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The Green Browser: A Proposal of Green Information Sharing and Life Cycle Design Tool

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Abstract

The environmental issue is, without doubt, one of the most important and critical issues to solve urgently. In this paper, we propose the *Green Browser* which enables stakeholders (e.g., employees, shareholders, consumers, regulators, NGO, etc.) to have access to environmental information. Through information-sharing and the promotion of public discussion, raising green literacy and ensued market selection are expected to produce effective pressure for corporate and public decision bearing positively on green production and environmental protection. First, we propose a representational scheme called *green life cycle model* which organizes corporate information for the Green Browser. For the purpose of supporting design for life cycle of green products (*green life cycle design*), the scheme is built to illustrate a product's potential impacts from the raw material stage through use and eventual disposal or recycling. Firms are encouraged to process their firm-specific information based on the scheme. Second, we discuss how the Green Browser can support information sharing to enable stakeholders to obtain the detailed picture of products. We propose the coupling of the Green Browser with Internet for the sharing of green life cycle models and relevant data resources.

1 Introduction

The environmental issue is, without doubt, one of the most important and critical issues to solve urgently. However, the following characteristics of the environmental issue make it quite difficult to deal with:

- It is impossible to solve the issue only by using technologies. Rather, collaboration among technology, policy, and economy is essential. In this sense, a multidisciplinery research project is important to tackle the issue.
- The environmental issue includes a wide variety of problems ranging from global problems such as the green house effect to local problems such as the disposal of hazardous materials. Moreover, the issue is so complicated that relationships and trade-offs among these problems cannot be defined universally. As a result, we do not have an universal estimation method. For example, even if one can optimize the recycling process of a car from the viewpoint of material consumption, this process might be worse in terms of the green house effect.

How can AI contribute to this issue? Can it help introducing environmental concerns into corporate, policy, and decision-making process?

One option is to develop a tool for environmental decision-making. A tool that clarifies trade-offs among strategic targets such as growth, industrial competitiveness, and environmental impact is thought to enhance the ability of reasoning of decision-makers, especially in the conventional centralized (command-and-control) system. However, once the tool explores the complex problem of gaining global sustainability, negative outcomes may result when the tool carries an incomplete or wrong model of cause and effect.

The one alternative is to develop the *Green Browser* enabling stakeholders (e.g., employees, shareholders, consumers, regulators, NGO, etc.) to have access to environmental information. Through information-sharing and the promotion of public discussion, raising green lit-

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eracy and ensued market selection are expected to produce effective pressure for corporate and public decision bearing positively on green production and environmental protection.

There has been already some networks about environmental information such as EcoNet[1], and EnviroWeb[2]. While we are planning to join these networks, our research focuses mainly on the manufacturing industry and aims at developing a methodology for supporting designers to design green products by using these networks.

This research proposes a representational scheme called *green life cycle model* which organizes corporate information for the Green Browser. For the purpose of supporting design for life cycle of green products (*green life cycle design*), the scheme is built to illustrate a product's potential impacts from the raw material stage through use and eventual disposal or recycling. Firms are encouraged to process their firm-specific information based on the scheme. Then, stakeholders can obtain the detailed picture of products by browsing information with the Green Browser in the internet space. We call it *green information sharing*.

In sections 2 and 3, we discuss requirements and our approach for the life cycle design support and the green information sharing, respectively. We sketch the ongoing implementation of the Green Browser in Section 4. Section 5 concludes this paper.

2 Green Life Cycle Design

Designers should design a product and its life cycle system so as to meet the requirements of environmental friendness over the life cycle of the product. Many researchers so far have pointed out the importance of design for reusing and recycling products effectively (e.g., [1, 2, 6]). Namely, reuse and recycling of products are ineffective and expensive unless they are purposely designed. For instance, design for disassembly and appropriate modular design are indispensable for economical disassembling and efficient reuse, respectively. Namely, in order to develop a green product, environmental requirements throughout life cycle of the product should be examined at the design stage. Table 1 shows some examples of requirements related to "greenness" in each life cycle process. As shown in this table, many requirements in each process are related to design. For example, in order to avoid producing hazardous waste in the manufacturing process, designers and manufacturing engineers should collaborate for designing the product so as to be manufactured in such a manner. Therefore, not only the product but also its appropriate life cycle system (e.g., manufacturing, operation support, maintenance, recycling, and disposal) should be designed at the design stage. We call this *green life cycle design*. The concurrent engineering [3] is a hopeful approach to support the green life cycle design.

