EnviroInfo 2013: Environmental Informatics and Renewable Energies
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Environmental Footprinting in the IT-for-Green Project – A CEMIS Use Case

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Abstract

This paper presents functionality and design elements of a Corporate Environmental Management Information System (CEMIS) in the project "IT-for-Green: Next Generation CEMIS for Environmental, Energy and Resource Management". The CEMIS under development in the IT-for-Green project uses a service-oriented architecture whose functionality will be demonstrated by means of a use case. Despite the theoretical development of CEMIS for as long as 20 years, CEMISs are not commonly used by companies. There is a substantial gap between the research and the use of CEMISs in companies, which the paper at hand aims to reduce by proposing a flexible and adoptable architecture to support companies in their current efforts. The developments in the case of company communication and the demands of stakeholders, especially in the field of corporate social responsibility (CSR) reporting, require handling. The development in the company communication and scientific community imply the extension of environmental to sustainability reporting which includes environmental, social and economic aspects.

Current CEMIS are required to handle more and more business processes (as data source etc.) in the daily business of companies; the paper will indicate benefits of using an integrated CEMIS in the information technology (IT) landscape of a company. The paper will briefly introduce the IT-for-Green project and the software developed. The main focus is on a real world example – the paper shows how our CEMIS can be used to assess the environmental impact of a product.

1. CEMIS: Current state

The topics of Green IT and IT for Green and their related concepts are currently in focus of discussions within the scientific community (Teuteberg/Marx Gómez 2010). Many processes and technologies to reduce the environmental impact of business processes and IT infrastructures are discussed by researchers and practitioners (Funk/Möller/Niemeyer 2008; Haubach/Schmidt 2008; Isenmann/Rautenstrauch 2007; Möller/Schaltegger 2012). CEMIS can support the reduction of environmental impacts by collecting, storing and processing of information and influencing corporate decision making (Teuteberg/Strassenburg, 2009; Wohlgemuth/Mäusbacher 2008). Analysing current IT landscapes of companies reveals that environmental information is often gathered and accessed manually, thus resulting in high costs. Even thou CEMIS were originally created to handle legal compliance regarding the environment; current publications show that CEMIS are increasingly considered as management tools. Therefore, the scope of CEMIS shifts from a documentation system (end-of-pipe solution) towards a proactive decision support system for sustainable value creation (Teuteberg/Freundlieb 2009). The shift in scope involves new challenges for the architecture and implementation of CEMIS. The systems have to be highly integrated into the existing IT architecture and be able to handle services and processes within the established information flows (Funk et

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al 2007; Funk et al 2008; Heubach/ Lang-Koetz 2006; Joschko et al 2009). The integration enables CEMIS to act not only as a warehouse for environmental information but also to derive correlations between environmental, social and economic information in the sense of a sustainable development (Elkington 1998; World Comission on Environment and Development 1987). Exemplary, a production process can be annotated with a bill of material indication the physical material flows, was well as value flows and workloads of employees. These aggregated information can be used in several processes, e.g. sustainability reporting (Gräuler et al 2013) or process management (Vom Brocke et al 2012).

Current trends in the public debate as well as the progress of legislative and non-legislative regulations, such as the Eco-Management and Audit Scheme (EMAS) and ISO 14001, indicate that current environmental goals of companies must be supported by IT. Moreover, the GRI guidelines and ISO 14040 standards guidelines are increasingly applied within companies on a voluntary basis to exhibit corporate social responsibility. Applying a use case we will demonstrate how environmental management workflows can be supported by CEMIS, according to recent standards and guidelines.

2. IT-for-Green: Next Generation CEMIS for Environmental, Energy and Resource Management

The project IT-for-Green[4] aims at increasing the environmental sustainability of companies and their processes by means of information communication technologies (ICT) (Rapp et al 2011). In this context, CEMIS are to be regarded essential for supporting sustainable development, integrated in the IT landscape and processes and decision processes in particular. The demand for a sustainable development requires that decision makers in all sectors and forms of organizations are able to incorporate sustainability related information into their decisions. The CEMIS resulting from the IT-for-Green project will particularly support the decision makers in the following considerable areas:

- Implementation of eco-friendly production and disposal processes (Borland 2000; Nielsen/ Wenzel 2002; Salhofer et al 2007).
- Creating synergies, cost savings and strategic advantages such as offering or using cloud computing (Baliga et al 2011; Müller et al 2011).
- Development of hybrid products (combined offers of material and services) in which the concept of sustainability is focused (Stolze et al 2011).
- Interactive exchange of information with various stakeholders (Ahmed/Sundaram 2012).
- Analysis of cause effect relationships between economic and environmental objectives to make these connections transparent. This will trigger and enable the strategic environmental management (Funk et al 2007; Thomas/Vom Brocke 2009).

