Commons-Oriented Information Syntheses: A Model for User-Driven Design and Creation Activities

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ABSTRACT

The phenomenon of user-driven creation activities has recently emerged and is quickly expanding, especially on the Web. A growing number of people participate in online activities, where they generate content by themselves, freely share their creations, and combine one another's creations in order to synthesize new material. Similar activities also occur in the area of product development, as people design products for themselves and share their designs for others to reuse or build upon. The phenomenon shows that under some special circumstances, typically passive users can become active creators. Also, under such circumstances, creation activities are not just isolated do-it-yourself activities of an individual; instead, people build on one another's creations and further share their own.

Recognizing the positive potential of user-driven design, this work endeavored to understand the underlying drivers of open source creation and essential environmental elements. The most important element is the commons, or shared resources, of the communities where the activities take place. A model of commons-oriented information syntheses was formulated. The model provides a unifying description of user-driven creation activities and, more importantly, serves as a general prescription for how to construct a circumstance to recreate the phenomenon for desired applications. Key aspects of the model include: that, in this particular form of information synthesis, the processes of information creating, participating in a community, and sharing of information take place integrally; that the three processes revolve around the commons; and that people consider the prospective benefits and costs of all three processes when they decide on whether or not to engage in a synthesis activity.

This understanding can be employed to build circumstances under which the phenomenon can be recreated. The ability to recreate the phenomenon of user-driven creation activities can be beneficial in many areas, including design and knowledge transfer. In the design area, the understanding can be used to build an environment that induces and fosters open-source design. With such environment, people can design things for themselves by reusing, remixing, and building on designs shared by others. They can also freely make available their own designs, which can continue to evolve through a series of building-on processes by others. In the knowledge transfer area, the understanding can be a key to constructing an environment that not only supports transfer of knowledge, but also enables people to further generate knowledge by building on what they receive, particularly when the transferred knowledge is in meta-forms such simulation models. Possible applications include:

engineering education (where students can connect models of fundamental topics in various ways to create simulations of complex systems and learn from them), sustainable development (where citizens can integrate models of potential environmental remedies to figure out which solution mix will be the most effective in their situations), and academic communities (where researchers can share and allow their colleagues to reuse or build on simulation models from which the results they publish in journal papers are derived).

A prototypical online environment was designed and implemented, employing the essential elements outlined in the model. Hosting a commons of environmental and energy-related simulation models, the environment functions as an open-source design environment for alternative energy systems and a public platform for generative transfers of environmental knowledge. Anyone can freely access the commons, build on them to synthesize new simulation models, and further share their synthesized models as new commons.

Thesis Supervisor: David Wallace
Title: Associate Professor

To my family

แด่ พ่อ แม่ กิ่ง แก่ และ ต๊อป

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1

Introduction

Motivation, what this work is about, and outline of the dissertation

1.1 Motivation

Creation activities by non-experts have become increasingly common. The growth of creation activities is evident in two major areas: product development and the World-Wide Web. In product development, a growing number of lead users innovate products to get precisely what they want[1] (E. von Hippel, 2005). They create designs and prototypes of the products by themselves. Examples of user-innovated products include high-performance windsurfing equipment (Shah, 2000), printed circuit CAD software (Urban & von Hippel, 1988), library information systems (Morrison, Roberts, & von Hippel, 2000), extreme sporting equipment (Franke & Shah, 2003), surgical equipment (Lüthje, 2003), free/open source software in general (e.g. those at SourceForge[2]), Apache server software (Franke & von Hippel, 2003), and kitesurfing equipment (E. von Hippel, 2005). Examples range from hardware to software, and from consumer to industrial products.

On the Web, more and more people, including common people, create and freely share multimedia content with one another. Many create and share home videos on YouTube (YouTube LLC, 2007). Many share their knowledge by collaboratively authoring articles in Wikipedia, a free content encyclopedia (Wikipedia contributors, 2007c). Many compose, record, and freely share music on ccMixter (Creative Commons, 2007b). Many also write blogs (or Web logs) (H. Jenkins, 2006b), broadcast their bookmarks on del.icio.us (del.icio.us team, 2007), rate products on Amazon.com (Amazon.com Inc., 2007b), and share photos on Flickr (Yahoo! Inc., 2007a). Web content creation activities, especially by common people, have increased fast and gained much attention in the past couple years. Time magazine named "you" as the 2006 person of the year, for being one of millions of people who participate and create on a scale never seen before (Grossman, 2006b).

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[1] Lead users are users who tend to be ahead of market trends, as other users in the same markets are likely to later experience the needs that the lead users have. Lead users typically expect high benefit from having their specific needs satisfied (E. von Hippel, 2005).

[2] http://sourceforge.net/

Creation activities by non-experts, both in product development and on the Web, defy the conventional conception that non-experts are merely users or members of a passive audience. Most creation activities are to be done by experts, or "the pros", only. Products are to be designed by professional designers and produced by commercial manufacturers. Web pages are to be created only by design firms or computer geeks. Not that long ago, the notion that the "passive audience" would become active creators and contributors on the Web was still highly doubted, especially by the media—including even Time magazine (Kelly, 2005).

Today, however, creation activities have spread beyond the conventional experts. In product development, the design has grown from traditional manufacturers to include lead users (E. von Hippel, 2005). On the Web, the spread has gone further: from experts, to lead users, *and* to common people. For example, Web page creation activities have spread from professional design firms, to people who have Web authoring program like Dreamweaver, to everyday bloggers. This latest development on the Web is often referred to as *Web 2.0,* signifying a new era of the Web[3].

Content creation by common people in Web 2.0 is especially interesting, not only because it reflects the change of roles of common people from passive audience members to active creators, but also because it is often done without any substantive incentives. Most Web 2.0 activities, such as those in Wikipedia, ccMixter, YouTube, etc., provide no financial return to the participants.

So, what drives these non-experts to engage in creation activities? What motivates the "passive" audience and users to take on the roles of creators and contributors? Why has the spread of creation activities reached common people in Web 2.0 but has yet to do so in mainstream product design? Can the essences of those phenomena be identified and understood? If so, can the understanding help recreate the circumstances in which creation activities by non-experts thrive, particularly in product design? What benefits could potentially come from recreating such circumstances?

1.2 About This Work

This work surveys and analyzes creation activities by non-experts in the areas of product development and Web 2.0. The following environments are covered: BitTorrent, Wikipedia, blogs, YouTube, del.icio.us, Flickr, ccMixter, Amazon recommendations, Slashdot, and Friendster (in the Web 2.0 area); free/open source software development, Apache, and

3 Different people have given different interpretations to the term "Web 2.0" and used it in different contexts. Some use the term to refer to the type of computer services used in a new generation of Web sites that support content creation and participation by users (Schauer, 2005). Other people use it to refer to a new business model for Web-based companies, aiming to capitalize on the new-Web phenomenon (O'Reilly, 2005). In general, "Web 2.0" refers to a massive social revolution on the Web (Grossman, 2006b).

kitesurfing equipment (in the product development area). The survey comprises literature reviews and direct experience with the individual environments.

This survey and analysis are used to identify key activities, participants, norms, incentives, and other relevant settings of the individual environments. The analysis is also intended to determine the nature of all components in the activities. The results of the analysis show that the creation activities by non-experts, in both product design and Web 2.0 areas, share many similar traits.

This work then draws upon these results to formulate a model of commons-oriented information synthesis (COIS). The model describes a special kind of information synthesis, which revolves around common resources. In this special kind of information synthesis, people do not only engage in the creation of information; rather, they also engage in the processes of participation and publication. In other words, the engagers do not perform just the act of information creation. They also participate in a community and make available the information that they have created. All three processes are integral and oriented around commons. These commons are different from typical commons, as an individual's use of the commons does not decrease the benefits available to others. Rather, a common's use can potentially result in an increase of the value available to others.

It is then proposed that all three processes' prospective benefits and costs, mostly in non-monetary forms, are essentially factors that integrally influence people's decisions of whether or not to engage in synthesis or creation activities in the commons. In other words, people are not only attracted by the potential outcomes of the creation process. Potential benefits from the participation or publication processes can also be reasons that draw people to engage from the get-go.

Fifteen prospective benefits and costs are identified and included in the COIS model. In addition, this work also identifies four mechanisms that can influence how people perceive the prospective benefits and costs of COIS. Deployed in most environments, the perception-influencing mechanisms often help highlight various benefits and eliminate or make some costs less of a concern.

The model provides insights into what constitutes COIS, how COIS functions and is sustained, and what COIS entails. These insights are useful for recreating environments that can induce and sustain COIS activities. Such environments could be applied in areas such as design and knowledge transfer. In the design area, COIS environments could foster open-source design practices, in which people design things for themselves by reusing, remixing, and building on designs shared by others. Also, people would be able to freely make available their own designs and let them continue to evolve through a series of building-on processes by others. In the knowledge transfer area, COIS environments could not only support transfers of knowledge, but also enable people to further generate knowledge by building on what they receive, particularly when the transferred knowledge is in meta-forms like simulation models. Such generative knowledge transfer can be used in many applications, including engineering education, sustainable development, and academic communities. In a COIS environment for engineering education, students can connect models of fundamental topics in various ways to create simulations of complex systems and learn from them. As part of sustainable development processes, citizens can integrate models of potential environmental remedies to figure out which solution mixes might be the most effective in their situations. In academic communities, researchers can share and allow their colleagues to reuse or build on simulation models from which the results they publish in journal papers are derived.

Finally, this work includes the design and implementation of a prototypical COIS environment, called PEMS Web. PEMS Web is a Web environment with common resources of environmental information, in forms of multimedia and simulation models. PEMS Web helps test the feasibility of creating an environment to foster commons-oriented syntheses of information. It also helps illustrate the applications of COIS in the abovementioned potential areas. Furthermore, PEMS Web is a functioning environmental information system. It can facilitate syntheses and dissemination of dynamic environmental knowledge among academia, local communities, and the general public. In addition, with commons of environmental and energy-related simulation models, PEMS Web functions as an open-source design environment for alternative energy systems.

1.3 Dissertation Outline

In the chapter 2, *Background: Creation Activities by Non-Experts,* examples of creation activities by non-experts are provided in more detail, both from the areas of product development and Web 2.0. Then, a literature review is provided. The review looks at existing studies of what motivates creation activities by non-experts. After that, the chapter's last section describes universal traits that can be observed in non-expert creation activities.

The *Commons-Oriented Information Synthesis Model* chapter focuses on the COIS model. First, the model's core definition is provided. Key components of the model are also explained. The following section then examines various creation activities by non-experts in terms of the COIS model. A total of eighteen environments are examined. For each one, the nature of different components and how they fit the COIS model are discussed. The third section explains the distinction between commons-oriented information synthesis and creation activities by non-experts. Many examples are given to help illustrate how to determine whether a creation activity by non-experts should be considered COIS. The last section discusses existing work that is related to the COIS model.

The *Prospective Benefits and Costs of Commons-Oriented Information Synthesis* chapter focuses on another important component of the COIS model. The first section describes fifteen benefit and cost factors of COIS. Each factor's role in various environments of non-expert creation activities is also explained. The next section describes four perception-influencing mechanisms. For each mechanism, its influences on the benefit and cost factors of COIS are also discussed. In addition, examples of how each mechanism influences the perception of the benefit and cost factors of COIS in different environments are also given. The influences of the mechanisms are then summarized from a different viewpoint. That is, each of the fifteen benefit and cost factors of COIS is discussed in terms of how it is influenced by the mechanisms. Then, the final section of the chapter explains why common people do not often engage in creation activities in the product development area.

The following chapter, *Potential Applications of Commons-Oriented Information Synthesis,* focuses on the COIS model's implications in the areas of i) information synthesis by common people, ii) knowledge diffusion, and iii) design development and concept exploration. For each area, a background is given. Then, potential applications of COIS in the area are described. A hypothetical scenario is also painted to help visualize each application of COIS. Additionally, the use of simulation models as information representations is discussed.

Next is the *Prototypical Environment* chapter. The first section discusses the objectives of designing and implementing a prototypical COIS environment. Then, PEMS Web, a prototypical COIS environment, is introduced, and its overall functionalities are described. A background on existing public environmental information is also provided. The next part of the chapter focuses on how PEMS Web addresses the necessary functionalities of a COIS environment. Each functionality is discussed in terms of why it is important, what part of PEMS Web is designed to deliver the functionality, how that part is designed and implemented, and why it is done that way. In addition, detailed example use scenarios are provided, in order to explain how users would interact with the different parts of PEMS Web and what goes on behind the scenes at the same time. Finally, the last section explains how the prospective benefits and costs of COIS and the perception-influencing mechanisms are considered in the design of PEMS Web.

The final chapter, *Conclusions,* gives an overall summary of the thesis. Short descriptions of future work are then provided. Finally, the thesis's contributions are summarized.

2

Background: Creation Activities by Non-Experts

Descriptions of examples, a review of existing studies, and observed universal traits of creation activities by non-experts

2.1 Examples of Creation Activities by Non-Experts

Recently, creation activities by non-experts have emerged in two major areas: product development and Web 2.0. In product development, more and more lead users design products to get precisely what they want by themselves. In Web 2.0, a growing number of common people generate their own multimedia content. In both areas, the non-experts often share what they have created with one another. They also often remix and build upon one another's shared works.

2.1.1 Product Development

The book *Democratizing Innovation* (E. von Hippel, 2005) offers extensive coverage of studies of user-led product innovations. The studies show that most of the non-experts who engage in creation activities in product development are lead users.

Depending on their needs, lead users can innovate both industrial and consumer products. The lead users create designs of the products they need and often implement prototypes of the designs. Examples of the user-innovated industrial products include free/open source software (e.g. Apache), library information systems, and hospital surgical equipment.

In free/open source software (F/OSS) development, people write code to create software that they need (in most cases, individually), freely give and exchange the code and software they have written, modify or build upon the shared code of one another, and further share the modifications. Although the practice of F/OSS development started as early as the 1960s, it gained much attention in recent years (Mockus, T Fielding, & D Herbsleb, 2002; E. von Hippel & von Krogh, 2003). Currently, SourceForge.net, an online platform that provides infrastructure for F/OSS projects, has a repository of over 160,000 projects and over 1,700,000 registered users (SourceForge Inc., 2007d). The people who engage in creation activities of F/OSS are typically lead users with computer programming skills. Nonetheless, people without programming skills also take part in the F/OSS movement by downloading and using the freely shared software.

One of the most popular open source software applications is Apache HTTP server. It started as a one person's effort in 1995[4]. Since then, a number of individual programmers have contributed to its development (The Apache Software Foundation, 2007). Apache is now used by over 50% of Web servers worldwide and has been the most popular Web server since 1996 (Netcraft LTD, 2007).

Another example of creation activities by non-experts in product development is given in a study of user-led innovation in Australian libraries (Morrison et al., 2000). The study surveyed the use of commercial computerized information search systems in 102 libraries in Australia. It found that 26 percent of the libraries had modified the hardware and software of the search systems beyond the user-configurations capabilities provided by the manufacturers. Examples of modifications that the library made include integrated images in records and added book retrieval instructions for staff and patrons, in the case where books were stored in complex ways across multiple buildings.

Surgical equipment yet is another example of industrial products whose innovations often result from creation activities by practitioners who are non-expert designers. A study of innovations by surgeons in Germany found that over 20 percent of respondents had developed or improved upon medical equipment for use in their own practices (Lüthje, 2003).

Moreover, non-experts also engage in creation activities of consumer products. Examples of user-innovated consumer products are various kinds of extreme sporting equipment. A study focused on four different extreme sports in Germany, including canyoning (combined mountain climbing, abseiling, and swimming in canyons), sailplaning (flying in a closed, engineless glider), boardercross (downhill snowboarding race with tunnels, steep curves, water holes, and jumps), and cycling with significant handicaps (such as cerebral palsy or an amputated limb) (Franke & Shah, 2003). The study found that over 30 percent of the respondents have developed or modified equipment that they used in their sport. Examples of innovations included a rocket-assisted emergency ejection system for sailplaning, improved boots and binding for boardercross, and a specialized way to cut loose a trapped rope in canyoning. The creation activities mostly took place in the communities of the extreme sport players.

Kitesurfers also engage in developing and improving activities of their equipment (E. von Hippel, 2005). In kitesurfing, the user stands on a special surfboard and is pulled along by a

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[4] By Rob McCool at the National Center for Supercomputing Applications, University of Illinois, Urbana-Champaign (The Apache Software Foundation, 2007)

large, steerable kite. Kitesurfers develop both techniques and equipment. They share designs and building plans with one another through a Web site. They also give advice to novices and help improve one another's designs.

The abovementioned creation activities by non-experts in product development are just examples of activities that were studied and published in academic literature. Many more similar activities exist and have recently received attention in the popular media. For instance, the New York Times Magazine recently published a feature article about an "amateur" who designed space glove technology, to be adopted by NASA, and other space-related creation activities by non-experts (Hitt, 2007).

2.1.2 Web 2.0

As part of Web 2.0, a large number of people participate in online creation activities. They create and freely share multimedia content. A recent survey of 1,600 Americans shows that 38 percent of respondents want to create and share content online (Garfield, 2006). People not only create; they reuse and build upon one another's work, and then freely share the remixes further. The multimedia contents that they create are in all forms: texts, pictures, music, and videos. Often, the creation activities also result in something beyond multimedia materials, like social connections and wisdom of the crowds. The boom of Web 2.0 creation activities by non-experts recently received major recognition from the media when Time magazine named "you", the non-experts, the 2006 person of the year (Grossman, 2006b).

Wikipedia, an online free content encyclopedia, is one of the biggest sites of creation activities by non-experts on the Web. Articles in Wikipedia are collaboratively written. Anyone, as opposed to the experts (i.e. professional encyclopedia producers), can contribute. People can edit any existing article or start a new one. They can also cross-reference other related Wikipedia articles, to reuse what other people have already said, instead of having to fully explain the already written topics. Because Wikipedia is collaboratively written without a formal review process, some people question the accuracy of the articles (Denning, Horning, Parnas, & Weinstein, 2005). Nonetheless, the articles whose accuracy is questionable typically deal with current events or highly divisive topics (Suzor & Fitzgerald, 2007). Most articles are neutral and cover existing knowledge (Wikipedia contributors, 2007c). A study by Nature found that Wikipedia came close to Britannica in terms of the accuracy of its science entries (Giles, 2005). As articles get reviewed and edited by more people, the articles' qualities improve (Suzor & Fitzgerald, 2007). As of December 2007, there are over 9 million articles in Wikipedia, with over 75,000 people actively contributing (Wikipedia contributors, 2007c).

Many people also blog, or write Web logs. Blogs are Web sites with journal-style entries. Blogs are free to create and easy to use. Anyone can sign up for a free blog and start writing within minutes, without having to know how to create a Web page (Google, 2007). Blogs are more dynamic than old-style personal Web pages, more permanent than posts to bulletin boards, more personal than traditional journalism, and more public than diaries (H. Jenkins, 2002). People blog, or write blogs, for various reasons: to document life, to provide commentary or opinion, to express deeply felt emotions, to articulate ideas through writing, or to form and maintain a forum (Nardi, Schiano, Gumbrecht, & Swartz, 2004). Active bloggers update their blogs by adding new entries several times a day. Currently, there exist well over 100 million blogs, with over 1.6 million new entries per day (or over 18 new entries every second) (Technorati Inc., 2007).

YouTube is another popular destination for creation activities by non-experts on the Web. People can share videos on YouTube for free. The videos that people share on YouTube are often home videos that they shot, animations or movies that they produced, or clips of TV shows that they have captured. According the founder of YouTube, "everyone, in the back of his mind, wants to be a star, and [YouTube] provide the audience to make it happen" (Garfield, 2006). YouTube has a large audience (over 100 million video streams a day) and large incoming supplies (more than 65,000 videos are uploaded everyday) (Garfield, 2006). In a way, YouTube is more than just a media-sharing platform. It provides a "shared cultural context" (H. Jenkins, 2006a). People go to YouTube to share with others what they have created and to see what others are seeing and enjoying.

A popular site of creation activities of music by non-experts is ccMixter. It is a community music-remixing site. Participants of ccMixter are mostly musicians and remix artists[5]. The participants can upload audio files of the music that they have composed or performed to ccMixter. The uploaded music is then part of the community's shared common resources. Anyone can freely listen to, sample, or mash-up any music files shared on ccMixter (Creative Commons, 2007b). Many participants remix several music tracks shared by others to create a new piece. The participants also often "reinterpret" others' works, by rerecording, remixing, or reperforming the shared music in their own styles (Suzor & Fitzgerald, 2007). The results of remixes or reinterpretations are also often shared back to the community. A particularly good piece of music created and shared by one participant can often inspire many others to create. For example, a vocal track *September* created by *calendargirl* has inspired more than twenty remixes or reinterpretations by other participants (Creative Commons, 2007c).

In addition to the environments mentioned above, other examples of sites of creation activities by non-experts on the Web include: BitTorrent, del.icio.us, Flickr, Amazon recommendations, Slashdot, and Friendster. The creation activities by non-experts in those environments are described and discussed in subsequent chapters.

The magnitude of the Web 2.0 creation activities by non-experts is enormous. The magnitude of the audience of the content created and shared on the Web is gigantic as well. People in the third millennium are willing to sift through millions of pieces of content created and shared by strangers to discover a few gems (Garfield, 2006). What makes the

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[5] The participants of ccMixter can be considered as non-experts in this context, as they are not conventionally professional music producers.

activities even more intriguing is that the non-experts, especially the common people, both the creators and the viewers, engage in the activities in spite of no financial incentives.

2.2 Literature Review: Studies of Creation Activities by Non-Experts

2.2.1 Product Development

There have been many studies of creation activities by non-experts in the area of product development (Franke & Shah, 2003; Franke & von Hippel, 2003; Herstatt & von Hippel, 1992; Lüthje, Herstatt, & von Hippel, 2002; Lüthje, 2003; Lüthje, 2004; Morrison et al., 2000; Urban & von Hippel, 1988). Most studies report evidence of user-led development and modification of products. In *Democratizing Innovation*, von Hippel (2005) describes those activities in a broader scope and discusses the overall area of product innovations by lead users.

The studies, especially by von Hippel (2005), reveal why many users try to get what they want by designing it for themselves. In short, users' needs for products are heterogeneous. Their needs cannot always be satisfied by manufacturers' "a few sizes fit all" strategy of developing products. Consequently, many users want custom products. Even though some users are willing to pay for the development of products that fit precisely what they want, they might decide to engage in the development by themselves, rather than hiring custom manufactures to do it for them. That is because when users develop their own custom products, they can trust that they act in their own best interests. In contrast, when users hire custom manufacturers, the situations can be more complicated if the interests of the two parties diverge. On the one hand, the users want to get precisely what they need. On the other hand, the custom manufacturers want to lower their costs by using solutions that they already have in their domains, even if that might not preserve their clients needs as well as they could. So, when only one or a few users want something special, they will likely get the best results by innovating for themselves when they can afford to do so. The latest improvements in computer and communications technologies play a major role in enabling users to innovate products for themselves. In addition, many users are also attracted to the problem-solving aspects of innovation processes.

Furthermore, many studies found that the users who innovate product solutions for themselves also tend to freely reveal their innovations to others (Allen, 1979; Franke & Shah, 2003; Henkel, 2003; Lim, 2000; Morrison et al., 2000; Nuvolari, 2004). The users freely reveal their innovations because it is often the best or the only practical option to them (E. von Hippel, 2005). Many other people know of similar solutions that can achieve the same functionalities, so keeping an innovation a trade secret cannot be successful for long. Freely revealing can also benefit the innovating users. By freely revealing what they have done, the users can receive suggestions or help to improve the products. They can also receive enhancement of reputation. Moreover, a product that is the first of its kind can potentially eventually become an informal standard after having been adopted by many people. In brief, it is deemed that freely revealing is a practical follow-up after innovation.

Additionally, studies also found that some innovating users join together in communities (Franke & Shah, 2003; E. von Hippel, 2005). They do so because the communities can provide them useful structures and tools for their interaction and for the distribution of innovations, and also because they can get assistance from one another. Essentially, it is deemed that the users who want to innovate products for themselves may also join an innovation community in order to enhance their innovation processes.

2.2.2 Web 2.0

Many studies, both academic and nonacademic, have identified key attributes of creation activities in Web 2.0 (Bruns, 2007; O'Reilly, 2005; Schauer, 2005). The attributes can be categorized into two groups: characteristics of the Web 2.0 participants, and features of the Web 2.0 environments. The key characteristics of the participants include: playing dual roles of both users and producers; creating content by remixing; and experiencing services on their own terms, not those of the authorities. Key features of Web 2.0 environments include: serving the long tail (the users with narrow niches) as well as the average; gathering values contributed by users; harnessing the wisdom of the crowds; providing network effects (the sites' values increase with more people joining); being a perpetual beta with ongoing updates of services; serving reusability and remixability (offering service interfaces and content syndication, and reusing data services of others).

In addition to broadly describing attributes of Web 2.0 activities, some studies also suggest ways for business to capitalize on the ongoing Web 2.0 activities (Bruns, 2007; O'Reilly, 2005).

There are also studies that analyze specific environments. For example, one study looks at the dynamics of social networking sites (Leonard, 2003). Another studies Wikipedia contributors in order to determine their motivation (Nov, 2007). Some analyze why bloggers blog (Efimova & de Moor, 2005; Nardi et al., 2004). Others look at the participation in YouTube (Garfield, 2006; Rose, 2006). Another describes the advantages of Amazon.com recommendations (Linden, Smith, & York, 2003). And, another analyzes social bookmarking tools like del.icio.us and Flickr (Hammond, Hannay, Lund, & Scott, 2005).

Outside of the abovementioned studies, there has yet been a study that analyzes content creation in Web 2.0 holistically, such as what motivates people to engage in Web 2.0 activities. One could propose that the spread of creation activities to common users in Web 2.0 is just a matter of technology transfer. It is true that improved technologies can assist common people in content creations that they may not have been able to do before. However, the availability or affordability of technologies may not be the sole driver of content creation by common people in Web 2.0. Consider, for example, when What-You-

See-Is-What-You-Get Web page editors like Netscape Composer or Dreamweaver became available, giving anyone, not just HTML gurus, capability to create their own Web pages. Inspite of these tools, only few common users created content. It usually takes more than just an affordable and easy-to-use technology to attract common people.

2.3 Observed Traits in Creation Activities by Non-Experts

Product development and Web 2.0 are two different domains. The characteristics of non-experts who engage in creation activities in each domain are also quite different. In product development, most non-expert creators are lead users[6]. In Web 2.0, non-expert creators consist of both lead users and common people.

Despite the differences in domains and characteristics of the participants, creation activities by non-experts in Web 2.0 and several in product development share many similar traits. The shared traits are especially strong in the following environments: BitTorrent, Wikipedia, blogs, YouTube, del.icio.us, Flickr, ccMixter, Amazon recommendations, Slashdot, Friendster, free/open source software development, Apache, and kitesurfing equipment.

One key shared trait is: the essence of creation activities is *information.* The nature of the act of "creation" by non-experts is creation *of information.* Thus, creation activities by non-experts can be described as a form of information creation, or *information synthesis.* When non-experts engage in creation activities, in either product development or Web 2.0 domains, they essentially engage in processes of information synthesis.

In product development, the essence of creation activities is *design information.* When lead users innovate products, design information such as design ideas, concepts, sketches, models, and prototypes are synthesized. In Web 2.0, the essence is *multimedia information.* When common people take part in Web 2.0 creation activities, various forms of multimedia information, including texts, videos, images, and audio, are synthesized.

Another key shared trait is: creation activities by non-experts take place in a context that consists of a *community* and shared resources, or *commons.* A community of non-experts may be well structured, such as Sourceforge.net, an online community in which lead users develop open source software products. It may also be totally unstructured, such as the blogosphere, the universe of blogs on the Internet.

Commons are the shared resources of a community and play a central role in creation activities. In most cases, commons are information synthesized and shared by members of the community. For example, commons in ccMixter are music samples. In an open source software community, commons are codes and software programs. In some cases, commons are abstract. Abstract commons may not be directly utilizable as synthesis ingredients but are

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[6] The lead users, such as software hackers or extreme sport players, often have expertise in their areas, but can still be considered "non-experts" with regard to product development.

nevertheless crucial. For instance, the shared cultural context and audience base of YouTube are abstract yet crucial commons of the community. They are arguably the most important forces that drive people to engage in YouTube's creation activities.

The commons involved in creation activities by non-expert are different from the typical notion of commons. In the typical notion of commons, commons can be depleted or polluted by over-usage, so any individual's use of commons detracts from the benefits available to others. Also, while each individual fully gains benefits from his or her personal use the commons, the ensuing costs (e.g. the diminishing or polluting of the commons) are shared among all parties, often resulting in socially tragic overuse of the commons (Hardin, 1968). On the contrary, in the case of creation activities by non-experts, an individual's use of commons does not decrease the benefits available to others. Rather, in many cases an individual's use of commons even results in an increase of the value available to others.

Another key trait of non-expert creation activities is the norm of *sharing, reusing,* and *building upon* commons. It is customary for participants to share their creations, making them available to others as commons. An example is how kitesurfers make their new equipment designs available as commons for others. It is also customary that members of a community reuse the shared commons or build upon them to synthesize new information for their own applications. Examples of reusing, remixing, and building upon of commons are observable in open source software development and ccMixter.

As the notions of communities, commons, and norms of sharing, reusing, and building upon commons suggest, *creation activities by non-experts are not about creation only. Participation* in communities and *publication* of synthesized information are also key activities that go along with *creation.* Users of ccMixter do not simply create music (as an act of creation). They also participate in the ccMixter community (as an act of participation) and make their music available to others (as an act of publication).

The coexistence of creation, participation, and publication activities by non-experts is recognized in the literature, especially in the area of lead-user innovation (E. von Hippel, 2005). Nonetheless, the three areas are viewed as separate processes. Creation is regarded as the main activity that attracts non-experts. Participation is regarded as an enhancer of creation. Publication is regarded as a low-cost, logical follow-up after creation. In other words, only the outcomes of creation are viewed as the reason that draws non-experts to engage in creation activities.

However, this survey of creation activities by non-experts finds that, in many cases, the activities of creation, publication, and participation are *integral processes.* Non-experts often value publication as more than a low-cost, logical follow-up after creation. Likewise, participation is often more valuable than being an addition to enhance creation. Prospective benefits from creation are not the only reason that draws non-experts to engage in creation activities. Prospective benefits from publication or participation could be enticing reasons as well. In other words, creation activities by non-experts are often more than just Do-It-

Yourself (DIY) activities. They are also social connections through which people communicate, relate, and express themselves to one another.

In many areas, non-experts are attracted by the *combined prospects of benefits from creation, participation, and publication*. For example, people take part in activities in ccMixter not only because they want to remix music. Rather, they are drawn by the prospects of being part of a community of remixers and other musical talents, getting inspired by the works of others, reusing and building upon music that others have shared, being able to share newly synthesized music with the community, and getting feedback from others (Suzor & Fitzgerald, 2007).

2.4 Chapter Summary

This chapter provided examples of creation activities by non-experts in the areas of product development and Web 2.0. Then, a literature review was provided. The review looked at existing studies of what motivates creation activities by non-experts. Finally, the last section described universal traits that can be observed in non-expert creation activities, including:

- Information is the essence of the activities. For product development, the essence is design information; and for Web 2.0, multimedia information.
- When non-experts create in this context, they essentially synthesize information.
- The activities take place in communities with commons, of different structures and forms.
- The communities have norms of sharing, reusing, and building upon commons.
- Non-experts engage in creation, participation, and publication activities, as integral processes.
- Prospective outcomes from creation are not the only reasons why non-experts engage in the activities. Rather, the non-experts are attracted by combined prospective benefits from the integral processes of creation, participation, and publication.
- The integral processes of creation, participation, and publication, as well as the norms of the communities, all revolve around the shared commons.

The next chapter describes how this work uses these traits as bases for formulating a model of creation activities by non-experts.

3

Commons-Oriented Information Synthesis Model

Definition, analysis of commons-oriented creation activities by non-experts, distinction from general creation activities by non-experts, and related work

Many key traits are observable in creation activities by non-experts. These traits are components that make up the pattern of creation activities by non-experts. Based on these components, a model can be formulated to describe general creation activities by non-experts and similar activities. Such a model could:

- Serve as a unified way to describe non-expert creation activities in multiple domains and other similar activities
- Give insights into how people, especially non-experts, are drawn to engage in creation activities, and how the activities are fostered and sustained
- Potentially be used as a recipe for recreating a circumstance to support creation activities, especially by non-experts, similar to creation activities by non-experts in Web 2.0 and product development.

3.1 Definition of the Model

This work proposes a model of *commons-oriented information synthesis* ("COIS").

3.1.1 Core Definition

The act of information creation (creation) is *information synthesis.* In a particular form of information synthesis, creation does not occur alone, but rather *in integral* with the acts of participation in a community (participation) and publication of information (publication). The creation, participation, and publication processes are integral in the way that they are interconnected and have equal significance. To the engagers in this special form of information synthesis, creation is not the sole mission, and participation and publication are more than just supplements to creation. In other words, the engagers do not just create. Instead, they engage in creation, participation, and publication as a whole.

This particular form of information synthesis is described as *commons-oriented* information synthesis ("COIS") because the integral processes of creation, participation, and publication all revolve around the community's shared resources, or *commons*. With respect to creation, the commons are utilized as part of the process or, in some cases, used to support the outcomes of the process. Access to the commons is a direct benefit of participation. Through publication, new commons emerge.

Given that creation, participation, and publication are perceivable as integral processes, *prospective benefits* from all three processes, not just creation, can be factors that attract people to engage in COIS. In addition to the benefits, *potential costs* associated with any of the three processes are also important factors, as they can deter people from engaging in COIS. In other words, the prospective benefits and costs of all three integral processes collectively constitute overall prospective benefits and costs of COIS. People consider the overall prospective benefits and costs when they decide on whether or not to engage in COIS.

Norms and the settings of each community can play a role in how different prospective benefits and costs of COIS are perceived. Most communities in which COIS takes place have *norms of sharing, reusing, and building upon commons.*

Engagers of COIS value not only the end results but also the processes. COIS is about creations as much as social relations, communications, expressions, and experiences.

3.1.2 COIS and Creation Activities by Non-Experts

Creation activities by non-experts that are commons-oriented are describable as a type of COIS. In the product development domain, these activities are describable as *commons-oriented design synthesis*. Similarly, the activities in Web 2.0 are describable as *commons-oriented multimedia synthesis.*

Engagers in non-expert creation activities in Web 2.0 and product development are primarily, as the terminology indicates, non-experts. On the other hand, engagers in COIS can be anyone, not limited to just non-experts.

Although the examples of selected creation activities by non-experts mentioned here and in the Background chapter are COIS, not all activities by non-experts are describable as COIS. Creation activities by non-experts that do not involve commons, by definition, are not COIS. For example, a lead user's independent innovation of a product is not COIS. Criteria for distinguishing between what is and is not COIS are discussed in details later in section 3.3.

3.1.3 Further Explanations of the Model's Components

Information

Information can be in various forms. For instance, in product development, the essential type of information is design information, such as design ideas, concepts, sketches, models, and prototypes. In Web 2.0, the essential type of information is multimedia information, such as texts, audio, images, and videos.

Creation (or Synthesis)

Information synthesis is synonymous with information creation. It can be original creation (from scratch), creation by combining existing information components, or creation by building upon or modifying existing information. Outcomes of information synthesis are *newly synthesized information.*

Participation

The act of participation in a community includes being part of the community, interacting with other community members, and gaining access to the community's commons. The nature of participation, including the intensity and how to participate, depends on the community's structure.

Publication

Through the act of publication, people share the information they have created with a community as commons. Publication may be done voluntarily or as required by the community's structure.

Commons

Commons are shared resources of a community in which information synthesis takes place. Commons can be *concrete*, in forms of information such as design sketches, CAD models, simulations, texts, pictures, etc. They can also be *abstract*, like a shared audience or the cultural context of the community.

Commons are often in reusable forms. Consequently, an individual's use of commons does not decrease, but rather potentially increases, the benefits available to others.

