EnviroInfo 2011: Innovations in Sharing Environmental Observations and Information

A Central collaborative CEMIS

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Abstract

There have been research projects on Corporate Environmental Management Information Systems (CEMIS) during the last 20 years. Nowadays we have different CEMIS in the market that provide different approaches and techniques that are solving environmental (-related) issues in companies. However, such environmental information systems are rarely used. In addition, different projects in Asia and USA has been developing and implementing industrial ecology/symbiosis strategy. This strategy has generated new revenues and reduced environmental emissions and disposal costs, while simultaneously improving the quality of services and products.

In her investigation, Elke Perl found out that CEMIS are rarely used in the German-speaking region (Perl, 2006). Following her research work, three rationales are mainly responsible for this situation. Collaborative Corporate Environmental Management Information Systems (Collaborative CEMIS) provide approaches to conquer the issue of rare use of CEMIS in the German-speaking region and support the efforts of collaborative work to gain the benefits of industrial symbiosis. In Collaborative CEMIS solution, Web Services and semantic techniques are involved. Collaborative CEMIS, been based on Web Services, provides powerful integration of environmental applications and data. Instead of being connected to several disparate environmental applications, Web Services-enabled collaborative CEMIS solution provides a connection point between these heterogeneous applications.

This work will present a collaborative CEMIS solution that is mainly relying on the idea of supplying Web Services from one CEMIS that can be used from different company information systems to handle corporate environmental issues. The requirements will be discussed and model will be presented for such a system. The main goals of this solution is reducing the efforts to achieve a legal compliance environmental management and supporting the new perspective on industrial development resembling natural ecosystem to use energy, water, material, and human resources optimally while at the same time minimizing wastes and efforts of environmental management. It proposes an environmental collaboration between companies via summing up all the required information from different involved players in form of Web Services. In this solution, the companies will act as clients and providers at the same time. They are both requesting and supplying environmental data. They maintain their identities by not revealing the information regarding their resource details.

1. Introduction

Corporate environmental management information systems are organizational-technical systems for collection, processing and making the data relevant to environment available (Marx Gómez, 2009). For more than two decades, theoretical and practical researches on CEMIS took place. Based on results of these research projects, many different CEMIS in the market are providing several approaches to solve environmental issues in companies. However, these systems are rarely used in the day-to-day work in the German enterprises (Lang & Jürgens, 2003, Perl, 2006, Wohlgemuth, Niebuhr, & Lang, 2004). In Germany,

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around 0.19% of the taxpayer companies are ISO 14001 certified and much less are EMAS[5] verified (Table. 1). In an empirical research, (Perl, 2006) stated that the reasons for this insufficient situation are:

- High costs to supply these systems;
- High expenses to install and maintain such systems and
- Particular absence of needed information.

Table 1. Certified companies in Germany based on (ISO, 2009), (Destatis, 2009), and (EMAS, 2011)

	Quantity	Percentage
Taxpayer companies (2009)[6] (Destatis, 2009)	3,135, 542	100.00%
ISO 14001 certified (2009) (ISO, 2009)	5, 865	0.19%
EMAS verified (2010) (EMAS, 2011)	1, 261	0.04%

Comparing the number of companies in Germany that uses environmental management systems based on standard (ISO and EMAS) from 2009 and 2007 shows that the situation does not change (Umweltbundesamt, 2010). For example, ISO 14001 certifications increased of 0.2% and EMAS verifications decreased.

In scientific discussion, environmental activities are separated in proactive and reactive measures. Reactive handling of environmental issues means that the companies comply with legal and achieve industrial standard (Braun, 2003). Especially small and medium-sized companies often do not have enough resources for proactive environment management. Proactive environmentalism is found mainly in big companies where resources are available to use new technologies. If so, proactive environment efforts support production oriented environment protection. This allows utilizing environmentalism as a competitive advantage (Rebe & Schlitt, 1993).

In order to apply proactive environmentalism in small and medium-sized businesses it is at least necessary to manage internal environmental issues such as legal compliance and environmental certifications in a simpler manner. For this reason, only compliance issues will be discussed in this article to open new options for proactive environment management. To support these proactive efforts, one possibility is the approach of collaborative corporate environmental information systems. cCEMIS should be understood as systems at inter-company level.