However, as we pointed out in Section 1, since the environmental issue is very complex, vague, and hardly well-evaluated, one of the most important needs for aiding the life cycle design is to support the designer to define the problem structure of the product life cycle at an early stage of design. This process includes picking out environmental and non-environmental requirements which the product should satisfy, clarifying the relations among these requirements, especially trade-offs, and selecting evaluation methods for the requirements.

In order to support this process, the Green Browser is designed to help a team of designers to form a consensus about "greenness" of the product. The Green Browser supports them to put together environmental requirements for the product into a model and thus to visualize trade-offs among them. The Green Browser is designed based on the following concepts:

1. Information generation

   While the green information sharing is important as described in Section 1, issues for it include by whom and how such green information is created. We believe that the created information about the life cycle of a product should be shared during and after the design. Therefore, the result of design should represent relations between the product and the environment over the life cycle clearly and explicitly.

   Here, two types of collaboration should be considered for supporting the information generation. One is collaboration in a process such as collaborative design work and the other is collaboration among different processes. For example, in the latter case, for executing design for disassembly, designers should collaborate with recycling engineers and be supplied basic data from the engineers.

2. Process modeling

   Environmental factors must be examined in each of the life stages such as raw materials, manufacturing the parts, assembly, shipping, duty time, reuse and recycling, and disposal. This means that the Green Browser should present the product information of different life stages. Furthermore, the planning of the production and the recycling process will be an important technical approach towards the environmental issue.

3. Qualitative representation

   Although impacts on the environment are important to be presented, it is not always possible to quantitatively evaluate them, as we pointed out in Section 1. For modeling such impacts, we use qualitative representations (e.g., [5]).

In order to support the life cycle design with these concepts, we here propose a representational scheme called *green life cycle model*. Figures 1 and 2 show the representational scheme of the green life cycle model and an example, respectively. The model of a product consists of three sub-models which are linked each other; namely, a strategy model, a process model, and object models.

Strategy Model

The strategy model represents how requirements for the product affect the achievement of overall goals of the

[1] http://www.econet.apc.org/lcv/score100/econet_info.html
[2] http://www.gnn.com/gnn/wic/env.13.html

Process	Requirements	
	Design Related	Others
Manufacturing	no hazardous waste, least amount of material	low energy consumption
Operation	maintenability, long life, no hazardous wastes, low energy consumption	
Reuse and Recycling	reusable components, easy disassembling, recyclable material	no hazardous waste, low energy consumption
Disposal	no hazardous waste, least waste	