Commons-Oriented

Commons play crucial roles in commons-oriented information synthesis. All three integral processes revolve around commons. Participation allows people to access and utilize commons. Through publication, people keep commons growing. In connection with creation, commons can be utilized *as part of a creation process*, in the following ways:

- *Key ingredients:* commons are put together, generally as is, to create new information. Often, information that is not part the commons is used as additional ingredients. File segments in BitTorrent are examples of commons that are used as ingredients for synthesizing new information. Other examples include music samples in ccMixter, software functions in open source software development, and designs of various kite components.
- *Starting points:* commons are modified or built upon to create new information. For example, a video in YouTube could be built upon to create a new one. Apache Web server code is modified to create a new version of the same software. Other examples of commons that are often modified or built upon are songs in ccMixter, open source software programs, and kite designs.
- *Guides or references:* commons provide guidance, reference, or inspiration for creating new information. Commons that are utilized for creation in this way are usually not part of the final, newly synthesized information. Use of commons as guidance, reference, or inspiration is evident in almost all communities.

In some cases, commons are utilized *after a creation process*:

- *Supplementing functions:* commons supplement or work in conjunction with the newly synthesized information. The functionalities or services provided by the commons are added to those of the newly synthesized information. For example, existing Wikipedia articles are commons that can supplement a newly written article by providing explanations for different parts of the new article. Other examples of commons that serve as supplementing functions to newly synthesized information are blogs in blogosphere and networks of friends and acquaintances in Friendster.
- *Multiplying functions:* commons and the newly synthesized information fuse their functionalities to give rise to a new functionality that is greater than just the individual functionalities combined. This is different from the case of commons as supplementing functions, where the functionalities of the commons only add up. Shared bookmarks in del.icio.us are examples of commons that work as multiplying functions. Each bookmark has tags that identify it. In del.icio.us, all the bookmarks do not just add up to a collection of independent bookmarks. Rather, they form a database of interconnected, tag-indexed bookmarks. A tag originally intended for identifying a particular bookmark can also lead a user to find other bookmarks in del.icio.us that could be identified by that tag as well.
- *Cultural context:* a community can have a common cultural context to which the newly synthesized information can be shared. A common cultural context can be more than just a channel for delivering newly synthesized information to the target audience or users. Rather, a common cultural context can be a voice that represents "wisdom of crowds" (Surowiecki & Silverman, 2007). Through a common cultural context, a myriad of information is filtered and "noteworthy" information is amplified. For example, the blogosphere has a common cultural context of blogging, to which people can share their opinions, news, etc. A countless number of readers indirectly "sift though" a myriad of blogs in the blogosphere. The noteworthy blogs are then "amplified" by being cited or linked to in other blogs. Before long, selected and highly amplified information can be seen by virtually everyone on the Internet.

> Such wisdom of the crowds is often powerful and recognized by the society. Thus, a common cultural context can be a powerful "voice" for newly synthesized information. Such a voice is especially valuable for information in the form of media that typically involves audience, such as videos, music, photographs, articles, etc.

As suggested by the above discussion, commons in many communities can play multiple, crucial roles in COIS simultaneously.

Sharing, Reusing, and Building-upon Norms

Communities in which COIS takes place have norms of sharing, reusing, and building upon commons. The norm of sharing sets up expectations that people share their newly synthesized information as commons to the community. In some cases, sharing is considered giving back to the community, since resources used for synthesis are originally from the community's commons. The norm of reusing allows people to freely reuse information that other people have created and shared as commons. The norm of building upon information synthesized by others encourages people to synthesize new information by remixing commons.

The norms are established largely due to the presence of commons and the practice of a community's early participants. Because of the norms, commons of a community continuously grow in number. They also are frequently utilized, reviewed, and improved by many different people.

Prospective Benefits and Costs of COIS

The prospective benefits and costs play an important role in people's decisions of whether or not to engage in COIS. In Web 2.0 and product development, non-experts engage in creation activities, not because they are attracted by prospective outcomes of creation alone. Rather, they are drawn to prospective benefits from creation, participation, and publication combined. Similarly, the costs of creation, participation, and publication combined also have an influence on non-experts' decisions.

Benefits and costs of COIS may be purely qualitative and not necessary always measured in monetary terms. On the one hand, some prospective benefits and costs are easily recognizable, such as the benefit of potentially utilizable outcomes or the cost of required effort. On the other hand, other prospective benefits and costs are harder to recognize. Such subtle aspects of COIS can be more important than they seem. In particular, people may fail to notice subtle prospective benefits and, as a result, decide that engaging in COIS is not worth the obvious prospective costs. Thus, it is important to identify all prospective benefits and costs, both subtle and obvious, so that they can be properly avoided or brought to the attention of people.

This work identifies 15 prospective benefits and costs of COIS, listed below. All of them are discussed in detail in chapter 4.

- Personal use of synthesized information
- Joy of creating and other side benefits
- Required effort and resources for creation
- Commons of information resources and shared cultural context
- Social networking
- Community membership cost
- Potential help debugging or improving synthesized information
- Reputation from publication
- Joy of giving
- Advancement from making first publication
- Network Effects
- Transaction cost to publish synthesized information
- Loss of proprietary and privacy information
- Satisfied needs
- Being ahead of or in trends

3.2 Analysis of Selected Creation Activities by Non-Experts using COIS Model

This section analyzes creation activities by non-experts, in various environments, from the perspective of commons-oriented information synthesis. Non-expert creation activities from both Web 2.0 and product development domains are covered. For each case, the nature of the following components is determined:

- Essential information
- Community and its commons
- The acts of creation (or synthesis), participation, and publication
- Roles of commons in synthesis
- Outcomes of synthesis
- Engagers and their general goals for engaging in COIS
- Community's norms

This following analyses show how each of the selected activities can be considered COIS. The roles of each component of COIS in each activity are also discussed.

3.2.1 Web 2.0

BitTorrent

A note about BitTorrent

BitTorrent is a protocol for sharing files over the Internet. People primarily use BitTorrent to download or upload files. Downloading files via BitTorrent is faster than other protocols because portions (or "bits") of the desired files are downloaded from multiple sources simultaneously. The sources of the file bits are people who already have the whole or portions of the files and make them available over the Internet. When someone wants to download a file, she uses a Web link to connect to a "tracker" – a central server that keeps track of who on the BitTorrent network has which files. The tracker then gives her a "torrent", or a pointer file that tells her computer which other computers on the network have the file or portions of it. Multiple downloads of different portions of the file can then progress simultaneously. BitTorrent uses a "tit-for-tat" principle, to encourage people to share files in return. The more files a person shares with others, the faster she can download other files (Carmack, 2007).

Files are the essential information of COIS in BitTorrent. A "swarm" – a group of people whose computers are simultaneously uploading or downloading the same file – can be considered a community in this context. It is very informal and unstructured. A community's commons are the shared files and file bits. There is no central collection of commons; instead, individual members hold commons across a swarm.

The act of participation requires no formal enrollment. People can join a swarm at will. Participation, however, has a cost. That is, the requirement of a BitTorrent program, which manages download and upload traffic according to torrents given by the trackers.

To create, in a BitTorrent sense, is to synthesize files by downloading file bits from the commons and piecing them back together. Commons play a role during synthesis as key ingredients for creating new information. The synthesized products are new to the engagers, who possess the files for the first time after the synthesis, but are not novel to the society.

The act of publication occurs automatically in conjunction with creation. The synthesized information immediately goes through publication to become commons, as newly acquired file bits are instantly made available to other participants in the swarm.

Engagers in BitTorrent COIS are general Internet users, of any level of computer expertise, that download and share files heavily. Members of a community rarely interact at a personal level. People usually engage in BitTorrent COIS for their personal benefits: to download files. Some people do it primarily to share files, benefiting other people.

Norms of sharing, reusing, and building upon commons are present: in the way people share and reuse files within a swarm, and file portions from different people are summoned and built upon to create whole files. The sharing norm is held up in part by the "tit-for-tat" principle. In a way, the principle entails a cost of creation in terms of publication. (People have to share their own files to be able to download effectively). Nonetheless, the publication is not necessary of the newly synthesized information. (Sharing files downloaded from other torrents counts, too).

Wikipedia

A note about Wikipedia

Wikipedia is an online free content encyclopedia, written collaboratively by volunteers from around the world (Wikipedia contributors, 2007d). People can edit any existing articles or start new ones. Because of its collaborative authoring nature – without a formal review process, Wikipedia possesses risks in regard to the accuracy of the articles (Denning et al., 2005). Nonetheless, the articles whose accuracy is questionable or debatable are typically those dealing with current events or highly divisive topics (Suzor & Fitzgerald, 2007). Most articles are neutral and informative. It is observable that the best articles are the ones that have been reviewed and edited by a large number of people (Suzor & Fitzgerald, 2007). This observed nature of Wikipedia closely aligns with "Linus's Law", a principle of F/OSS development, which states "given enough eyeballs, all bugs are shallow" (Raymond, 2001). Given many people contributing to the same articles, any mistakes or inaccuracies are often quickly spotted. As of December 2007, Wikipedia has more than 2 million articles in English, with an average of over 16 edits per page (Wikipedia contributors, 2007b).

Articles, primarily consisting of texts and images, are the essential information of COIS in Wikipedia. The community of COIS comprises all Wikipedia contributors. Existing articles are the community's main commons. The commons in this case are centrally held at the Wikipedia Web site (http://wikipedia.org). Regular readers of Wikipedia are also commons of COIS in Wikipedia. They constitute a shared audience and cultural context.

To create in Wikipedia is to synthesize an article, either by editing an existing article or by writing a new one. Creation in Wikipedia can be commons-oriented in many ways. Existing articles can be used as starting points for a new article. Most articles contain links to other articles, often as a way to offer further description of a term or topic to readers without having to rewrite it. In that way, the commons (existing articles) serve as supplementing functions to the synthesized information (new articles). Additionally, the regular readers make up a shared cultural context to which newly synthesized articles can be delivered.

Anyone is free to participate. The act of participation in Wikipedia COIS is to become a contributor, which can be done by logging into the Web site and then editing an article. Participation is, thus, tightly coupled with creation. Similarly, publication is also tightly coupled with creation. The act of publication is to make newly synthesized articles available on the Web site. Publication is convenient as creation takes place at the site of the commons. While editing, contributors can "save changes" to keep the progress of the editing. Not only does saving keep the progress, it also automatically publishes the changes. Thus, creation, participation, and publication are tightly integral processes.

Engagers in Wikipedia COIS are general Internet users who want to share their knowledge with others. The primary goal of most engagers is to contribute to the greater good, instead of for their own benefits. To the engagers, participation is no less significant than creation.

Norms of sharing, reusing, and building upon articles as commons are prominent.

Blogs

A note about blogs

Blogs are personal Web sites with journal-style entries. Anyone can sign up for a free blog and start writing within minutes, even without knowing how to create a Web page (Google, 2007). People blog, or write blogs, for various reasons: to document life, to provide commentary or opinion, to express deeply felt emotions, to articulate ideas through writing, or to form and maintain a forum (Nardi et al., 2004). Blogs are attractive to users because they are more dynamic than old-style personal Web pages, more permanent than posts to bulletin boards, more personal than traditional journalism, and more public than diaries (H. Jenkins, 2002). By expressing their thoughts and ideas on blogs, people are open to comments and opinions of others. Often, a series of blog entries and comments evolve into conversations. Active bloggers update their blogs by posting new entries many times a day. There are currently well over 100 million blogs, with over 1.6 million new entries per day (or over 18 new entries every second) (Technorati Inc., 2007).

Essential COIS information in blogs is the content of blogs. Blog contents are in all forms of multimedia, including texts, images, videos, and audio. Most of the contents are constantly updated or added to in a diary style.

The blogosphere, the set of all blogs on the Internet, is the community of COIS in blogs. The community in this case is, thus, very loose and unstructured. The community's commons are the contents of all blogs in the blogosphere. The commons are dynamic, as the contents change constantly. A high number of blogs in the blogosphere are about personal stories, opinions, emotions, and lives of the writers. Therefore, the commons of the blogosphere are not just the multimedia, but also the personal "information" like opinions and emotions embedded in and conveyed by the multimedia as well. In addition, the shared cultural context of blogging is part of the commons as well. Since the commons comprise contents of all blogs, they are not held in just one space, but instead distributed across the blogosphere.

To create is to synthesize a new post in a blog. As commons, contents of existing blogs can play many roles related to creation. Existing blogs can serve as a guide, reference, or inspiration for creating new content. In addition, bloggers often link to other blogs, so that while readers read the new blog, they can further obtain related information. In this way, the commons provide supplementing functions to the newly synthesized information. Also, the blogosphere and blog readers constitute a shared cultural context, which can benefit newly synthesized information.

In blog COIS, the processes of creation, participation, and publication are tightly integrated. Participation is to become part of the blogosphere, which can be done by publishing a blog. Also, since bloggers write blogs in order to publish them, publication is also tightly coupled with creation.

Engagers in blog COIS, or bloggers, are general Internet users. No expertise is required to blog. Their goals vary. Those who blog to let out their emotions, to express opinion, or to document their lives, do so primarily for themselves. Those who blog news, knowledge, etc., do so for others.

COIS in blogs have norms of sharing, reusing and building upon. People share their thoughts, news, and other contents. Other people then repost or build upon those contents for their own blogs.

YouTube

A note about YouTube

YouTube is a popular video-sharing site. Anyone can upload videos that they want to share onto YouTube, where a large audience is waiting. Over 100 million video are viewed in a day (Garfield, 2006). Sharing videos on YouTube is free, and many people like sharing their videos on YouTube, as over 65,000 videos are uploaded everyday (Garfield, 2006). The videos that people share on YouTube are often home videos they have shot, animations or movies they have produced, or clips of TV shows they have captured. YouTube is more than a media outlet. It is a shared cultural context, in which people come to share their creations and to see what others are enjoying.

Videos are the feature attraction of the YouTube Web site (http://youtube.com). They are also the essential information of COIS in YouTube. The community of COIS in YouTube includes everyone who shares their videos on the Web site. The community's commons for COIS include existing videos, the shared cultural context, and audience. The video commons are held in a central space.

Creation in YouTube COIS is to synthesize a new video, including original production, such as home videos, and modification of existing videos of others. Simply reposting videos that were downloaded or recorded from TV, DVD, etc. is not considered creation. Thus, not all videos shared on YouTube are outcomes of synthesis. All videos in YouTube, however, are considered commons that could be used for creation. Existing videos can serve as key ingredients, starting points, references, or inspiration for synthesis of new videos. Nonetheless, remixed or inspired videos are not as commonplace as originally produced videos. The use of commons in this way is not very popular. The more typical use of commons is, however, the use of shared cultural context and audience of YouTube for supporting newly synthesized videos. Most people share their videos on YouTube to benefit from the community's established culture and large audience base.

Publication of synthesis outcomes (the produced videos) is a primary goal. Doing so also makes the synthesized videos available as commons to other engagers in YouTube COIS. Thus, publication is tightly coupled with creation. Also, participation to become part of the YouTube community is a prerequisite to publishing. So, participation and publication are also coupled.

People who engage in COIS in YouTube include anyone who can create a video and wants to share it, ranging from amateur movie makers, to artists, to companies. The engagers' primary goals could be to benefit themselves or others. Some create and share their original production to gain public attention. Others simply want to entertain the public.

The norms of sharing, reusing, and building upon are present but do not play a significant role in COIS in YouTube. Engagers are aware that they are welcome to reuse or build upon productions of others and vice versa, but such practices are not as commonplace as original productions.

del.icio.us

A note about del.icio.us

del.icio.us is primarily an online bookmark organizer. It allows users to store their bookmarks online, to access their bookmarks from any computer, and to add bookmarks from anywhere (del.icio.us team, 2007). This way, the users can virtually take their bookmarks with them, instead of having their bookmarks stored only on certain computers. In addition, users can use "tags" to organize and remember their bookmarks. Tagging allows multiple, overlapping associations that the human brain uses, rather than rigid categories (O'Reilly, 2005). For example, a user might find a Web site of a neighborhood bookstore, create a bookmark for the link in del.icio.us, and tag the bookmark as "books". The user can later use the tag "books" to recall that link as well as other bookmarks in her collection that she has tagged as "books". The same bookmark can have multiple tags, to represent different associations, so the user can also tag the link to the neighborhood bookstore's Web site as "local".

del.icio.us is also considered a "social bookmarking" Web site (del.icio.us team, 2007). Users can share with other people their bookmarks, which often are links to Web sites that they came across and found interesting. Moreover, users can use their tags to discover more links to which other users assign the same tags. For instance, the tag "books" could lead the user in the example above to many other book-related Web sites that other users have already discovered. In addition, anyone, not just registered users of del.icio.us, can view the "hotlist" on del.icio.us's home page to see the current most popular tags and Web sites. Social bookmarking in del.icio.us is also referred to as "social tagging" or "folksonomy" (Hammond et al., 2005). It is as example of *collective intelligence* in Web 2.0. When numerous individual sets of personal bookmarks are connected together by tags, they become a collective cognition of all the users. Out of countless materials and pages that are constantly discovered and seen on the Web, those that are not worth noting are filtered out, while those that are deemed noteworthy are remembered.

Bookmarks and associated tags are the essential information of COIS in del.icio.us. A bookmark contains a URL link to a Web site and sometimes a description of the Web site.

All del.icio.us users constitute the del.icio.us COIS community. The community is informal. Its commons are all users' bookmarks and tags, fused and cross-indexed as one big collection. The collection represents "collective cognition" of all users. The bookmarks and tags are held in one central space, the del.icio.us Web site (http://del.icio.us), but the ownership of each bookmark is still clearly indicated.

The act of creation in del.icio.us COIS is to create a bookmark and assign tag(s) to it. Thus, creation, in this case, requires minimal effort. The commons can assist creation. While deciding how to tag a new bookmark, a user is usually offered a list of suggested tags, based on popular tags that have been applied to the same link by other users. In this way, the commons serve as a reference during a creation process. Additionally, as mentioned above, commons in del.icio.us serve as multiplying functions to newly synthesized information. That is, when a newly created bookmark and its tags are published, they are automatically fused with the already cross-indexed, existing bookmarks and tags. The tags of the newly published bookmark then have increased functionalities. They can help lead users to find not only the originally intended bookmark, but also other bookmarks with which they can associate as well.

Participation requires a membership to del.icio.us. Users also have to install a small plug-in on their Web browser. The plug-in allows users to add pages that they are viewing as bookmarks in their del.icio.us bookmark lists. In this case, participation is a prerequisite to creation.

Publication is coupled with creation. When a user adds a new bookmark to her own list, the bookmark and tags are automatically made available publicly, unless otherwise specified by the user.

Engagers in del.icio.us COIS are general Web users who are keen on having their bookmarks accessible from any computers, organized by tags, and sharable to other people. Most people engage in del.icio.us COIS primarily for their own benefit (to organize their bookmarks), but they also enjoy sharing their bookmarks with others.

COIS in del.icio.us have norms of sharing, reusing, and building upon commons. People share their bookmarks and reuse others' tags. Some people also reuse others' bookmarks, by adding links to Web sites found though others' bookmarks to their own bookmark lists. The building upon of commons in COIS in del.icio.us is unlike most other cases. Bookmarks and tags are not built upon to synthesize a new bookmark or tag. Rather, they are fused to create one large set of cross-indexed bookmarks that represents collective cognition of all users.

Flickr

A note about Flickr

Flickr is an online photo management and sharing application (Yahoo! Inc., 2007a). Anyone can sign up for a free account and upload their photos to their Flickr albums. People can organize the photos in their albums with tags, much like how del.icio.us users organize their bookmarks. In addition to managing their photos, people can also share their photo albums with others. People can choose to allow only certain other people see their photos, or to license their photos under Creative Commons, so that anybody can freely use the photos as long as they comply with certain terms, such as the requirement to accredit the original owners of the photos.

Similar to del.icio.us, Flickr is also considered a social tagging tool (Hammond et al., 2005). A tag of one photo can lead to other photos with the same tag, allowing people to discover similar photos. For example, there are over 160,000 photos tagged as "morning", and over 6 million as "wedding". The site harnesses people's tags to make Flickr one massive collection of interconnected photo albums. Several thousand photos are uploaded to Flickr per minute (Yahoo! Inc., 2007b). Flickr is also a shared cultural context for photography enthusiasts. Many people share their photos to solicit comments from others, and many comments are usually received.

Photographs and their associated tags are the essential information of COIS in Flickr. The community of COIS in Flickr is made up of those who have a photo collection on Flickr. The community includes both people who keep their collections private and those who make their collections publicly accessible. The community's commons include publicly accessible photos from all collections and associated tags of the photos. All commons are centrally held at the Web site of Flickr (http://flickr.com), even though the photo collections still belong to the individual users. The viewer base of the Web site is also another form of commons of the community.

To create in Flickr COIS is to take a photograph and assign tags to it. The outcome of creation is a personal, tag-indexed, collection of photos. COIS in Flickr is commons-oriented in many ways as well. The commons can assist during creation, as existing photos shared by others can be an inspiration for taking new photos. Additionally, existing tags in the commons serve as multiplying functions to the newly created tags. Similar to the case of del.icio.us, newly synthesized information fuses with the commons to become one large collection that represents the collective cognition of all users. After newly created tags and photos are made publicly available on Flickr, they fuse with the existing, already cross-indexed, overall collection of all shared photos and tags. The newly shared tags can then help lead people to locate, in addition to the originally intended photos, other shared photos with which the tags can associate, from the whole Flickr community. Vice versa, existing tags in the commons can help lead users to discover the newly shared photos as well. Moreover, the shared audience of the Flickr community is also part of the commons. It forms a cultural context to which a newly synthesized photo collection can be shared.

As mentioned above, publication allows tags to have increased functionality. It is also a way for people to showcase and solicit feedback on their photos. Publication is tightly coupled with creation. One part of the act of creation (adding photos and tags to a personal collection online) takes place at the Flickr Web site, which is also the site of the commons. Thus, making the products of synthesis available as commons to other people requires no extra effort.

The act of participation involves registering for a Flickr user account. To be able to utilize the community's commons, other than as an inspiration, Flickr users have to make their photo collections become part of the commons. Thus, participation and publication are coupled in this sense.

The engagers of COIS in Flickr are general Internet users who want a personal, online, photo collection that can be organized by tags. The engagers range from people who want to share their photos online with friends, to professional photographers who want to share and solicit feedback on their photos. That indicates that the primary goal of the engagers in general is for themselves. Nonetheless, some people also engage in Flickr COIS to help create a free resource of photos on the Internet.

The primary norm of COIS in Flickr is sharing. Most people make their photo collections publicly accessible. There is also a *build up* norm in the way that individual photo collections fuse to create one large, free, online, cross-indexed photo resource. As most of the photos are freely shared, they can be reused by anyone. Many people download and reuse photos from Flickr for their own applications; however, the reusing in this sense is not part of the information synthesis in Flickr. That is, unless someone synthesizes a new photo based on a shared photo in Flickr, which is not often the case.

ccMixter

A note about ccMixter

ccMixter is a community music-remixing site. Participants of ccMixter are mostly musicians and remix artists. They can upload audio files of the music that they have composed or performed to ccMixter, to share their music as part of the community's common resources. Music files are shared on ccMixter under Creative Commons, so anyone can freely listen to, sample, or mash-up any shared music files, as long as they comply with the terms set by the original owners of the music (Creative Commons, 2007b). People are not allowed to share music of others, unless they have permission from the original rights owners.

Most participants in ccMixter remix several music tracks that were shared by others to create a new piece. Many participants also often "reinterpret" others' work, by rerecording, remixing, or reperforming the shared music in their own styles (Suzor & Fitzgerald, 2007). The results of remixes or reinterpretations are also often shared back to the community. A particularly good piece of music created and shared by one participant can often inspire many others to create. For example, a vocal track *September* created by *calendargirl* has inspired more than twenty remixes or reinterpretations by other participants (Creative Commons, 2007c).

The essential information of COIS in ccMixter is music in various forms, including tempo, vocal, and instrumental tracks. The community of COIS in ccMixter consists of everyone who shares music at the ccMixter Web site (http://ccmixter.org). Straightforwardly, the commons of the community are all the shared music. The commons are centrally located on the Web site, with the ownership information of each piece clearly indicated.

To create, in the sense of COIS in ccMixter, is to synthesize a new piece of music, whether as an original composition or a remix. The commons play many major roles in ccMixter. In remixing, existing pieces of music are often used wholly as key ingredients for synthesizing a new piece. Existing pieces are also often modified to create a new piece, or adapted and used as part of a remix. In those cases, the commons are used as starting points. Commons also serve as guides and inspiration. People are often inspired or moved by music created by others, and often express their impressions of the original music by recreating it in their own styles. Another form of commons is the shared audience of the community. The shared cultural context of ccMixter provides a stage for newly synthesized music to reach a large mass of listeners.

To participate is to be part of the ccMixter community, which can be done by sharing music to the community's commons. Participation is, thus, tied to publication. Publication allows people to showcase and solicit comments about their music. Many people create music because they like sharing it.

People who engage in COIS in ccMixter are music enthusiasts with some musical ability. They are not necessary professional musicians. Knowledge of music remixing is not a prerequisite.

As the discussion above shows, norms of sharing, reusing, and building upon commons are very strong in ccMixter COIS.

Amazon recommendations

A note about Amazon recommendations

Users of Amazon.com can review products by writing comments and assigning ratings. Product reviewing benefits not only other prospective buyers, but also the reviewers themselves. By reviewing products, the reviewers train the Web site to learn about their interests and preferences. The next time the reviewers visit the site, they can be provided with personalized lists of recommended products that they might prefer. Amazon.com's recommendation algorithm is called "item-to-item collaborative filtering" (Linden et al., 2003). The algorithm analyzes a user's profile of product ratings and history of purchases, matches that profile to those of other users who have rated or purchased similar products, and then generates a "recommended products" list based on other items that are also on those profiles.

Product ratings and comments are the essential information of COIS in Amazon recommendations. The community of COIS in this case includes all Amazon buyers who rate and write comments on the products they have bought. All ratings and comments on products make up the commons of COIS. The commons are all held at the Amazon Web site (http://amazon.com), but ownership of each pair of rating and comment is clearly stated.

To create in Amazon-recommendation COIS is to rate and write a comment on a purchased product. The commons typically play no role during creation. That is, existing ratings or comments are not typically used to help rate or write a new comment on a product.

However, the information synthesis in this case is still commons-oriented because the commons serve as a multiplying function to newly synthesized information after it is published. Publication occurs in conjunction with creation. Ratings and comments are created at the site of the commons and are immediately published upon completion. When new ratings and comments are published, they fuse with the commons (the ratings and comments that already exist) to become "item-to-item collaborative filtering". The newly written comment and rating then have a new, additional function. The intended function of ratings and comments is to express the buyer's opinion on products. With item-to-item collaborative filtering, the newly written comment and rating can also help lead the buyer to "recommended products," based on what other buyers who have bought the same product also bought.

Participation is to be part of the community of Amazon buyers who rate and write comments. Thus, participation also occurs automatically in conjunction with publication.

Engagers in Amazon-recommendation COIS are all buyers in Amazon who care to rate and write comments on the products they have bought. They do it for both themselves as well as others. For themselves, rating of products is a way to "teach" the Amazon Web site of their preferences in products, so that the Web site can recommend them other products they might also like. Comments are intended to help other prospective buyers know the pros and cons of the products.

Sharing of product ratings and comments is a prominent norm in Amazon recommendation. There is also a norm of building upon commons, as the shared ratings are used to construct the item-to-item collaborative filtering system.

Slashdot

A note about Slashdot

Slashdot is a popular science- and technology-related news Web site, providing "news for nerds" and "stuff that matters" (SourceForge Inc., 2007a). The majority of the news on Slashdot is user-submitted. A large number of stories are submitted to Slashdot each day, and those that the editorial team deems interesting get posted (SourceForge Inc., 2007b). The contributors of Slashdot collectively go through countless numbers of stories on the Web before only a few of them make it on the home page. They are examples of what Garfield (2006) calls the "third-millennium humanity"—those who are willing to sift through millions of pieces of content created and shared by strangers to discover a few gems. More specifically, Slashdot is an example of citizen journalism, which includes other similar site like OhmyNews International (http://ohmynews.com) and independent media center (http://indymedia.org) (Bruns, 2007).

> Each news story in Slashdot has a forum-style comment section prominently attached to the bottom of the page. Some publishers use this opportunity to practice what is called "open-source journalism". That is, they submit an article to Slashdot and ask the readers, who are mostly "nerds" with science and technology backgrounds, to review it. The publishers then incorporate the comments into the article and publish it through the real outlets. The practice raises debate among journalists about using open sources on the Internet to check facts (Moon, 1999).

News stories make up the essential information of COIS in Slashdot. The community of COIS in Slashdot comprises people who submit articles of or links to news stories to the Slashdot Web site (http://slashdot.org). The commons of COIS in Slashdot are purely abstract and are not information. They include the shared audience and opinions of experts among the readers.

The act of creation in COIS in Slashdot is to identify a news story. Often, this involves sifting through countless material on the Web to find an interesting story. Some people also write articles to report on news stories by themselves. The abstract commons play no role during creation in this case.

Publication is a primary action in COIS in Slashdot. People come up with interesting news stories in order to have them published on the Web site. The mass of Slashdot's audience (readers) provides a shared cultural context to which the news stories can be shared. People who wrote the news by themselves can also benefit from the commons of expert opinions from the readers. Having readers, especially those who are experts in certain areas, proofread or fact-check a news story, sometimes so that it can be corrected before being published in another, more formal news outlet, is the principle of "open source journalism". Expert opinions are usually provided as comments to a posted news story. In this way, the commons (expert opinions) serve as supplementing functions to the newly synthesized information (posted news story). Moreover, the expert opinions also serve as a guide or reference for the next round of creation if the authors take into account the comments and edit the stories.

Participation is to be part of the community of people who submit articles of or links to news stories to Slashdot. That can be done in conjunction with publication.

People who engage in Slashdot COIS include Web users who enjoy browsing and reading on many different Web sites and those who like to report the latest happenings on the Internet. Most people engage in Slashdot COIS primarily for others. That is, to inform other Internet users of news stories. People who aim to take advantage of open source journalism, however, aim primarily to benefit themselves.

There are norms of sharing and building upon commons in COIS in Slashdot. The norm of sharing new stories is prominent. Building upon commons occurs when authors of new stories incorporate comments given by experts among readers into their revision of the stories.

Friendster

A note about Friendster

Friendster is one of the first major social-networking sites. It precedes but functions much like other social networking tools, such as Orkut, MySpace, and Facebook. Anyone can sign up for a free account and build explicit, hyperlinked networks of their friends and acquaintances (Leonard, 2003). People on the same network can see pictures, profiles information, and communities of one another. Two people who share a common friend are connected, as part of an extended network. Friendster, like other social networking sites, captures "the strength of weak ties" (Leonard, 2003). A Friendster member can contact the people on his or her extended network to look for a job, date, party, etc.

The essential information of COIS in Friendster is connections. Connections include social and professional contacts or relationships. All members of Friendster constitute the community of COIS in Friendster. The community is purposely well formed. The community's commons consist of all connections of all members. In addition, opportunities and other benefits from having a connection are also commons of the community. Thus, commons in this case are abstract.

Creation in the Friendster COIS is to make a connection. In Friendster, and most other social networking Web sites, making a connection is called "add as friend". This involves requesting to be friend with another person and requires only a few mouse clicks. The commons can help as a reference during creation. People can help introduce one another. When two members become friends, the friends of the two members are also connected and become within three degrees of connection (friends of friends of friends) to one another.

Participation is a prerequisite to creation in this case. Participation is to become a member of the Friendster community. Membership is free. However, being a member has a cost of privacy loss. If a member's profile is public, anyone can see her profile and list of friends. Even if her profile is private, depending on the settings, friends and people within two degrees or three degrees of connection may still be able to see her profile and list of friends. In general, people do not perceive allowing people within low degrees of connection to see their profiles as a loss.

Publication is to make a newly created connection available as a common. It occurs automatically in conjunction with creation. After the new connection is published, it not only connects the two people together, but also connects them to each other's existing connections. This way, the commons (existing connections) serve as supplementing functions to the synthesized information (new connection).

People who engage in COIS in Friendster are Web users who want to socialize over the Internet. They engage in COIS primarily for themselves.

COIS in Friendster has norms of sharing, reusing, and building upon connections.

3.2.2 Product Development

Free/Open Sources Software (F/OSS) Development

A note about F/OSS development

The people who engage in creation activities of F/OSS are typically lead users with computer programming skills. They write code to create software that they need, freely give and exchange the code and software they have written, modify or build upon the shared code of others, and further share the modifications. Currently, SourceForge.net, an online platform that provides infrastructure for F/OSS projects, has a repository of over 160,000 projects and over 1,700,000 registered users (SourceForge Inc., 2007d). People without programming skills can also benefit from the F/OSS development by downloading and using the freely shared software.

The essential information of COIS in F/OSS development is software programs and code. There are many communities of COIS in F/OSS development. A typical community consists of programmers who collaborate on software programs. Shared software programs and code are important parts of a community's commons. Another part is a pool of beta users, who regularly help test beta releases of software. In most cases, programs and codes are centrally stored and version-controlled at a community's Web site, such as SourceForge.net (http://sourceforge.net).

To create in the F/OSS COIS development is to write a software program. F/OSS creation is often done collaboratively. Commons play many significant roles in creation. Often, pieces of code or programming libraries are incorporated in creation of a new program. In such cases, commons function as key ingredients in creation. Commons also often serve as starting points for new F/OSS creation. That is when existing and often already functioning software programs are modified and developed upon to create a new program. Additionally, code inside existing software programs are often studied and used as a reference for developing a new program. Furthermore, commons can serve as supplementing functions to newly synthesized information, as existing programs can be called up to run in conjunction with a newly developed program.

The act of participation involves being part of a COIS community in F/OSS development. Publication is to make a synthesized program or code available as commons to the community. A pool of beta testers, as commons, serve as a shared cultural context, to which newly created software programs can be published.

People who engage in COIS in F/OSS development mostly have software programming abilities. Even though many of them have much programming expertise, they are still considered non-experts, or at least amateur, in this context, since most of them only engage in their free time. Many people engage in F/OSS COIS for themselves, to create a program that does exactly what they need. Many people also engage in F/OSS COIS just to benefit others. For example, many people help others develop or debug a program.

Norms of sharing, reusing, and building upon commons are all prominent in COIS in F/OSS development. Engagers freely share, reuse, and build upon one another's codes and software programs all the time.

Apache

A note about Apache

Apache is a HTTP server program. It is one of the most popular open source software applications. It started as a one person's effort in 1995. Since then, a number of individual programmers have contributed to its development (The Apache Software Foundation, 2007). Apache is now used by over 50% of Web servers worldwide and has been the most popular Web server since 1996 (Netcraft LTD, 2007).

Apache is a F/OSS program, so COIS in Apache is very similar to COIS in F/OSS development. Nonetheless, unlike in general F/OSS COIS where many small software programs are involved, there is only one program as a focus in Apache COIS. Many people work on different parts, or modules, of Apache. After there have been enough major changes, a new version of the program is released. Different people then work on different parts of the new version to improve the program further. Once a substantial amount of improvement is made, another new version is release. Such improvement progression is also practiced in COIS in development of other major software programs as well. Thus COIS in Apache is a representation of COIS in development of other major F/OSS software programs.

The essential information in COIS in Apache is the program and its code. The community is made up of all developers of Apache. The community's commons are the code and the program itself.

Creation in Apache COIS is to write another module to add on to the program, or to debug or improve upon an existing module from the latest released version. The commons serve as a starting point for new creation. The outcomes of synthesis are newer versions of the commons. The newly synthesized outcomes then become commons for a subsequent version of creation. COIS in Apache is, thus, special in the way that the commons upon which creation is based and the outcomes of creation are almost synonymous. That latter are just a newer, and often improved, version of the former.

The nature of other components of COIS in Apache are the same as those in general F/OSS COIS, namely the acts of participation and publication, the type of engagers and their motives, and the norms of sharing, reusing, and building upon commons.