You can differ between vertical, horizontal and diagonal cooperation. Vertical cooperation refers to successive value-added steps alongside of the supply chain (Pfohl, 2009). Horizontal cooperation is networks of companies that work with each other on the same level of enterprise in the same industry (Pfohl, 2009). The companies of diagonal cooperation are from different industries and work together in variable value-added steps. There is some scientific research about vertical cooperation in the academic discussion for environmental issues. Environmental horizontal cooperation is rarely presented but there are some projects in Asia (e.g. India) and North America (Center of Industrial Ecology, 2010). However, diagonal forms of cooperation are until now not discussed, even though there are many suitable industry parks where such cooperation is possible. It refers to collaboration among geographically proximate individual firms to physically exchange by products, share in the management of utilities, and share ancillary services[7]. This kind of cooperation networks brings synergistic effects for all participants of such collaborations. Furthermore, such systems would simplify environmental management. This means that it:

- Allows to use CEMIS for low cost;

[5] Eco-Management and Audit Scheme

[6] The data from the "German statistics agency" shows only firms with a value of goods and services > 17, 500 €.

[7] Theoretically, firms can share ancillary services, such as transportation, landscaping, waste disposal/collection, and share the management of their utilities, such as energy, wastewater treatment or water. It is also possible to build common organizational infrastructure such as buying syndicate.

- Reduces the overall costs of environmental protection;
- Reduces the investment to use such systems;
- Supports increasing material and energy efficiency;
- Supports Emission reduction,
- Enables exchange of information between companies and
- Permits the increasing of the competitive advantages by realizing economic and environmental benefits simultaneously.

Pressure by governments and societies will increase in the next years in this direction. Companies are forced to handle with it in a sustainable manner. This will have a direct impact on the individual companies. The implementation of successful CCEMIS will help to deal with it. The inter-company approach reduces the investments to fulfill environmental legal compliance and eliminates existing barriers for proactive environmentalism. Actors engaging in CCEMIS are thought to be motivated by potential economic and environmental benefits.

1.1 Inter-Company cooperation

Cooperation between companies is growing based on the drive of globalization from marketplaces and the internationalization of competition consequentially[8]. Collaborations today are presented along supply chains preserving the market position to get advantages in competition. Thus, consideration focuses on business shift more and more from the individual enterprise to the complete Supply Chain (SC). To handle such production structures effectively, Supply Chain Management (SCM) concepts are used. They provide tools to plan, control and monitor the business processes in a SC to meet customers' and the involved parties' expectations.

An Environmental Supply Chain (ESC) uses the given possibilities on a SC (Bleis & Helling, 2002). The enterprise borders here are no more the frame of action for environmental efforts. The application of such inter-plant cooperation can be different. For example, if the physical flows are focused in the collaboration, the vertical material flow management can be applied[9].

SC gives and limits possibilities of inter-company cooperation at the same time. With the focus on a SC, the cooperation is dependent on all of its participants. On the one hand, if one of the companies in the cooperation does not want to work on environmental issues, the whole sustainable efforts are endangered consequentially. On the other hand, many of the existing environmental efforts in network are initiated from an influential company such as car manufacturer. Sub-contractor or suppliers works in the network under constraint with the focus dictated from influential company (focal institution). One's own initiative is very important in sustainable development and such cooperation is not ideal. Research on interorganizational politics, however, suggests that when possible, firms use coercive sources of power. Conversely, in a marketing channel relationship firms down the channel are more likely to be satisfied with the interorganizational relationship when non-corrective sources of power are used.

Horizontal cooperation is not widely used in common business. Companies from the same industry on the same production level are normally in competition. It is very difficult to convince them to share data, information and activities to save environment.

An approach that is rarely discussed until now is the diagonal cooperation. Normally you have geographical concentrations of companies spanning various classes of business and on different value-added steps in industry parks. These companies do not have a lot in common except the location nearness. How-

[8] The reduction of the real net output ratio: the depth of added value is the result of globalization. The real net output ratio presents the part of additionally bought services/products in relation to in-house efforts (Bleis & Helling, 2002). At 1981, the real net output ratio was 71% and today it is nearby 43% (Wildemann, 2005).