The IT-for-Green project is currently developing a runtime environment and three modules to present functionality and design elements of a next generation CEMIS not only able to assist with legal compliance as an end-of-pipe solution, but to enrich traditional CEMIS using an integrated approach of handling processes. Processes can be combined into workflows; e.g. the process of decision making could be supported by such a system. The IT-for-Green core team comprises of researchers from the University of Oldenburg, Osnabrück University, University of Göttingen and several corporations from the states of Lower Saxony and Bremen and one municipality.

[4] http://www.it-for-green.eu

3. A CEMIS enabling IT-for-Green

The research project aims at implementing a more strategic oriented next generation CEMIS. Our CEMIS is built in a modular manner, with service-orientation as a major conceptual design element. In this context service-orientation means that the smallest units of the CEMIS modules are realized as services (called Green Web Services); these services are published in the so-called Green Service Mall (service registry). Following the service-orientation approach, functionality will be established and expanded via the integration of new or modified services to add any kind of functionality.

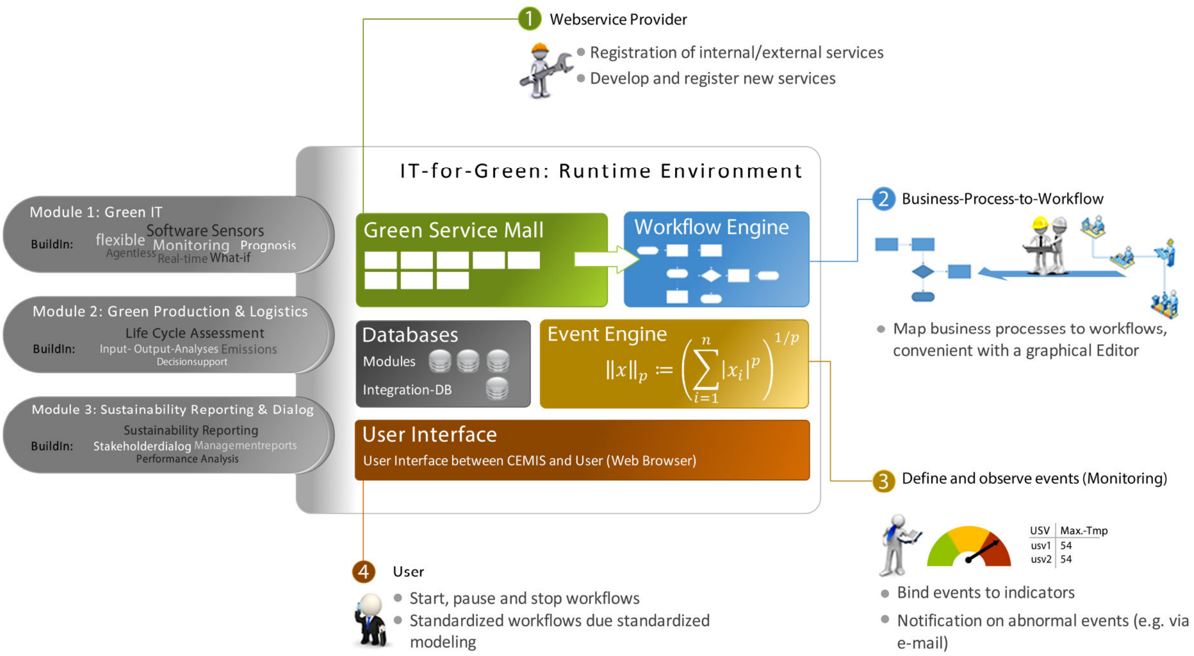

Figure 1
IT-for-Green: Runtime Environment.