Kitesurfing Equipment Design

A note about kitesurfing equipment design
In kitesurfing, the user stands on a special surfboard and is pulled along by a large, steerable kite. Kitesurfers engage in developing and improving activities of their equipment (E. von Hippel, 2005). They share designs and building plans with one another through a Web site. They also give advice to novices and help improve one another's designs.

The essential information of COIS in kitesurfing equipment design is design information, ranging from sketches, to CAD models, to design guidelines. The community of COIS in kitesurfing equipment design are kitesurfers who also design their own equipment. The community is informal but well defined. The community's commons include all forms of kitesurfing equipment design information.

To create in COIS in kitesurfing equipment design is to create a new design or to improve upon an existing design. Creation is commons-oriented in many ways. Multiple existing designs of different components can be key ingredients in creation of a new design. Also, existing designs can be used as starting points for a new design to build upon. In addition, existing designs and guidelines can serve as a reference for new creation. Outcomes of creation are new kitesurfing equipment designs.

The act of participation is to become a member of the kitesurfing equipment design community. Anyone who is interested in kitesurfing is free to join. To publish, people make their newly created designs available as commons to others. Kitesurfers are usually eager to share their equipment designs with one another. Being able to share and exchange design ideas is part of the reason why they engage in COIS in kitesurfing equipment design. Thus, the purposes of their engagement in COIS are to benefit both themselves and others.

The community has norms of sharing, reusing, and building upon commons. People freely share their new designs and often reuse and build upon designs of others in their own creations.

3.2.3 Summary

In the above analyses, creation activities by non-experts in various environments were examined in terms of commons-oriented information synthesis (COIS). The nature of the activities vary in many aspects:

- Altruism – from benefiting the greater good (e.g. contributions in Wikipedia) to personal benefit (e.g. making connection in Friendster)

- Effort – from a tremendous amount of time and effort required (e.g. programming in F/OSS development or Apache) to just a few mouse clicks (e.g. bookmarking in del.icio.us)
- Community sense – from frequent interaction with other community members (e.g. exchanging of kitesurfing equipment design ideas) to rare direct interaction with others (e.g. product rating in Amazon)
- Free-riding on synthesized information – from free to take and use for anyone (e.g. YouTube video clips) to give-to-receive (e.g. BitTorrent files)
- Prerequisite expertise – from some skills and abilities required (e.g. composing or remixing music in ccMixter) to anybody can do it (e.g. writing anything in blogs)
- Special interest – from interest of a specific group of people (e.g. news for nerds in Slashdot) to interest of general people (e.g. personal bookmark organization in del.icio.us or photo organization in Flickr)

Despite their differences, the activities can all be described in terms of COIS.

In most cases, the information that is essential to COIS is of the same kind as the information that is synthesized, and also available as commons. In those cases, the information commons often come from the sharing of synthesized information with the communities.

In the case of Slashdot, however, the commons are not derived from the products of synthesis. That is because the commons (shared cultural context and audience) are in a different form from the products of synthesis (news stories). Nonetheless, the commons assist the information synthesis, so creation activities in Slashdot are COIS.

Creation, participation, and publication are integral in all cases, even though the nature of integration varies. In some cases, such as Friendster, participation is a prerequisite to creation. In others cases, participation occurs in conjunction with publication, such as in Amazon recommendations. In the cases where the primary goals of the engagers are altruistic, such as Wikipedia, publication is perceived as a necessary co-process of creation. Sometimes, when altruism does not apply, such as downloading in BitTorrent, publication is required as a co-process of creation.

Even though the engagers in all cases are non-experts, some have more special abilities than others, depending on the natures of the activities.

3.3 Distinction between COIS and Non-COIS Creation Activities by Non-Experts

As mentioned earlier in the Definition of Model section, not all creation activities by non-experts can be considered COIS. Some activities contain components of COIS, but may not actually be COIS. For example, information synthesis may take place within a community that has commons, but the commons may not play any role with regard to the creation process and its outcome.

A creation activity that can be considered COIS must have all of the components of COIS as described in the definition. Nonetheless, simple criteria, which represent the crucial components of COIS, are sufficient for making distinction between COIS and non-COIS creation activities. The simple criteria of COIS are:

- There must be an act of information synthesis
- There must be common(s)
- The information synthesis must be commons-oriented. That is, the commons are utilized during or after the creation process

With those simple criteria, the following example scenarios can be assessed as to whether or not they are COIS.

- Person A gives information X to person B for reuse.

  There is no COIS in this scenario, since there is no act of information synthesis. There is only an act of sharing. (Nonetheless, A and B can be considered a community, albeit a very small one. X can be considered a common of the community. The act of sharing by A can be considered publication, making X available as a common.) This scenario is just an act of information transfer.

- Person A uses his personal resource Y to create information X, which he then gives to person B for reuse.

  There is no COIS in this scenario, since no common is utilized for the creation process (neither during nor after). There is an act of information synthesis, the creation of X. However, the creation of X is not commons-oriented, even though it is based upon Y. That is because Y only belongs to A and, thus, is not a common.

  After X is shared, it becomes a common of the community that comprises A and B. Still, with regard to the only act of synthesis in this scenario, X is just the outcome of that synthesis. An act of synthesis that does not utilize any commons would still remain not commons-oriented, even after the outcome of the synthesis is later shared as a common.

- C shares information Y to A. A then uses Y to create information X, which he then gives to person B for reuse.

  The creation of X in this scenario is COIS. There is an act of information synthesis (the creation of X). Y is a common of the community that comprises C and A, and maybe also B. The common Y is utilized in the creation of X, so the act of synthesis is commons-oriented.

- Person A innovates product Z for his own use.

  There is no COIS in this scenario, since there is no common involved. This scenario may just be an act of user innovation.

- Multiple people form a community, then share and reuse information that each of them has created.

  There may not be COIS in this scenario, if no common is utilized for any of the acts of information synthesis. There are acts of information synthesis, but they may not be commons-oriented, if everyone just uses his or her own resource to create information. After the synthesized information pieces are shared, they become commons of the community. However, with regard to the original acts of synthesis, the synthesized information pieces are still just their outcomes. The original acts of synthesis still remain not commons-oriented, even after their outcomes are shared as commons. The activities in this scenario may be just acts of innovation and sharing innovated products in an innovative community.

The last scenario is one of the most common scenarios of creation activities by non-experts that seem like COIS but are actually not COIS. Many cases of lead-user innovations fit in this scenario. In such cases, lead users innovate products for themselves and make their designs freely available to other users in the community. There is information synthesis, i.e. creation of product designs. There are commons, i.e. freely shared designs. However, the information synthesis may not be commons-oriented, as the creation of product designs may involve utilization of personal resources only. That is the only missing key criterion. If the lead users utilize common resources in their design syntheses, whether during or after the design processes, the innovations would be COIS. Also, if other lead users later utilize the freely shared designs in their own innovations, those subsequent innovations would be considered COIS. Examples of lead-user innovations that are discussed in previous chapters but may not be COIS are:

- Printed circuit CAD software
- Library information systems
- Extreme sport equipment (canyoning, sailplaning, boardercross, and cycling with handicaps)

This work proposes that the commons-oriented nature of non-expert creation activities draws people, especially common people, to engage in the activities. (How that works is discussed in chapter 4). In order to focus on only creation activities that are commons-oriented (COIS), it is important to be able to make a distinction between COIS and non-COIS creation activities.

3.4 Related Work

In chapter 2, the section *Literature Review: Studies of What Motivates Creation Activities by Non-Experts* gives an introduction of existing studies related to creation activities by non-experts. Now that the COIS model has been explained, this section revisits the related work once again, in order to illustrate their differences from this work. The published studies on creation activities by non-experts can be categorized into two main groups: focused and overall studies.

One group of the focused studies (Efimova & de Moor, 2005; Garfield, 2006; Leonard, 2003; Linden et al., 2003; Nardi et al., 2004; Nov, 2007; Rose, 2006) looks at individual activities, such as Wikipedia, blogs, YouTube, etc., in terms of what goes on, who participates, and what motivates the participants. Another group of the focused studies (Hammond et al., 2005; Suzor & Fitzgerald, 2007) looks at common mechanisms or tools, such as open content licensing and social tagging, each of which is applicable to a few activities. Those studies explain how the mechanisms shape what goes on in the activities. In summary, the focused studies analyze specific activities or narrow groups of activities. The approaches and depth of analyses vary considerably from study to study. Conclusions from a particular analysis are often inapplicable to other activities or a broader scope.

The overall studies look at creation activities in a broad scope. There are three different studies that are most closely related to this work. One is the study of "democratized innovation" (E. von Hippel, 2005), focusing only on product development by lead users. The study describes how product innovation by lead users is need-driven. It also describes how creation is the main activity, since the only main objective is to create products. The creation processes are enabled by advancement in computer and information technologies. The study also describes how lead users also participate in innovation communities and freely reveal their innovated products. In some cases, such as F/OSS, a "private-collective" innovation model can explain the motivations behind free revealing of privately funded innovation and the enthusiastic participation in a project to produce a public good. However, in overall, participation and publication are considered a tool to facilitate creation and a logical next step after creation, respectively. In other words, unlike creation, participation and publication are not considered by the study as main objectives of the lead users.

Another broad-scoped study that is closely related to this work is "Web 2.0 design pattern" (O'Reilly, 2005). It looks at Web 2.0 activities overall and identifies characteristics, of ongoing activities, that make Web 2.0 novel. Based on those characteristics, the study suggests patterns[7] that businesses can follow to be successful in the Web-2.0 era. In summary, the study points out interesting traits of successfully operating Web 2.0 businesses, and suggests ways for other businesses to follow suit.

Focusing on Web 2.0 activities, "produsage" model (Bruns, 2007) is another study that is closely related to this work. The study describes ongoing Web-2.0 activity systematically. Nonetheless, like "Web 2.0 design pattern," the "produsage" model does not focus on why people engage in those activities or what motivates them. It recognizes that the ongoing

[7] The suggested Web 2.0 Design patterns (O'Reilly, 2005) include: use customer-self service and algorithmic data management to serve not only average customers but also those with narrow niches; seek to own a unique source of data; involve your users in adding value to your application; set inclusive defaults for aggregating user data as a network effects; design for hackability and remixability; add new features on a regular basis, instead of as monolithic releases; offer web services interfaces and content syndication with other services; design application to integrate services across multiple levels of devices.

activities consist of creation, participation, and publication processes, all intertwined; but, since the study only focuses on the "what" and not the "why", it does not look at the contributions or influences of each individual process. In terms of applications, the study concentrates on possibilities of capitalizing on ongoing activities, but not on how to recreate one.

In summary, the existing literature does not look at the overall phenomenon of creation activities by non-experts across multiple domains (e.g. both Web 2.0 and product design). Also, the existing literature only analyzes what motivates creation activities by non-experts on a single-activity scale. When the literature considers a broader scale of activities, it focuses on what is happening, but not why. Application-wise, the literature concentrates on how to capitalize on ongoing activities, or what it takes to build a business to be like one of them. In other words, the existing literature neither focuses on understanding what drives creation activities by non-experts in a broad, multi-domain scope, nor aims to use such understanding to recreate a circumstance in which non-experts' creation activities can thrive.

3.5 Chapter Summary

This chapter focused on the COIS model. The first section provided the model's core definition along with explanations of the model's key components. In short, the COIS model describes a special kind of information synthesis, which revolves around common resources. The creation of information is not the sole process in this special kind of information synthesis. Instead, creation takes place integrally with participation and publication, and all three processes are oriented around commons. The prospective benefits, as well as costs, of the three processes integrally influence people's decisions on whether or not to engage in the synthesis. Engagers of COIS value not only the end results but also the processes. COIS is about creation as much as social relations, communications, expressions, and experiences.

The second section examined various creation activities by non-experts in terms of the COIS model. A total of eighteen environments were examined: BitTorrent, Wikipedia, blogs, YouTube, del.icio.us, Flickr, ccMixter, Amazon recommendations, Slashdot, Friendster, free/open source software development, Apache, and kitesurfing equipment. For each environment, the nature of different components and how they fit the COIS model were discussed.

The COIS model applies not only to commons-oriented creation activities by non-experts, but also to commons-oriented creation activities by experts as well. In other words, anyone can engage in COIS. However, not all creation activities can be considered COIS. The third section explains the distinction between commons-oriented information synthesis and creation activities by non-experts. Many examples are given to help illustrate how to determine whether a creation activity by non-experts can be considered a COIS. Some creation activities, even if done by non-experts, do not involve commons and are, thus, not

COIS. Nonetheless, virtually all creation activities in Web 2.0 by common people, and many in product design by lead users, are describable by the COIS model.

The last section discussed existing work related to the COIS model.

4

Prospective Benefits and Costs of Commons-Oriented Information Syntheses

Descriptions, roles in commons-oriented creation activities by non-experts, perception-influencing mechanisms, and common people's lack of engagement in product-development creation activities

The commons-oriented nature of COIS is a common ingredient in environments that can draw people to engage in creation activities.

People weigh the pros and cons of creation activities, in order to decide on whether or not to engage in such activities. The pros and cons that people consider are the benefits and costs that people can perceive. When creation activities are in the form of COIS, the activities are not just creation processes. Rather, they are integral processes of creation, participation, and publication. Thus, the potential benefits and costs of COIS come from not only creation alone, but also participation and publication as well. In other words, while deciding on whether or not to engage in creation activities, people take into account all prospective benefits and costs that they can anticipate from creation, participation, and publication processes.

The costs of participation and publication are typically small, compared to the added benefits. Also, commons often help reduce the cost of creation. Consequently, people are more likely to perceive more prospective benefits, and maybe also fewer costs, from creation activities that are in the form of COIS.

4.1 Descriptions and Roles in Selected Creation Activities by Non-Experts

Fifteen prospective benefits and costs of COIS are identified in this work:

- Personal use of synthesized information
- Joy of creating and other side benefits

- Required effort and resources for creation
- Commons of information resources and shared cultural context
- Social networking
- Community membership cost
- Potential help on debugging or improving synthesized information
- Reputation from publication
- Joy of giving
- Advancement from making first publication
- Network Effects
- Transaction cost to publish synthesized information
- Loss of proprietary and privacy information
- Satisfied needs
- Being ahead of or in trends

Some benefits or costs in the list above are already recognized in the literature (E. von Hippel, 2005), but only as benefits or costs of an individual process like participation or publication. In other words, the literature recognizes that some of the following benefits and costs are factors that affect people's decisions to participate in a community, or to share what they have created, independently from their decision to create. However, this work proposes that, even though each of the following benefits and costs may be directly related to one individual process, all of them can affect people's overall decision of whether or not to engage in COIS.

In addition to the descriptions of the fifteen benefits and costs, examples are also provided to illustrate how each benefit or cost affected the decision-making of engagers, i.e. those who have already decided to engage, in various COIS activities.

4.1.1 Prospective Benefits and Costs related to Creation

The following prospective benefits and costs are directly related to creation.

Personal use of synthesized information

This benefit is one of the most easily perceivable benefits[8]. Many people engage in COIS primarily to create what they want for personal use. They are likely to value this benefit as a pro in their decision-making. Often, though, people may engage in COIS to create for other people but not themselves. In those altruistic cases, people may perceive the personal-use benefit but do not value it as a pro.

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[8] Most literature on user-led content creation in Web 2.0 and lead-user innovation recognize this benefit as the major, and often sole, driver of creation (Bruns, 2007; E. von Hippel, 2005).

Among the COIS activities selected and discussed earlier, engagers in the following activities highly value personal use of synthesized information: F/OSS, Apache, Kitesurfing, BitTorrent, del.icio.us, Flickr, ccMixter, Amazon recommendation, and Friendster. (See Appendix B for more detailed descriptions of this benefit's roles in selected COIS activities).

Joy of creating and other side benefits

People receive the joy-of-creating benefit when they engage in a creation process that they find enjoyable[9]. The joy comes from performing an act of creation, not just from being part of a creation community or making available information that others created. Other favorable secondary effects from a creation are also considered part of this benefit.

Engagers in the following activities value the joy of creating and other side benefits: F/OSS, Apache, Kitesurfing, Wikipedia, Flickr, ccMixter, Slashdot, and Friendster. (Also, see Appendix B for more detailed descriptions of this benefit's roles in selected COIS activities).

Required effort and resources for creation

Required effort and resources for creation are a chief cost that virtually everybody can perceive and take into account in their decision-making. In this context, this cost includes all effort or resources *that would normally be needed* for the creation, even if some could be offset by using commons of a community, or by help from other people. The cost-offsetting commons and help from other people are considered separately as benefits. In this way, the effects of creation, participation, and publication can be clearly recognized.

This cost is a major factor that engagers in many activities have to consider, including: F/OSS, Apache, Kitesurfing, BitTorrent, Wikipedia, blogs, YouTube, Flickr, ccMixter, and Amazon recommendation. (More detailed descriptions of this cost's roles in selected COIS activities are in Appendix B).

4.1.2 Prospective Benefits and Costs related to Participation

The following prospective benefits and costs are directly related to participation.

Commons of information resources and shared cultural context

People can receive this benefit by participating in a community and gaining access to its commons[10]. As discussed in the previous chapter, commons can enhance creation and its

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[9] The joy of developing, e.g. development of free/open source software, is recognized as a driver for lead-user innovation (E. von Hippel, 2005). Other secondary benefits are, however, not recognized as drivers.

[10] Resources from a community's commons are recognized in (E. von Hippel, 2005) as a driver for users to join innovation communities, but not as a driver of the overall synthesis activity. Shared audience or end-user bases are not recognized as an overall driver, in the literature of user-led content creation, either.

outcomes in various ways. A shared cultural context is especially significant when the synthesized information's performance is contingent upon having an established recognition and audience base.

The benefit of commons is highly valued by engagers in all of the following activities: F/OSS, Apache, Kitesurfing, BitTorrent, Wikipedia, blogs, YouTube, del.icio.us, Flickr, ccMixter, Amazon recommendation, Slashdot, and Friendster. (This benefit's roles in these activities are described in more detail in Appendix B).

Social networking

Getting to know more people is an obvious benefit from participating in a community. In some activities, social networking also means getting to know people who have similar needs and interests.

Engagers in ccMixter and Friendster highly value the social-networking benefit. Some of the engagers in the following activities value social networking: F/OSS, Apache, Kitesurfing, blogs, YouTube, del.icio.us, Flickr, and Slashdot. (See Appendix B for more detailed descriptions of this benefit's roles in these activities).

Community membership cost

To be part of certain communities may require some cost. A cost may be in a monetary form, such as a typical membership fee. It may also be in a non-monetary form. For example, users may be required to share products of their synthesis as commons. In most cases, a membership cost is meant for improving or maintaining the communities, for the sakes of the members. Still, some people could perceive it as too high and not worth the benefits.

The membership cost is a major factor in only BitTorrent and del.icio.us. (Also see Appendix B for descriptions of this cost's roles in selected COIS activities).

4.1.3 Prospective Benefits and Costs related to Publication

The following prospective benefits and costs are directly related to publication[11].

Potential help on debugging or improving synthesized information

When people make the products of their syntheses available for free, and in some cases reveal how the creation process works, they can benefit from potentially having other people help debug or improve the products. This benefit translates into potential improvement of

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[11] Many of the publication-related benefits (including the benefits of potential improving help, reputation, joy of giving, and advancement from making first publication) are recognized in the literature of lead-user innovation (E. von Hippel, 2005) as factors that drive users to reveal their innovation after creation, but not as motives of creation at the outset.

the products, as well as potential reduction of future debugging or improving cost, which the revealers would otherwise have to pay by themselves. Additionally, other users may help improve the products indirectly by offering comments and suggestions.

This benefit has an impact on creation, but it does not help offset the *immediate* creation cost. In other words, potential debugging and improving help only becomes useful after the creation process is done and the product is made available to other people. Nonetheless, for people who are considering engaging in COIS, this benefit assures that even if the products of their creation are imperfect, there is a potential that they will receive help from others to improve the products.

Note that this benefit is considered related to publication, not participation, because *in general* people could still gain this benefit by revealing their synthesized information to others, without having to join a community. Also, if people only join a community but do not make their synthesized information available to other people, they would not receive this benefit. However, in the context of COIS, participation and publication are integral. So, people would perceive this potential improving help as an overall benefit of COIS, without trying to attribute it to any individual process away.

Engagers in the following activities highly value the potential-improving-help benefit: F/OSS, Apache, Kitesurfing, Wikipedia, and ccMixter. (Appendix B provides detailed descriptions of this benefit's roles in these activities).

Reputation from publication

Reputation is another benefit that can draw people to engage in COIS from the get-go. People could decide to engage in COIS not only because they want to use the products of creation, but also because they believe that they can be known for their creation.

Some engagers in the following activities value the reputation benefit: F/OSS, Apache, Wikipedia, blogs, YouTube, Flickr, ccMixter, Amazon recommendation, Slashdot, and Friendster. (See Appendix B for detailed descriptions of how this benefit is a factor in these activities).

Joy of giving

Many people enjoy giving to others and contributing to the greater good. Engaging in COIS is one way to create something new and make it available for other people to use. In addition, users who have received benefits from communities' commons may want to give back to the communities.

In the following activities, engagers highly value the joy-of-giving benefit: F/OSS, Apache, Kitesurfing, Wikipedia, YouTube, Flickr, ccMixter, and Slashdot. (The roles of this benefit in these activities are described in detail in Appendix B).

Advancement from making first publication

In the domain of product development, innovators can sometimes gain benefits from making products available without charge or revealing the designs, as there is a potential for their products to become informal standards (E. von Hippel, 2005). Making some products available for free can lead to a high number of total users. Also, open designs, combined with high numbers of products' users, attract additional development. Other developers would not only improve upon the existing designs, but also create plug-ins or add-ons – related products that work together with the original products. Being the first to publish some information can also be beneficial as well.

The first-publication benefit is valuable to some engagers in F/OSS and YouTube, but is irrelevant in most other activities. (Appendix B provides descriptions of this benefit's roles in selected COIS activities).

Network Effects

Network effects of an object are values resulting from increased use of the object (Katz & Shapiro, 1994). For an object that has network effects, the more people that use the object, the better certain aspects of the object become. For example, phones have network effects. The more people using or owning phones, the more useful phones become, as they can be used to contact more people.

In the case of phones, the objects' *performance* is the aspect that gets better with more product use. Additionally, more users of objects can also result in better *publicity* of the objects. This effect is nearly trivial, since more users automatically mean more people knowing of the objects anyway. A higher number of users can also lead to improvement of an object's *site*. An object's site is where the object is associated, e.g. a community from which the object is available or a Web site on which the object is hosted. With more users, the object site may also improve, such as by performing better or becoming more widely known.

In the context of COIS, synthesized information can have network effects. Nonetheless, despite the potential values, network effects of synthesized information may not appeal to all engagers in COIS. Whether or not the engagers are appealed to the network-effect benefits depends on whether they value any of the ensuing benefits, i.e. improvement of performance, publicity, or site.

For instance, engagers who intend to reveal their synthesized information for the greater good, but not for their own reputation, would not care much about publicity. Therefore, they would not find the increased publicity beneficial. On the other hand, those who cherish the reputation-from-publication benefit would value the improved-publicity network effect. Likewise, engagers who also benefit from personal use of the synthesized information would value the improved-performance network effect. Those who also utilize the site, especially for the social-networking or commons benefits, would likely value the improved-site network effect.

In the following activities, engagers personally benefit from the information they synthesize, *and* the synthesized information performs better with more users. So, the engagers in the following activities value the improved-performance network effect: BitTorrent, blogs, del.icio.us, Flickr, and Friendster.

Some engagers in the following activities value the reputation from making their synthesized information available, *and* the synthesized information has an improved-reputation network effect: F/OSS, Wikipedia, blogs, YouTube, Flickr, ccMixter, Amazon recommendation, and Slashdot.

Engagers in all activities value improved-site network effects in general. That is because all engagers benefit from use of the sites, or communities, and their commons. Also, in general, more users eventually lead to improvement of the sites and their commons. For example, in F/OSS, as more people use F/OSS programs, F/OSS development projects become more popular and attract more developers. As more developers join, the commons of software codes and libraries improve. With improved commons, better F/OSS programs can be developed. With better programs, there can be even more end-users, eventually leading to improvement of F/OSS sites and commons again. Such *upward spirals* of commons' improvement can occur in any COIS activities, as long as the interest from end-users continues and the engagers value the use of commons. The improved-site network effects appeal to the engagers because the engagers can feel that they are part of COIS activities that have continuously improving commons. The commons in all the activities can benefit from improved-site network effects.

See Appendix B for detailed descriptions of how the network-effects benefit plays a role in selected COIS activities.

Transaction cost to publish synthesized information

It may cost people to make the products of their creation available to other people, even if the products are free of charge. Similar to the community-membership cost, this cost may be in a monetary form, such as a typical transactional fee to publish, as well as non-monetary forms. For example, to make a certain computer-based product available by hosting on a server would require some dedicated networking and computer resources.

This publication-transaction cost is a factor in BitTorrent and kitesurfing, while engagers in the following activities do not have to worry about publication-transaction cost at all: F/OSS, Apache, Wikipedia, blogs, YouTube, del.icio.us, Flickr, ccMixter, Amazon recommendation, Slashdot, and Friendster. (Also see Appendix B for descriptions of how this cost is or is not a factor in these activities).

Loss of proprietary and privacy information

A loss of proprietary information is an obvious cost that can be associated with making synthesized information available without charge to other people. However, the literature of lead-user innovations (E. von Hippel, 2005) found that users consider revealing their innovations to be practical, since it is not too hard for other people to come up with products with similar functionalities. Also given that there are many potential benefits to gain from publication, the cost of proprietary loss is relatively small.

In addition, making products or designs available without charge can incur a cost of privacy information loss. This cost is applicable in cases where the information that is made available is private or personal.

A loss of privacy information is an important factor that engagers in the following activities have to consider: del.icio.us and Friendster. This cost can also be concerning for engagers in F/OSS, Apache, Kitesurfing, BitTorrent, Wikipedia, blogs, YouTube, Flickr, ccMixter, and Slashdot. (Appendix B provides detailed descriptions of this cost's roles in these activities).

4.1.4 Prospective Benefits from Creation, Participation, and Publication Combined

The last two prospective benefits can be related to any of the three integral processes.

Satisfied needs

Some people want to get precisely what they want or need. So, they would consider having their needs satisfied a significant benefit of engaging in COIS for themselves. In contrary, other people may be less critical about getting precisely what they want, so they would not care much about the satisfied-needs benefit.

"Needs" in this context are not limited to people' needs for products. Needs may also include people's desires to carry out a creation, publication, or participation process.

Engagers in all of the following activities value the satisfied-needs benefit: F/OSS, Apache, Kitesurfing, BitTorrent, Wikipedia, blogs, YouTube, del.icio.us, Flickr, ccMixter, Amazon recommendation, Slashdot, and Friendster. (See Appendix B for a description of the role of this benefit in each activity).

Being ahead of or in trends

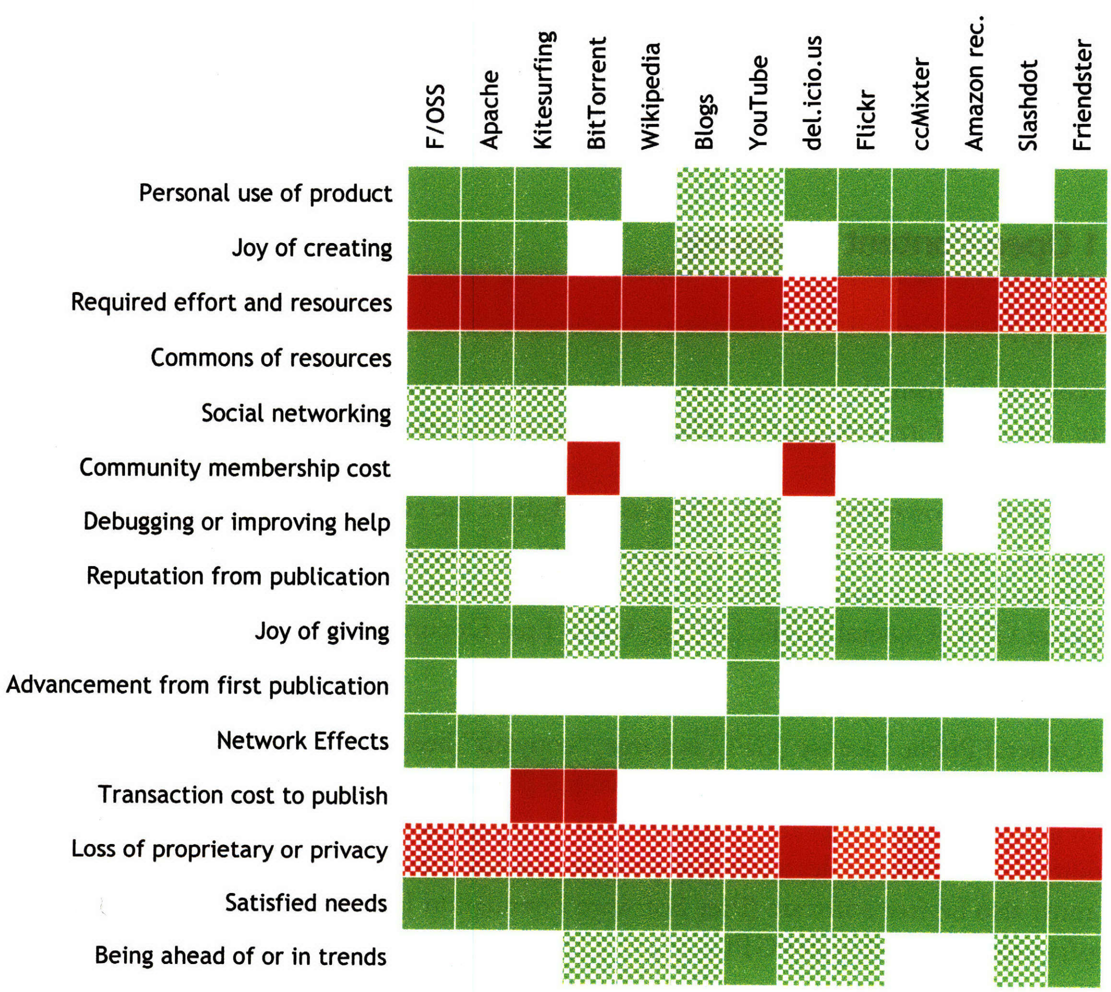
For lead users, being ahead of trends is simply their nature and unlikely a motive for their creations. For other users, trends may be important, and they may value being ahead of or in trends as a potential benefit from engaging in COIS. In some cases, even though most people might consider engaging in a particular COIS activity trendy, some people may engage in COIS for a practical reason and, thus, would not value the trend benefit.

Engagers in YouTube and Friendster highly value the trend benefit. Some engagers in the following activities value the trend benefit: BitTorrent, Wikipedia, blogs, del.icio.us, Flickr, and Slashdot. (Appendix B also provides detailed descriptions of this benefit's roles in selected activities).

4.1.5 Summary

The roles of prospective benefits and costs of COIS in the selected activities are summarized in Table 1. The cells filled with a solid color (either red for a cost, or green for a benefit) signify that the factors are relevant to the activities and highly valued by the engagers. The cells that are filled with a checkered pattern (also, red for a cost, and green for a benefit) signify that the factors are partially relevant or valued by some of the engagers. Lastly, blank cells signify that the factors are irrelevant to the activities or not of concern to the engagers. For example, the personal-use benefit is relevant and highly valued by the engagers in most activities, except for blogs and YouTube, in which the benefit is only valued by some engagers, and Wikipedia and Slashdot, in which it is not valued by the engagers.

Table 1 Summarized relevancies of prospective benefits and costs of COIS in selected creation activities.



The table may mislead in that, since that there are more prospective benefits than costs, people would always perceive more benefits than cost and decide to engage in COIS. It should be noted, however, that the total numbers of benefits and costs do not matter. Two benefits do not necessarily outweigh one cost. All factors are almost always valued qualitatively. Different people in different circumstances often regard different costs and benefits differently. Seemingly trivial costs may be unaffordable to some users and enough to deter them from engaging in COIS.

In this work, benefits are broken down into finer factors, resulting in a higher number of benefits than costs. The reason for that is to figure out what *drives* the people who have decided to engage in COIS. Obviously, they can perceive some prospective benefits from COIS. Finer benefit factors provide a more detailed means to understand the motivations of the engagers.

4.2 Perception-Influencing Mechanisms

The previous section shows how different benefits and costs of COIS play a role in people's decision-making. Some benefits and costs are more easily perceivable than others. Combinations of which benefits and costs are easily perceivable vary from activity to activity. This section looks at four mechanisms that influence how benefits and costs of COIS can be perceived by people. Each mechanism influences multiple benefits and costs simultaneously.

4.2.1 Open Content Licensing

Description

Open content licensing is a genre of licenses used for negotiating legal rights in digital content (Suzor & Fitzgerald, 2007). The basic idea is that, through an open content license, a rights owner of digital content can give permission *in advance* for the content to be shared and reused. Any downstream users could use and share the content without having to explicitly ask for permission from the rights owner, as long as certain conditions initially set by the rights owners are met. Three of the most currently popular types of open content licenses are GNU General Public License, GNU Free Document License, and Creative Commons.

GNU General Public License (GPL) is a free, "copyleft" license for software works (Free Software Foundation Inc., 2007c). When developers release software under GPL, they still assert copyright on the software, but give other people permission to freely copy, distribute, or modify the software. Released improved versions of software originally released under GPL must also be free software (Free Software Foundation Inc., 2007a). A large number of free software is released under GPL.

GNU Free Document License (GFDL) complements GPL. The purpose of GFDL is to make manuals, textbooks, or other useful documents free for anyone to copy, distribute, or modify, while the authors still get credit for their work (Free Software Foundation Inc., 2007b).

Inspired by GPL, Creative Commons (CC) are designed for creative works, including Web sites, scholarship, music, film, photography, literature, courseware, etc. (Creative Commons, 2007d). The purpose of CC is "to offer creators a best-of-both-worlds way to protect their works while encouraging certain uses of them — to declare 'some rights reserved'" (Creative Commons, 2007a). Creators can choose a set of conditions to apply to their work, based on the four basic conditions (Creative Commons, 2007e).

- Attribution – other people can copy, distribute, display, and perform the copyrighted work and its derivatives, as long as they give credit the way the rights owner requests.
- Noncommercial – other people can copy, distribute, display, and perform the work and its derivatives, but for noncommercial purposes only.
- No Derivative Works – other people can copy, distribute, display, and perform only verbatim copies of the work, not derivative works based upon it.
- Share Alike – other people can distribute derivative works only under a license identical to the license that governs the original work.

The role of open content licenses is discussed in the literature (Suzor & Fitzgerald, 2007). The literature states that licenses can set the norms of interaction between members in a community. Specifically, selection of licenses in a community can affect the level of participation of the members, the willingness of the members to share and build off each other's work, the manner in which the members interact, and the long-term sustainability of the community.

Influences on Benefits and Costs of COIS

Open content licenses foster norms of sharing, reusing, and building upon information in COIS. When an open content licensing scheme is incorporated in COIS activities, it can influence how people perceive prospective benefits and costs of COIS.

- More valuable *joy-of-giving* benefit – open content licensing creates a sharing atmosphere and influences people to enjoy sharing the information that they have synthesized.
- More valuable *commons-of-resources-and-shared-cultural-context* benefit – open content licensing indirectly fuels and fosters commons. By encouraging reusing, modifying, and re-sharing of commons, open content licensing ensures that existing commons are tested by different people and supplemented by newly synthesized and improved information.
- More valuable *potential-debugging-or-improving-help* benefit – open content licensing encourages reusing and modifying of shared synthesized information. People can

perceive that if they engage in COIS with open content licensing, their synthesized and shared information has a good chance to be derived from or improved upon by other people. This increased value can be highly regarded in COIS of creative works.

- More valuable *social-networking* benefit – open content licensing induces fluxes of people, especially those who like to use freely shared works and those who like to build upon or help improve others' works. Thus, prospective engagers in COIS can perceive the likely opportunity to interact and network with other people.
- More valuable *network-effects* benefit – open content licensing encourages reusing of shared synthesized information. People can perceive that if they engage in COIS with open content licensing, many people will likely use the information that they synthesize and share. Thus, there is a good chance that there will be network effects.
- Less concerning *loss-of-proprietary-information* cost – open content licensing preserves the rights of the copyright owner, while still allowing other people to reuse, modify, and redistribute the works. Thus, the licensing lessens the loss-of-proprietary concern that people who engage in COIS may have.