[9] The material flow between different companies represents the focus of such collaboration.

ever, especially this situation allows the use of synergistic effects. Most firms are not in competition in the market and there is no limit of business classes or SC. The co-operation does not depend so deeply on individual company. The participants work with each other because of the advantages through synergistic effects of such cooperation.
Another term that is implicated in this context is the industrial symbiosis[10]. The industrial symbiosis has been used to describe the physical exchange and shared management of input and output materials by geographically proximate firms. Most studies have focused on the technical aspects of symbiosis rather than organizational, social facets or the use of information systems to support the cooperation (Jacobsen, 2005).

1.2 Synergistic effects through collaboration

Companies that have been actively working towards saving the environment often find it increasingly difficult over time to further improve their environmental efforts. Eventually the environmental activities within the firm borders become expensive. Collaborations open new ways for environmentalism. In addition, companies that do not have a lot of work on environmental management can be animated to introduce an environmental management system to increase their environmental efforts. It occurs interorganizational, including options for exchange of by-products and other forms of collaboration among several firms.
By collaboration, businesses should strive for a collective benefit that is greater than the sum of individual benefits that could be achieved from acting alone. This kind of networking brings economical benefits and can improve environmental performance, product quality and social relationships among the participants, which can also extend to surrounding neighborhoods.
Based on the achievement of the empirical research done by (Perl, 2006), the synergistic effects will be separated in three categories[11]:

- Costs reduction;
- Expenses reduction and
- Increasing necessitated information.

Sharing a software system is cheaper than developing or buying one. Using a system that serves collaboration functionality allows planning and executing activities in common. For example, it is possible to arrange employee training or use consulting services for energy efficiency in a community or manage the disposal of hazardous material together. Companies can build buying syndicates or use a product transport in common. These few examples give an overview about the ways to reduce costs in collaboration.

This gives different options to reduce expenses when companies work with each other like using the same register of law from the same database. If a law is changed, only one database must be updated. In addition, material safety data sheets for hazardous materials should be checked once a year. Not everyone must check the materials that are the same in different companies. They can be separated so that every participant manages a few of the hazardous material information.

A cCEMIS must provide a platform where exchange of experiences is possible and where environmental problems can be discussed. This helps to increase necessitated information and reduce the fears to implement environmental management.

[10] In the industrial ecology field, the term industrial symbiosis was first used to describe the high level of resource cycling among separate firms in Denmark. Industrial symbiosis describes cooperation among firms in a region to physically exchange and share the management of resources such as raw materials, energy and any input and output materials (Chertow, Ashton, & Espinosa, 2008).
[11] Most of the advantages influence all the three categories but the categorization helps to structure them.

1.3 Requirements for cCEMIS

The volume of communication that a cCEMIS approach entails would swamp traditional "Email and Telephone" systems. A Software tool is integral to the success of such a system. Based on the investigation done by (Perl, 2006) and the theoretical concepts of CEMIS in the literature, all the requirements for cCEMIS can be defined as follows:

Equal Rights for all Participants

First, the participants of such collaboration must be strongly involved in the network for a successful cCEMIS. The additional values from the cooperation must be available for all. The companies' attitude towards such collaboration is essential. In addition, it is important that in each company a defined work group manages the implementation of a cCEMIS because of the complexity of such system. Furthermore, an environmental management system must be integrated in the whole organization of a company and the cCEMIS software system that supports this effort must be available for all employees in a company regardless of their location. Firms are more likely to be satisfied with the interorganizational relationship when non-corrective sources of power are used. Hence, coercive sources of power should be used to animate the work in such collaboration.

Expandable and Intuitive Use

A system that allows such cooperation must be built in a modular manner. Gradualist policy[12] helps to avoid the problems of megalomania where projects try to achieve all the aims in one single step. This is the reason of many project failures (Pieler, 2003). Many companies do not engage in information systems to solve environmental issues and do not care about sustainable development (Perl, 2006). Comprehensive changes here will scare firms to participate in such cooperation[13]. The incremental approach also helps to keep the financial investments low[14].

Guaranteed Data Privacy and Data Security and Trust between participants

Regardless of that trust is critical to the success of any inter-company relationship also data privacy protection and data security (integrity) are essential conditions for any business information system. Taking into consideration that communication and trust among actors must be recognized as very important. Especially for a system that supports collaboration, it is very difficult to create trust because there are organizational elements that cannot be controlled by software in addition to the technical requirements. A cCEMIS must provide the possibility for any participant to decide which data can be used in a network i.e. which data can be seen by the other members. In some cases, data anonymity helps so that it is possible to cooperate without information of the source. However, it is mostly necessary that participants be prepared to invest some of their "data" for a successful network. This can be the biggest barrier for cCEMIS implementation in the praxis. It is also important that all participants should be aware of the issue of goal congruence and power dynamics. A main critical issue in the success of such approach appears to be the development and maintenance of trust between the network partners.

