TOWARDS BUILDING AN OPEN ENVIRONMENT FOR DESIGN INFORMATION

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ABSTRACT

In this paper, I discuss needs for openness of design information and methods to realize it. I argue why design information should be open and what benefits will result by opening and sharing design information. In software design, open source software is getting accepted as a way of developing software products. I overview it and analyze how it can be applied to artifact design. Then I discuss how such an environment can be built. Identification, representation, and sharing mechanism are crucial. Lastly I summarize discussion with people in the design community. Many people disagree with opening design information, but I dispute with their objections.

Keywords: information sharing, design knowledge, knowledge representation, open source software, ontology, Semantic Web

1 INTRODUCTION

We have designed a very wide variety of artifacts and have fulfilled our environment with such artifacts to make our life happy. But now a new demand for design arises. Our design capability is tested by the global environment problems, i.e., we are requested to achieve optimal solutions by design artifacts with limited resources on the earth. Since we are struggling to maintain such a variety of artifacts even now, the new demand is challenging to design community.
In this paper, I discuss needs for openness of design information and methods to realize it. I argue why design information should be open and what benefits will result by opening and sharing design information. Then I discuss how such an environment can be built. Identification, representation, and sharing mechanism are crucial. Lastly I summarize discussion with people in the design community. Many people disagree with opening design information, but I dispute with their objections.

2 DEFINITION OF OPENNESS OF DESIGN INFORMATION

First, I define openness of design information in general. Here design information on a product means all kind of information that is used to realize it as an artifact. It includes not only information that the product itself has but also provenance of the product.

1. Inherent information: information that the product itself has. It includes design specifications which show performance and basic attributes of the product, 2D or 3D drawings which represent structure, shape, and materials. It can be obtained approximately by the third party with analysis of the product itself.
2. Provenance information: information that indicates the process of realization of the product, i.e., how the product is suggested, how it is articulated, and how it is gotten its details. It includes required specifications, design rationale, used knowledge, and design process including decision makings. It is no way to know this kind of information except designers that design it.

The former is relatively easy to imagine but it alone is insufficient as design information because designed artifacts are meaningful when we know how designers intend and how the intention is articulated.
In addition to design information, we also need manufacturing information on a product. It is another kind of provenance information, i.e., how it is materially realized. It includes information on tools and machines that are used and manufacturing process that is actually done. It is equally important information to design information, but I discuss design information in this paper to focus on design issues.
Then I refer to openness. Openness of information here means that information is publicly available. It doesn't care where information is located or who owns, but it is important that information is permanently available. World Wide Web (WWW, Web) is now a good practice of openness of information. Information on Web is basically publicly and permanently available.

3 REASONS AND BENEFITS FOR OPENING OF DESIGN INFORMATION

The ultimate reason to realize openness of design information is sharing of intellectual work by human being. Design is one of the most important intellectual activities by human being. It is not exclusive like artistic activity but ubiquitously exists in our society. We have spent a huge amount of effort on designing artifacts for a long time. But the effort is basically isolated, i.e., very locally collaborated and inherited. We can learn how to write novels by reading novels more or less. But designed artifacts, in particular modern industrial artifacts are by far harder to learn how we can design from. They are mostly like a black box, i.e., understanding artifacts is difficult because of its complexity and understanding of design intention is by far difficult because of implicit nature. It is nature of design that every effort on design is embedded as a physical artifact, so it has been reasonable until now. But the situation is changed. One is that most of design process is digitized. We can preserve all information on design in computers. The other is that we have the way to distribute information, i.e., Internet and World Wide Web. So we have opportunity to enhance sharing of design activities.
The above is the ideal goal, but there are many benefits to enable openness of design information.
I here picked up six benefits as follows;

1. **Benefits for customers:**
Customers of products can know more information about products. It is useful for them to decide which products they buy. They can understand designers' intention and compare it with their purpose of purchase. It is also useful to increase creditability for products. It is analogous to food safety. People prefer not only food without toxic or other problematic ingredient but also food of which production process is clear and reliable. In designed products, it corresponds to inherent design information and provenance

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design information respectively. It is becoming right for customers to know such information on products.