Overall, open content licensing can influence people's perception in regard to commons, community, and public sharing in COIS. In a COIS community with open content licensing, sharing is about benefiting other people, not about revealing to gain advantages. So, benefits like *reputation* and *advancement from making first publication* are not increased in value. Open content licensing does not concern the infrastructure of a COIS community, either, so costs like *transaction cost to publish synthesized information* and *community membership cost* are not affected.

Examples of Influences in Creation Activities by Non-Experts

The influences of open content licensing are evident in many creative COIS activities. The following are some examples:

- F/OSS – GNU General Public License (GPL) is a typical form of open content license used in the area of F/OSS development. Due to the influences of GPL, F/OSS programmers highly value:
  - The joy of sharing the software they have created
  - Commons of open source software and free codes, and the shared culture of hacking and free software movement
  - Potential that their software can later be reused, debugged, and extended by other programmers
  - Opportunities to collaborate and socialize with other programmers with similar interests.
  - Network effects that result in improved software commons

  GPL also influences F/OSS programmers to cherish more of the value of sharing and other benefits, and to worry less about the loss of potentially profitable software sales.

- Wikipedia – articles in Wikipedia are released under GNU Free Document License (GFDL). GFDL helps influence Wikipedia contributors to highly value the following:
  - The joy of contributing their knowledge to society
  - A large number of articles that can be referenced or used as supplementing explanations, and the culture of a free online encyclopedia as commons
  - Potential for their articles to be improved by other contributors, as part of collaborative authoring
  - Network effects resulting in an increasing number of improved articles as well as more readers

  The open content license also makes the Wikipedia contributors not worry about the loss of copyright claims on their written articles. However, GFDL does not influence the contributors' perception on the value of networking.

- Flickr – People are encouraged to publish their photos in Flickr under Creative Commons (CC). Because of the influences of CC, most participants in Flickr highly value:
  - The joy of sharing photos
  - The commons of shared photos and viewer base
  - Opportunities to receive comments on their photos
  - Chances to interact and network with other professional photographers and photography enthusiasts
  - Network effects that lead to more versatile tags in their personal collection, bigger overall photo collection, and more audience

  CC also helps influence engagers in Flickr to not worry about the loss of opportunity to make a profit from their photos.

- ccMixter – all music shared in ccMixter is licensed under Creative Commons. Due to influences of CC, engagers in ccMixter highly value:
  - The joy of sharing music that they have created
  - The commons of music and listener base
  - Feedback and reinterpretation of their music by other people
  - Opportunities to collaborate and network with other musicians and people with musical abilities
  - Network effects that can lead to more listeners and larger selection of music

  Also, CC helps influence engagers in ccMixter to not worry about the loss of opportunity to make a profit from their photos.

Additionally, influences of open content licensing are also evident in Apache and kitesurfing communities.

4.2.2 Pioneering Work

Description

The literature on online collaborative knowledge systems shows that the workload in systems like Wikipedia and del.icio.us have shifted from "elite" users to "common" users (Kittur, Chi, Pendleton, Suh, & Mytkowicz, 2007). In the recent years, the absolute numbers of activities by "elite" and "common" users have both increased, but the number of activities by "common" users has grown more sharply. As a result, the percentage share of the total contribution by "common" users has grown, while that of "elite" users has shrunk. The same trend can be observed in del.icio.us as well. The literature argues that such trends happened because early participants generate sufficient utility in the system for the larger masses to later find value in low cost participation.

This work takes the argument a step further and supports it with the COIS model. Early participants, often but not only lead-users, did pioneering work in a certain environment to make it appealing enough for later users, often common people, to engage in it too. It is proposed here that, the pioneering work "generates utility" *by influencing the prospective benefits and costs of COIS,* in such a way that other people are then also appealed to engaged in COIS. Early participants, in this context, do not include the environments' developers. For instance, early participants of Wikipedia include all participants, both lead and common, in the early years, but not the founders and official developers.

Influences on Benefits and Costs of COIS

Pioneering work by early participants affects the following prospective benefits and costs of COIS:

- More valuable *commons* benefits – early participants establish and seed commons as part of their pioneering work.
- Reduced *required-effort-and-resources-for-creation* cost – pioneering work in forms of guideline and help forums established by early participants can be helpful. People can perceive that if they engage in COIS, they would be able to get some help on their creation. Additionally, early participants may have revolutionized how creation is done. Later prospective engagers can then perceive that creation is easier than before.
- More noticeable *network-effects* benefit – pioneering work by early participants often helps establish an initial user, or audience, base. Since network effects start off with "more users of the product", an initial user base can help jumpstart network effects.

  People can perceive that if they engage in COIS in an environment that already has an initial user base, their synthesized information is more likely to have network effects (than in an environment with no initial user base).
- Reduced, or avoided, *transaction cost to publish synthesized information* – early participants overcome the learning curve how to make synthesized information available and

make it easier for later participants to do so. Development of a publishing infrastructure by the environment's official developers is not considered pioneering work.

- Reduced, or avoided, *community membership cost* – early participants help establish a mature community that does not incur additional cost to take on new members. Prospective engagers in COIS then do not need to worry about a membership cost at all.
- More valuable *social-networking* benefit – a community established by pioneering work also adds value to social networking. Prospective engagers in COIS can perceive the networking value of an established community.
- More valuable *being-ahead-of-or-in-trend* benefit – pioneering work not only establishes a community and user base, it can also establish a trend. When a trend of engaging in a particular COIS exists, some people can perceive that they could be in trend by engaging in COIS too.
- More valuable *reputation* benefit – in addition to being part of commons for engagers, a new cultural context established by pioneering work can also be a new ground upon which people can earn reputation.

Overall, pioneering work affects all benefits and costs related to participation and many related to publication. Benefits that are personal, such as *satisfied needs*, *joy of creating*, and *joy of giving*, are unaffected.

Examples of Influences in Creation Activities by Non-Experts

Influences of pioneering work are evident in most non-expert creation activities. The following are some examples:

- del.icio.us – early participants are early users of del.icio.us who created many bookmarks and tags. The pioneering work in del.icio.us helps influence later prospective engagers to value:
    - The seeded commons of existing bookmarks and tags
    - Network effects in forms of more versatile personal tags and more capable collective bookmarks, resulting from initial bookmark base

  The pioneering work also influences some prospective engagers to value:
    - Social networking with people who have similar interests, among the existing participants
    - Being in trend, based upon a trend started by early participants

  The pioneering work helps later prospective engagers not worry about community membership cost, by forming a big enough user base of del.icio.us for the owners of the site to create income revenues through advertisement. Also, tags created by early participants are pioneering works that help offset efforts to create new bookmarks.

  There is no transaction cost to publish bookmarks in del.icio.us, but that is a result of the design of the infrastructure, not the pioneering work. Also, the infrastructure keeps publication nearly anonymous, so the pioneering work has no effects on how prospective engagers perceive the reputation benefit.

- YouTube – early participants in YouTube are users who share their videos at the beginning. Their pioneering work helps influence how later engagers highly value:
  - The seeded commons of shared videos and an established cultural context
  - Being in the trend of sharing videos online

  The pioneering work also helps influence how some engagers value:
  - Social networking with others with similar interests
  - Reputation from sharing famous videos on a well-known Web site
  - Network effects of more videos and viewers, as by-products of the established cultural context

  The pioneering work, however, does not help make prospective engagers worry less about any costs. The cost to create a new video cannot be offset by the pioneering work. Also, the cost to publish videos and the community membership cost are already avoided as part of the infrastructure of the site.

- Kitesurfing – early participants are those who started kitesurfing and designing of kitesurfing equipment. Their pioneering work helps influence how later engagers highly value:
  - Social networking with other kitesurfers in an established community
  - Established commons of kite designs
  - Network effects of more kite designs and expanded communities of kitesurfers

  The pioneering work also helps influence later engagers to be less concerned about the effort required to create new kite designs, given help and guidelines from existing members of a community of kitesurfers. The early participants also form their communities in a way that they would not incur any transactional or membership costs on later engagers.

  In general, kitesurfers do not value the *being-ahead-of-trend* and *reputation* benefits much, so the pioneering work does not influence prospective engagers in those aspects.

In addition, influences of pioneering work can also be seen in F/OSS, BitTorrent, Wikipedia, Blogs, Flickr, ccMixter, Amazon recommendation, Slashdot, Friendster, and Apache.

4.2.3 Communal Taxing

Description

Communal taxing is a mechanism that induces collective social benefits as private-cost-incurring side effects of self-serving creations. Individual creators are aware of the taxing but do not mind it. They feel good that they can contribute to their communities while engaging in creation for their own personal benefits.

The literature on social bookmarking tools touches on the notion of communal taxing in the form of social tagging or folksonomy (Hammond et al., 2005). It discusses social tagging in del.icio.us and Flickr from the systems' points of view. That is, it focuses on how the systems derive benefits from aggregated actions by individuals.

This work looks at the effects of social tagging from individuals' points of view. Social tagging is a type of communal taxing, which also includes other activities that do not involve tags or classification. It is proposed here that when communal taxing is used, it does not benefit only the community or system. Rather, communal taxing can also benefits the taxed individuals. It affects many potential benefits and costs of COIS that prospective engagers may consider. The presence of communal taxing in a COIS activity can positively influence the decisions of prospective engagers.

Communal taxing has four main criteria:

- Private benefits are primary objectives.
- Social benefits are side effects.
- Social benefits are derived from an aggregation of multiple individuals' actions.
- The derivation of social benefits incurs costs to the individuals.

Influences on Benefits and Costs of COIS

Communal taxing can influence how people perceive the following prospective benefits and costs of COIS.

- More valuable *joy-of-giving* benefit – engagers can feel good that they can contribute to the community by paying some, often little, costs.
- More valuable *commons* benefits – communal taxing often benefits commons of the community, since new resources are continuously taxed from individuals and added to the commons. Prospective engagers in COIS can perceive the value of continuously improved commons.
- More noticeable *network-effects* benefit – since the commons are constantly improved, coupled improvements of commons and products of syntheses are likely. The coupled improvement, also referred to as "upward spiral" earlier, can draw many

end-users, resulting in more network effects. People can perceive that if they engage in COIS, the products of their syntheses are likely to create network-effects benefits.

- Increased *transaction cost to publish synthesized information* – communal taxing may incur transactional costs, in forms of fees or required computer resources, to make synthesized information available.
- Increased *loss-of-proprietary-information* cost – communal taxing may tax some personal information.
- Increased *community-membership* cost – community membership costs may need to be raised, in order to accommodate the taxing mechanism.
- More valuable *advancement-from-making-first-publication* benefit – some taxing schemes recognize people who contribute more significantly than others.

Communal taxing not only makes some prospective benefits more valuable. It also increases some costs, which can deter some people from engaging. Nonetheless, the increased costs in most cases are often small compared to the increased benefits.

Examples of Influences in Creation Activities by Non-Experts

Influences of communal taxing are evident in many non-expert creation activities, including the following examples:

- BitTorrent – the tit-for-tat policy is essentially a form of communal taxing. The objective of most BitTorrent users is to download files for themselves. The tit-for-tat policy taxes the users by requiring that they share files back to the swarms, in order for their downloading to proceed effectively. The side-effect social benefits are the increasing number of file uploads, enriching the commons. The private costs that the users have to pay for the communal taxing include not only the files they share back to the swarms, but also their personal computers' memory resources.

  Communal taxing influences BitTorrent users to value:

  - The commons of files, which the users know are continuously enriched by the taxing
  - The joy of giving back to the swarms, from which they have taken resources
  - Network effects that result in more people being drawn to join the swarm, hence improving performance of torrents in the swarm
  - Being a "seed" by contributing complete files

  The communal taxing in BitTorrent incurs two costs on the users:

  - A BitTorrent software for managing torrent connections, downloading, and uploading file bits, as a cost to participate
  - Computer memory resources required to make their files available

  The two costs, however, are trivial to most BitTorrent users. The communal taxing does not incur a loss of proprietary or privacy information on the users.

- Friendster – the objective of engagers in Friendster is to create connections, as personal benefits. The system taxes each engager by automatically making all of his or her connections available as commons in everyone he or she has a connection with. For instance, suppose that A already has connections with B, C, and D. When A makes a connection with E, the system automatically shows to E all the connections that A already has, so that, if E wants to, E can make a connection with B, C, or D as well. The social benefit from the taxing is the automatically shared connections, which aggregate to be networks of people. The private cost incurred to all engagers is a considerable loss of privacy information.

  Due to the influence of communal taxing, engagers in Friendster value the following benefits:

  - The commons of connections
  - Joy of sharing connections
  - Network effects that lead to more people joining the networks

  The communal taxing in Friendster, unlike the one in BitTorrent, does not incur any membership cost or transactional cost to share connections, so the engagers do not have to worry about those costs. The loss of privacy, however, could be a concerning cost to some people, but most people engage in Friendster to socialize. So, they would consider sharing connections of people they know as a gesture of introducing friends to friends, but not as a loss.

- Blogs – communal taxing in blogs is not as formal as the ones in the previous two examples. The communal taxing in blogs is not part of a rule in the system. Instead, it is a result of bloggers' activities in the blogosphere. Bloggers write and publish their blogs for their own objectives. They link to one another's posts. They repost one another's stories and opinions. Stories and issues that are of importance to bloggers get highlighted and amplified through multiple blogs. The result is wisdom of crowds (Surowiecki, 2005). The way that the blogosphere collects and aggregates information from all the blogs can be considered communal taxing. The cost that is incurred on the bloggers is a loss of privacy and potentially proprietary information, as the writings of their personal information are passed along and echoed in the blogosphere. Of course, such cost is totally insignificant to the bloggers, since they are well aware that anyone can read their blogs. Thus, the communal taxing incurs a negligible cost on the bloggers.

  The communal taxing helps influence bloggers to value the following benefits:

  - Commons of blogs and readers in the blogosphere and the blogs' collective power as wisdom of crowds
  - Joy of giving, as bloggers know that materials that others utilize from their blogs (by reposting or linking to them) could eventually be highlighted and amplified throughout the blogosphere
  - Network effects that lead to even more blogs and more readers in the blogosphere

The communal taxing does not incur any membership cost or transactional cost to publish blogs, besides the trivial cost of privacy loss.

- del.icio.us – as mentioned above, communal taxing in del.icio.us is in a form of social tagging. The taxing occurs when the system collects shared bookmarks and tags from all users, and aggregates them to form one large, cross-tag-indexed bookmark collection. The users create bookmarks and tags for personal purposes. Having the bookmarks that they shared be utilized to create a large bookmark collection is a side effect. The communal taxing incurs a cost of privacy loss on the users, since their *personal* bookmarks can be seen by anyone. Nonetheless, del.icio.us users are well aware of the communal taxing mechanism and do not mind the privacy loss. (Any particular bookmarks can also be set as private and do not get shared or utilized as part of the system-wide collection).

  Communal taxing also helps influence the engagers in del.icio.us to value the following benefits:

  - commons of bookmarks, since the engagers are aware that the commons are continuously enriched
  - joy of sharing their bookmarks to be part of a bigger, more sophisticated system-wide collection
  - Network effects that result in more people joining del.icio.us and ultimately expanding the commons

  Besides the trivial cost of privacy loss, the communal taxing does not incur any membership cost or transactional cost to share bookmarks.

In addition, influences of communal taxing are also evident in Flickr.

4.2.4 Power-Member Status

Description

In some communities, members who have shown commitment and contributed significantly can earn the status of a power member. Members with power-member status have more privileges and capacities to perform more functions than other members in the community. In an altruistic community, after having demonstrated enough benevolent performance, members can earn power-member status, which allows them to contribute even more to the community. In other words, power-member status is an incentive for people to do good deeds, in order to earn a chance to do greater deeds. Such incentive, nonetheless, often works only with people who enjoy doing good deeds.

Influences on Benefits and Costs of COIS

Power-member status can influence how people perceive the following prospective benefits of COIS:

- More valuable *reputation* benefit – people who want power-member status value being recognized for their good contributions.
- More valuable *joy-of-giving* benefit – the incentive can make it more rewarding to give.
- More valuable *being-ahead-of-trend* benefit – with power-member status, some people can feel that they are more special than other normal members.

Examples of Influences in Creation Activities by Non-Experts

Influences of using power-member status as an incentive are evident in many non-expert creation activities, including the following examples:

- Amazon recommendation – people who have written many good reviews can earn "Top Reviewer" badges, which range from #1, top 10, top 50, top 500, to top 1000 (Amazon.com Inc., 2007a). When a reviewer has one of the badges, her review of any product is featured as one of the product's top reviews and has a much better chance than other reviews to be seen by prospective buyers. Reviewers with a badge also earn themselves the satisfaction of having done their contribution.

  The incentive of a Top Reviewer badge influences some reviewers to highly value:

  - Being recognized for the reviews they write
  - Being more special than other normal reviewers

  The incentive also makes writing reviews more enjoyable and rewarding for some reviewers.

- Slashdot – people who have been part of Slashdot for a long time and have shown good contributions (by writing comments and submitting stories) can become moderators (SourceForge Inc., 2007c). Moderators have privileges to moderate news stories and comments that people have written. In a way, the privileges allow moderators to contribute more to Slashdot than normal members can.

  The incentive of becoming a moderator influences engagers in Slashdot to value:

  - Being recognized for their commitment and contributions
  - Having more privileges than other normal engagers

  Also, some engagers enjoy contributing more because of the incentive.

- Apache – like in many F/OSS projects, people who have shown commitment and abilities to make significant contribution can earn administrator status. An administrator has privileges to direct and manage the project or a part of it. So, effectively, an administrator has more opportunities contribute.

  Administrative status is an incentive that can influence engagers in Apache to highly value:

  - Recognition for their contributions
  - Having more privileges than other engagers

For some engagers, the incentive is also a motivation that makes their contributions more rewarding.

Additionally, influences of power-member status are also evident in F/OSS and Wikipedia.

4.2.5 Further Notes

It is interesting to note the differences between the mechanisms of communal taxing and power-member status. On the one hand, with communal taxing, engagers receive private benefits as a main objective, and also induce social benefits as side effects. The induction of social benefits incurs private costs on the engagers. On the other hand, with power-member status, engagers generate social benefits as a main objective, and also receive personal satisfaction as a side effect.

4.2.6 Summary of Mechanisms' Influences from a Different Viewpoint

From the above discussions of the mechanisms' influences, it is apparent that some prospective benefits and costs are influenced by multiple mechanisms, while some are not influenced by any mechanism at all. This subsection summarizes the mechanisms' influences from a different perspectives – of prospective benefits and costs of COIS.

- Personal use of synthesized information – a "personal" value that is not influenced by any mechanism.
- Joy of creating and other side benefits – also a "personal" value that is not influenced by any mechanism.
- Required effort and resources for creation – can be influenced to be less of a concerning factor by revolutionary improvement in creation procedures, techniques, or technologies (results of pioneering works by early participants).
- Commons of information resources and shared cultural context – can appear more valuable when there are already abundant "seeds" (results of pioneering works), or when sharing is a norm in the community (result of open content licensing), or when there is almost a guarantee that the commons are constantly enriched (results of communal taxing).
- Social networking – can be influenced to appear more valuable by an established network (result of pioneering work), or norms of sharing, collaborating, and interacting in the community (results of open content licensing)
- Community membership cost – can be made lower by early participants' sufficient establishment of a community (pioneering work); but can be raised as part of a fee to maintain status in the community and access privilege to the commons (results of communal taxing).
- Potential help on debugging or improving synthesized information – can be influenced to appear more valuable when the community has a norm that encourages members to reuse and help improve one another's works (results of open content licensing).

- Reputation from publication – can be influenced to appear more valuable when there is an established audience base upon which reputation can be built (results of pioneering work), or when there exists a special member status that requires a good reputation to obtain (results of power-member status).
- Joy of giving – can appear more valuable when giving is a norm of the community (result of open content licensing), or when giving can amount to a greater aggregated power (result of communal taxing), or when giving can lead to a good reputation that is needed to attain a special member status (results of power-member status).
- Advancement from making first publication – can appear more valuable when being the first to share is distinguishable (result of communal taxing).
- Network Effects – can appear more valuable when reusing of shared products is encouraged (result of open content licensing), or when an initial user base is already started (results of pioneering work), or when commons are likely to be constantly enriched (result of communal taxing).
- Transaction cost to publish synthesized information – can be made less concerning when early participants have helped shape the infrastructure to avert publishing cost (results of pioneering work); but can be raised by a taxing mechanism (result of communal taxing).
- Loss of proprietary and privacy information – can be influenced to appear less concerning when the community's norm is to share (result of open content licensing); but can be raised when taxing of personal information is involved (result of communal taxing).
- Satisfied needs – also a "personal" value that is not influenced by any mechanism.
- Being ahead of or in trends – can appear more valuable when a trend has been established (result of pioneering work), or when a more special user status exists (result of power-member status).

The mechanisms' influences on the prospective benefits and costs of COIS are also summarized in Table 2. An up arrow signifies that the mechanism influences the increase in the value of the benefit or cost. Likewise, a down arrow signifies that the mechanism influences the decrease in the value of the benefit or cost. A blank cell signifies that the mechanism does not influence the value of the benefit or cost. Red arrows are associated with costs, and green arrows with benefits. For example, the mechanism of open content licensing influences the increase in value of the joy-of-giving benefit. The mechanism also makes the loss-of-proprietary-information less of a concerning cost. Meanwhile, the mechanism of communal taxing influences the increase in the values of many benefits, but it also causes three cost factors to rise.

Table 2 Summary of the mechanisms' influences on the prospective benefits and costs of COIS.

	Open content licensing	Pioneering work	Communal taxing	Power-member status
Personal use of product				
Joy of creating				
Required effort and resources		▼		
Commons of resources	▲	▲	▲	
Social networking	▲	▲		
Community membership cost		▼	▲	
Debugging or improving help	▲			
Reputation from publication		▲		▲
Joy of giving	▲		▲	▲
Advancement from first publication			▲	
Network Effects	▲	▲	▲	
Transaction cost to publish		▼	▲	
Loss of proprietary or privacy	▼		▲	
Satisfied needs				
Being ahead of or in trends		▲		▲

4.3 Explanation for Lack of Common People's Engagement in Product-Development Creation Activities

Common people do not always engage in non-expert creation activities. As shown in the analyses in the previous chapters, common people engage in non-expert creation activities in Web 2.0, but not in product development. Such lack of engagement can be explained in terms of prospective benefits and costs of COIS.

In terms of costs, creation processes in product development usually have high costs in the forms of required effort and resources. The development costs are usually high because special capabilities or resources, such as computer programming abilities or tools for building prototypes, are required. Lead users usually possess or have access to the special capabilities or resources, so they perceive the development cost to be manageable. Common people, on the other hand, do not usually have access to such special capabilities or resources. As a result, they perceive the *required-effort-and-resources-for-creation* cost in product development to be very high.

In terms of benefits, lead users usually obtain high reward from creation in product development, in forms of functional prototype. The extent of creation by common people, on the other hand, is limited due to the lack of special capabilities. As a result, common people typically anticipate little, if any, *personal-use-of-synthesized-information* and *joy-of-creating* benefits from creation.

Furthermore, common people are used to settling for standard products that they can obtain, even though those products may not fit their needs exactly (F. T. Piller, 2004). Consequently, some common people may not highly value the *satisfied-needs* and *being-ahead-of-or-in-trends* benefits that they could get from COIS.

When creation activities in product development are non-COIS (such as the cases of printed circuit CAD software, library information system, and hospital surgical equipment), only benefits and costs of creation are taken into account. Common people can only perceive high development cost and few benefits in this case, so they are unlikely to decide to engage in the activities.

Common people also do not engage in creation activities in product development that are COIS (such as in the cases of F/OSS, Apache, and kitesurfing equipment). This means common people do not perceive the additional benefits from participation and publication, together with the offset of development cost by commons, to be high enough to outweigh the development cost. In general, that is because the development cost, especially in forms of necessary special capabilities, is very high. In many cases, it is also because the communities and commons are not set in a way that is suitable or beneficial for common people.

4.4 Chapter Summary

This chapter focused on the prospective benefits and costs of COIS, which are derived from the creation, participation, and publication processes. There are fifteen benefit and cost factors of COIS, including:

- Personal use of synthesized information
- Joy of creating and other side benefits
- Required effort and resources for creation
- Commons of information resources and shared cultural context
- Social networking
- Community membership cost
- Potential help on debugging or improving synthesized information
- Reputation from publication
- Joy of giving

- Advancement from making first publication
- Network Effects
- Transaction cost to publish synthesized information
- Loss of proprietary and privacy information
- Satisfied needs
- Being ahead of or in trends

Each factor's roles in various environments of non-expert creation activities were explained.

The second section described four mechanisms that can influence how the prospective benefits and costs are perceived. The mechanisms are open content licensing, pioneering work, communal taxing, and power-member status. They generally help highlight certain prospective benefits and eliminate or downplay certain prospective costs. Each mechanism was discussed in terms of its influences on the benefit and cost factors of COIS. In addition, examples of how each mechanism's influences in different environments were also given. The section also looked at the influences of the mechanisms from the viewpoint of each of the fifteen benefit and cost factors.

Finally, the last section explained, in terms of the prospective benefits and costs of COIS, why common people do not often engage in creation activities in the product development area.

5

Potential Applications of Commons-Oriented Information Syntheses

Information synthesis by common people, knowledge diffusion, and design development and concept exploration

The COIS model provides insights into commons-oriented information syntheses, especially regarding:

- The essentials of COIS – necessary components of an environment in which COIS can thrive
- The motivations of COIS engagers – what drives people to engage in COIS; factors that influence the decisions' of prospective engagers
- The implications of COIS – when information is synthesized in a commons-oriented fashion,
    - The synthesized information is not the only meaningful outcome that benefits the engagers.
    - The synthesized information is continuously evolving through open, unstructured collaboration.
    - The creation process is socially efficient and the synthesized information can have far-reaching implications.

The insights into the essentials of COIS and the motivations of COIS engagers can provide a recipe for how to recreate environments in which commons-oriented creation activities can thrive. Such environments could be useful in many areas. In this chapter, three major areas that could benefit from COIS environments are identified:

- Information synthesis by common people
- Generative diffusion of knowledge
- Design development and concept exploration

Specific applications of COIS environments in the three areas are discussed and possible approaches to implement these applications are also proposed.

5.1 Information Synthesis by Common People

When information synthesis is performed in a commons-oriented fashion, the participants can benefit from not only the synthesized information, but also other potential outcomes. As discussed in chapter 4, people can perceive more prospective benefits from COIS than from a creation process alone. Multiple prospective benefits can collectively outweigh an otherwise prohibitive cost. Some commons can also help offset costs directly.

Common people are, thus, more likely to engage in creation activities that are commons-oriented, such as Web 2.0 activities, than those that are strictly about creation. In this regard, *the COIS model can be a recipe for recreating an environment that invites and fosters information synthesis by common people.*

5.1.1 Product Design Synthesis by Common People

One area in which information synthesis by common people can benefit is product design. The COIS model can be a recipe for getting common people to engage in product design synthesis.

Customer Co-design in Mass Customization

All product users, including common people, have heterogeneous needs. However, not everyone can always attain products that satisfy their needs (E. von Hippel, 2005). Unlike lead users, common people do not have product-building capabilities to create what they want for themselves. They often have to settle for the best attainable standard products, which often do not satisfy their needs perfectly (F. T. Piller, 2004).

Mass customization is a field dedicated to solve that problem. Mass customization (F. T. Piller, 2004) is

> "A customer co-design process of products and services, which meet the needs of each individual customer with regard to certain product features. All operations are performed within a fixed solution space, characterized by stable but still responsive processes. As a result, the costs associated with customization allow for a price level that does not imply a switch in an upper market segment."

One of the earliest visions of mass customization comes from Robert H. Anderson, in which he imagined that, at the beginning of the 21st century, consumers would design products for themselves and have the products made by computers and machines (Toffler, 1981). But, now, already almost a decade into the 21st century, such a vision is still unrealistic. Few consumers today are designing products that will be manufactured just for them, and most people are still buying products manufactured in a mass production system (F. Piller, Schubert, Koch, & Möslein, 2005).

Many challenges that hold back mass customization from reaching its full potentials are discussed in the literature (Boer & Dulio, ; Brown & Bessant, 2003; MacCarthy, Brabazon, & Bramham, 2003; F. T. Piller, 2004; Salvador, Rungtusanatham, & Forza, 2004; Squire, Readman, Brown, & Bessant, 2004; M. M. Tseng & Jiao, 2001; M. Tseng, 2002). One major challenge of mass customization is that systems for customer co-design processes are still inadequate, e.g. in terms of usability (F. T. Piller, 2004). The inadequacies in customer co-design often lead to the problem of "mass confusion". That is, when consumers are asked to act as co-designers, they feel confused about what to do and uncertain of the outcomes (F. Piller et al., 2005).

One proposed approach to reduce mass confusion problems is to use "online communities for collaborative customer co-design" (F. Piller et al., 2005). Such communities can help reduce mass confusion problems in three ways. First, general preferences of customers in a certain group in a community can be extracted and used to form starting pre-configurations. Each customer can then use the group's pre-configurations as starting points for further personalizing his or her own configurations. Second, users in the communities can support one another in finding and evaluating design solutions, reducing the burden-of-choice problem. Third, design solutions that are jointly developed are likely robust and trusted by members in the communities. Essentially, the approach is to let customers help one another overcome confusion in co-design.

COIS in Customer Co-design

One contribution of COIS to mass customization could be to help reduce mass confusion problems in customer co-design. In particular, COIS can add to the approach of "online communities for collaborative customer co-design" by introducing the notion of design commons within the communities.

With design commons, customers can help one another overcome mass confusion problems in a way other than direct collaboration. That is, design commons can facilitate indirect and unstructured collaboration among customers. For example, a design developed by one customer may be shared as a common to the community, and later be reused, improved, modified, or incorporated into new designs by other customers. In that way, the collaboration is indirect, unstructured, and open. Thus, COIS can introduce the notion of design commons as an additional way to reduce mass confusion problems.

In a broader scope, COIS can be a step toward customer co-design in the next generation of mass customization. Up until now, mass customization has only been about configuring customizable products (F. T. Piller, 2004). The next generation of mass customization should be beyond that; it should be about open innovation (F. T. Piller, 2004).

It is uncertain how the open innovation in the next generation of mass customization will turn out. It could become like the current user-led product development, in which only lead users, but not common people participate. Or, it could become like the content creation in Web 2.0, in which everyone participates, even people who were used to be just "passive audience".

The COIS model can be used as a recipe to create an open-innovation environment that can draw common people to engage in customer co-design in the next generation of mass customization. Especially, the COIS model provides highlights into factors that could affect people's decisions. The factors include prospective benefits and costs that people could perceive and mechanisms that could influence their perception. Common people are more likely to engage in mass customization when they can perceive sufficient and clear benefits, together with significantly reduced costs. Nonetheless, as mentioned earlier, customer co-design is a major, but not the only, challenging part of mass customization. So, the help by COIS in customer co-design alone would unlikely make mass customization a reality, until after the problems in the other parts (Boer & Dulio, ; Brown & Bessant, 2003; MacCarthy et al., 2003; F. T. Piller, 2004; Salvador et al., 2004; Squire et al., 2004; M. M. Tseng & Jiao, 2001; M. Tseng, 2002) are addressed as well.

Hypothetical Scenario

Imagine the mass customization of chairs in the future. There will be a Web site supported by a company specializing in custom chair manufacturing. The company will have technologies, e.g. special laser-cutting, that allow them to manufacture chair parts of any designs at relatively low costs. Chair users will form an informal community around the Web site. The commons of the community will be designs of chairs and chair parts. The chair-design commons, hosted and accessible on the Web site, will come from various members of the community as well as the company.

Anyone, including common people, will be able to join the Web site, and hence the community, for free. Then, they will be able to create their own chair design by using a simple, Web-based CAD tool that is part of the Web site. They can make a new design from scratch, or reuse, adapt, build upon, or remix designs from the commons. The company will manufacture chair parts for the new design and then ship the parts to the customers. The customers will then assemble their own chair once they have received the parts from the company. Also, the new chair design will be shared with the community as a new common.

People who will engage in this mass customization will do so because they perceive more benefits than costs. The engagers will mainly value

- The *personal-use* benefits – the finished chair designs can become actual chairs that the engagers can use.
- The *joy-of-creating* benefit – the engagers will enjoy exploring their own creativity and remixing others'.

- The *commons-of-shared-resources* benefit – the engagers will not have to come up with a new design from scratch; instead, they can use the shared design commons as starting points or references.
- The *social-networking* benefit – the engagers will be able to socialize among people who like to custom design chairs.
- The *reputation* benefit – the engagers can be known for their chair designs
- The *joy-of-giving* benefit – the engagers will enjoy sharing their designs with others and seeing their designs get reused or remixed.
- The *satisfied-needs* benefit – the engagers can satisfy their needs of uniquely and personally designed chairs.
- The *trend* benefit –The engagers will be able to catch up to the trend of owning custom-made, yet affordable, chairs.

The other benefits will not be as important. Additionally, the engagers will also have to consider the following costs:

- *Required effort and resources for creation* – thanks to the Web-based simplified CAD tool and the commons of chair designs shared by previous customers, creating a new chair design will not be very difficult. Even though the engagers will not have to pay for the designing, they will still have to pay for the materials, the manufacturing, and the shipping premiums. Nonetheless, the special manufacturing technology will be mature enough that it will not make the total cost of a custom-designed chair much more expensive than a generic one.
- *Loss of proprietary information* – a new chair design may be patentable, but the engagers will not worry too much about such lost opportunities, since their chair designs will likely be based on design commons, obtained for free from the community.

There will be no costs to participate and to make their designs available.

Two mechanisms will play important roles in the mass customization. First, in the early days, the company will invite some designers to perform *pioneering work* by creating some chair designs to seed the commons. The pioneering work will most significantly help bring down the *required-effort* for later engagers. Second, the company will grant *power-member status* to the engagers whose designs are outstanding. Those engagers will be given more power to contribute to the community, as their designs will be featured for other engagers to reuse or refer to.

This hypothetical scenario is an example of how COIS can help contribute to customer co-design in the next generation of mass customization.

A note about use of models in product design

Various types of models of product designs are used for different purposes throughout product development processes (Ulrich & Eppinger, 2007). Models of product designs can be physical (e.g. drawings, sketch/soft models, physical mockups, alpha prototypes), or virtual (e.g. thought experiments, computer simulations, CAD models, economic analyses) (D. R. Wallace, 2007a; D. R. Wallace, 2007b). In the context of COIS, most communities are formed through the Internet, so virtual models are more appropriate for sharing among the communities' members.

The following are important functionalities of virtual models in product design:

Representation. CAD and simulation models can represent appearance, properties, or behaviors of products. Most virtual models are computer-based and parametrically configurable. For instance, dimensions of CAD geometries and inputs of simulations can be changed. Thus, unlike physical models, like blueprints, virtual models can embody more than one fixed design. (Nonetheless, appropriate limits and ranges of inputs within which configurations can be made need to be carefully provided). In other words, models can be considered as *live* or *dynamic* representations of designs.

Prediction. Due to their *live* nature, models can be quickly reconfigured for answering what-if questions. For example, dimensions of two CAD geometries can be changed to see if they can fit together, or inputs of a simulation can be changed to see what outcomes will turn out. Virtual models also allow cheaper experiments than real physical test, e.g. car crash tests (E. von Hippel, 2005).

Integration. Virtual models of design components can be integrated to represent a bigger scope. For example, models of parts can be integrated to represent a whole product, or models of a product's performance and economic analyses can be integrated to predict the product's placement in the market. Because of the parametric nature of virtual models, integration can be done by using outputs from one model as inputs of another.

Transfer. Models are relatively easy means for transferring designs. Virtual models allow encapsulated design essentials to be passed along to different people while still leaving the details configurable.

