (see Fig. 2): Transaction, analytics and collaboration. Besides the transactional use case support which is ensured through lightweight gadgets and applications on top of the platform as well as an interface for backend integration, analytical functionality can provide

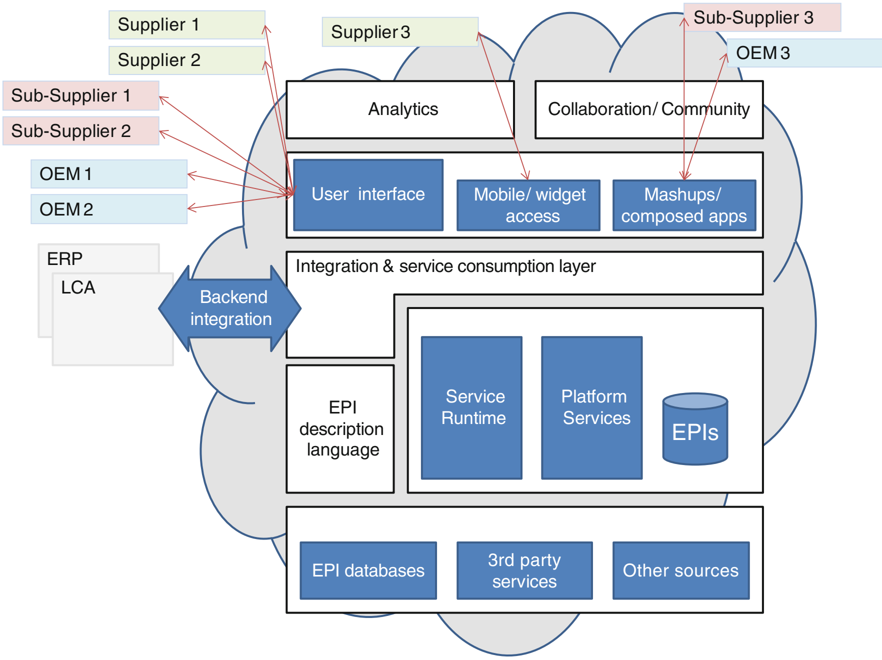

Fig. 2 Network-centric EPI-sharing system

information about the status of the supply chain, industry averages, industry benchmarks, typical problems and solutions, extended search functionality etc. Collaboration functionality enables easy connections to partners, fast communication and problem-solving tools.

7 First Assessment of the Network-Centric Solution

7.1 Expected Benefits

During the second industry workshop with the three partners involved in the use cases, potential benefits of the proposed system were identified. Interestingly, the potential benefits of the system that have been identified by experts relate to the problems of the status quo. It cannot be presumed that all benefits can be achieved to the same degree.

7.1.1 EPI Availability

The system is planned as a common source for EPI data within a supply chain, or even within an industry. Thereby, it will be able to make EPIs available across organizations. By dramatically decreasing the amount of connections and data sources needed while increasing availability of support and best practices through the community, providing EPIs will become easier and less expensive. Also, increased transparency in EPI calculation may lead to higher demand for environmental reporting by the stakeholders. In the case of Sustainable Sourcing and Procurement, the whole supply chain including small and medium enterprises can be enabled to take part in the process of providing data for e.g. product assessments through reducing the effort for publishing by providing a single platform offering simple web access and community support as well as example implementations and best practices. Similar results are expected in the case of Design for Environment.

7.1.2 Transparency and Comparability of EPIs

With a network-centric solution, it will be easier to implement and converge towards common baselines, system boundaries and methodologies. Furthermore standardization will be encouraged by providing best practices. In the case of Design for Environment, the community can help to provide more standardized EPIs. Furthermore, a common EPI "language" leads to a clear understanding to what is included in the indicators and thus the reports. The idea is not to provide the standards top-down but to encourage the community to reach de-facto standards by reuse of the most commonly used practices in EPI calculation and sharing so that system boundaries and EPI calculation methodologies will converge within an industry. The reason why this is presumed to happen is that cost pressure will not allow for several reporting standards to exist at the same time because the additional effort exceeds the benefits. Although the workshop indicated the possibility of this development, this hypothesis remains to be tested.

7.1.3 Flexible Calculation of EPIs

The long periods of time that are required for the implementation of completely new EPIs can only be solved if environmental reporting becomes as much of a standard as financial reporting is today. Establishing a network-centric solution as a primary source for providing and consuming EPIs would support this process and speed up data acquisition. However, as one expert stated, the implementation of new EPIs can only work if it goes hand in hand with a change in processes and corporate culture, including executive support.