Table 1: Examples of Requirements in Each Life Cycle Process

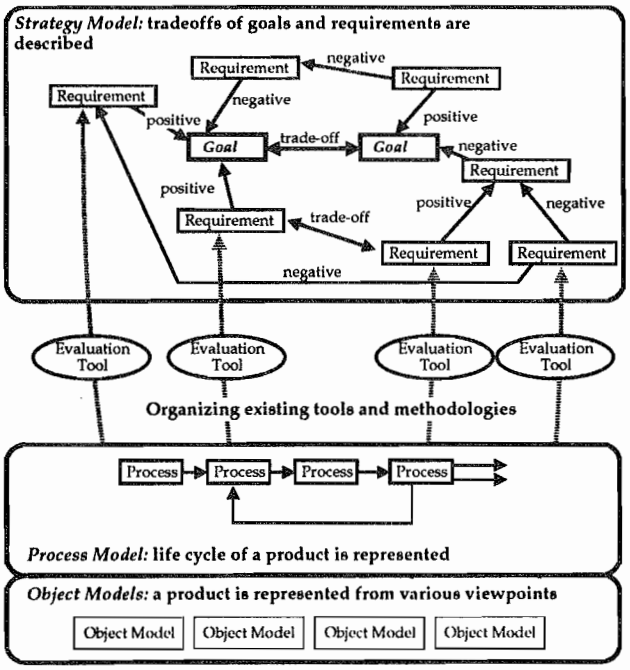

Figure 1: Scheme of the Green Life Cycle Model

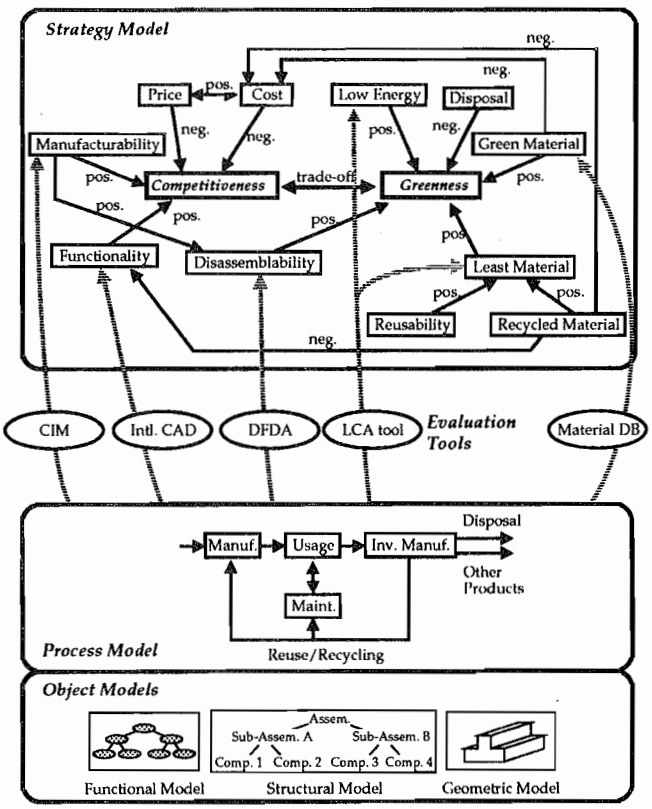

Figure 2: Example of the Green Life Cycle Model

development. The designers describe the following information in the strategy model.

- Requirements and goals

  Requirements includes environmental requirements such as "recyclability" and "no emission of hazardous materials" as well as general requirements such as "inexpensiveness" and "high speed." We call the most abstract requirements such as "competitiveness" and "greenness" *goals*.

- Relations among requirements

  The designer will find out relations among the defined requirements. For instance, a goal of greenness is positively affected by least materials, which is again achieved by selecting a recyclable material. For the same product, improving functionality will positively affect competitiveness. These two goals of greenness and competitiveness, however, may contradict in respect to materials because the selection of a recyclable material may reduce the functionality. Such positive, negative, and trade-off relations among requirements are represented with nodes and links as shown in Figure 1. Among these relations, it is the most important for designing green products to specify the trade-off relations explicitly.

- Weighing and evaluation criteria

  We assume that the designer can describe importance of each requirement as weight and evaluation criteria for concrete requirements. These kinds of information are put in each requirement node and will be used for evaluation of the product.

- Pointers to the process and the object models

  Each requirement should be related to some portion of the life cycle process and/or object models of the product. By using these pointers, the designer can organize existing tools and methodologies. This feature enables the designers to create green products and evaluate their whole life cycle.

Process Model
The process model represents the life cycle of the product. It depends on the life stage how a product requirements impacts on the environment. For instance, design for disassembly reduces impact in the recycling process, but may increase complexity in the manufacturing process. Links from the strategy model show on which stage of the life cycle the impacts of the requirements are considered.