Customization. Models represent general forms, properties, or behaviors, of designs. Different people can customize designs by configuring the models. The parametric nature of virtual models allows people to adapt designs to specific circumstances.

In the above hypothetical scenario of mass customization of chairs, CAD models are used as design representations. One can further imagine that other forms of models can also be utilized. The company can also make simulation models of chair strength available as commons. Then, if the company can also provide an easy-to-use Web-based tool for connecting models, customers can link the CAD models of their designs to the strength models, to see how their chairs will perform under certain loads. The company can also provide a model for determining manufacturing cost as a function of a design's complexity. Then, customers can also link the cost model to their chair CAD models, to see how their designs affect the costs.

5.1.2 General Information Synthesis by Common People

COIS and Common People's Participation in Policy Drafting

The COIS model can also be used as a recipe for getting common people to engage in information synthesis in other scenarios. For example, a COIS environment can be implemented to entice common people to engage in policy drafting in local communities.

Benefits of new policies can be indirect and not immediately perceivable. Drafting policies in a COIS fashion may provide other benefits to which common people can be drawn. There are also general barriers that hinder common people from engaging in policy drafting. For example, some people may feel intimidated to bring up or argue against some issues in front of certain other people (Craig & Zimring, 2000). Drafting policies in a COIS way may help overcome those issues. In addition, common resources of past and existing policies may help offset some required effort to draft a new policy. The collective, potentially easily perceivable, benefits, combined with some cost offsetting of COIS, might be enticing enough for common people to engage in policy drafting, or other types of information syntheses.

Additionally, use of models can also make policy COIS more engaging. Some policies can be represented by simulation models, which can help predict implications of the policies based on inputs of different policy options. For example, the Tokyo Half Project (Tokyo Half Project, 2007), which aims to reduce CO_2 emissions in Tokyo by 50%, uses simulation models to represent different emission-reduction policies. Multiple policy models are integrated to represent an overall strategy, which is then used to predict how different mixes of policy options will perform. In general, government agencies and other institutes can make their policy models available as commons, so that common people may also utilize the models in their policy COIS.

Hypothetical Scenario

Imagine a small community's policy drafting in a COIS approach. There will be a community Web site set up in a style similar to Wikipedia. There will be past and current policies available as commons. Any members of the community are free to participate. They can draft up a new policy to address an issue that concerns them. Like in Wikipedia, participants can freely reuse or build upon policy commons as part of their new draft. The new draft can be made available as a common for other people to help edit. The draft will be a result of collaborative authoring, while individuals' contributions can be traced. The draft can then be later submitted to seek formal approval and implementation. The new draft can be shared as a common for use by other communities as well.

Also, imagine that policy models from government and development agencies are also made available as commons. Moreover, imagine that there is an easy-to-use tool, embedded in the community's Web site, allowing people to connect different policy models together. People will be able to use the models to predict the implications of their new policy while they are drafting it.

Common people will be able to perceive that, by engaging in the community's policy drafting COIS, they will receive several benefits. There will not be any cost, and the required effort will be not be too daunting, thanks to the policy commons and collaborative authoring. Using policy models to predict the implications, people will be able to assert that the newly drafted policy has at least been virtually tested.

5.2 Generative Diffusion of Knowledge

Knowledge diffusion is another area in which COIS can be applied.

Information Sharing in COIS

When information synthesis is performed in a commons-oriented fashion, redundant syntheses within a community can be prevented. Information synthesized by a member of the community is shared as a common, so that other members can reuse or build upon it, without having to unnecessarily recreate what is already done. Consequently, collective effort and resources of the community can be saved. Additionally, in COIS environments where commons are publicly accessible, synthesized information that is shared as a common can reach and potentially benefit many people. Often, commons are used in other COIS, helping seed further knowledge generation.

Existing Practices of Knowledge Transfer

There are two current practices of knowledge transfer that are related to this context: knowledge-based collaboration and academic journal publications. A knowledge-based collaboration consists of a group of people collaborating and sharing knowledge. An example is a group of researchers working together and sharing their results. Knowledge-based collaboration is different from COIS in the way that the former focuses on people working together, while the latter is not necessary about teamwork, although participants in COIS can collaborate as well. For example, kitesurfers may directly interact and collaborate on the same kite design. Some knowledge-based collaborations have the qualities of, and thus can be considered, COIS. Most knowledge-based collaborations focus on knowledge transfer *within* the groups, so some shared knowledge bases may not be intended for public access and do not benefit people outside of the groups.

Academic journal publications go farther than knowledge-based collaboration to benefit the public. Most material in academic journals is text, not multimedia or simulations. Most articles that involve use of simulations only provide derivations, results, and conclusions, but not the simulations from which the results are obtained. As a result, it is not uncommon that researchers have to rebuild simulation models that are known to already have been done, in order to be able to do further research. In other words, the complete knowledge is not transferred. A journal article is an efficient means for researchers to succinctly present their work, but sometimes it means that some crucial parts of the work have to be left out. Furthermore, journal publications have a relatively high barrier for common people to participate. Many journals are difficult and costly for common people to access. They are even more difficult, if not nearly impossible, for common people to contribute to.

Both existing practices are effective ways to transfer knowledge within or by limited groups of people. However, they are not very good at diffusing knowledge on a societal scale.

Social Knowledge Diffusion with COIS

Information synthesized in some COIS environments can be considered knowledge (e.g. encyclopedia articles or ways to design a product). As discussed above, information synthesized in COIS can be socially efficient and far-reaching and allow for further knowledge generation downstream. Thus, *the COIS model can be a recipe for socially efficient and far-reaching knowledge diffusion.*

Common people can be involved in many ways in generative diffusion of knowledge with COIS. They can benefit from the shared knowledge within publicly accessible commons. In addition, since common people can find values from engaging in COIS, they can contribute their knowledge to the commons of an inviting COIS environment. Moreover, they can also use the shared knowledge to generate further knowledge.

Since information in COIS can be in various forms (e.g. texts, multimedia, simulations, etc.), knowledge diffused through COIS needs not be in text form. Indeed, use of models can greatly enhance knowledge diffusion with COIS. Computer-based models can be representations of *live* knowledge[12]. Since a model is parametrically configurable, it can represent more than just a specific piece of knowledge. For example, a simulation can represent knowledge of a material's properties over a range of conditions. Thus, models allow live knowledge to be transferred. In addition, predictive abilities of knowledge can also be encapsulated in models and become transferable. Since models can be integrated, different pieces of knowledge transferred in forms of models can be combined into more complex knowledge. Furthermore, recipients can localize transferred knowledge by configuring the model. For instance, people can configure the locale and climate parameters of a model that represents how a solar panel works, in order to learn about the panel's performance at their locations. The transferred knowledge is localized and essentially transformed into new, specific knowledge.

When knowledge is synthesized and shared as commons in forms of models, it can be diffused flexibly and effectively.

Hypothetical Scenario

Imagine a Web site for diffusing environmental knowledge to the public. A community of environmental researchers shares their knowledge as commons on the Web site. The shared knowledge commons are in various forms, including written articles, pictures, videos, audio, simulation models, etc. Anyone can access the commons for free. Common people can learn from the knowledge in the commons. Anyone can also reuse, build upon, and combine the shared knowledge to synthesize new knowledge, which can then also be shared as common.

Imagine teachers creating lessons about the environment by combining knowledge from the commons, and later sharing the finished lessons as commons for other people to reuse.

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12 See discussion of live information in the *Product Design Synthesis by Common People* section.

Imagine small communities and homeowners accessing environmental simulation models in the commons through a simple Web-based interface, localizing the models to learn about the environmental conditions in their towns, connecting a few simple simulations of environmental remedies to predict how different mixes of potential solutions will perform, and sharing the newly synthesized simulation as a common for other communities to reuse.

A note about reliability and accuracy of shared knowledge

A question can be raised about the reliability and accuracy of freely contributed and shared knowledge. Such a question is often raised about online knowledge sources of Wikipedia. To answer that question, one has to look at the Internet overall. There is myriad of information in the Internet. Of that which be considered knowledge, some is accurate, and some is false. People realize this, but they still turn to the Internet to look up information all the time. The important point is that, while looking up information from the Internet, people have to pay attention to the sources of the information and consider how reliable the sources are. The risk of getting false knowledge is overcome by the value of being about to look up information instantly. Since looking up information on the Internet is very easy anyway, people can always refer to multiple sources and compare the results.

In some cases, the wisdom of crowds can help. Opinions of many different people, such as those in blogs, can crosscheck each other and help filter false information. Likewise, words of many people can also help amplify truth. Furthermore, at sites of freely contributed and shared knowledge for the greater good, there are usually vigilant people who protect the sites from vandalism.

Some mechanisms can also help with the issue of accuracy of shared knowledge. Pioneering work by early participants can help steer the commons in the right direction. Sites can also grant power-member status to people who have shown dedication and contribution, so that they have privileges to safeguard and moderate information shared with the commons.

5.3 Design Development and Concept Exploration

COIS can also be applied to the area of design development and concept exploration.

Perpetually evolving design development and concept exploration

When designs are synthesized in a commons-oriented way, they can continue to evolve through open, unstructured collaboration. That is, the synthesized designs can be shared as commons and later get picked up and used by other people. When being used by different people, the designs are also practically tested. The designs may also get improved or built upon by other people and evolve into new versions or other new designs. The new versions of the designs may also be shared as commons and have a chance to be further developed. Thus, the COIS model can be *an approach to foster perpetually evolving open design development.* Moreover, designs that are shared as commons may not be fully developed. They may be in forms of design ideas or concepts. Nonetheless, they can be explored and evolved through COIS by multiple people as well. One shared design concept could be further thought out or inspire new designs by different people. Thus, the COIS model can be *an approach to foster perpetually evolving open design concept exploration.*

An important aspect of a design process is the cycle of design-evaluate-redesign (Ulrich & Eppinger, 2007). COIS can be applied to all stages of the cycle. For "design", commons can be used as ingredients, starting points, references, and inspirations. For "evaluate", COIS provides test beds in which other designers and the public can evaluate designs that are shared. Finally, for "redesign", COIS facilitates open-source-style improvement as well as unstructured collaboration.

F/OSS is an example of existing environments that use COIS as an approach to develop designs. Programmers make their programs and codes, which embody the designs of the programs, available as commons. Anyone can freely obtain the shared programs, use them, and give feedback to the programs' developers. Other programmers can also look at the code and modify the designs of the programs. The modified programs can then be shared as commons for further free use, evaluation, and development.

Many Web-2.0 sites, such as Google Scholar[13] and Gmail[14] label their products' identities with "beta" for several years. These sites are considered "perpetual beta" (O'Reilly, 2005). The concept signifies that the sites are perpetually improved and are never finished. No service packs or batches of fixes are released. It is expected that the sites' users are aware of the perpetual beta status of the sites and that their feedback and contribution are always solicited. The perpetual beta concept can also make some users feel that the sites are common resources which they are entitled to help foster and develop.

Computer-based models, such as simulations, CAD geometry, etc., can be used as design representations, as discussed earlier in the section *Product Design Synthesis by Common People.* The parametric nature of models enables quick turnarounds in the design-evaluate-redesign cycle (Kuljis & Paul, 2003). A design tool like DOME (Distributed Object-Based Modeling Environment) facilitates ad-hoc integration of heterogeneous and physically distributed models (Abrahamson, Wallace, Senin, & Sferro, 2000; D. Wallace, Yang, & Senin, 2001). For example, DOME can be used to connect a Matlab simulation on one computer to an Excel spreadsheet on another computer, over the Internet, to create an integrated simulation. DOME is a software prototype of a World-Wide Simulation Web paradigm, in which computational services of models from anywhere can remotely shared, utilized, and combined to create new services, over the Internet (Yang, 2003). COIS can complement the WWSW paradigm. Commons of models shared through COIS can serve as public design-model libraries, offering design resources that anyone in the WWSW can access.

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[13] http://scholar.google.com

[14] http://mail.google.com/

Hypothetical Scenario

Imagine a Web site for open design development. Designers from anywhere can make their designs in all forms (e.g. sketches, written descriptions, 3D geometries, simulation models, etc.) available for free as commons on the Web site. The shared designs are shared under an open content license. The original designers still own the rights to their creations, while anyone is free to reuse, remix, and redistribute the designs and their derivatives, as long as they respect the conditions set by the original designers. Anyone can freely access and provide feedback about the shared designs. They can also modify or improve upon the designs and further share them. People may have some neat ideas but do not know how to turn them into concrete designs. They can share those concepts as commons as well. All concrete design and concepts that are shared as commons have a chance to be perpetually tested and improved.

5.4 Chapter Summary

In this chapter, potential applications of COIS were identified in three areas: information synthesis by common people (including product design and policy syntheses by common people), knowledge diffusion, and design development and concept exploration. In particular, the COIS model can be used as

- A recipe for recreating an environment that invites and fosters information synthesis by common people. Two potential applications in this aspect are to draw common people to take part in customer co-design in mass customization, and to interest common people to engage in policy drafting.
- An approach to socially-efficient and far-reaching knowledge diffusion that also allows for further knowledge generation downstream.
- A means for supporting perpetually evolving open design development and concept exploration.

The implications of COIS in all three areas can be enhanced by use of models to represent information. Furthermore, access to the Internet, which has become ubiquitous, also helps broaden the impacts of COIS. That is because the Internet broadens people's access to shared commons that are online. Virtually any Internet users can access online commons, so the reach of the commons' impacts can be virtually limitless.

6

Prototypical Environment

Objectives, design, implementation, functionality, and example use scenarios

6.1 Objectives

A prototype environment is designed and implemented in order to fulfill the following goals:

- To test the feasibility of recreating a system design environment to foster COIS. The design and implementation processes of the prototype can help prove if it is feasible to achieve functionalities needed in the hypothetical scenarios mentioned in the previous chapter. That is, besides the basic necessity that the prototypical environment itself be easily accessible, can the environment provide the following functionalities?
    - The environment must establish common resources.
    - The commons must be publicly accessible.
    - The commons must be utilizable (e.g. can be reused or built upon) for synthesis.
    - People must be able to share their private and newly synthesized information as commons.
    - The environment must support social networking and unstructured collaboration.

  The required functionalities listed above can be considered as design attributes of the prototypical environment. Thus, put another way, this objective is to test whether the design attributes of the prototypical environment are feasible to achieve. Another feasibility question is, can those requirements be made easy? For example, can the commons be easily accessed, or can people easily share information as commons?
- To identify key risks and problems that may arise in an implementation of a COIS environment.
- To illustrate whether and how the potential applications, proposed in the previous chapter, can be achieved.

- To construct a functioning prototype that can serve as a tool for a meaningful, practical application outside of this study.

6.2 Public Environmental Modeling and Simulation Web

PEMS Web (Public Environmental Modeling and Simulation Web) is a prototypical COIS environment. The environment is in the form of a Web site, available at the URL http://cadlab.mit.edu/pemsweb.

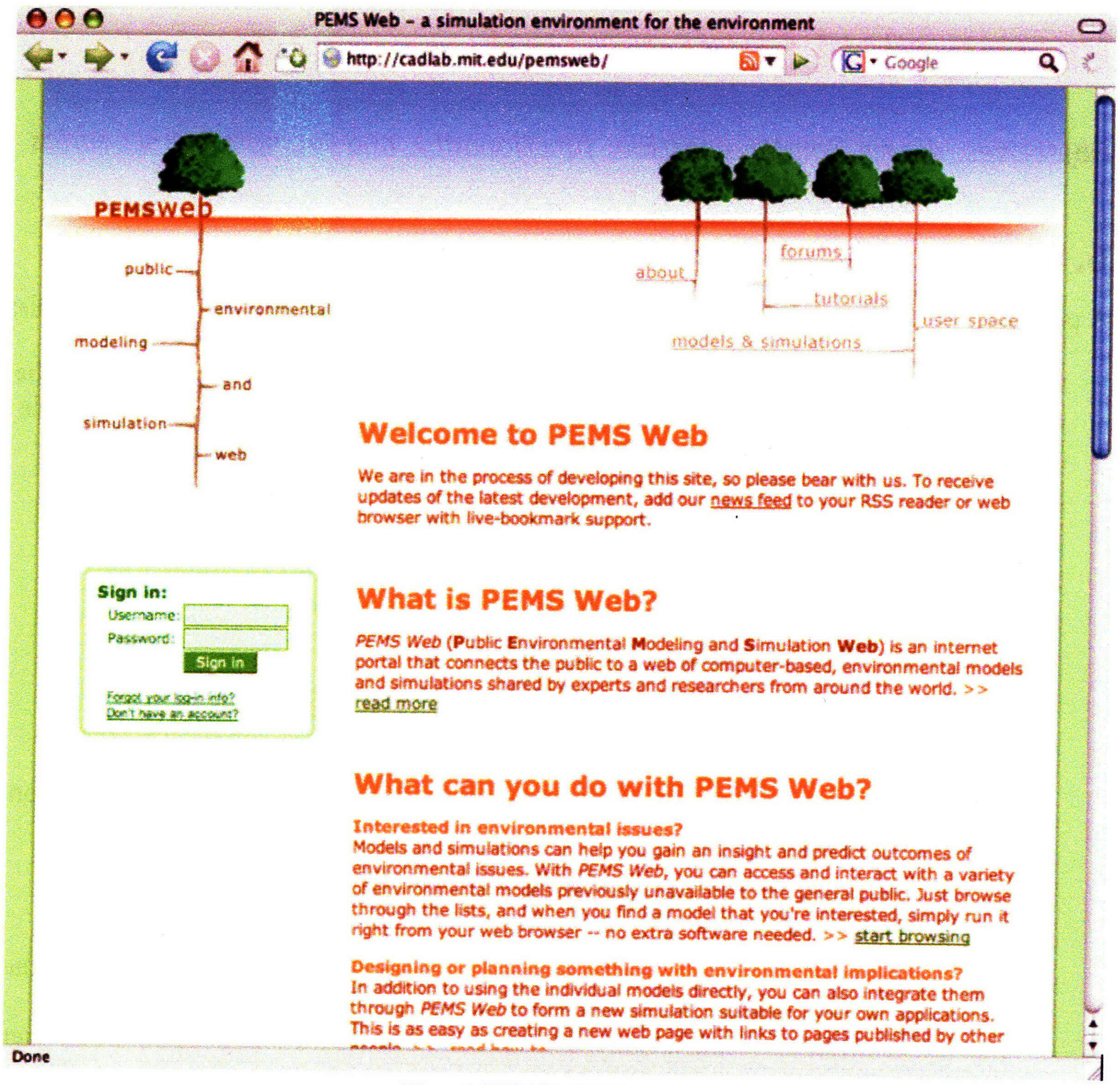

Figure 1 PEMS Web's home page.

6.2.1 Overview

PEMS Web is an online environment that helps people access, utilize, share, and synthesize environmental information, ranging from environmental knowledge, to principles, designs, guidelines, and policies. The environmental information shared on PEMS Web constitutes the site's publicly accessible commons – the key components around which most activities in PEMS Web revolve. PEMS Web functions as both a public platform for generative transfers of environmental knowledge and an open-source design environment for alternative energy systems.

Most of PEMS Web's environmental-information commons are represented in the form of parametric simulation models, for two reasons. First, as discussed in the previous chapter, a simulation model in general can be an effective representation of *live* information. Second, while many forms of information representations, such as text, video, audio, etc., have been shown to work well in the context of COIS, the feasibility of using models to represent information in COIS is still unclear. Thus, using simulation models to represent environmental information in PEMS Web can help assess that feasibility. A snapshot of a partial list of commons is shown in Figure 2.

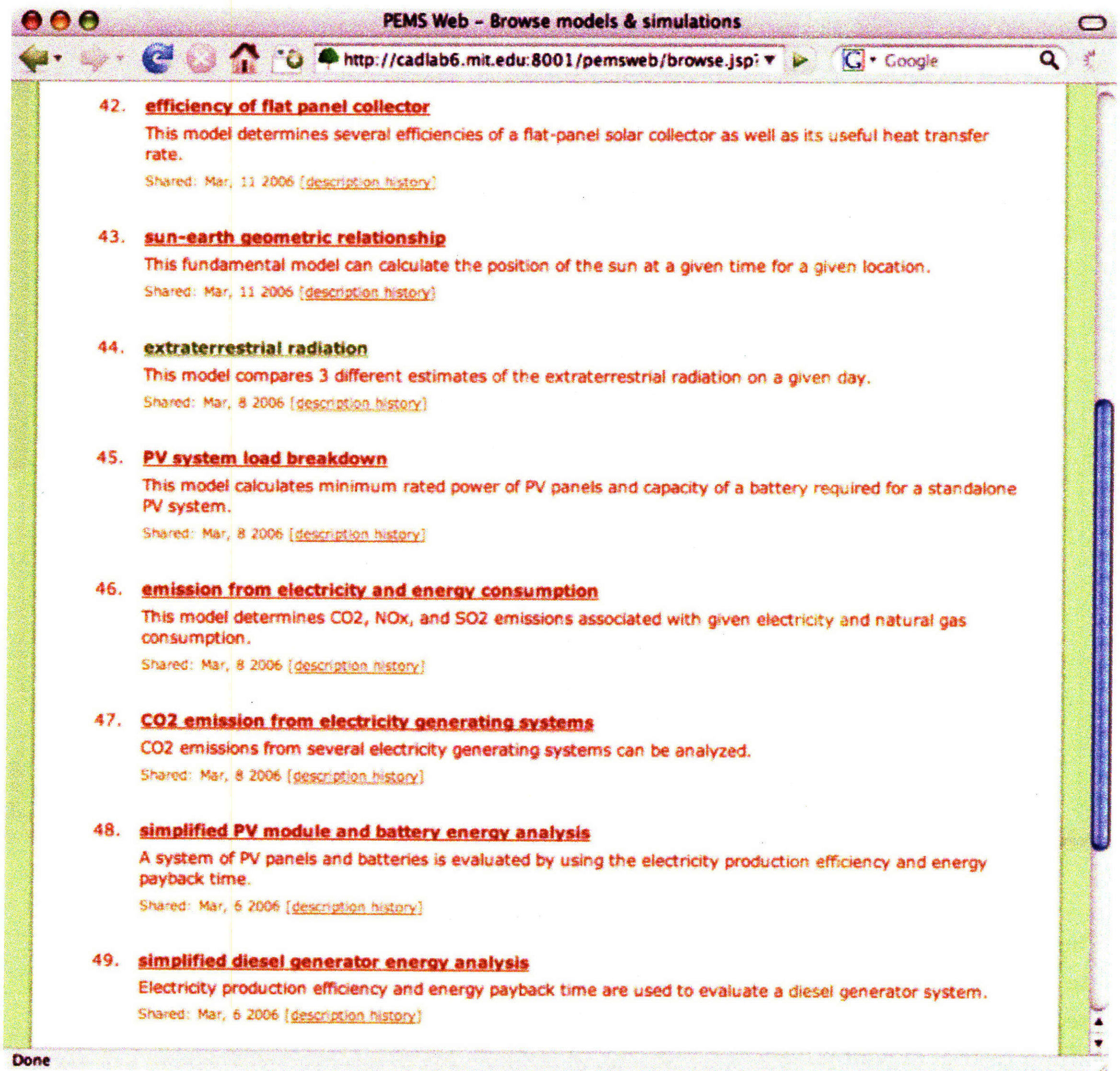

Figure 2 A partial list of models in the commons.

Every model in the commons has a Web page as a user interface, as shown in Figure 3. Users interact with a model through a normal Web page, with form fields for entering inputs, a button for running the model, and fields for displaying outputs. The model pages, as well as all other pages in PEMS Web, can be viewed and utilized in a normal Web browser, on any devices. Special software programs, such as a Flash player or Java Web Start, are not needed. Because the model pages behave like regular Web pages, they can also be bookmarked.

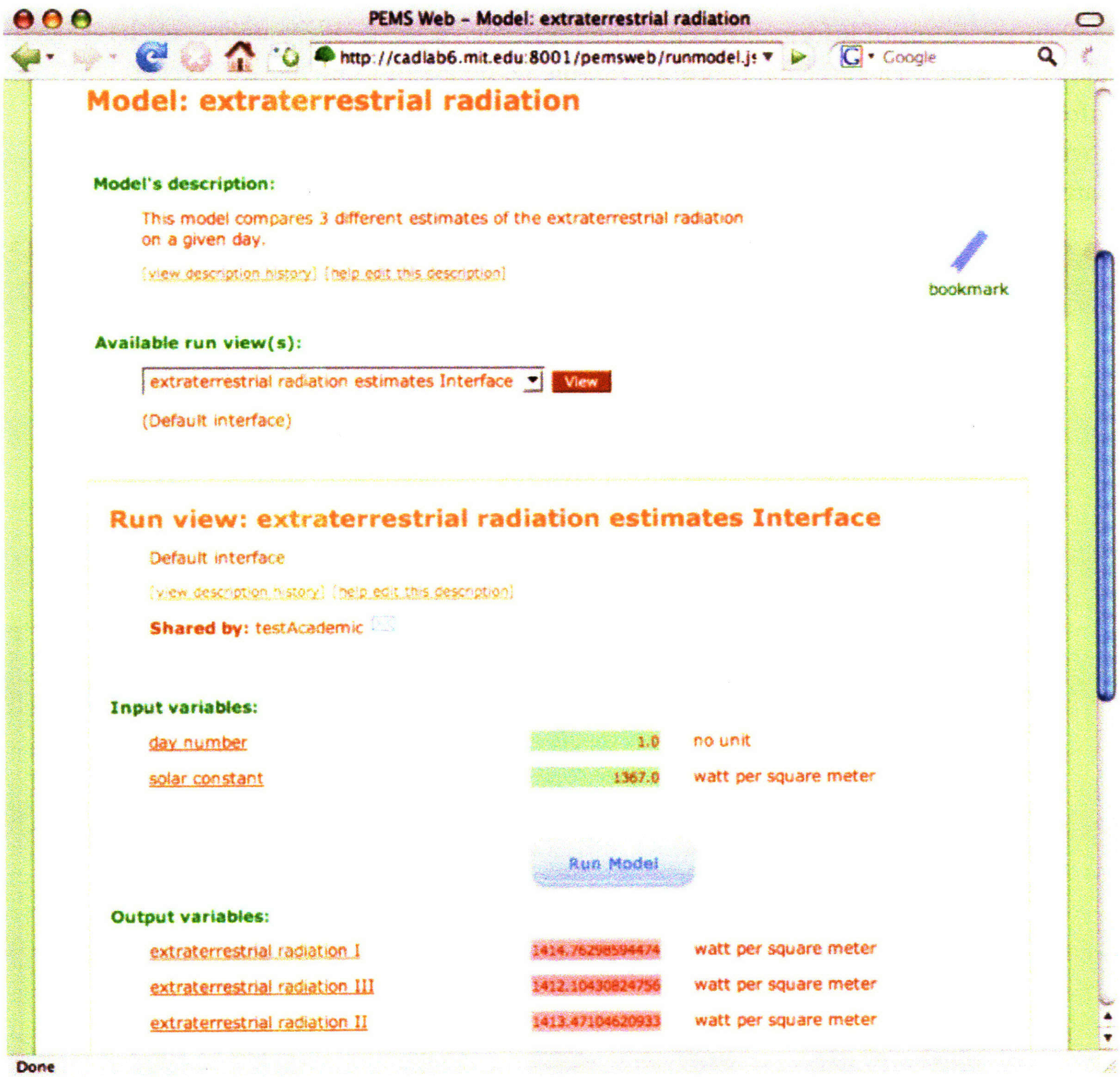

Figure 3 User interface of a model.

The individual environmental models in PEMS Web's commons are tools that people can use to answer simple what-if questions. For example, the model shown in Figure 3 can be used to answer a question like "if it is in the middle of the summer, what would the extraterrestrial radiation be?"

Another main component of PEMS Web is an interactive Web page for synthesizing models (Figure 4). Model synthesis is the main act of information synthesis in PEMS Web. Through the interactive page, people can synthesize a model by defining new mathematical relations, building upon an existing model from the commons, integrating multiple models, or a combination of all three.

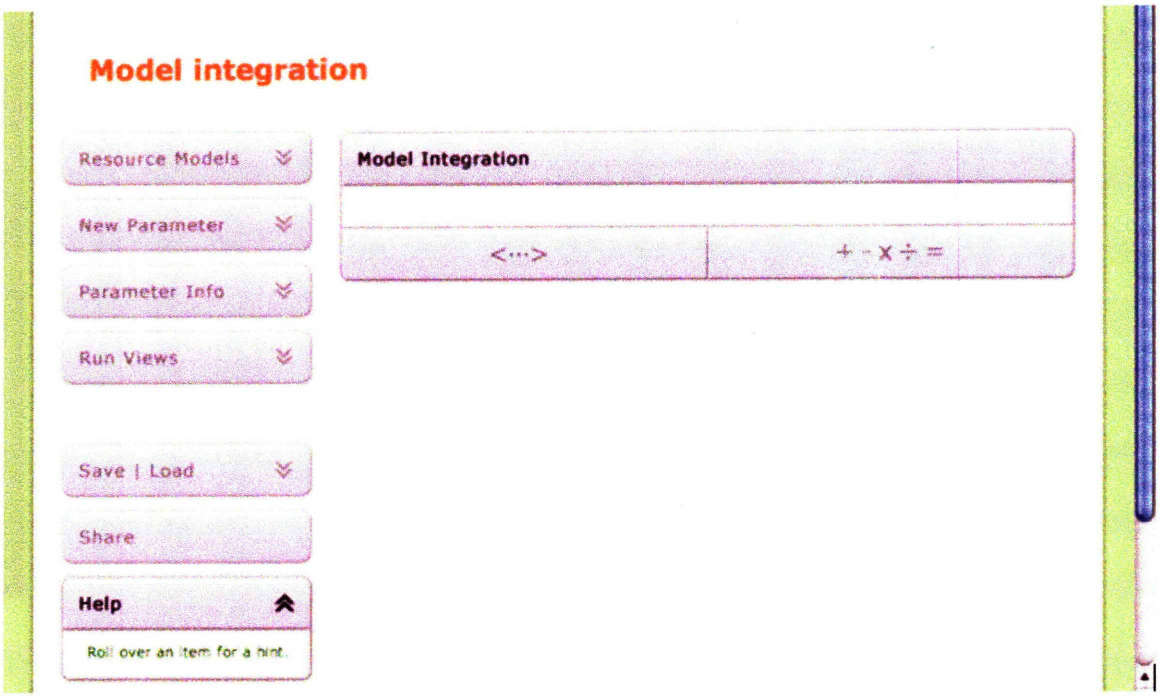

Figure 4 An interactive page for synthesizing a model.

The synthesis page enables people to synthesize new models (either from scratch or based upon existing models in the commons), making it possible for people to answer more what-if questions and explore more ideas. For example, a user can integrate a model of solar radiation with a model of solar panel's operation, to synthesize a new model for predicting amount of power that a solar panel can generate on a given day at a given location.

Another main component of PEMS Web is an interactive page for sharing models as commons (Figure 5). The page allows people to upload their personal models to PEMS Web and make them available as commons. Models of different formats, such as Excel or Matlab, can be shared. A sharer can choose to share only the service of the model, without exposing the model's "code", or to share the entire model. If the sharer chooses to share only the model's service, other people will still be able to access the model's user-interface page, run the model, and use the model in a synthesis; however, they will not be able to download the model or see inside the model's "code". For example, if only the service of an Excel model is shared, people will be able to utilize the model, but will not be able to download the model to see how the underlying spreadsheet works. On the other hand, if the entire model is shared without any restrictions, anyone can also download the model and see inside the model's "code". Consequently, other people are allowed to modify the model and share the modified version as another common in PEMS Web.

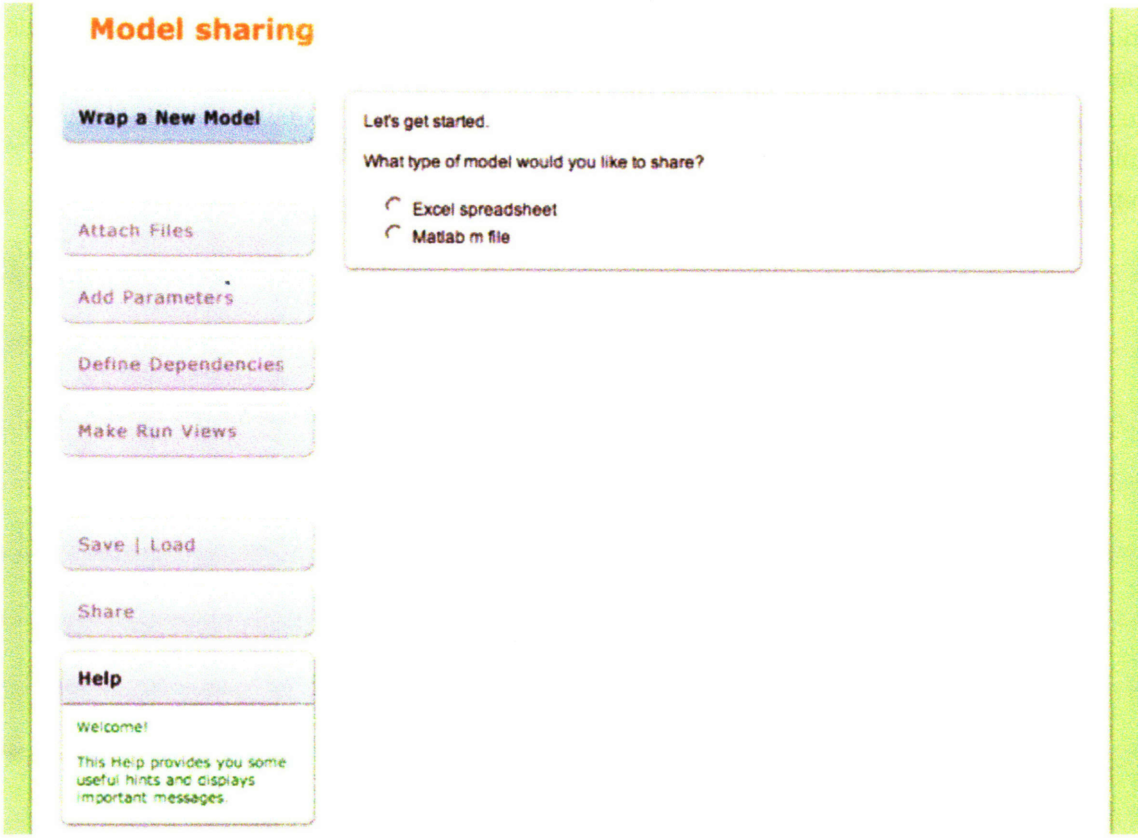

Figure 5 An interactive page for sharing a model.

Unstructured collaboration in PEMS Web goes beyond improvement of models. There are several components in PEMS Web that allow text-based environmental-information commons, such as descriptions of models and parameters, to be edited by anyone in a collaborative authoring fashion. There are also mechanisms that let people rate and review models, to reflect the wisdom of crowds. In addition, there are mechanisms to support social networking: Web forums and members' personal pages.

Figure 6 A partial forum listing.