As presented in Figure 1, the runtime environment comprises of the core building blocks: a Green Service Mall, a Workflow Engine, databases, an Event Engine and a user interface, to handle the internal and external services and business processes. The Green Service Mall, as web service provider, handles the registration of external and internal services. The registration of new web services allows developing services which are not available in the stock version of the CEMIS and also to change only parts such as one service without changing all other services to reduce efforts (numbered 1 in Figure 1). The Workflow Engine allows combining services and processes to one workflow using a graphical editor (2). The architecture supports different kinds of databases e.g. relational data bases or data bases using an XML format. An Event Engine allows monitoring and ad-hoc reporting of events (3), by continuously comparing current states of user-selected indicators with the normal behavior. The meaning of normal is learned from examples from the past. The user interface of the runtime environment visualizes the software and allows user interaction via a web browser (4). The runtime environment is made available on a web server. Additionally, there exists a standardized and well documented information exchange format and interface to allow for future extensions. Authorizations for specific functions and areas can be granted using the rights and role system that is responsible of issuing permissions to access services. The rights and role system does not restrict the access to individual services, it hides the information from the unauthorized users (or groups) instead.

What enables our CEMIS (built-in services of the stock version) to

- meter, model and simulate data centers,
- build life cycle assessments based on ISO 14040,
- measure environmental impacts of logistic processes, compare different modes of transport based on environmental criteria,
- offer a holistic, interactive and target-oriented reporting like sustainability reporting

is provided by the three modules called Green IT, Green Production & Logistics, and Sustainability Reporting & Dialog.

4. Use Case: Assessing environmental impact

The use case presented here shows how the three modules of the IT-for-Green project can contribute to the life-cycle assessment of a product made by a medium-sized enterprise called Cewe Color AG & Co. OHG. The product under examination is called Cewe Fotobuch (Cewe photobook). Customers use a special software to create their own photo book by adding images, texts and a cover. As stated in Hausmann (2011) the typical book is of size DIN A4, has 50 pages containing 120 photos and weighs 500 gram.

A detailed gate-to-gate analysis for 1,000 units of a typical copy was presented in Gösling et al. (2013). The analysis covered:

- The energy consumption of the required ICT (Input provided by module 1).
- In- and outputs of the production process based on ISO 14040 as well as transport emissions from Oldenburg (production facility) to Göttingen (sales branch of the customer) based on ISO 16258 (Both compiled by the second module).
- Finalizing the analysis by generating a structured report (Analysis serves as input to module three).

In order to orchestrate such a comprehensive workflow, like assessing the environmental impact of 1,000 units of a typical photo book, the runtime environment (section **Fehler! Verweisquelle konnte nicht gefunden werden.**) can be used. It combines the functionalities of several services and modules to one integrated workflow.

As stated above, module 1 (called Green IT) will be used to calculate the energy consumption semi-automatic by using Green IT ontology. The ontology can be used for simulating and analyzing different components in data centers. Exemplary, recording load on servers assigned to operations used in the process of producing 1,000 units of the product. The service-oriented approach employed by IT-for-Green necessitates a focus on high interoperability and flexibility. To facilitate this for module 1, we have defined a ontology as a shared vocabulary to exchange data and describe the module's behavior. We have used an existing top-level ontology as a foundation, to make a possible future translation between ontologies in this domain easier. We have selected DOLCE for this, which is a fairly abstract top-level ontology, dealing with basic concepts from a philosophical point of view. It defines four top-level categories (Borgo/Masolo 2009):

- `Endurants` are entities which are wholly present at different times. In our case these are things like servers, routers or racks.
- `Perdurants` are entities that are extended in time and therefore have different parts at different times. The categorization of an entity as endurant or perdurant is often a matter of the desired temporal resoluation, as most endurants become perdurants over long enough time spans. In our case perdurants are things like a power failure or a load balancing procedure.

- `Abstracts` are entities outside time and space, like the number "26".
- `Qualities` map particulars to abstracts, such as the temperature on a specific point of a hot aisle is assigned to "26".

On top of this base layer, one important aspect we specify, are three abstract flows in the data center: Power flow, heat flow and network traffic flow. All data center elements are looked at from the point of view of their effect on these three flows. Therefore elements of the data center are viewed as HeatSources, HeatSinks, EnergySources, EnergySinks, and/or TrafficFilters. For example, a server is a HeatSource, an EnergySink, and a TrafficFilter whereas an air conditioner is a HeatSink, an EnergySink.