Heterogeneous Information-Infrastructure

Environmental data are found throughout the company, in different formats, on different systems, using different databases. One of the issues is the information gaps in the context of systems within firms. The interorganizational gaps are probably more challenging, however. Information infrastructure gaps arise when information needs cross-organizational boundaries. It is created and developed by different drivers and is going in different directions with different core area without paying attention to each other. There-

[12] Gradualist policy is the implementation of an information system in an organization gradually.

[13] Complexity scares companies to use software for the environmental management (Perl, 2006, p. 250). Modular software system allows companies to pick up the functionality that they need. The software for the environmental management can be expanded later with different modules. Individual adjustment is an important requirement for cCEMIS implementation.

[14] Based on the investigation of Elke Perl, financial aspects are one of the reasons why firms do not use software to increase environmental efforts.

fore, further requirement is the availability of interfaces to other company information systems. Ideally, data input must be done one time from an employee and the data are available in all the other company information systems. In addition, it is good when a CCEMIS provides import and export functionality to standard software tools in a company like word processing software (e.g. MS Word, Excel or Open Office Writer, Calc) or PDF (Perl, 2006).

Non-functional requirements that have to be taken into consideration while defining the requirements are efficiency, performance, scalability, reliability so that the system can be always available in high performance, and issues like load balancing can be seen as future requirement of realization.

These requirements are more theoretical in nature and are not complete. It is also impossible to fall back on experiences of other software systems that are used in other business-to-business networks. Most of the networks in Germany and Austria do not use information systems to manage their cooperation (Perl, 2006). To achieve significant results for cCEMIS it is helpful to develop a prototype that can be used in existing networks. The investigation of such a prototype will deliver detailed and practical oriented requirements that cannot be fetched from theoretical investigations.

2. cCEMIS approach

With the requirements mentioned above, a cCEMIS approach is exemplary built to manage the use of hazardous materials. Based on European and German law on chemical substances, enterprises that handle with hazardous materials must provide up-to-date information about the materials and preventive measures (Chemikaliengesetz, 2008). A register of hazardous materials is required. Important data are:

- Place and quantity of storage;
- Place of utilization;
- Instruction for use[15];
- Risk assessment[16] and
- Classification of danger for human, animals, and environment.

A company normally regulates the storage and utilization information but the other data are company independent. A network can manage this. For example, three companies work with hazardous materials. Most of the substances are the same in the different firms. Instead of making every company updates its data alone, using central data storage helps to reduce the efforts to manage the data that must be updated yearly. In addition, it gives the possibilities to exchange information like to substitute a material through another one.

2.1 Abstract Model for cCEMIS

To realize the cCEMIS concept, one possible solution is to expose all its functionalities in form of Web Services and put these services together as actions in form of workflows. One system that is fulfilling such prerequisites is the lightweight Semantic-enabled Enterprise Service Oriented Architecture (SESOA) (Mahmoud, Marx Gómez, & von der Dovenmühle, 2011). SESOA is an enterprise solution that links businesses to external systems based on Web Services. All the functionalities that are exposed using Web Services can be invoked by SESOA framework. This means that this framework can deliver traditional Web Services supplied by various service vendors, validate them following businesses' criteria, evaluate them and annotate them with semantics.

[15] Instruction for use is a document. It is created based on the information of a substance like the classification of it. This should be checked once a year.

[16] Risk assessment is normally combined in a work sheet (document). In addition, this should be checked once a year.

The main idea behind SESOA framework is to have an architecture that has the role of dealing with semantic annotations of services relations as well as representing the whole aspects of Web Services. In this way, we can see the services as black box and both traditional and semantic Web Services can be used.