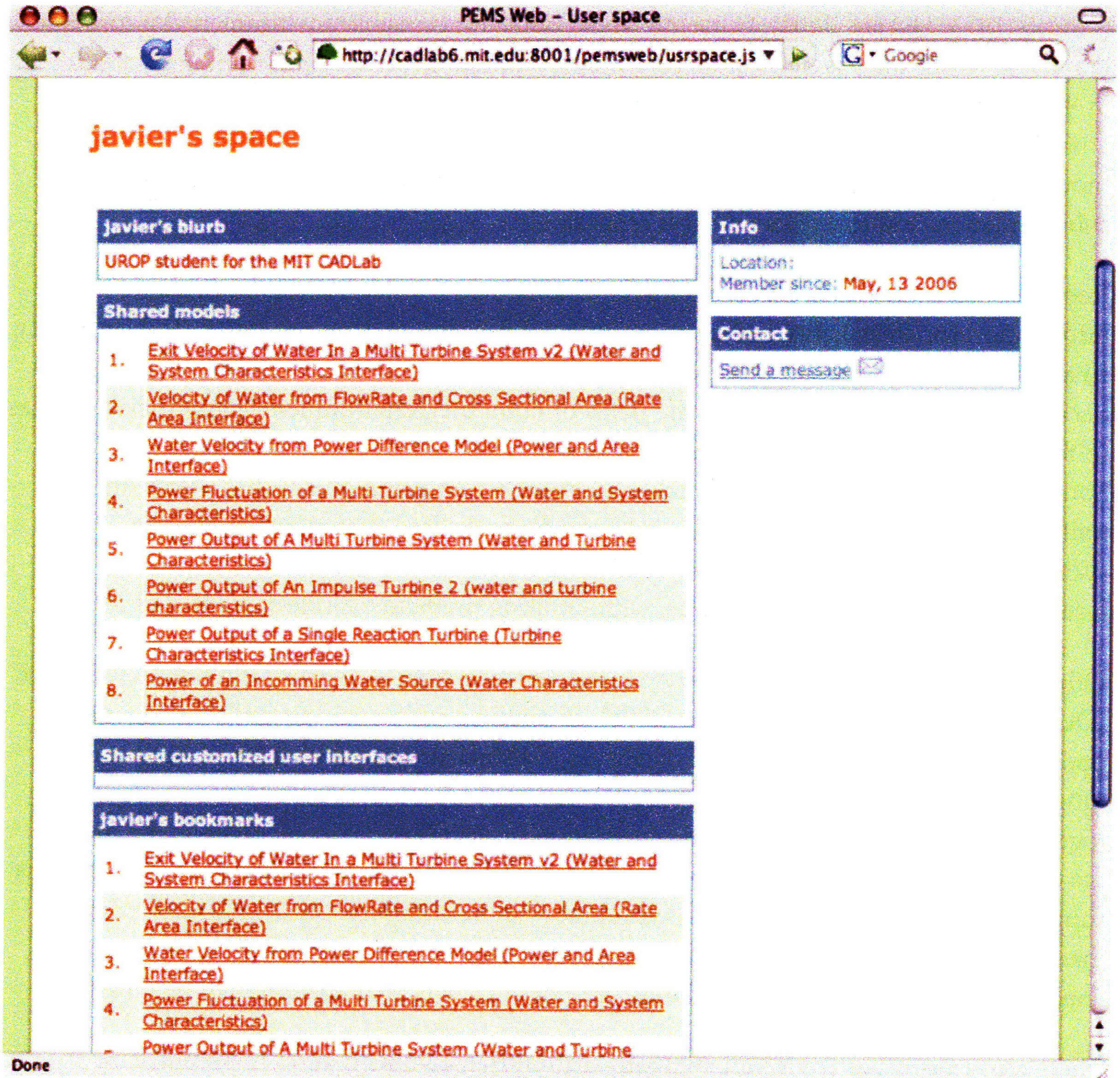

Figure 7 A member's personal page.

Detailed example scenarios of how people may use each mechanism are provided in section 6.2.3.

6.2.2 Background on Public Environmental Information

To strive towards sustainable development, people need to be aware of the status of their environmental resources, as well as understand the implications of their economic and technological activities on the environment. Many international movements[15] realize the significance of this need and call for wide public access to environmental information

[15] Examples of such movements include Agenda 21 (adopted at the United Nations Conference on Environment and Development (UNCED), Rio de Janeiro, 3-14 June 1992) and Aarhus Convention (or, Convention on Access to Information, Public Participation in Decision Making and Access to Justice in Environmental Matters – adopted by the United Nations Economic Commission for Europe (UN/ECE) in 1998).

(Grubb, 1993; Haklay, 2003). Currently, most publicly accessible environmental information is static in form, such as news, articles, forums, and reports on scientific findings, published in Web pages or paper publications. In addition to static information, there also exists computer-based, more dynamic, *live* environmental information, in the form of simulation models, which have predictive capabilities that can be employed to further understand subject matters and to explore what-if scenarios.

Recently, there have been many international initiatives to widen access to dynamic information for all stakeholders in environmental decision-making processes (Haklay, 2003). In accordance with these efforts, several environmental information systems (EIS) have been developed, bringing together the fields of computer, environmental, and social sciences to form a new field called Environmental Informatics (or Enviromatics) (Schimak, 2005). Some EIS, such as EMIKAT – database software for emission inventories, focus on unifying data from different sources and providing one-stop data access to the users (Winiwarter & Schimak, 2005). The data systems alone, although convenient, can be insufficient for most decision makers, without using predictive models or simulations.

Other environmental information system frameworks, such as GIMMI, go one step further (Denzer, Riparbelli, Villa, & Guttler, 2005). In addition to integrating and allowing inter-operability of physically distributed databases, GIMMI also provides a set of fundamental models (of pesticide impact assessment domain) that are Web-accessible and can be put together to form a simulation. While integration of distributed data is possible, the models are centralized and integration of physically distributed models from different sources is not supported. Having centralized model resources can be computationally ineffective when many models are used simultaneously in a simulation. It is also difficult for others to contribute their models and, thus, limits the extent to which simulations can be created.

There also exist other environmental information frameworks that do not emphasize incorporation of databases but focus more on integration and reusability of models. Examples of these frameworks are ECLPSS and ICMS (Argent, 2005; Wenderholm, 2005). The users of such frameworks can share, reuse, and integrate each other's models to create a new simulation for their own applications. However, the actual model codes or files, not just their computational capabilities, need to be shared as well. There is no option for people to share just the services of their models. People who are concerned about intellectual property infringement may be discouraged from contributing their models. Also, since the shared models need to be integrated and executed locally, either on a user's computer or a central server of the framework, the computational power is still limited.

Recent studies show that, besides the issues discussed above, existing environmental information systems can also fail to take into account the variation of needs and views of the different stakeholders (Haklay, 2003). Since the shared models or simulations were originally developed for use among environmental experts, they can be very difficult to understand and use for researchers in other fields – let alone typically less-technical policy-makers, grassroots innovators, and the general public.

Many more EIS and information systems for sustainable development exist, as surveyed in the literature (Hilty, Seifert, & Treibert, 2005; Pillmann, Geiger, & Voigt, 2006). Most of them are designed for and excel in certain specialty areas, ranging from environmental performance and eco-efficiency, to supporting change toward sustainability, to risk management, to creating a higher level of environmental awareness, to information management, to environmental modeling (Hilty et al., 2005; Hilty, Page, & Hrebicek, 2006). Nonetheless, a system that allows worldwide environmental computational resources to be connected, and embraces the power of public participation, is still missing.

6.2.3 Addressing Necessary Functionalities of a COIS Environment

The different components of PEMS Web deal with functionalities that are necessary for recreating an environment to foster COIS. The necessary functionalities are mentioned above as part of the objectives of building a prototypical COIS environment. The functionalities, listed here again, can be considered design attributes of PEMS Web:

- The environment must establish common resources.
- The commons must be publicly accessible.
- The commons must be utilizable (e.g. can be reused or built upon) for synthesis.
- People must be able to share their private and newly synthesized information as commons.
- The environment must support social networking and unstructured collaboration.

Each of the design attributes is discussed next, in terms of its importance, what infrastructure is designed to deliver it, technologies of the infrastructure, how the infrastructure works, and why the infrastructure is chosen or designed that way.

The environment must establish common resources.

The importance of this design attribute: This design attribute is important because common resources are the core of all COIS activities. There are two types of commons in PEMS Web: simulation models and multimedia data (e.g. texts and images).

The infrastructure designed to deliver this design attribute: The infrastructure designed to establish the commons in PEMS Web includes:

- Multimedia-data commons – information about models, model-related knowledge, forum messages, etc., in multimedia forms
- A database for storing the multimedia data. The database also stores model commons' information such as names, locations of repositories, sharers' names, but *not* the data from *inside* the models, such as codes or lists of parameters.
- Models of various formats, i.e. the commons themselves, all "wrapped" into a standard format

- A central model repository, for holding the model commons
- A network that allows the central model repository to potentially communicate with other, remotely located model repositories

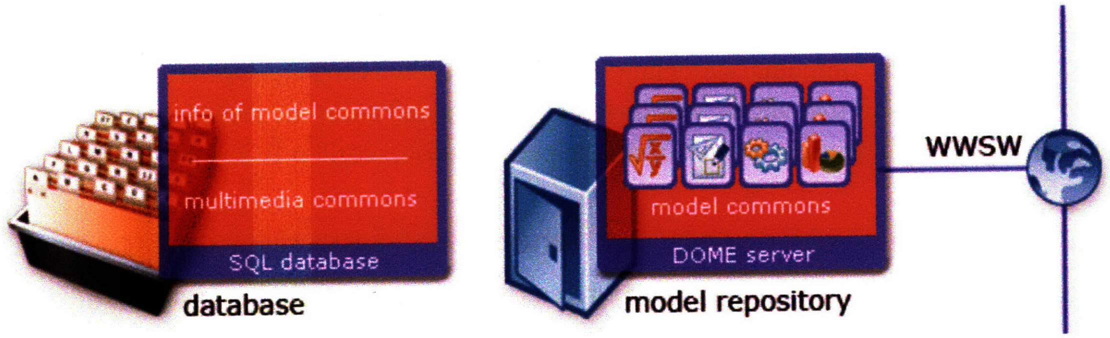

Figure 8 Infrastructure for establishing commons in PEMS Web.

The infrastructure is illustrated in Figure 8. The red boxes signify the infrastructure's components that need to be designed and implemented from the ground up. The blue box and lines signify the components that can be adopted from existing technologies.

Enabling technologies of the infrastructure: An open source database technology called MySQL[16] is used. Although the database technology can be directly adopted into the infrastructure, the database itself and the data structure needs to be designed and implemented. The finished database has nearly 30 data tables, for managing both information about the model commons and the actual multimedia commons. (See the Appendix B for a complete list of database tables). The multimedia commons are stored in their native forms, such as texts, images, etc.

DOME server technology is adopted as a technology for storing models in the model repository. The technology allows the model repository to potentially connect to and interoperate with other DOME servers, through the World-Wide Simulation Web. Even though the server technology can be directly adopted, the structure of the model directories within the server needs to be designed.

Any model that is shared as a common would be wrapped into a standard format. DOME technology is adopted for wrapping models of various types into a standard, WWSW-compatible format. For each model, an appropriate DOME wrapper is used according to the model's type, e.g. Excel, Matlab, SolidWorks, etc. Once a model is wrapped, it is ready to communicate and interoperate with other wrapped models. For example (Figure 9), once an Excel spreadsheet is wrapped, it can interoperate with wrapped models of other types, such as Matlab m files or SolidWorks CAD geometries. To communicate with a wrapped model, users, or other models, would interact with the wrapper, and the wrapper would act as an intermediary agent for the underlying model via an Application Programming Interface (API).

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[16] http://mysql.com

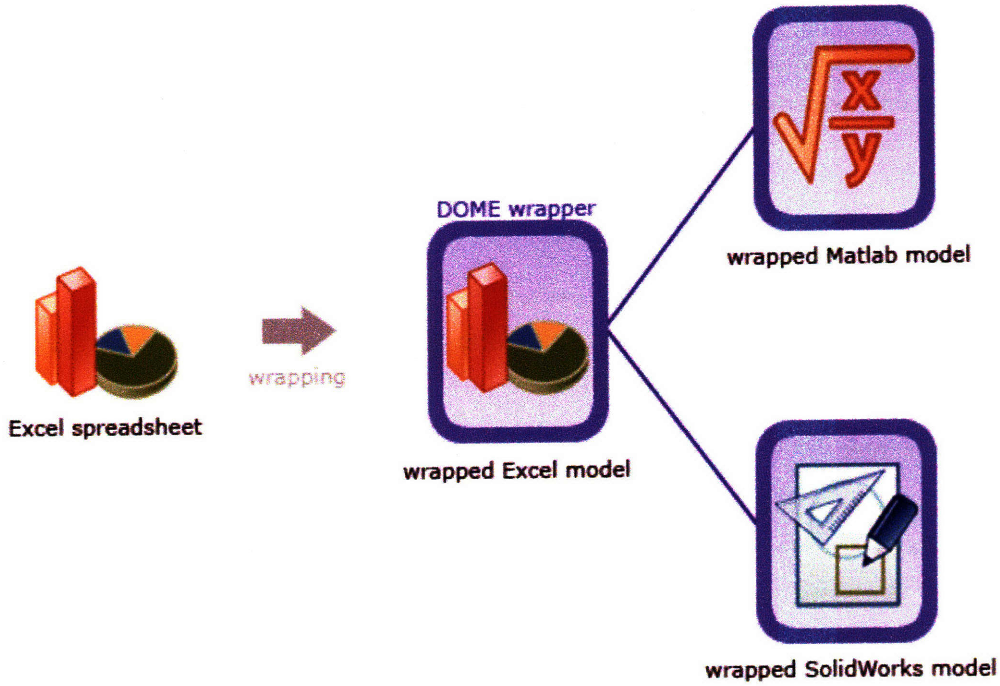

Figure 9 Wrapping of a model.

Reasons why the infrastructure is designed this way: Using a database to manage the information about the model commons and the multimedia commons allows the information to be neatly organized, accessible, and easy to work with. Some models, especially the ones on remote servers, may be updated after being shared as commons on PEMS Web, so it is not wise to store the models' internal data (e.g. codes or lists of parameters) in the database. Instead, only the models' basic information (e.g. names, locations of repositories, sharers' names) is stored.

The models are wrapped into a standard format, so that they all can interoperate in the same environment. Wrapped in the same format, all models can be accessed and executed in the same way regardless of the underlying model types.

The model repository infrastructure is a hybrid between a central server and distributed remote servers, in order to address concerns of two user groups. First, the central model repository can serve users who cannot or do not want to have the burden of running their own model servers. Second, people or firms who do not want to expose their models to outsiders but still want to share the models' services can run their own DOME servers and make their models' services available over the Internet. Information on how to connect to models on remote servers is stored in the database. Furthermore, through the WWSW, models on PEMS Web's central server and those on remote servers can also interoperate.

The commons must be publicly accessible.

The importance of this design attribute: It is important that the commons be easily accessible to everyone, especially common people. This is because common people are more likely to engage in COIS when the commons are easy to access. Participation of common people is especially crucial in the areas of public knowledge diffusion and customer co-design in mass customization.

The infrastructure designed to deliver this design attribute: The infrastructure for enabling easy access to the commons works in conjunction with the infrastructure that establishes the commons. It is composed of the following components:

- A Web server
- Web-based user interfaces for browsing, searching, and listing the commons. The user interfaces can search and sort the commons by
    - Model names
    - Times at which models are shared
    - Types of models' contributors
    - Names of models' sharers
    - Tags
    - Models' descriptions
    - Names of models' run views
    - Descriptions of models' run views
- A Web-based user interface for model – a dynamically generated page for individual models
- An asynchronous information transporter – for facilitating exchanges of small pieces of information between the database and the Web-based user interfaces
- A User-interface-to-model communicator – for translating information between formats that the user interfaces and models can understand

Enabling technologies of the infrastructure: The Java-based Tomcat[17] Web server technology is utilized for making the user interfaces available over the Internet. The user interfaces (UIs) for browsing, searching, and listing the commons, as well as the UI for individual models, are in dynamic Web page formats called JSP (JavaServer Pages)[18]. The pages can be viewed on any normal Web browsers. The contents in dynamic Web pages can be dynamically generated, when a user requests the pages, unlike Web pages in static formats, e.g. HTML. A diagram of the infrastructure is shown in Figure 10. Blue boxes and lines represent existing

[17] http://tomcat.apache.org
[18] http://java.sun.com/products/jsp

technologies that are adopted. Red boxes represent components that need to be designed and implemented from the ground up.

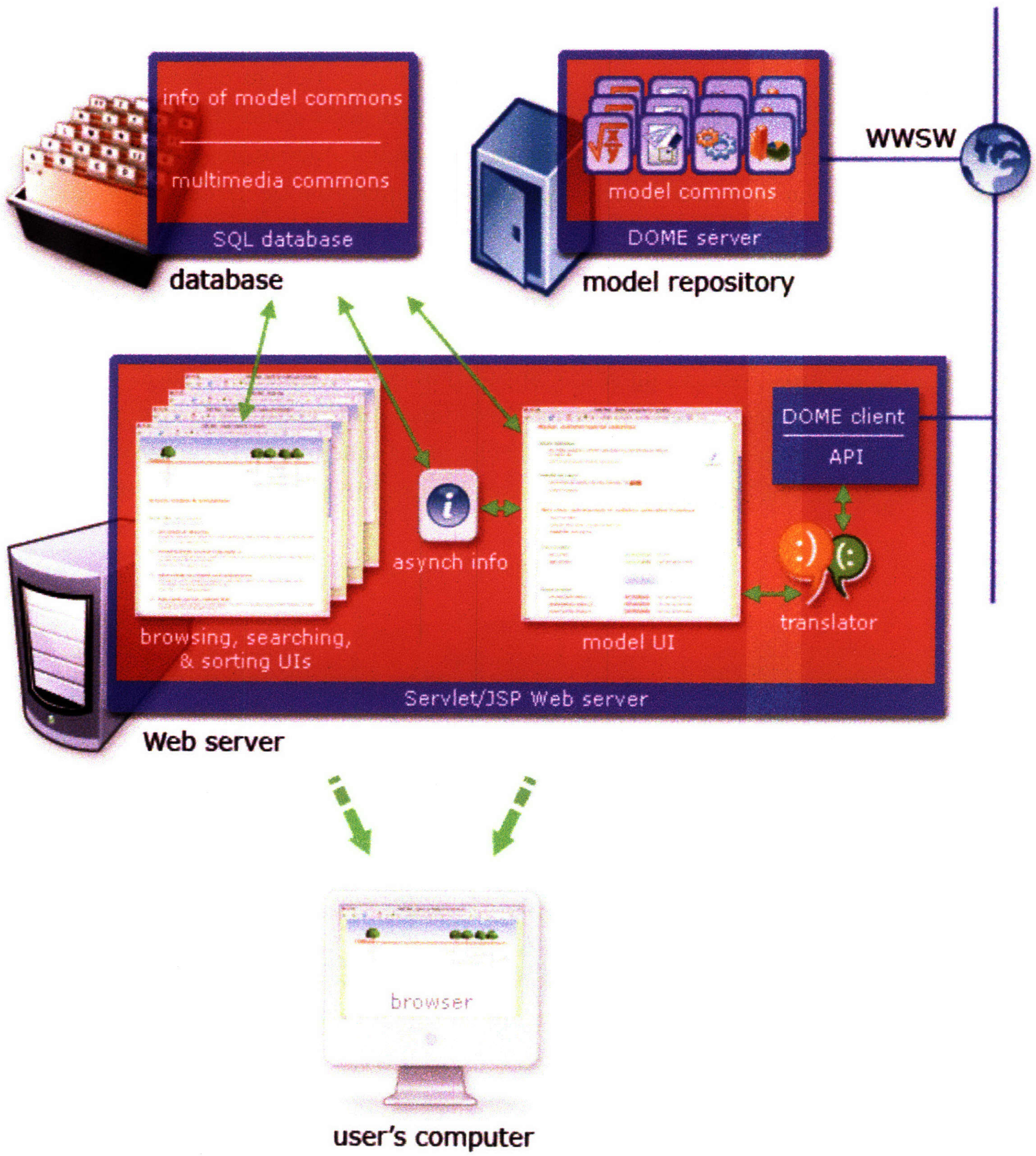

Figure 10 Infrastructure for making commons easily accessible.

The user-interface-to-model communicator comprises a translator program, a DOME client application, and the application's API. The DOME client application is a program in the DOME software suite that can be used to access and run models hosted on a DOME server over the Internet. The DOME client application has an API, a programming interface that allows programmers to write codes to utilize the program without using the program's graphical user interface. In the user-interface-to-model communicator, a translator program is created for facilitating the Web-based UI's interactions with the DOME client application's API. The translator can translate data from the format that the API understands to that of the Web-based UI, and vice versa. The translator is a Java Servlet, a program written in Java for server-side Web applications.

Last, the asynchronous information transporter is built on AJAX (Asynchronous JavaScript and XML) technology. AJAX allows packets of information to be sent between a Web page and a Web server without page loading. Thus, AJAX enables the contents of a page to be updated and modified in real time without the user's having to reload the page or to go to a new page. Probably the most well known examples of application of AJAX are Google Maps[19] and Gmail[20].

How the infrastructure works: an example use scenario and a look behind the scenes: To access the model commons on PEMS Web, a user uses the menu at the top-right corner of PEMS Web's home page (http://cadlab.mit.edu/pemsweb) to go to the *models & simulations* section. There, she is presented with a list of model-related functions (Figure 11). The description (in green text) of what the user can do dynamically changes as she moves her mouse cursor over the different options. She selects *BROWSE* to see a complete list of all model commons.

Figure 11 A menu of model-related options and dynamic text describing the options.

Behind the scenes, a list of all model commons and their basic information is retrieved from the database. The Web server dynamically creates a page for displaying the retrieved list of models.

On the user's browser, a list of models is presented on a new page. At the top, a dynamic menu allows her to sort the models by date (most recent first or oldest first) and name (ascending or descending), and to filter by contributor (individual, laboratory, research center, company, academic institute, or specific contributor). A snapshot of part of a sorted model list is shown in Figure 12. For each model, its name, description, and the time that it was shared are displayed. The user clicks on "PV array operation" to access that model.

19 http://maps.google.com/
20 http://mail.google.com/

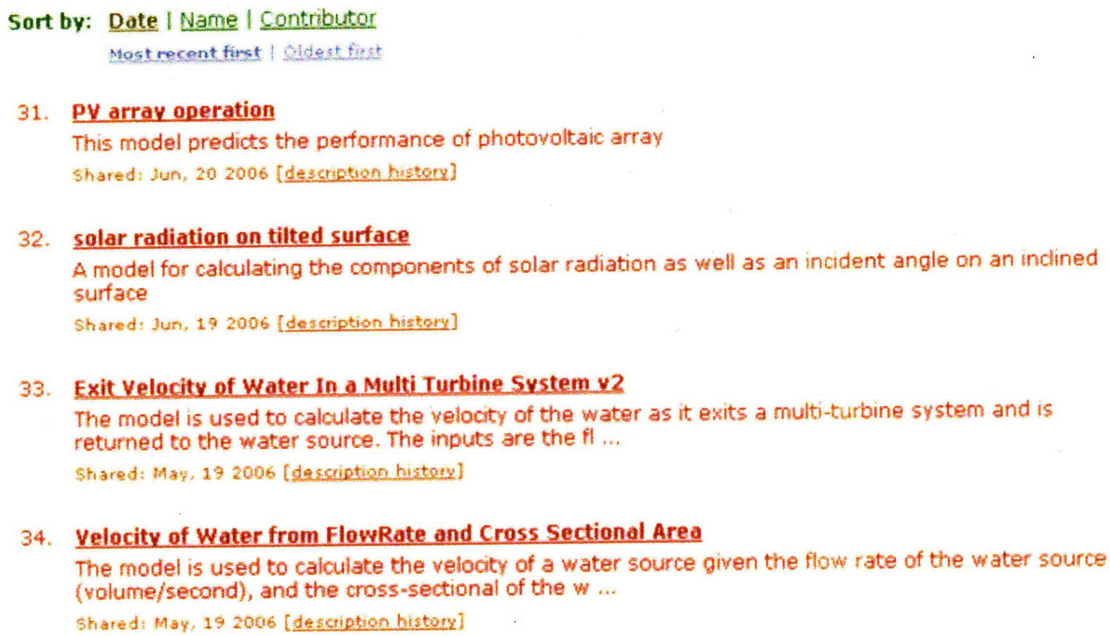

Figure 12 A sorted list of model commons.

Behind the scene, the Web server receives the user's request and queries the database for the location and the access information of the requested model. The translator then asks the DOME client application to try to connect to the specified server and to locate the model, through the WWSW. The model may reside on PEMS Web's central model repository or on a remote server.

On the user's browser, a new page shows an animated graphic to inform the user that the system is trying to locate the server machine on which the model resides. Once the server is found and successfully connected to, a message announces that the system is trying to locate the model within the server (Figure 13). If the server hosting the model is offline or the model is no longer active on the server, the user will be redirected to an error page that describes the situation.

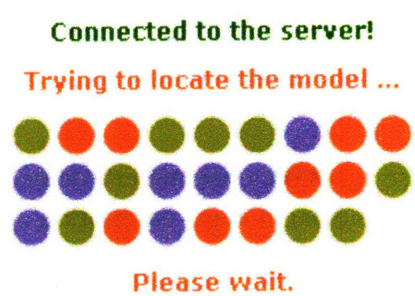

Figure 13 An animated graphic indicating that the system is trying to locate the requested model.

Behind the scenes, if the DOME client can successfully locate the requested model, the model's details (including lists of input and output parameters, and the parameters' types, default values, and units) are retrieved and sent back to the Web server via the translator. The Web server uses that information, in conjunction with additional information about the model retrieved from the database, to dynamically create a user-interface page for the model.

On the user's browser, a user interface of the model is displayed (Figure 14 and Figure 15). Below the model's name is the model's description. The model description is part of PEMS Web's multimedia commons and can be collaboratively authored. The user can view the history of changes of the description. Also, if she finds that the current description can be improved, she can help edit it. Any new changes will be submitted to the Web server and passed along to the database.

Below the model's description, a dropdown menu shows a list of available *run views* of the model. For some models, the sharer may provide multiple views of the model, each of which is suitable for a specific group of users or scenarios[21]. For example, a run view intended for technical users may have a complete set of complex inputs available. Another run view intended for laypeople may expose only basic parameters, while keeping complex parameters hidden and set to default values. Additionally, parameters in one run view may be provided with English units, while those in another run view in SI units. The user can switch through the list of run views and read each run view's description from the dynamic text underneath. To change the run view, she can click on the View button. When a new run view is selected, the lists of parameters and other related content are automatically updated without reloading the page.

The currently selected run view of the model is displayed in a light-green-bordered box. The description of the run view is also part of PEMS Web's multimedia commons and is open for collaborative authoring. Below the run view's description is the username of the sharer. The user can send a message to the sharer, without knowing the sharer's email address, through a built-in messaging function. The Web server looks up the sharer's email address from the database and emails the message for the user.

Below the model sharer's name is the user interface's central component – a list of input and output parameters of the current run view. Each parameter is displayed with its name, a text field for its value, and its unit. When the user clicks on a parameter's name, the parameter's description is popped up in a mini window (Figure 16). Again, if the user finds that the description is not informative, she can help edit it.

Behind the scenes, when the use clicks on a parameter's name, the Web server queries the database for the latest version of the parameter's description and uses the AJAX-based asynchronous information transporter to deliver it to the user interface. This way, the mini window can pop up to display the parameter's description without reloading the main user-interface page. This is important because reloading the page can lose the input values that the user may have already entered.

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[21] A detailed example of how multiple run views can be created is shown in a later section.

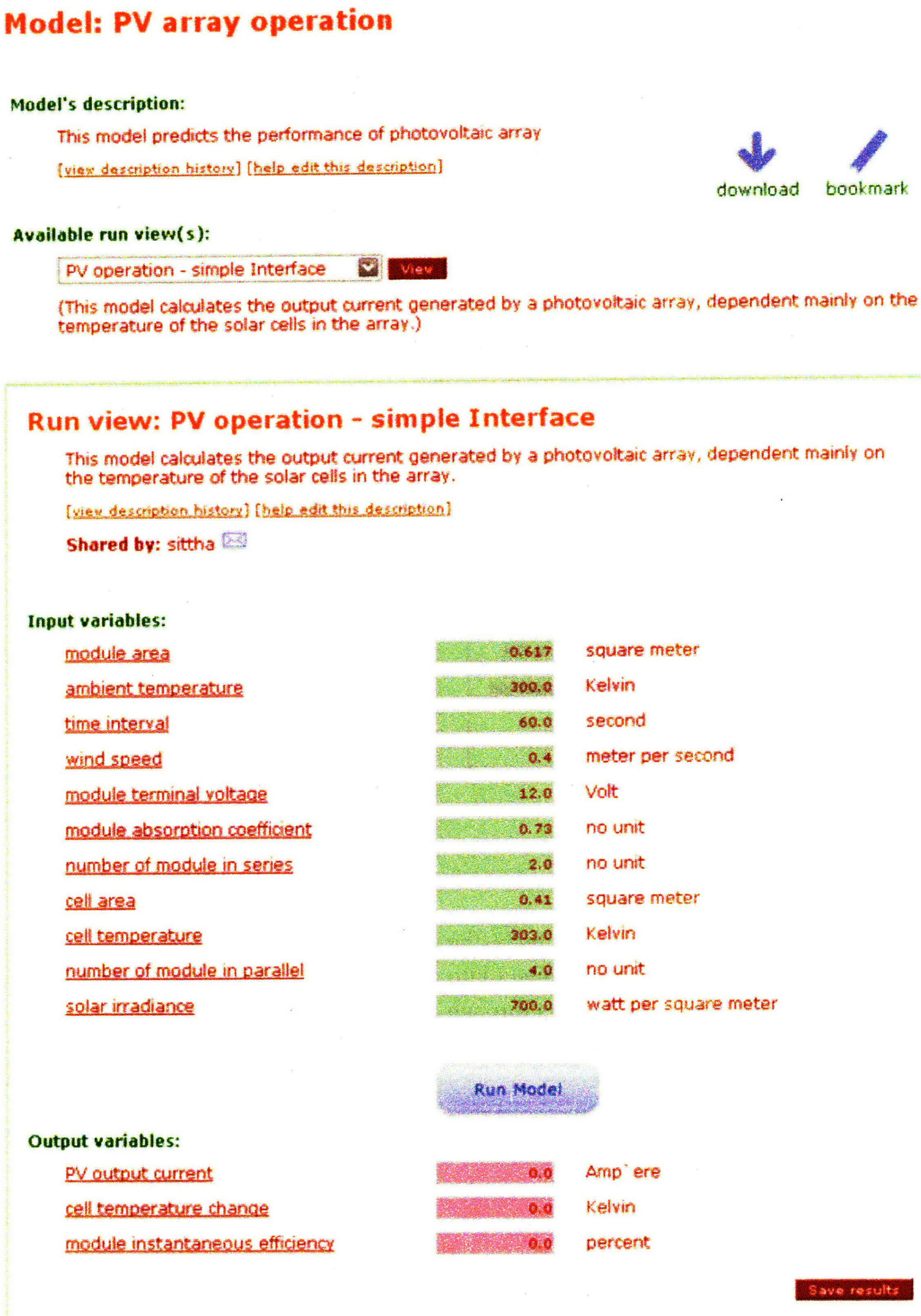

Figure 14 The top portion of a user interface of a model common.

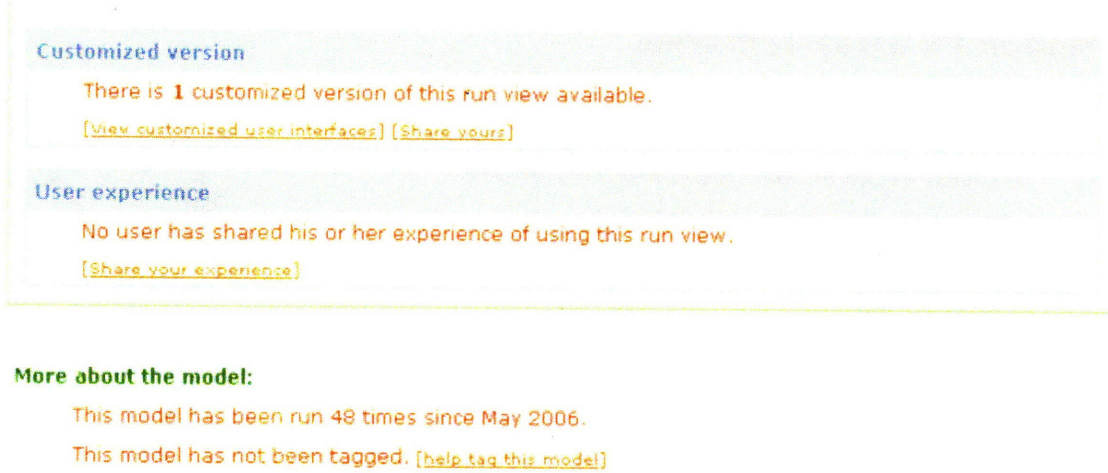

Figure 15 The bottom portion of a user interface of a model common.

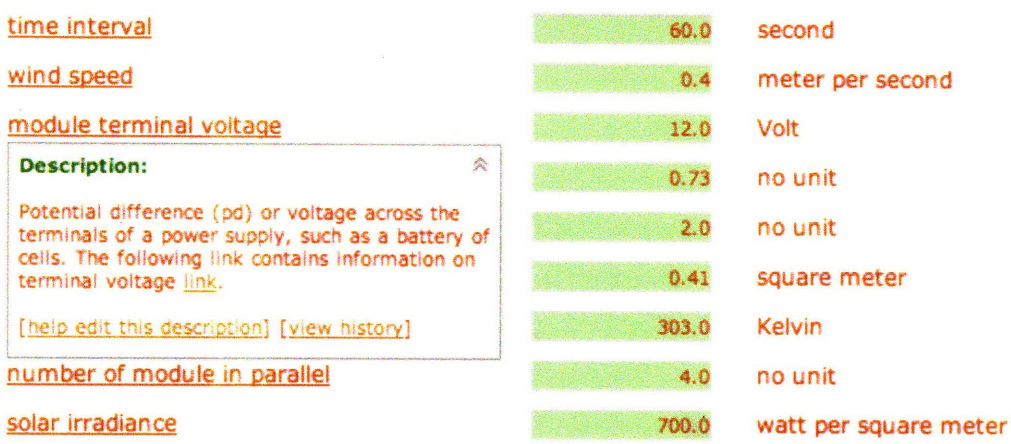

Figure 16 A popup window displaying a parameter's description.

After changing the values of desired inputs, the user clicks on the *Run Model* button to run the model. The *Run Model* buttons changes into an animated wait icon. Behind the scenes, the Web server passes along the inputs through the interpreter to the DOME client application. The DOME client submits the values to the model on the server, tells the model to start running, and *listens* for changes. As soon as the client knows of a parameter's value or status changes, it notifies the interpreter of the change. The new information is relayed through the Web server to the user interface. Changes of parameters' values and statuses happen and are relayed to the user interface asynchronously. Because all models in the commons are wrapped into the same, WWSW-compatible format, the DOME client in the Web server can access and execute them all in the same way.

On the user's side, new values and statuses of output parameters are updated asynchronously. That is, new values are updated as soon as they are done, without waiting for the whole model to finish computing. While the model is simulating, the user can tell the status of each parameter from the background color of the value field. A yellow background of input parameters' values means that the user has changed the values from the default values. A red background of output parameters means that the values are inconsistent with the current inputs and are yet to be computed. Once an output value is calculated, its background turns green, meaning that the value is consistent with the input values. Finally, when all computations in the model are done, the backgrounds of all fields turn white. With this parameter status notification, the user can see how far the simulation has progressed and also is able to use computed values even before the overall simulation finishes. All value and status updates are done without the pages reloading.

The user can keep changing the inputs and run the model as many times as she wants without having to reload the model. By clicking on the *Save result* button, she can save the results to an XML file and keep it on her own computer. Behind the scenes, the server composes an XML file to represent a snapshot the current values and statuses of all parameters. The Web server then sends the XML file to the user for download.

Below the list of parameters (see Figure 15), the user can see that there is a customized version of the current run view available. The customized view, shown in Figure 17, functions like the default run view but is specially formatted and stylized. A customized Web-page UI can be created for any models' run views.