2. **Benefits for designers:**
   It is clear that sharing design information will increase productivity of design. Products are rarely created from scratch. Rather products are created as improvement of existing products or use them as reference. It takes a lot of time to understand such existing products, namely reverse engineering. If design information is open already, designers can start their new design from the top of existing design. It will sometimes result in reduction of costs and sometimes result in faster evolution of products. Another benefit is to enhance more collaboration among designers. One designer may add extra ideas in addition to ideas by the other designer if they could understand their design processes to each other. They will be able to collaborate to each other by integrating their ideas.
3. **Benefits for both designers and customers**
   Opening of design information makes a new opportunity for collaboration between designers and customers. As mentioned in the above, customers can share understanding of designed artifacts with designers. Some advanced customers can make feedback to designers to improve the products, or furthermore they may join design. Such a process will result in more suitable design to customers' needs. It is also expected that it will reduce mistakes in design. It is valuable for both designers and customers.
4. **Benefits for product life cycle**
   We are now conscious that product life cycle includes not just design, manufacturing and use but maintenance, recycle, and disposal [1]. The whole product life is basically governed by design because other processes are dependent on products already produced according to design. Opening design information can smoothen these processes, e.g., it reduces analysis for disassembly and recycle.
5. **Benefits for society – preservation of knowledge –**
   Designed products are results of our intellectual work. We spend a lot of time to design various artifacts. We've produced tremendous artifacts but most of them have been disappeared according to change of our society and often market. Preserving all physical artifacts is impossible, but preserving information on them is possible. By preserving artifacts as information is our heritage for future generation.
6. **Benefits for society – design as commons –**
   The computer technology created a new environment where people easily operate and distribute information. It doesn't simply mean that information becomes public. Rather information can be controlled more intentionally. Now there is danger for digital divide between developed and developing countries. Information commons is needed [2]. Design should be also commons. Sharing design information between developed and developing counties can help to improve quality of life in developing countries by designing and manufacturing products by themselves

In above six types of benefits, the first three are directly related to the current product markets, while the rest are indirectly but the impact to the society is larger.
Of course, there can be demerits. We will discuss them in Section 8.

4 CONSIDERATIONS FOR ADAPTABILITY TO INDUSTIRIES

Before going on methods for openness of design information, I discuss whether openness of design information is acceptable depending on types of industries in two ways. One is typology by product architecture and the other is by technology developing phases.

4. 1 Integral architecture and modular architecture

Function is the purpose of design and attribute is means to realize function. Generally speaking, design is mapping from function to attribute [3]. Since functions required for modern industrial products are sophisticated, attributes of products are complicated. They usually consist of some amount of components. So composition of components is a common feature of modern industrial products, rather the way of composition is often more important than components themselves. Ulrich pointed out that there are mainly two types of component composition in modern industrial products [4]. He called it "product architecture". One is "integral architecture" which means functions and structures are complicatedly interdependent. It takes a lot of efforts to integrate components. It is done by human communication. But the tuning of over all performance is relatively easy. The typical example is automobile.
The other is "modular architecture" which means functions and structures are well correspondent to each other. Since interfaces for components are predefined, composition of components is easy. On the other hand tuning of performance is not easy. The typical example is personal computer.
Product architecture is not solely related to products themselves but it is said that it is also related to organization culture which varies from country to country [5]. Companies in countries like USA often show strength in products in modular architecture, on the other hand, those in Japan in integral architecture.
Design information in modular architecture is easy to shift open, since openness of interface is already done. Standardization lies in the same line. So we don't worry about openness of design information on this type of products so much. Sooner or later, at least inherent information becomes open. But concerning provenance information, we need another system to push towards openness.
Design information in integral architecture looks difficult to open. But the effect seems larger, i.e., openness of design information can compensate the current difficulty in design process. When designers of components integrate their components, a lot of time is consumed by understanding design to each other. Explication of not only inherent information but also provenance information can help such understanding. Software design is exactly this case, and it looks successful as we will see in the next session.