Object Model
The object models represent the product from various viewpoints. Examples of the object models include functional model, geometric model, and structural model. These modelers of various viewpoints are being integrated into a framework called *Knowledge Intensive Engineering Framework* [4], which is currently developed by the authors. One of the features of the Knowledge Intensive Engineering Framework is to integrate various kinds of modelers including traditional modelers such as FEM modelers by providing a common knowledge base of ontology and relating concepts manipulated in each modeler to this ontology base.

3 Green Information Sharing

We believe that the basic information about "greenness" of an product must be included in the green life cycle model and shared among stakeholders using the Green Browser (see Figure 3). We designed the green information sharing facility of the Green Browser based on the following concepts:

1. Linkage to external data sources

   Recent advances of the computer network gives support to the effort of tackling the environmental issue. For example, as EcoNet and EnviroWeb provide, on the WWW one may find data of interest including life-cycle assessments, surveys, research papers, and reports. Such data resources may provide information relevant to the product. The Green Browser is designed so that the designer can obtain relevant data using it. Links to external data sources are associated with requirements in the strategy model. By selecting a requirement, the user can learn background information or relevant products associated with the data. For a team of designers, the browser allows to retrieve relevant data that have been linked up by other members.

2. Model sharing

   To obtain a consensus about the concept of the product, it is important to learn the views of other designers. The browser is planned to be a common workspace for making a consensus in which the designers collaborate to construct a common green life cycle model of the product. The model represents explicitly different viewpoints of the designers in the strategy model; namely, while the strategy model representing difference is shared among the designers, the process and object models related to the strategy model might differ according to the difference of viewpoints.

   It is supposed to happen that the same requirement is found in the strategy models of different products. For instance, for many products the requirement of least material is considered as a possible way to improve the greenness. So the requirements considered for one product might be used again for another product. For this reason we plan to collect strategy models of products, to extract requirements from them, and to put out a list of requirements on the network. Each requirement in the list has links back to the strategy model it was extracted from. This will allow the user to retrieve relevant strategy models as references.

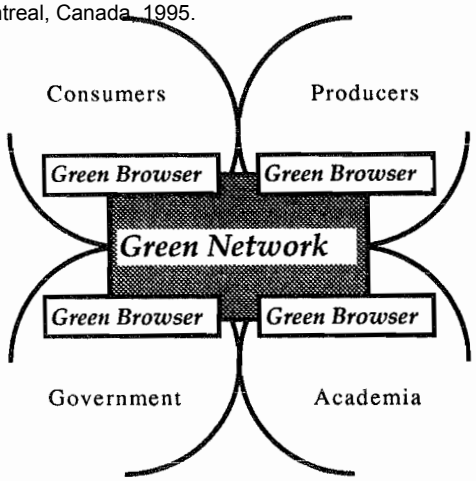

Figure 3: Green Information Sharing

4 Implementation

Currently, we are developing the Green Browser by mainly focusing on the strategy model and green information sharing. The system is being implemented in X-windows environment. Links to external data sources and tools are written in URLs (Universal Resource Locators) as practiced in the WWW. The Green Browser runs as a client of WWW, so that data requested by the user are obtained from remote servers in HTML. The Green Browser will be published with successful examples of life cycle design. The case of automobile is planned to be the example.

5 Conclusion

In this paper, we have proposed the *Green Browser* which supports green life cycle design and green in-

formation sharing. For supporting the green life cycle design, we have proposed the *green life cycle model* which consists of the strategy model, the process model, and the object models. In order to design green products, it is essential to support the designers to define the problem structure from the viewpoint of greenness. The green information sharing of the system encourages to share transparently the information about greenness of a product among designers, customers, regulators, NGO, and other stakeholders. We believe that, through information-sharing, green literacy is raised. It is expected that the green life cycle design support enables the designers to find out an answer for the green literacy of engineering.

Future work includes;

- continuing to develop of the Green Browser by integrating various modelers, evaluation tools, knowledge and data bases through the network,
- applying the system to many kinds of products in order to collect basic data, and
- providing the system as a public software for facilitating the green information sharing.

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