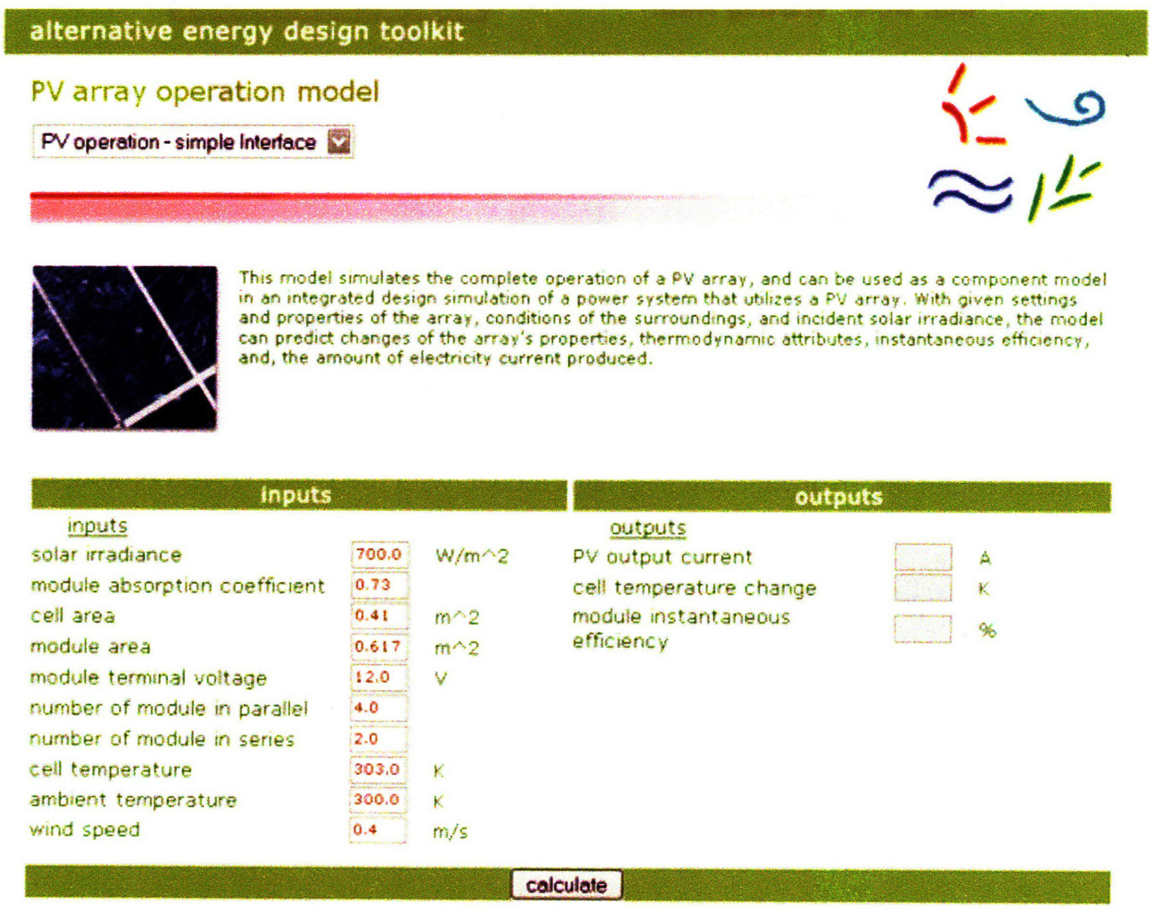

Figure 17 A customized user-interface page of a model.

Besides accessing models by browsing through the list of all model commons, the user can also use the *SEARCH* option from the menu shown in Figure 11. There are two search modes: simple and advanced. With the simple search, the user can search for keywords in model names, model descriptions, run view names, run view descriptions, or all of the above. The advanced search allows more complex search criteria to be specified, as shown in Figure 18. The search results (Figure 19) include the name and description of matched models as well as the relative relevancy of each result. The relative relevancy is a simple measure of how relevant the results are, relative to the most relevant result. Thus, at least one of the results will always have a relative relevancy of 100%. Other results that match the search criteria, but are not as relevant as the most relevant result, will have low relative relevancy.

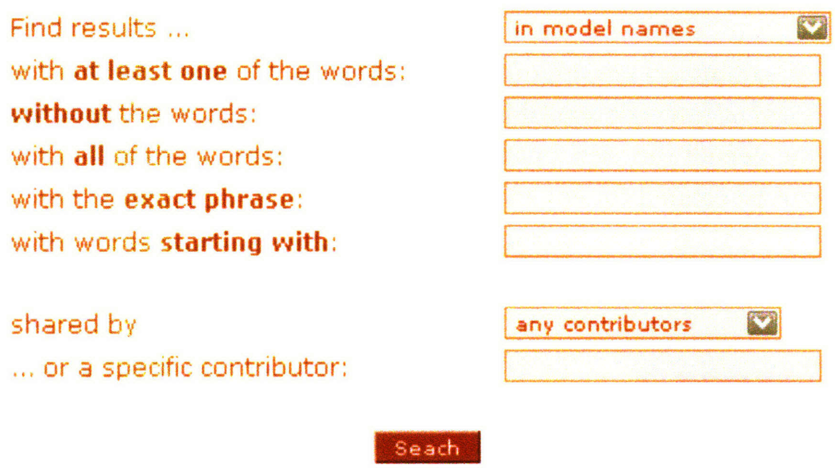

Figure 18 Advanced search.

In addition to using the search functions, the user can find models by using tags. Tags are used because it is impractical to categorize all models into exclusive groups. One model can have multiple tags for the multiple groups to which it belongs. Tags are part of PEMS Web's multimedia commons, so anyone can help tag a model. With the *VIEW TAGS* option, from the menu shown in Figure 11, the user can view all tags that have been applied to any models. A snapshot of model tags is shown in Figure 20. A number in parentheses next to each tag signifies the number of models to which the tag is applied. The user can see a list of all the models applicable to a particular tag by clicking on it. Furthermore, if the user feels adventurous, she can use the *WANDER* option and be led to access a random model.

15 results found in *model descriptions*:

1. **daily heating energy consumption due to ventilation**
   This model calculates the required daily heating energy in a building due to energy losses carried by the ventilation of the building. The model produ ...
   Relative relevancy: 100%

2. **daily heating energy consumption due to transmision heat losses**
   This model calculates the energy consumption in a given room (in english units) due to transmission losses. Energy will be lost through a common wall ...
   Relative relevancy: 97%

3. **Power of an Incomming Water Source**
   The model is used to calculate the power contained within a water source, given the depth, width, and flow rate of the water source. The model is usua ...
   Relative relevancy: 91%

4. **24-hr profiles of roof-wall conduction cooling loads**
   This models calculates the amount of energy required to maintain a constant temperature in a building through cooling, because of energy gains due to c ...
   Relative relevancy: 75%

5. **service water heating**
   This model calculates the daily energy consumption for heating water within a building. There are 10 different building types available as inputs, as ...
   Relative relevancy: 71%

6. **PV module life-cycle energy analysis (LCEA)**
   Based on a work where life-cycle energy analysis is applied to a photoviltaic module.
   Relative relevancy: 60%

Figure 19 Search results.

air conditioner (1), axial turbine (1), building (2), building energy (3), conduction (1), cooling (3), cooling energy (1), diesel generator (1), discount rate (1), electricity (1), electricity consumption (1), electricity consumption and cost (1), electricity cost (1), energy (7), energy analysis (1), engine (1), fenestration (2), fluid characteristics (1), fuel (2), generator (2), heat transfer (1), heating (1), ideal gas (1), impulse turbine (1), irradiance (2), lattitude (1), local standard time (1), longitude (1), panel (1), photovoltaic (1), power (1), pressure (1), PV (3), radial turbine (1), radiance (1), roof (1), single reaction turbine (1), solar (4), solar time (1), standard time meridian (1), sun (1), sunrise (1), sunset (1), temperature (1), test model (1), thermodynamics (1), time vector (1), turbine (2), turbine flowrunner (1), turbine power (2), turbine power output (2), ventilation (2), wall (1), water flow (1), water source (1), window (2)

Figure 20 Model tags.

Reasons why the infrastructure is designed this way: Besides the reasons already mentioned above (e.g. why tags are used, etc.), the following are reasons behind the design of the infrastructure. The user interfaces are implemented in dynamic Web pages, so that users can view and utilize them in any normal Web browsers without having to install special software like Flash or Java Web Start. This means that the user interfaces, and thus the commons in PEMS Web, can be accessed from any devices that have a normal Web browser, such as an iPhone[22]. Moreover, most people are familiar with how to use Web pages. Having the user interfaces in Web-page formats can help users avoid the learning curve.

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[22] http://www.apple.com/iphone/

The DOME client application is a proven technology for accessing and running models that are shared through the WWSW. The technology enables PEMS Web's infrastructure to be able to utilize model commons outside of the system's central model repository. The application also has an API that can be called by any Java code. Thus, adopting the DOME client application and its API, the infrastructure can access and run a wide range of remotely hosted models flexibly with Java code. Furthermore, since JSP, the language used in the dynamic user-interface pages, is Java-based, the translation of data between the user-interface and the model sides can be done efficiently.

The AJAX technology is used because it enables efficient transporting of only small, essential packets of information. For instance, when a user requests a description of a parameter, the Web server can send over only the description, which typically consists of a few short paragraphs of texts, which is much more efficient than resending the whole user-interface page with graphics.

The infrastructure offers many different ways for users to locate model commons. The different interfaces (browsing, different ways of sorting, two methods of searching, and viewing by tags) can hopefully help users navigate in an increasingly large and complex model repository.

Finally, the additional information related to models and parameters, which are part of the commons and open for collaborative authoring, can make the model commons easier to understand and use.

In summary, the infrastructure can make the complex model commons easily accessible and usable by common users.

The commons must be utilizable for synthesis.

The importance of this design attribute: It is important that the commons be utilizable for synthesis with reasonable ease, so that people can synthesize information to satisfy their own needs.

Syntheses in PEMS Web can revolve around both types of commons, model and multimedia. In this section, only syntheses that revolve around model commons are described. Syntheses of information around multimedia commons are closely integrated with the process of sharing multimedia commons, so they are described together in the next subsection.

The infrastructure designed to deliver this design attribute: The infrastructure for enabling model-commons-oriented syntheses works in conjunction with the infrastructure that establishes the commons. The following are components of this infrastructure, many of which are shared with the infrastructure for enabling easy access to the commons:

- A Web server

- An interactive, Web-based user interface for synthesizing models
- User-interface controller. It in charge of detecting actions from the user and formulating requests based on the detected user actions to send to the Web server. The UI controller also detects information sent from the Web server, interpret the information, and updates the user interface accordingly. In addition, the controller also manages data that is relevant to the display on the user interface.
- An asynchronous information transporter – for facilitating exchanges of small pieces of information between the user-interface controller and the model builder.
- A model builder program. It executes model-synthesizing commands according to the requests received from the information transporter.

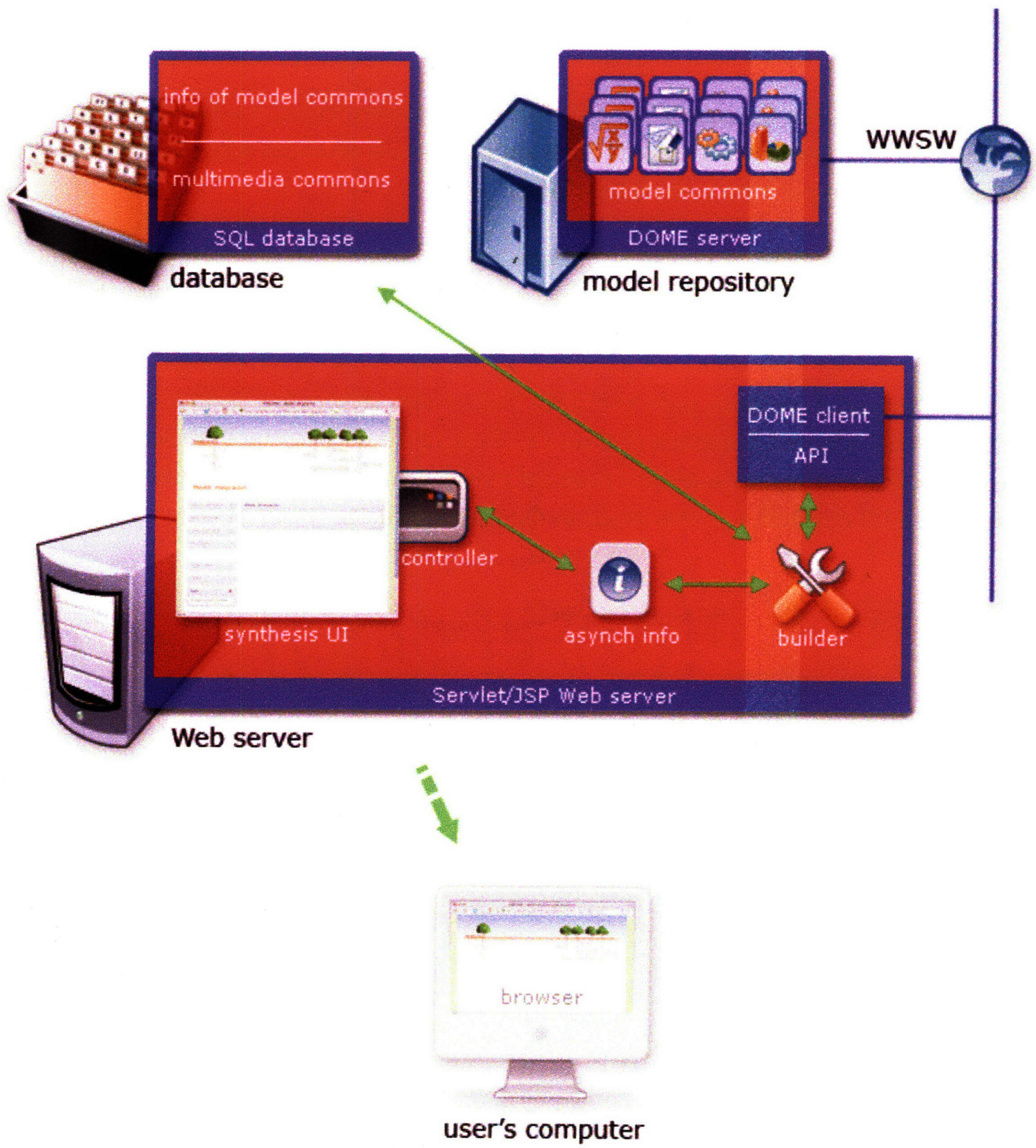


Figure 21 Infrastructure for enabling model-commons-oriented syntheses.

Enabling technologies of the infrastructure: The diagram of the infrastructure is shown in Figure 21. The same Tomcat Web server that is part of the infrastructure for enabling access to the commons is also utilized in this infrastructure. The same DOME client application is also used. However, the application's API for integrating models, not the one for accessing models, is used.

The user interface, the UI controller, and the asynchronous information transporter are built with AJAX technology. The user interface is a Web page designed with the DOM (Document Object Model) structure, so that all elements in the page can be precisely controlled and manipulated, making the page interactive. For example, a particular image element on the page can be called out and set to show a different image. The controller is written in JavaScript, capable of making dynamic changes on a Web page without contacting the Web server.

The model builder, like the translator in the previous infrastructure, is a Java Servlet, a program written in Java for server-side Web applications. It interacts with the DOME client application's API to perform a model synthesis.

How the infrastructure works: an example use scenario and a look behind the scenes: In this example scenario, a user synthesizes a new model by building upon model commons that she has noticed on PEMS Web.

To access the model synthesis page in PEMS Web, a user selects the *Integrate* option in the menu of model-oriented functions (Figure 11). Behind the scenes, the Web server dynamically creates the user-interface page for model synthesis and sends it to the user's browser. The UI controller is embedded in the user interface.

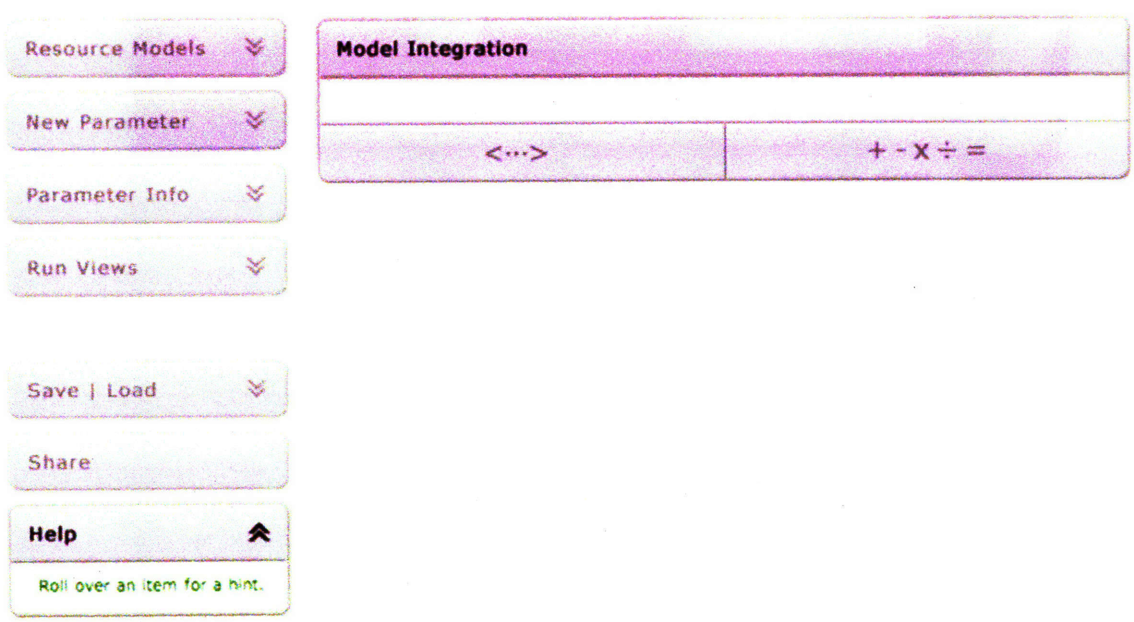


Figure 22 Model synthesis user interface.

The model-synthesis user-interface page (Figure 22) is displayed on the user's browser. The main menu is the column on the left. A menu item is highlighted (Figure 23 left) when the user rolls her mouse over it. When the menu item is clicked, it expands to show more options (Figure 23 right). Behind the scenes, the JavaScript UI controller detects the user's mouse-over action and substitutes the image with a highlighted version. When the controller detects a mouse click on the menu item, it accesses the page's DOM structure to locate the region (DIV element) that is associated with the clicked image. The controller then removes the button image from the located region and adds new contents to the region to create an expanded menu item. The expanded menu item includes an image of the item's top (with an up arrow suggesting that the menu can be collapsed back if it is clicked), a background image of the body of the region, an image of the bottom border, and an area in the center for options. In case of the *Resources Models* menu item, the expanded menu shows an *Add resource models* link.

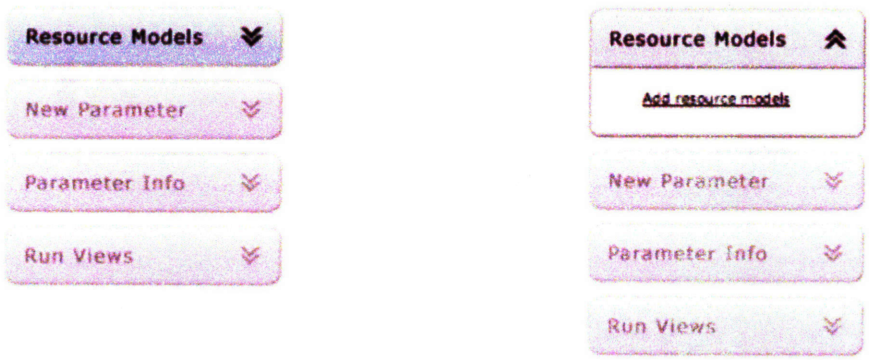


Figure 23 Highlighted menu (left); and expanded menu (right).

The user clicks on the *Add resource model* link, and a window pops up asking her to log in. Behind the scenes, after the Web server verifies the submitted login information, it queries the database for a list of all model commons that the user has bookmarked. The Web server then dynamically creates a page listing all the user's bookmarks and sends it to the user's browser.

On the user's browser, a window pops up to display a list of all model commons that she has bookmarked (Figure 24). To add a model common to the synthesis, the user clicks on the *Add* link next to the model's name. In this case, the user first adds a model called *sun-earth geometric relationship* with a run view that can calculate solar azimuth and altitude angles for any given location and time. Behind the scenes, the controller knows which model common the user wants to add to the synthesis. The controller first accesses the page's DOM structure to locate the region (DIV element) of the *Help* menu item and changes the content to be an animated image to notify the user that the request is being processed (Figure 25). The controller then forwards the request via the asynchronous information transporter to the Web server. The builder program on the Web server receives the request and starts working with the DOME client application, through its API. A new blank model is formed for the synthesis. The Web server also queries the database for the location information of the *sun-*

earth geometric relationship model common. With the location information, the builder program locates the model common and *subscribes* to its computational service for the synthesis. The builder program also obtains the details of input and output parameters from the model, and forwards the information via the asynchronous information transporter to the UI controller.

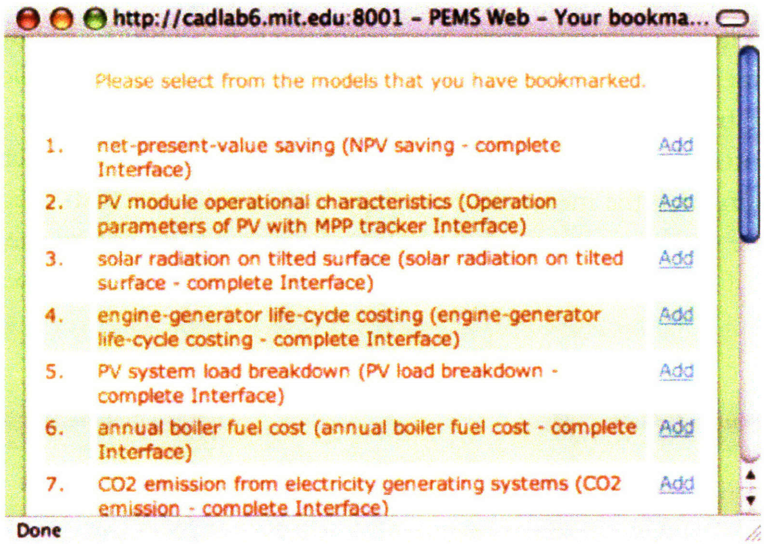


Figure 24 A pop-up window showing a list of bookmarked model commons.

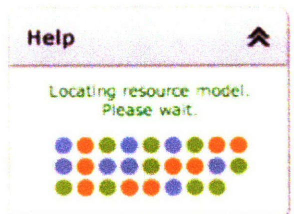


Figure 25 The Help menu item displaying an animated wait image.

Upon receiving the confirmation that the Web server has successfully subscribed to the requested model common, the UI controller sets the *Help* menu to replace the wait image with a success message. Using the DOM technique, the controller also adds a new graphic in the *Resource Models* menu item to signify that the model common is available as a resource in the current synthesis (Figure 26). In addition, the controller also creates a new table-like graphic and adds it to the *Model Integration* space (Figure 26), to represent an instance of the newly subscribed common in the synthesis. The graphic is composed of two main sections: header and body. The header is a blue tab, comprising a big capital letter, the name of the model common, the selected run view, and two arrows. The big capital letter, *A* in this case, is a representative label of that particular instance of the common in the synthesis. It is refered to later as the synthesis progresses. The left arrow can be clicked to remove the instance of the common from the synthesis, but the service of the model common will still be available as a resource. The up arrow can be clicked to collapse the body of the instance's graphic so that only the header is shown. The body of the instance's graphic comprises lists of input and output parameters of this particular run view of the model common. Each row represents each of the parameters. For a clean look, only parameters' names are displayed in the rows. The UI controller stores the other parameter information (e.g. type, unit, default value) in an array in the Web browser's memory. As discussed later, full information about each parameter can be displayed using the *Parameter Info* menu item.

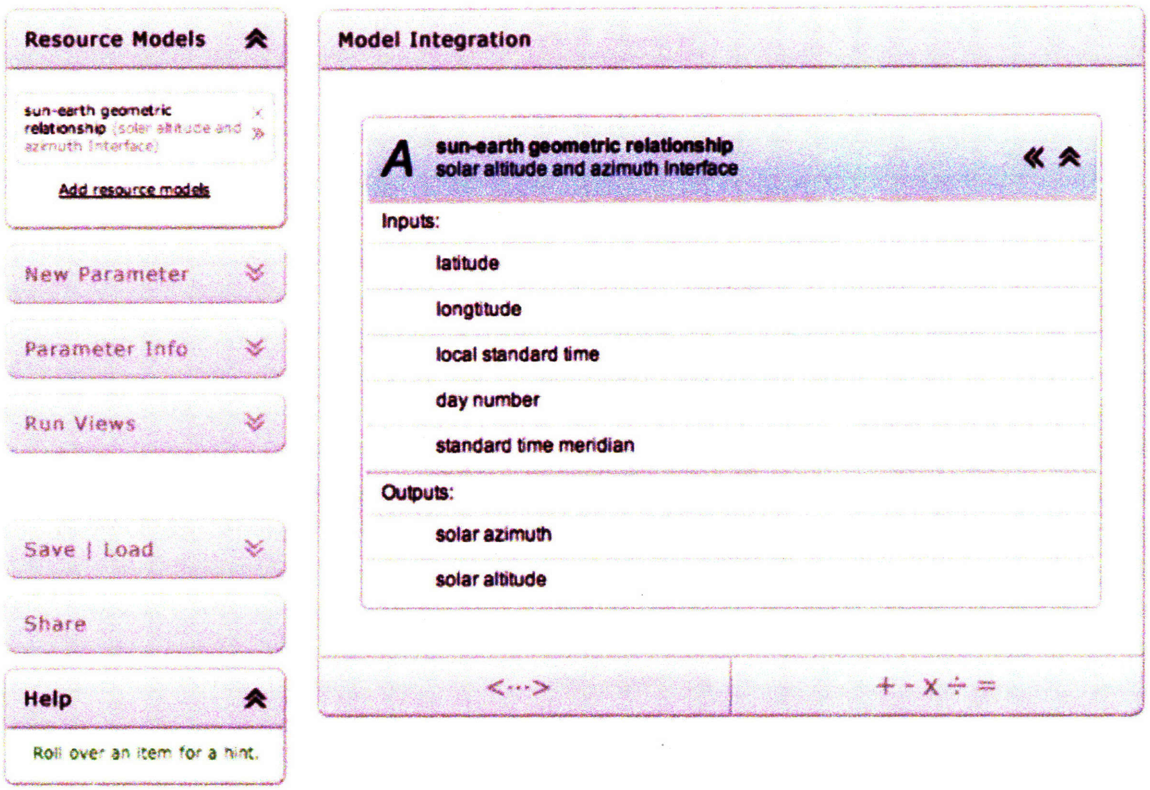


Figure 26 Model synthesis with one resource available.

The user sees all the changes in the user interface, including the additions of the graphics to represent the newly subscribed model common, without any page reloading. The user interface, thus, looks and behaves like a conventional desktop software application, even though it is simply a Web page. In addition, when the user rolls her mouse over parts of the user interface that can create actions, such as the left and up arrows, the UI controller sets the content of the *Help* menu item to display a hint of what the user can do.

The user adds another model common that she has bookmarked, *solar radiation on tilted surface*, to the synthesis. The same process as described above takes place behind the scenes. After the process is successfully finished, the user can now see that there are two model commons available as resources (Figure 27). An instance of the newly subscribed common is also added to the *Model Integration* space and is labeled *B* (Figure 28).

If for some reason, the user wants to remove the service of a subscribed model common, she can click on the *x* mark on the graphical representation of the subscribed common (Figure 27). Once removed, the service of the common is no longer available for use in the synthesis. Nonetheless, the common can be re-subscribed later, too.

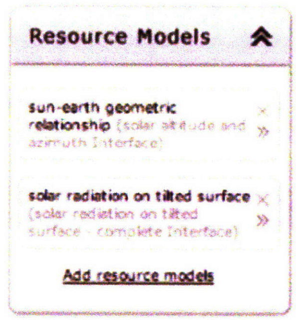


Figure 27 Two model commons available as resources.

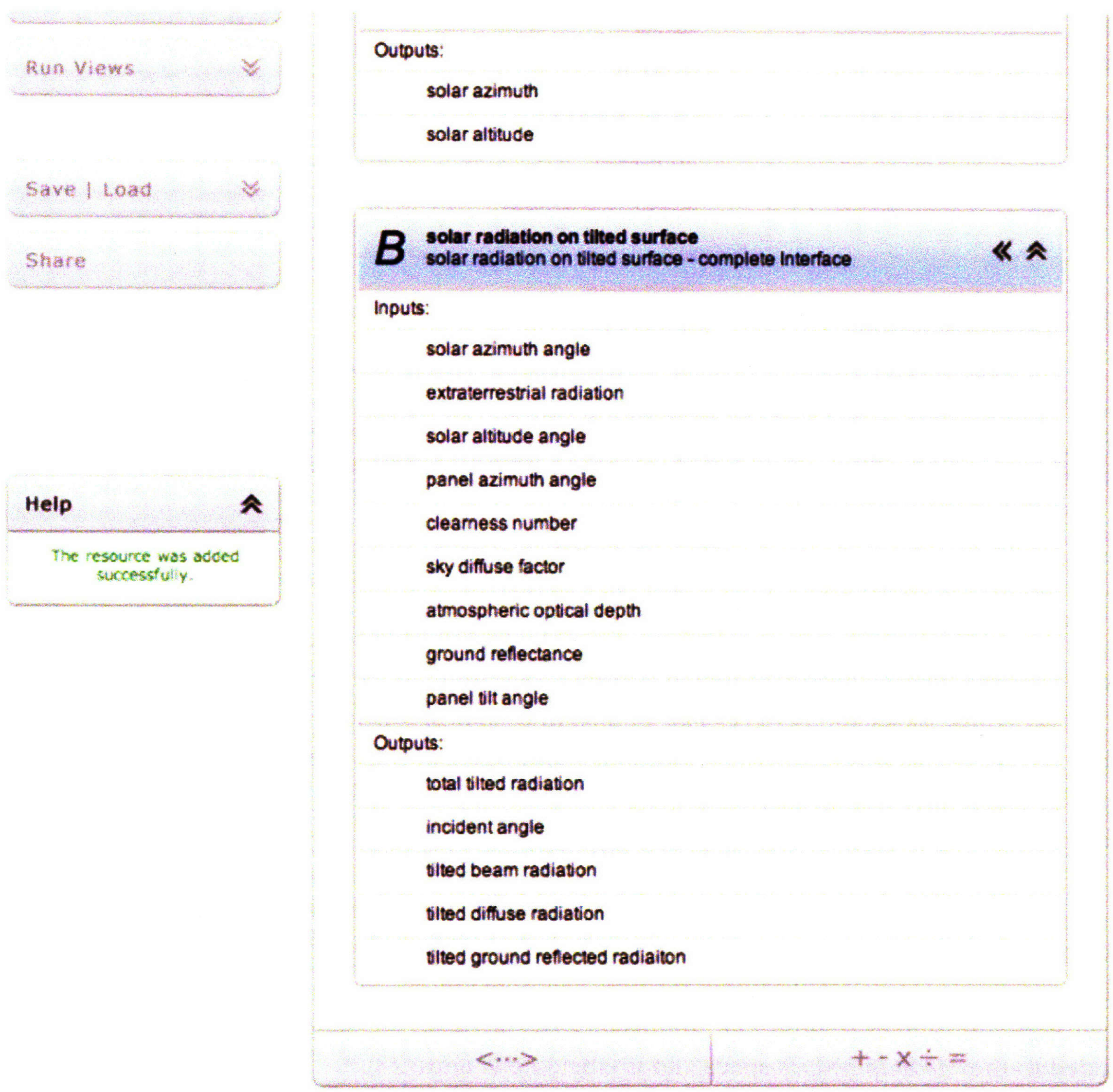


Figure 28 An instance of the newly subscribed model common in the Model Integration space.

Note that in Figure 28, the *Help* menu item has shifted down. This happens when the whole user-interface page is too long to fit in the browser window, and the user would have to scroll up and down the browser to see the whole page. When the UI controller detects that the whole user-interface page cannot fit in the browser, it dynamically adjust the position of the *Help* menu item so that it always appears in view of the user. To the user, the *Help* menu item looks like it floats along in the browser window as she scrolls. This is important because the *Help* menu item often displays useful hints and critical messages. Nonetheless, if the user does not want the *Help* menu item to follow as she scrolls down the page, she can click on the up arrow. Doing so collapses the menu item and keep it anchored right below the other menu items.

When the user moves her mouse over a parameter row, the UI controller detects the action and highlights the row by painting the background orange (Figure 29). When the user clicks on a parameter row, the UI controller paints the border of the row with a thick dark orange line. If the *Parameter Info* menu item is expanded, the UI controller sets the content of the menu item to display information of the selected parameter (Figure 30).

Figure 29 Highlighted parameter.

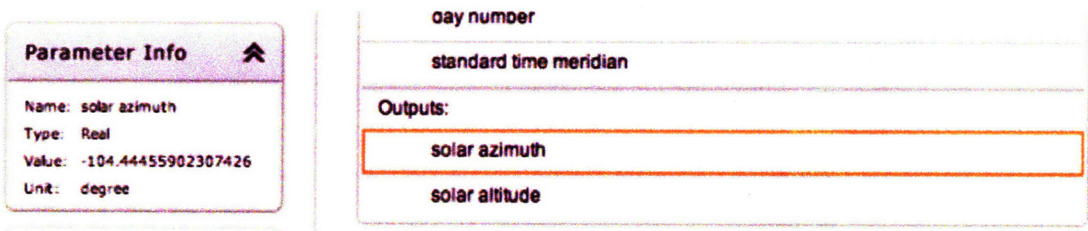


Figure 30 Displayed parameter information of selected parameter.

Now the user can synthesize a new model based on the two model commons. She first links the output parameter *solar azimuth* of the first model to the second model's input parameter *solar azimuth angle*. To do that, all she needs to do is to select both parameters (Figure 31) and then click on the link button (Figure 32).

Behind the scenes, the UI controller detects that the user wants to link parameters from two models. It sets the *Help* menu item to show a wait image (similar to the one shown in Figure 25), and forwards the request to the Web server. The builder program on the Web server receives the request and checks the validity of the requested link. For example, it checks whether the causality of the link is valid (e.g, an output of one model cannot be linked to an output of another), and whether the parameters involved are compatible (e.g. a parameter with a unit of length cannot be linked to a parameter with a unit of mass), etc. If the requested link is invalid, the builder sends a notification, via the asynchronous information transporter, to the UI controller, which then sets the user inter interface to display an error message to notify the user. If the builder determines that the requested link is valid, it asks the DOME client application to create the link in the model of the synthesis.

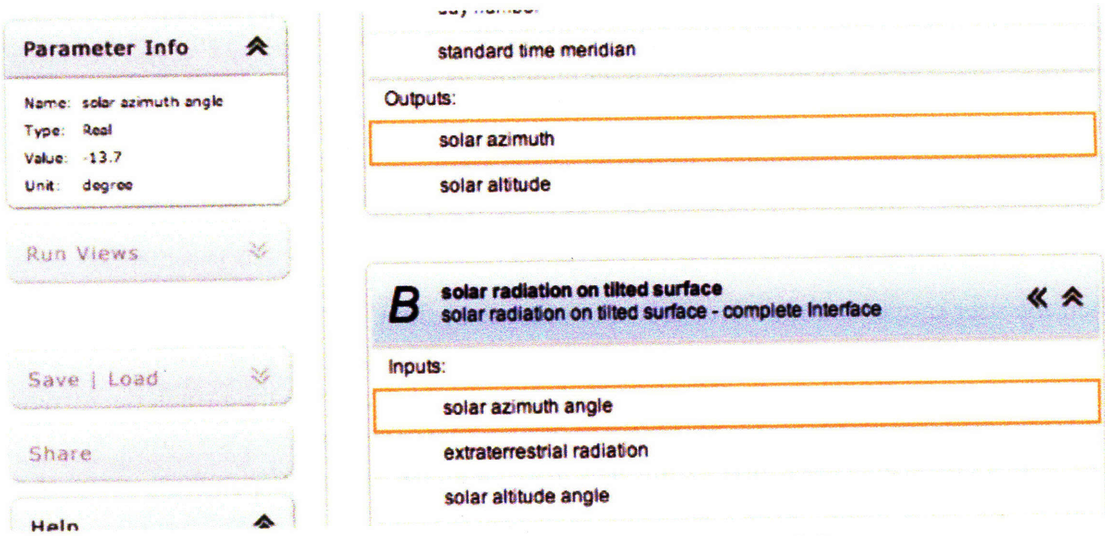


Figure 31 Selected parameters from two models to be linked.