4.2 Pre-competitive, Competitive, and post-competitive products

Yoshikawa addressed that there are three different phases in technology development, namely pre-competitive, competitive, and pos-competitive phases [6]. Pre-competitive phase means that technology is not matured to complete so that stakeholders like academia and industries are easy to cooperate. Competitive phase means that technology is well established but still under development so that competition in the market occurs. Post-competitive phase means that technology is already matured and no more development is expected so that little competition occurs.
If products are now in competitive phase, it is difficult to impose openness of design information.
If products are in post-competitive phase, companies may welcome openness of design information because in this phase companies are often continuing production not for benefits but for social duty. In this case, enforcement by laws and social consensus can work well.
If products are in pre-competitive phase, stakeholders naturally exchange information to improve technology.

5 LESSONS LEARNT FROM PRACTISES

In this section, I overview design practices in the open source culture. Open source design is originated in software design, and it becomes a movement or a culture. It is now spreading out other product design slowly but steadily.

5.1 Open source software

We can learn from the recent movement in software engineering so-called "Open source" software. Open source software means that codes of software products are open and can be re-used. By opening codes, programmers can develop their own software products by re-using or modifying existing open source software products. The most typical example is Linux, but there are more products like Firefox and Apache. Another example is Wikipedia which is not a software product but a huge knowledge base contributed by a lot of people who are mostly anonymous.
Open source movement changes the software development process. A new development process is called "bazaar" style in contract to "cathedral" style [7]. In the bazaar style, software products are open from the early stage so that everyone can contribute the development. Frequent release policy is also included in the list of Web 2.0 features [8]. It is said that it contributes to improve software quality and users' satisfactions.
Once open software movement was regarded as enemy of software industry. It seemed that they claimed invalidity of business of software industry. But people realized that anyway the bazaar style could produce nice software products recently. So many software companies are now collaborative to the open software community.
We can learn many lessons from success in software engineering. Firstly sharing design information can reduce design costs with keeping quality. If we could re-use existing design solutions, we can focus on more creative part of design. It already happens that design information is shared in a company. If we could extend it to community-wide sharing, more effects on cost and quality would be expected.
Secondly design information could be preserved. In open source software, even if the original developer of a software product looses interest on it and stop developing it, other people can succeed to develop it if they like. So software can survive. In engineering design, death of companies implies death of design information. There are no ways to access information on products of which manufacturer closed its business. If design information is already opened, information can be accessible whichever manufacturer is alive or not.

5.2 artifact design in the open source culture

As we mentioned, there are many successful projects on software products. There are already some projects that actually run open design activities even for non-software products. Most of them are products related to computers. It is called open source hardware [9]. For example Opencores.org [10] is developing microprocessors and other chips with open source style [11]. They are mainly inspired by success of open source software and also technically related to open source software.
There are some exceptions. ThinkCycle, a spinout of MIT student project, offers an environment for open collaborative design [12][13]. The aim of the project is sharing of design knowledge, in particular design for products needed socially. The project offers a collaborative environment where domain experts and designers discuss and show design solutions. The results are archived as documents. A typical design case with this project is design of a novel low-cost IV drip flow for patients infected with cholera. There are more than 200 documents and many design results in the site.
There are also other projects like "The Open Prosthetics Project"[14] in which designers share knowledge about prosthetics design.
The main focus on these projects is how to provide collaborative environments among people who work in different domains and spread out geographically. Thanks to recent development of the Internet technologies, it is not so difficult to provide them. The tackling problem is a social one, i.e., how to involve and encourage people or develop a culture for sharing. If there arises such a culture in a project, it will continue. Otherwise it will disappear even if there is a good computer environment for collaboration.
The other problem is representation. In open source software projects, information on design is represented as software products themselves (source codes), documentation, and discussion archives like mailing-list logs. The significant feature of software in comparison to artifact design, source codes basically contain all information on software products. Designers can understand design of software products by reading source codes.
In artifact design, it is different. In the projects on artifacts, information is shared as documents written with texts and drawing. It just contains partial and ambiguous information about design.
It is not a serious problem when the amount of information is relatively small. People may compensate information by communicating to each other. But if it becomes large enough, it would be troublesome and maybe obstacle for information sharing. We need formal representation for design information sharing in a large scale.

6 METHODS TO REALIZE OPENNESS OF DESIGN INFORMATION

As we mentioned, we need a formal system for sharing design information. Opening and sharing design information on artifacts needs some new technologies. I pick up three issues here, i.e., identification, representation, and sharing mechanism.