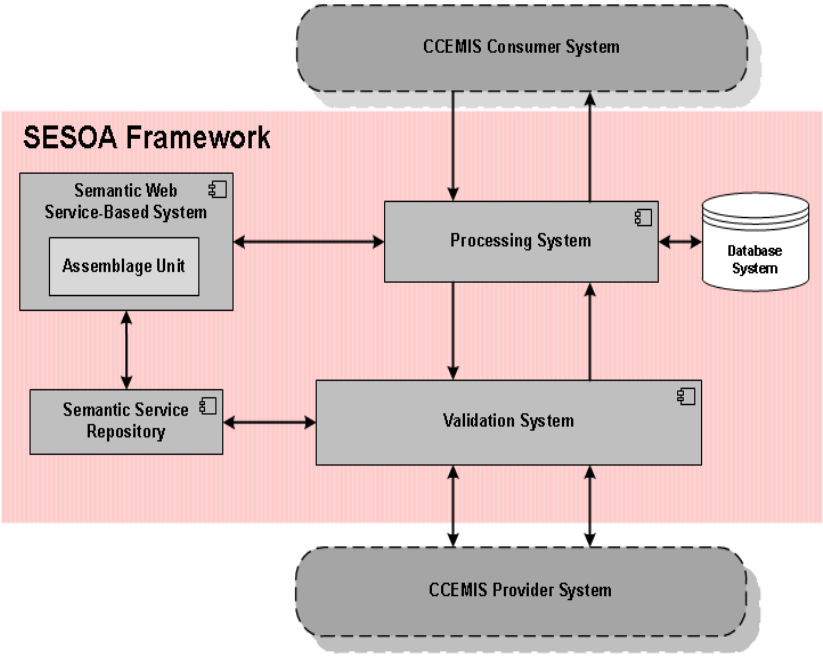

Figure 1
CCEMIS Realization Using SESOA Framework

Figure 1 represents the realization of CCEMIS using SESOA framework. The main and centric component in this framework is its processing system. It is workflow-based system from which all the business processes can be initiated. By relying on the workflow system, we can use the market best practices by storing workflows in an internal database named SESOA database. It is linked to CCE-MIS consumer and provider systems using semantic-enabled interface and validation system respectively. The semantic-enabled interface has the responsibility of annotating the CCESMIS consumer systems requests' objects with semantics using RDF vocabularies. The validation system is validating the CCEMIS provider systems' services and annotates them with similar annotation used in the consumer side. The services in this system are grouped based on the domains to which they belong in so-called "assemblages". These assemblages are relating the objects of both requests and services in the semantic Web Service-based system. These assemblages are containing the CCEMIS services as members, annotating these relations with RDF annotations, and storing these annotations in the semantic service repository.

By using SESOA framework as realization for CCEMIS approach, all the afore-mentioned requirements can be fulfilled and the CCEMIS participants can easily provide their environmental relevant- data and consume it. Bigger amount of data can be shared using SESOA framework as a medium in the CCEMIS environment where all the players can hide their identity or reveal it depending on the data value and their policies.

3. Conclusion

The researches of diagonal cooperation[17] represent new research direction. Refining the requirements of cCEMIS is the next step of the researches in this area. The processes of handling environmental issues should investigate how it is possible to handle it in a network and what the synergistic effects of collaborations in the different area of legal compliance are.

The proposed cCEMIS approach based on an abstract example of managing hazardous materials, how collaboration can help to reduce company's efforts for legal compliance. This can be a way to animate companies to manage environmental issues actively[18]. It also gives reasons for enterprises to use software for the environmental management systems. The implementation of cCEMIS using SESOA framework is a way to fulfill its requirements. It is fully Web Service-based system where all the players can offer and ask for cCEMIS services. This approach allows reducing costs and financial expenses for introducing a new corporate environmental management information system. In addition, it increases the information availability and helps to overcome the resistance to new technologies because other firms respectively a network of firms demonstrate its applicability.

The next eight steps issues that firms are likely to face when implementing cCEMIS:

1. Standardization,
2. Cost,
3. Information exchange,
4. Disparities between the goals and objectives of member firms,
5. Power control,
6. The handling and alignment of environmental management with collaborative strategy,
7. Problems of explicit knowledge (information) tacit knowledge or know-how in introducing/improving collaboration and
8. The impact such approach on the relationships between information systems within a firm.

Based on the result of these points the reference model should improve and refined.

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[17] See chapter 1 and 1.1 for inter-company cooperation.

[18] See chapter 1 proactive environmental management.

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