7.1.4 Process Integration

The increased environmental transparency achieved at reasonable costs enabled new business benefits that can help anchoring the awareness of integrating EPIs with processes. This is supported by a standardized interface for backend integration. The interface can facilitate integration with Product Lifecycle Management (PLM) tools in the case of Design for Environment or to SRM/procurement tools in the case of Sustainable Sourcing and Procurement.

7.1.5 Performance and Costs of EPI Calculation

For many experts, costs were only a secondary problem, since the availability and quality of EPIs has not reached a satisfactory point. Nevertheless, if environmental reporting and business considerations become more of a standard, costs will ultimately become an important factor. With a single network, transactional costs to provide the data (once instead of per-request) will decrease. In the case of Design for Environment, the EPI language can foster streamlined system boundary setting, methodologies and data source discovery, and a message system can send notifications to required contributors. At the same time, the support of the community can help to learn best practices and enhance the speed and quality of reporting, while reducing costs.

7.2 Risks Associated with the Introduction of the System

We describe in this section a list of potential risks that may hinder the adoption or the applicability of the system, which were identified through industry interviews.

7.2.1 System and Technology Risks

Critical requirements are not met: A system that doesn't adequately satisfy (at least the high-priority) users' functional and non-functional requirements would not meet its business purpose and runs into a high adoption risk.

Technology does not scale: The underlying goal of the platform is to connect many companies and huge amounts of their environmental data to use across multiple processes. This poses a technology scalability requirement that should be met to realize the full potential of the system.

Ease of use: The value and adoption of an information system is closely linked with its ease-of-use, especially for non-IT experts, e.g. business users and environmental experts. The severity of this risk can only be assessed based on the first results of the development effort.

Cloud computing acceptance: There are still a few insecurities concerning the use of cloud computing for business critical applications: These relate to data security, legal terms and a general insecurity about the risks and future of cloud computing.

7.2.2 Market Adoption Risks

No critical mass: The platform only has value through high availability of user-provided content. With only a few participants, the proposed use cases, most of which are in inter-organizational scenarios, will not add value compared to the status quo solutions. After a certain critical mass of adopters, it will become easier to gain even more users because of network effects.

Perception of environmental issues: Different companies, industries, and countries have a very different perception of the importance of environmental issues. If they are not seen as highly significant for businesses and not backed by top management, there is a high risk of market acceptance.

Lack of community commitment: A lack of community commitment will directly affect the standardization potential and content which is intended to be provided by the community.

Quicker solution on the market: There are also issues related to the competitive landscape, e.g. if a solution that addresses the same domain with similar technology gets quicker on the market. Once such a competitor wins many customers, it would become difficult to gain much market share by another solution.

7.2.3 Platform Data Risks

Data confidentiality: A network-centric EPI sharing system requires partners to provide their EPIs to a wider community of companies that may include competitors. This may give rise to confidentiality concerns among companies that need to be addressed with suitable mechanisms.

Data availability: Another data dimension is its availability: the network-centric EPI sharing platform would not be used if it lacked valuable information. This situation can be due to many of the risks above which results in lack of users and wide adoption, directly affecting the availability of data.

Data accuracy: The value of a network-centric platform lies in the data it has. EPI providers may enter data that shows a better performance than is actually the case. There are several similar situations where, without a data assurance mechanism, the platform EPIs would not be usable. A very important aspect of data quality is related to the reliability and accuracy of data, which are recurring themes in environmental studies and information sources. Low data reliability, e.g. because certain companies do not have the capability or integrity to provide data with sufficient accuracy, would directly affect the leverage and value of the platform.

Data actuality: The applicability of the data provided on the platform is closely related to its actuality. Only current data enables functions such as a comparison of different materials by different suppliers in the "Design for Environment" use case, or ad-hoc reporting in the environmental reporting use case.

8 Conclusion

This paper is motivated by the importance of incorporating environmental indicators in core business processes, in particular in those with a high need for inter-organizational data. The availability of such indicators enables making the right decisions; however current systems still rely on one-to-many solutions to collect the data. Since these do not scale for the industry needs, this paper introduces a many-to-many network-centric solution to solve this problem. To make the current shortcomings and solution more concrete, we presented three use cases where sustainability has a prominent role to play. These were analyzed by experts with respect to their status-quo, current problems and desired goals, in addition to the impact of introducing the network-centric system for collecting and managing inter-organizational EPIs. The paper provides an assessment of the potential impact of such a system. As future research, a prototypical solution will be implemented which enable a more detailed assessment of the system, thereby better analyzing its actual impact.

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