6. 1 Identification

In order to distribute design information on artifacts, artifacts and design information should have identification, and then they should be associated to each other. Each design should have its own identification. In the Internet, it can be achieved by URI (Uniform Resource Identifier)[15] . URI is generalization of URL (Uniform Resource Locator) and can work not only as address of web pages but also as identification of any objects. Any URI is unique in the Internet. But URI itself is not sufficient because it cannot carry any information about relationship among objects. In Semantic Web [16], it is realized as RDF/S (Resource Description Framework/RDF Schema) [17][18] and OWL (Web Ontology Language) [19]. A RDF statement is a triple among URIs and represents a relation between a resource to another with a label (property). RDFS offers modeling mechanism for RDF statements like class hierarchy. OWL offers more powerful modeling mechanism than RDFS. By using these languages, we can represent not only relationship among design but also contents of design.
In mass production, many products are produced from a single design model. It is analogous to class-instance relation in object-oriented programming paradigm. Mass products usually have manufacturer's serial number that is unique in a company or product. Serial numbers can easily be converted into URN (Uniform Resource Name), which is another subset of URI. It can be associated to class representation by RDF/S or OWL. But

association mechanism is needed. Association can be realized by resolution servers such as DNS (Domain Name System) in networking and DOI (Digital Object Identifier) [20] in digital libraries.

6. 2 Representation

The second problem is how to represent design information. I categorized design information into two types of information, i.e., inherent information and provenance information

There are many efforts how to represent design objects such as 3D CAD and product modeling, which is what I mentioned as inherent information. But it is not sufficient because they are just representation of the final product. We need to represent information on the other stage like conceptual design. That is what I called provenance information.

Concepts in design should be represented in a formal way. It is the role of ontology for design [21] [22], and Semantic Web enables to publish representation with concepts in ontology in the Internet.

Furthermore we need information on design process, i.e., how designers proceed their design. It is a more serious problem because there are no general agreements how design process should be represented. I here show an attempt to publish design process information. In [23], we represent design knowledge related to design process with XML syntax. A design document consists of two parts. One is a human-readable part in which a normal text is included. The other is a logical part in which knowledge on design is described in a logical form. Knowledge is described with concepts in predicate ontology, attribute ontology, and object ontology. We model design process by abduction [24] and represent design process as application of design knowledge in abductive inference. Then we can know design rationale for each design by tracing design knowledge, i.e., why it is designed in such a way. It is merely a proposal how design knowledge and design process can be represented, but we need to discuss it seriously to make design process more transparent.

6.3 Sharing mechanism

Another problem is sharing mechanism, i.e., how information is actually distributed and shared. As I mentioned, it is important how to involve and encourage people in community of sharing information.

We can learn from recent development of information technology such as blogging and social networking services.

7 DISCUSSION

I already talked this idea on a symposium in a design community in Japan. Many participants, in particular designers in companies, disagree with opening design information. I summarize their objections and my answers to them.

[Question] Secret of design can not be opened. It is core competence of companies.

[Answer] Competitive design can be excluded. Even accepting this exception, there is a lot of useful design information for others.

[Question] Design information is not understandable for others. For example, design information is usually valuable with the manufacturing knowledge. So it is useless to open design information.

[Answer] I agree that design information is not completely understandable for others. But even partial understanding is valuable. If it would be true, it implies that opening design information would not make direct dangers for companies because other companies cannot produce copy products easily even if such information is available.

[Question] Exhibit of design information increases danger for product-liability lawsuits. Companies should control information carefully not to crease this kind of risk.

[Answer] I think that it is opposite. Information hiding may cause a lot of cost, e.g., if serious accidents with products would happen. Opening design information in advance can reduce such risk.

[Question] There are no reasons to bear such cost.

[Answer] Opening design information is beneficial for companies.

- Wise consumers trust companies that open their information more than those that do not.
- Opening design information will reduce future costs to maintain products. Products may be maintained by other parties with such information.

8 SUMMARY

In this paper, I discuss the value of openness of design information. I admit that discussion here is rough and not comprehensive at all. What I intended is to invoke open discussion for this issue. Design information is valuable but it is not solely valuable for companies it is valuable for society. I believe that openness of design information is crucial for design community just to adopt the Internet era but to unlock the future of design for the welfare of mankind.

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