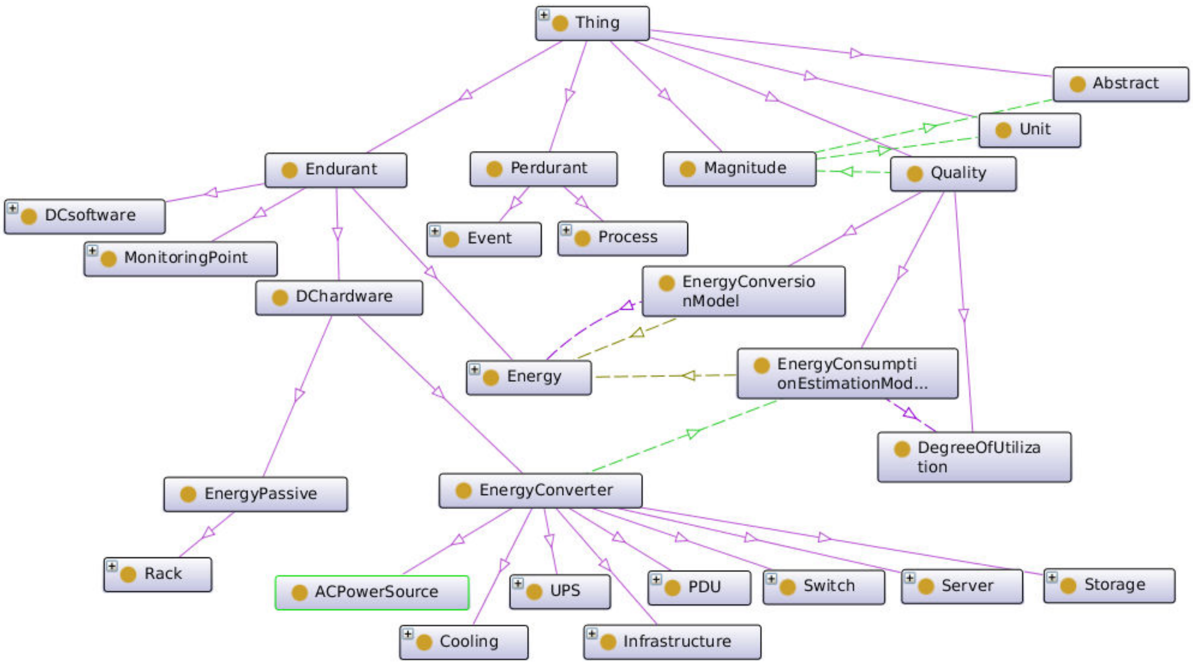

Figure 2
The ontology used within the Green IT module.

Figure 2 shows the current state of the ontology. It is still a work in progress, but already usable for our requirements and expansions are possible later, as many other components of module 1 are derived from this single source.

The second module consists of the two sub-modules Green Production and Green Logistics. In the sub-module Green Production for each of the processes that comprise the life cycle of the cewe Photobook the in- and outputs are specified in a structured way: energy, material, space, waste, emissions into air, water and soil. Due to limited personnel resources and availability of specific upstream information only those in- and outputs were collected which incurred inside the cewe color AG. The result is a gate-to-gate analysis, which is an incomplete life cycle inventory. Naturally, the impact assessment based on an incomplete life cycle inventory would be again incomplete. In order to overcome these problems the sub-module Green Production is expanded by the inventory databases Probas (German Federal Office for Environment) and ELCD (European Comission), whereby gate-to-gate analysis can be enriched to some extend

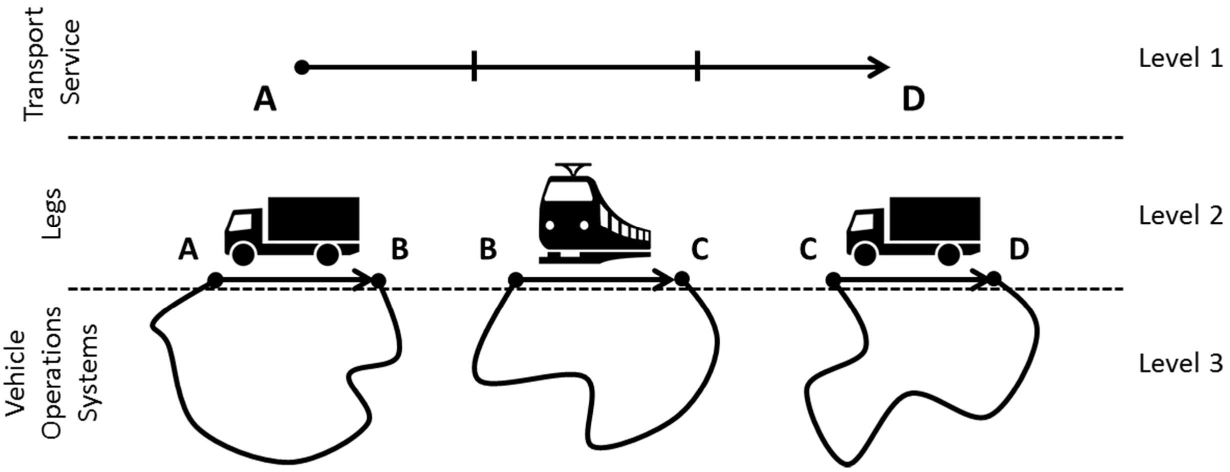

Figure 3
Overview of a general transport service

into life cycle inventories. Based on these inventories, established impact assessment can be applied. (e.g. Goedkoop et al 2009).
In the next step the sub-module Green Logistics calculates the transport emissions for the impact assessment. Therefore various information need to be collected. Generally an external logistics process consists of three levels, the overall transport, the various legs that make up the transport and the vehicle operations system for each of those legs. In our case since we regard only one leg, levels one and two are equal. Level three is the most important one because here information is gathered that helps to allocate fuel consumption and emissions of total values to the product we are interested in, the photobooks. Additionally, if data like total fuel consumption cannot be assessed directly, because the transport is undertaken by sub-service provider, the module can make use of default values.
Both parts of module 2 also generate data that can be used in a following multi-criteria analysis, which may identify the most preferred production system or transport route based on several preferences stated by the decision maker.

Finally, a structured report, such as a management summary or as a part of a sustainability report, can be generated based on the available input data provided by the modules one and two. The information about the energy consumption of the data centers and the results of the gate-to-gate analysis for 1,000 units of the photo book can be processes by the third module, named Sustainability Reporting and Communication, with a strong focus on stakeholder-oriented publishing. The module is able to handle any kind of structured report due to the fact that a schema of each structured report can be created in advance and subsequently enriched with content. If a report will be used several times, it is recommended to the main editor to extract a reusable schema. If a report is used only once, it is recommended to start with an empty report and add necessary layers and articles for the other editors and writers without extracting a schema.

The main benefit of generating structured reports based on predefined schemata is the separation of concerns. It separates the contribution of writers from building and validating the schema, checking the overall report and approving the publication. The module allows the centralization of the generation process and provides information about the current status of each article and the overall progress. According to an integrated rights and role concept articles and action items are only available to the responsible persons. Each article has a status (new, processed, published, etc.), required information (e.g. indicators to be covered) and associated contributors. Each final report is available as XML document to allow any kind of transformation, e.g. different reports for each stakeholder group and level of detail for internal or external usage.

5. Next Steps

The use case presented in this paper illustrates the present state of the CEMIS developed in the project it-for-green. Areas for future works have been identified both, for the implementation and evaluation of the CEMIS. In respect to module 1, the next steps will be a full evaluation of the accuracy of the energy consumption estimations by comparing them to actual measurements taken in a small data centre. Module 2 is currently executed via two stand-alone prototypes. The next steps will be to integrate the prototypes into the surrounding web service infrastructure. Moreover the use case revealed the demand for some minor updates. Furthermore, the interfaces to existing systems, ERP-software for instance, need to be implemented. In the third module further implementation will include a tutorial. The tutorial will present functionalities and benefits of the web based approach, such as a role based concept for sustainability reporting, the import of sustainability indicators and the generation of schemes. Moreover, a unified front-end for all three modules of the CEMIS in development will be created. The front-end is intended to offer a simple and coherent work environment for anyone using the CEMIS whilst offering great flexibility in regard to data representation. Iterative evaluation steps are planned for all single modules, as well as the runtime environment. Scenarios and use cases with increasing complexity will be conducted within the consortium of the IT-for-Green project.

Acknowledgment

This work is part of the project IT-for-Green (Next Generation CEMIS for Environmental, Energy and Resource Management). The IT-for-Green project is funded by the European regional development fund (grant number W/A III 80119242). The authors thank for the support.

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