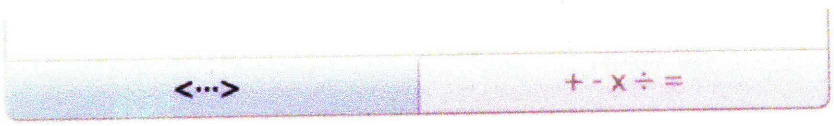


Figure 32 Link button (left).

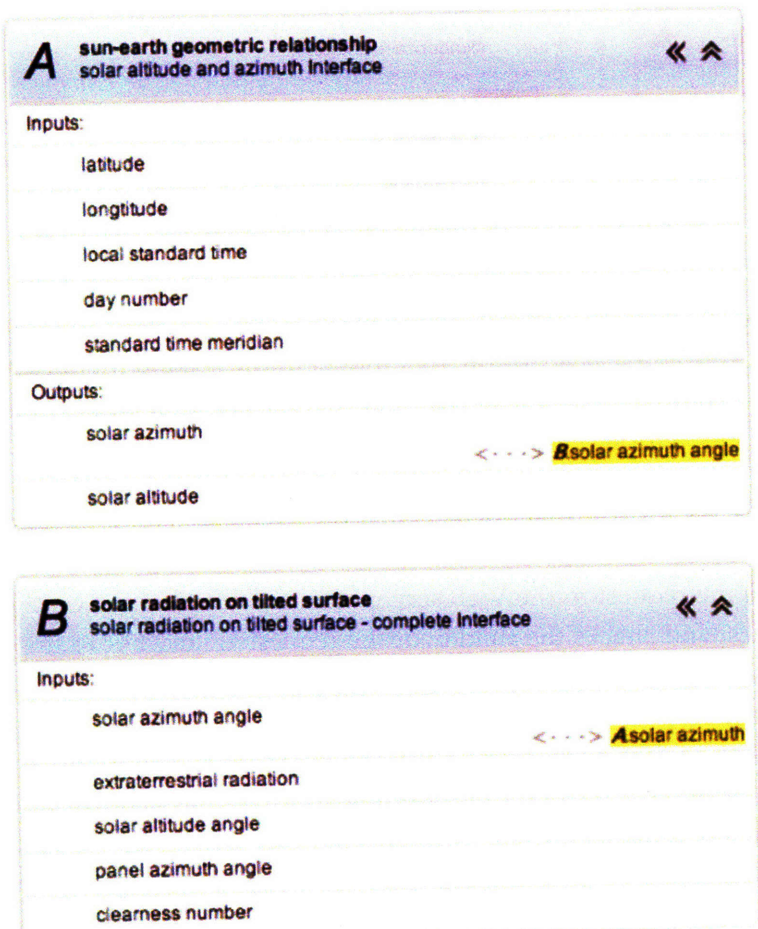


Figure 33 Graphics signifying linked parameters.

Up to this point, the model that is being synthesized is based on services of the two model commons. It utilizes the service of the *sun-earth geometric relationship* to calculate the solar azimuth angle, and, based on that result, utilizes the *solar radiation on tilted surface* model to calculate the radiations.

Once the linking is successfully done, the builder program notifies the UI controller via the asynchronous information transporter. The controller updates the message in *Help* menu item to notify the user that the link is successfully done, then creates graphics to represent the link, and adds them to the rows of the parameters involved (Figure 33). In the row of the parameter *solar azimuth*, the additional graphic shows that the parameter is linked to *solar azimuth angle* of *B*. Similarly, in the row of the parameter *solar azimuth angle*, the graphic shows that the parameter is linked to *solar azimuth* of *A*.

The user then further links the two model commons, by linking the parameters *solar altitude* of the first model to *solar altitude angle* of the second. The same process then takes place behind the scenes. Now the model that is being synthesized utilizes the service of the *sun-earth geometric relationship* to calculate the two solar angles, and, based on those results, utilizes the *solar radiation on tilted surface* model to calculate the radiations. In effect, the newly synthesized model is a streamlined version of the two commons integrated.

On the user interface, the UI controller creates a new set of graphics to signify the second link and adds them to the rows of the parameters involved (Figure 34). Besides the differences in the names of the parameters, the graphics signifying the second link are similar to the first. The important difference is the color. The UI controller assigns a unique color to each set of linked parameters, so that when the user glances at the user interface, the different colors can serve as a visual cue to show which parameters are linked to which. When the user rolls her mouse over a link graphic, that graphic and others that represent the same link shift (yellow link graphics in Figure 35). The movement is another visual effect that can help the user locate all parameters pertaining to one specific link. In addition, when the user rolls her mouse over a link graphic, the UI controller detects the action and sets the message in the *Help* menu item to say that the user can click the graphic to edit the link (Figure 35).

When the user clicks on a link, the UI controller changes the action buttons at the bottom of the *Model Integration* area to buttons for editing and deleting the link (Figure 36 left and right, respectively). When the user clicks on the edit-link button, the UI controller replaces the edit- and delete-link buttons with an area displaying the details of the link to be edited (Figure 37).

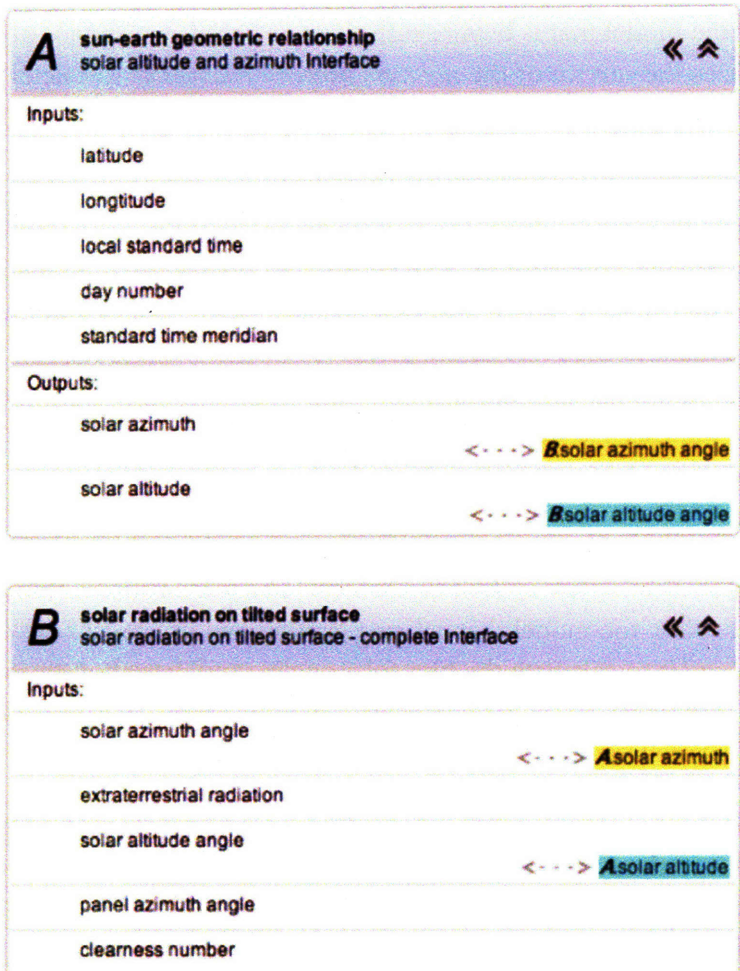


Figure 34 Graphics signifying two sets of linked parameters.

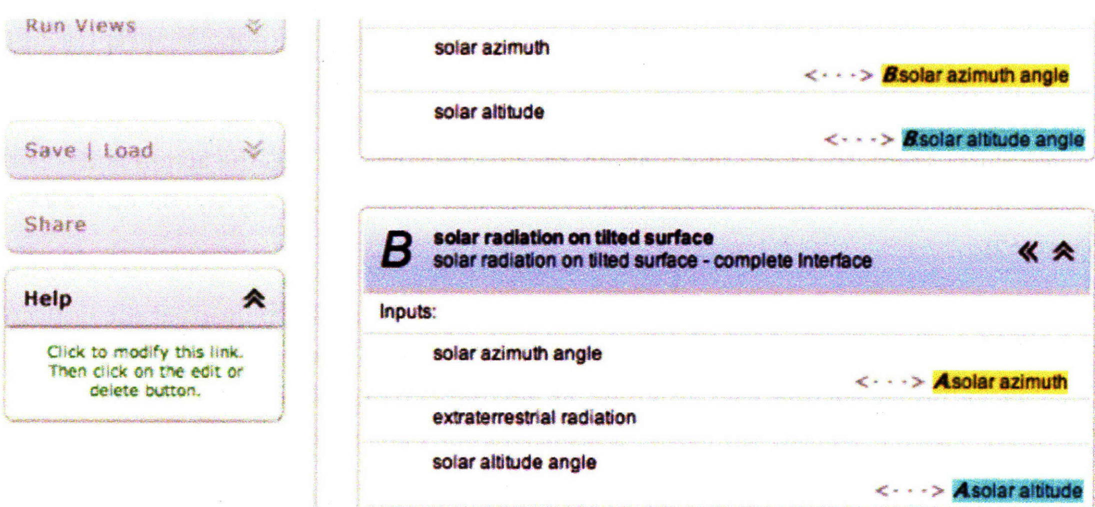


Figure 35 Shifted link graphics (yellow) and a message hinting possible link editing actions.

Figure 36 Context-sensitive buttons for editing and deleting links.

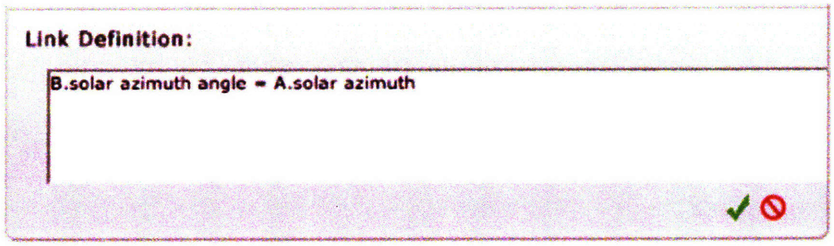


Figure 37 Details of link to be edited.

If the user wants to edit the link definition, she can modify the text in the field and click on the green check button to confirm the edit. The UI controller then sends forward the new link definition to the Web server. The builder program on the server tries to parse the new link definition. If the builder cannot parse the new definition or deems it invalid, it notifies the UI controller, which then displays an error message to the user. But, if the new definition is valid, the builder works with the DOME client application to make the change. The outcome of the change is forwarded to the UI controller as well.

The user can run the model while she is synthesizing it. She clicks on the *Run Views* menu item (Figure 22). Using the same DOM technique used for expanding the *Resource Models* and *Help* menu item, the UI controller expands the *Run Views* menu item to show a list of run views of the model being synthesized. At this point, the user has not created any new run views, so only the default one is listed (Figure 38).

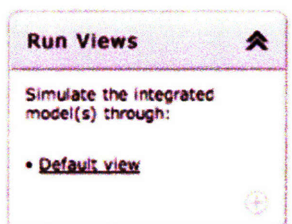


Figure 38 Run Views menu item.

To see a run view, the user clicks on the run view's name on the list. Behind the scenes, the UI controller detects the user's action. It sends a message to the Web server to ask for details of the requested run view. The builder checks the causalities of parameters in the specified run view of the model that is being synthesized, constructs lists of input and output models, and sends them via the asynchronous information transporter to the UI controller. Upon receiving the lists of parameters in the run views, the controller creates graphics for an area to display the run view. The new area is labeled *Run View* and is placed below the *Model Integration* area. The UI controller then populates the *Run View* area with lists of input and output parameter associated with the requested run view (Figure 39). The run view looks similar to how a run view looks in the user interface for accessing model commons (Figure 14). The first line in the *Run View* area is the name of the specified run view. Below the run view's name is the list of input parameters. Each row contains the parameter's name, a field displaying the parameter's value, the parameter's unit, and an *x* graphic for removing the parameter from the run view. Below the list of inputs is a button for running the model. Finally, below the run button is the list of output parameters.

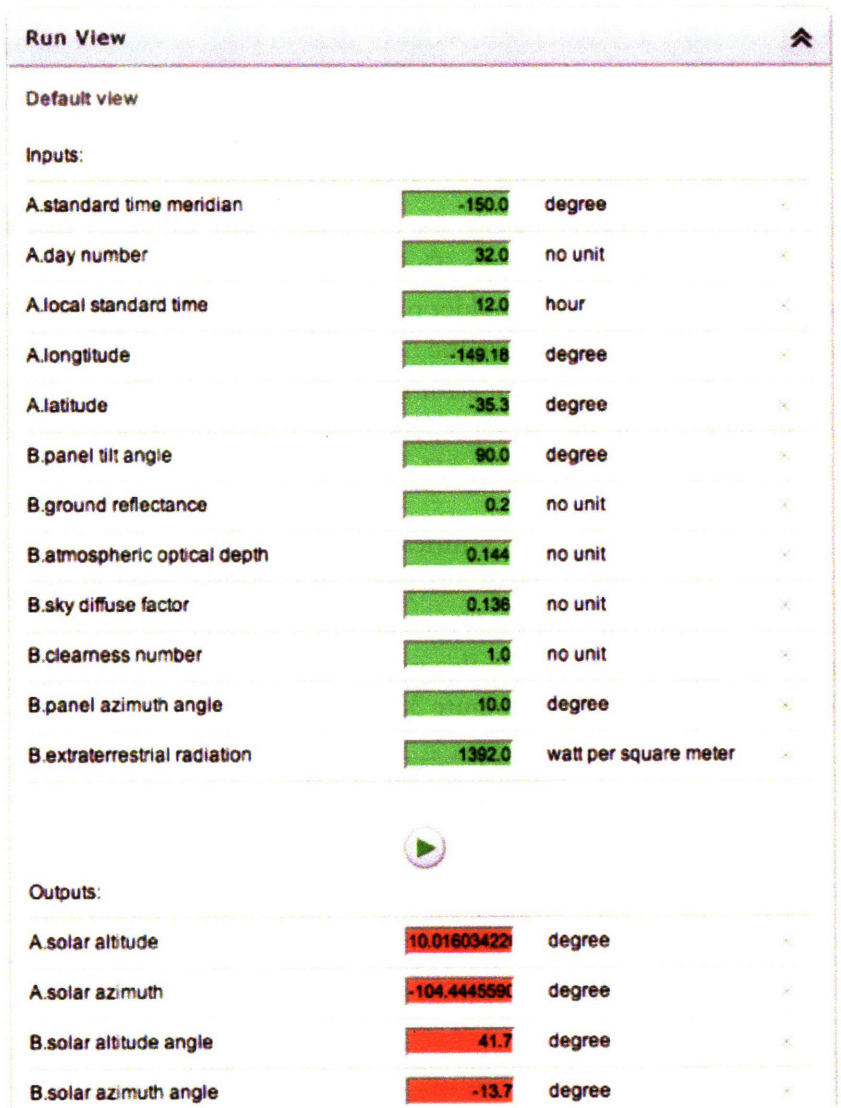


Figure 39 The Run View area displaying lists of input and output parameters of a specified run view.

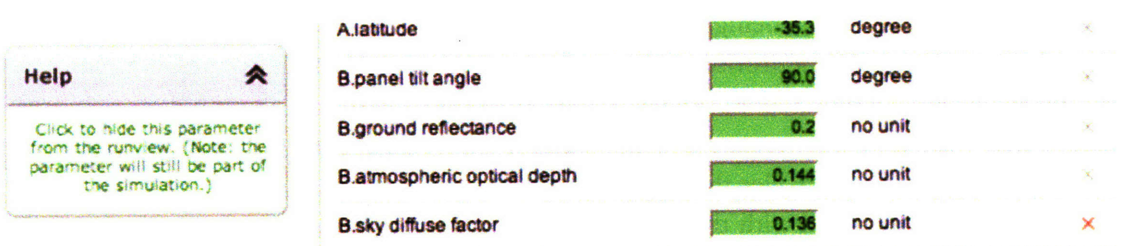


Figure 40 The graphic for deleting a parameter in a run view and a hint message.

When the user rolls her mouse over an *x* graphic, the UI controller makes the graphic appear red and sets the *Help* menu item to display that the user can remove the parameter from the run view (Figure 40). When a parameter is not part of a run view, the user is not able to see or set its value, but it is still part of the model's simulation.

The user clicks the green-arrow run button to run the model that she is synthesizing. The UI controller gathers changed inputs from the run view and forwards them to the builder program on the Web server. The builder works with the DOME client application to set the changes on the model's inputs. Then the model is set to start running, and the builder listens for changes of the parameters. As soon as any changes happen, the builder packages the information about the changes and forwards it to the UI controller via the asynchronous information transporter. The UI controller immediately updates the user interface to reflect the changes. Figure 41 shows a snapshot of the output parameters while the model is running. The first four parameters have already been computed and are consistent with the input values. When the overall simulation is done, the UI controller sets the backgrounds of all output parameter to white, to signify that all output values are consistent with the inputs.

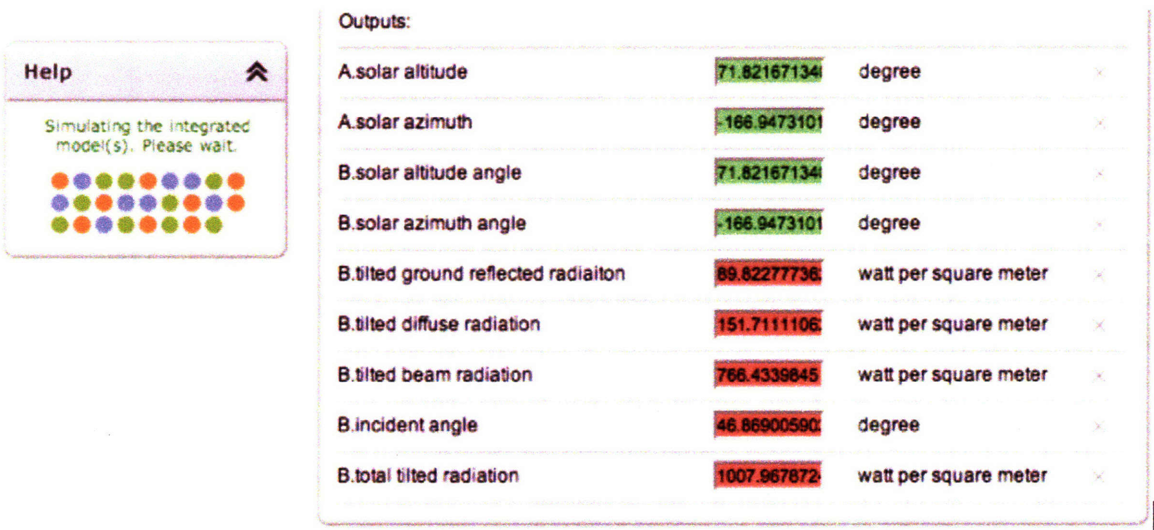


Figure 41 Output parameters with statuses and values updated while the model is running.

The user can change the unit of any parameters in the run view by double-clicking on the unit's text. The UI controller replaces the unit's text with a text field and action buttons (Figure 42). The user can type a new unit in the text field.

Figure 42 A field for changing units of a parameter in a run view.

As the user types the new unit, the UI controller looks up a list of units that are compatible with the original unit of the parameter, picks the units that partially match what the user is typing, and creates a menu to suggest auto completion for the user (Figure 43).

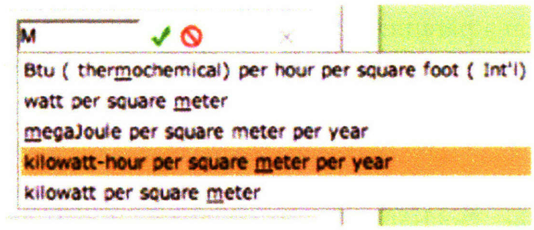


Figure 43 An auto-complete menu of compatible units for changing units of a parameter in a run view.

The user picks the desired unit from the suggested auto-complete list and clicks on the green check-mark button to confirm the change. Behind the scenes, the UI controller forwards the change to the builder program on the Web server. The builder converts the value of the parameter from the old unit to the new one, and then works with the DOME client to change the value and unit of the parameter. The builder also sends back the converted value of the parameter to the UI controller. The controller then updates the value of the parameter in the user interface, and changes the background of the value field to yellow, to signify that the value has been changed. Finally, the controller displays the new unit in text (Figure 44).

Figure 44 A parameter in a run view with its unit changed and value automatically converted.

The user can save the progress of the synthesis process at any time by using the *Save | Load* menu item (Figure 45). When the user clicks on *Save progress*, the UI controller forwards the request to the Web server.

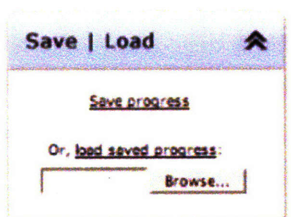
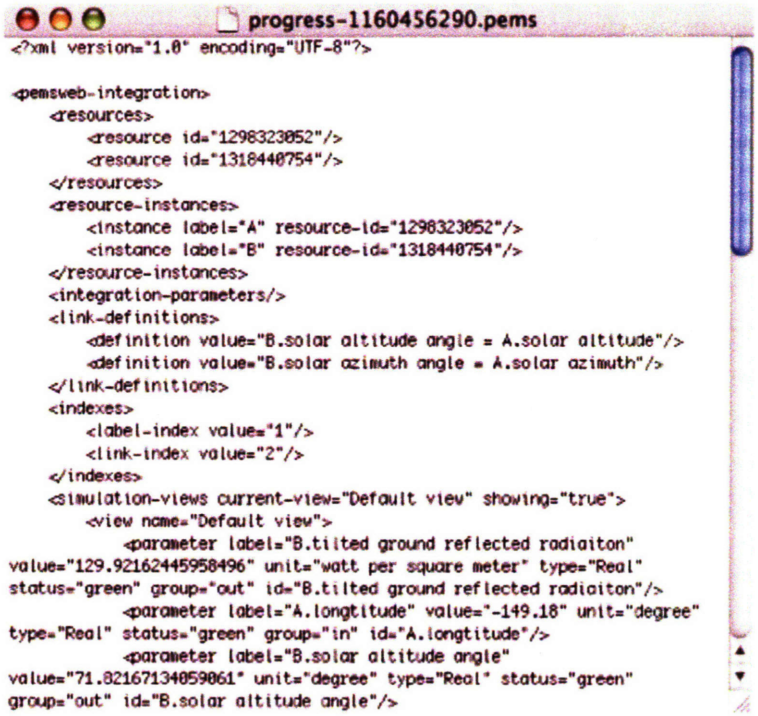


Figure 45 Save | Load menu item.

The builder program receives the progress and composes an XML file to record the current state of the model being synthesized. Figure 46 partially shows the content of the XML progress file. The file is sent back to the user interface, which then pops up a dialogue to ask the user to save the file on her computer (Figure 47). Because the synthesized model is not yet shared as a common, no record of the synthesis is stored on the Web server. The XML file that is sent to the user is the only record of the progress of the synthesis. The XML progress file's size is usually very small, since it is essentially a text file, and can be easily transported or transfered.



```
progress-1160456290.pems
<?xml version="1.0" encoding="UTF-8"?>

<pemsweb-integration>
    <resources>
        <resource id="1298323052"/>
        <resource id="1318440754"/>
    </resources>
    <resource-instances>
        <instance label="A" resource-id="1298323052"/>
        <instance label="B" resource-id="1318440754"/>
    </resource-instances>
    <integration-parameters/>
    <link-definitions>
        <definition value="B.solar altitude angle = A.solar altitude"/>
        <definition value="B.solar azimuth angle = A.solar azimuth"/>
    </link-definitions>
    <indexes>
        <label-index value="1"/>
        <link-index value="2"/>
    </indexes>
    <simulation-views current-view="Default view" showing="true">
        <view name="Default view">
            <parameter label="B.tilted ground reflected radiaiton"
value="129.92162445958496" unit="watt per square meter" type="Real"
status="green" group="out" id="B.tilted ground reflected radiaiton"/>
            <parameter label="A.longtitude" value="-149.18" unit="degree"
type="Real" status="green" group="in" id="A.longtitude"/>
            <parameter label="B.solar altitude angle"
value="71.82167134059061" unit="degree" type="Real" status="green"
group="out" id="B.solar altitude angle"/>
```

Figure 46 Partial content of a model-synthesis progress file.

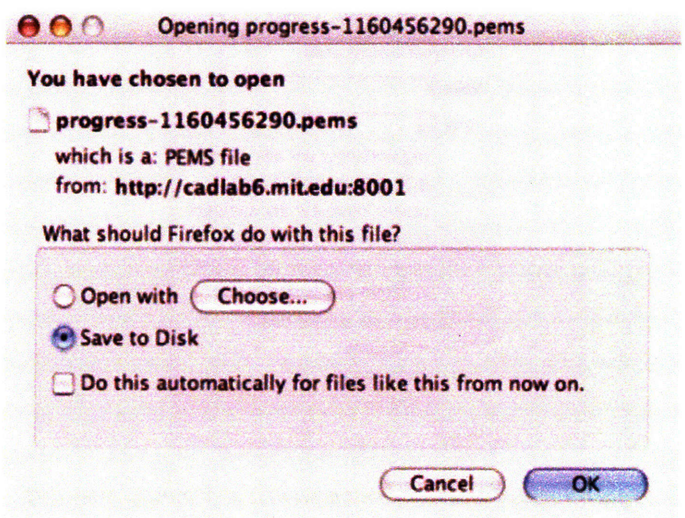


Figure 47 Browser dialogue for saving progress file.

Later on, the user can revisit the model-synthesis user interface, on any computer, and use the *Save* | *Load* menu item (Figure 45) to load up the latest progress of her model synthesis. To do that, the user clicks on *Browse* ... to locate the progress file on her computer, and then clicks on *load saved progress*. The user interface then uploads the progress file to the Web. The builder program parses the XML information in the uploaded file and rebuilds the synthesis. Once the rebuilding of the synthesis on the server is done, the builder notifies the UI controller so that it can update the contents in the user interface to reflect the latest state at which the synthesis was saved. The user can then resume synthesizing the model.

Mathematical relations can also be defined in model synthesis. In this scenario, the user wants to also calculate half of the value of the output parameter *incident angle*. She first uses the *New Parameter* menu item (Figure 48) to create a new parameter for representing the half value. She sets the parameter's data type, name, default value, and unit.

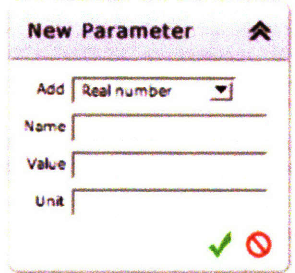


Figure 48 New Parameter menu item.

The UI controller also helps automatically complete the unit's name while the user types, for convenience and to avoid a typo error (Figure 49). The user then clicks on the green check-mark button to confirm the new parameter addition.

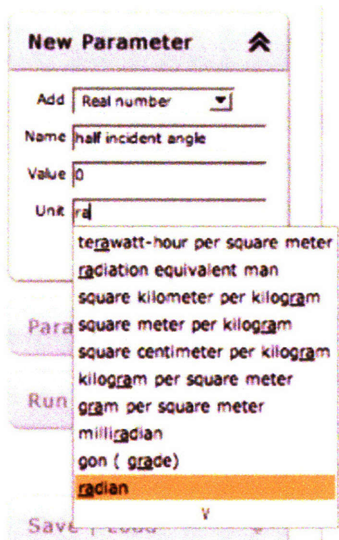


Figure 49 Auto-completion of unit name in New Parameter menu item.

Behind the scenes, the UI controller forwards the entered information for the new parameter to the Web server. The builder program works with the DOME client application to add the new parameter to the model being synthesized. Once the parameter addition is successfully done, a confirmation message is sent via the asynchronous information transporter to the UI controller. The controller then creates a new graphic, which looks similar to the row of a parameter in a model, to represent the newly added parameter and appends it to the *Model Integration* area (Figure 50).

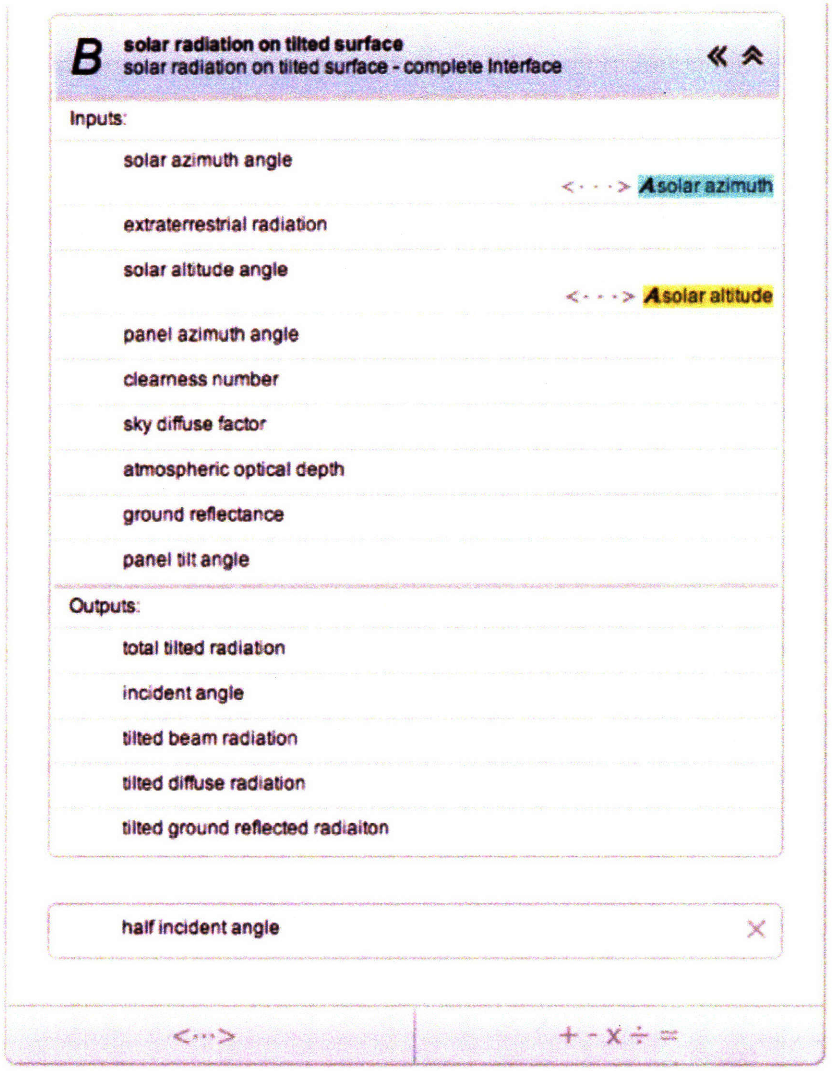


Figure 50 A new parameter added to the Model Integration area.

The user then defines the relation between the new parameter *half incident angle* and the output parameter *incident angle* of B. She selects the two parameters and clicks on the relation button at the bottom right of the *Model Integration* area (Figure 51). Behind the scenes, the UI controller detects the user action, replaces the action buttons at the bottom of the *Model Integration* area with a field for defining a relation, and inserts the names of the parameters involved in the field to help get the user started. The user then fills in the details of the mathematical relation for the parameters involved (Figure 52) and clicks on the green check-mark button to confirm the relation addition.

The UI controller forwards the relation definition to the Web server. The builder program parses the relation definition, in a similar fashion to how it parses a request to edit a link, as described earlier. If the builder determines that the requested relation is valid, it works with the DOME client to create the relation in the model. Once the relation is successfully created, the builder notifies the UI controller. The controller then creates graphics to signify the mathematical relation and appends them to the rows of parameters involved in the relation (Figure 53). The symbol representing a mathematical relation (Figure 53) is different from the one for a direct link (Figure 34). Nonetheless, both types of graphics have the same functions. That is, they serve as visual cues and can be used for editing or deleting the associated links.

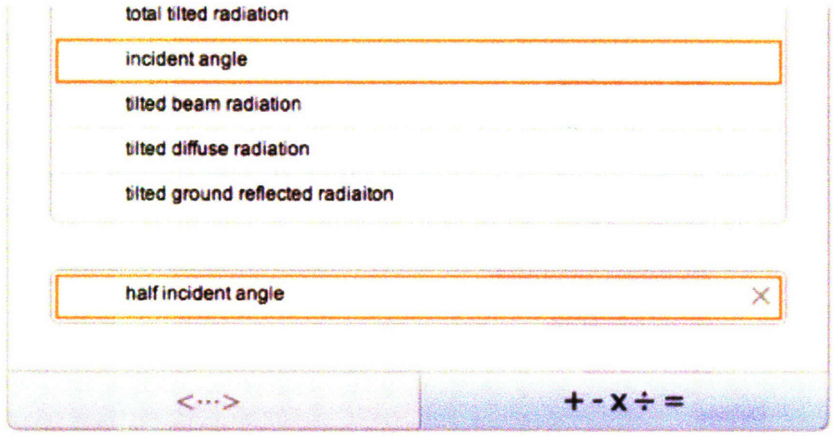


Figure 51 Selected parameters to define a mathematical link and a button for defining a mathematical link.

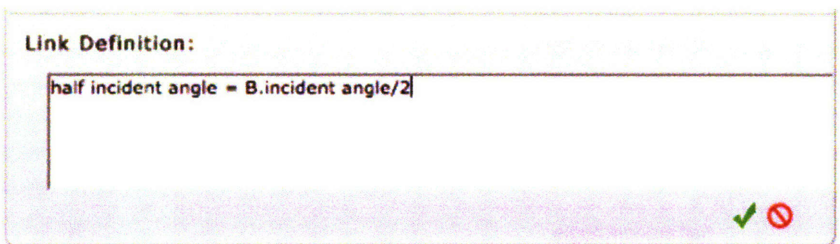


Figure 52 A mathematical relation between two parameters.

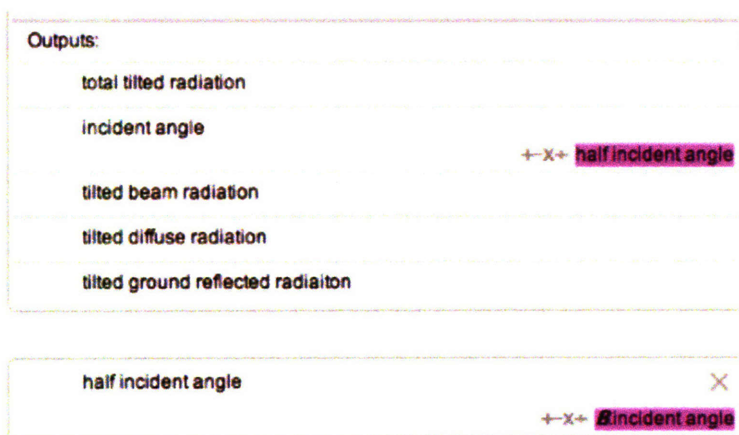


Figure 53 Graphics signifying that the parameters are related mathematically.

When the user looks at the default run view, she can see that the newly added parameter is also listed as an output. The user now wants to create another run view with fewer input and output parameters and to leave the other parameters hidden with default values. She can click on the plus-sign button at the bottom right corner of the *Run Views* menu item (Figure 38). The UI controller responds to the user's action by adding another row to the list of run views, with a field for the user to fill in the name of the new run view (Figure 54).

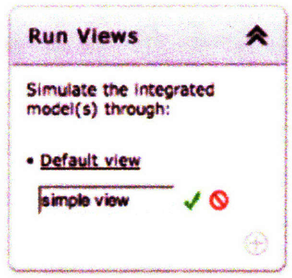


Figure 54 Adding a new run view.

When the user clicks on the name of the new run view in the *Run Views* menu item, she sees that the new run view has no parameter yet (Figure 55). The user can add parameters to the new run view by selecting the parameters from the *Model Integration* area and clicking on the plus sign a the top right corner of the *Run View* area. The user chooses to have the location and panel-setting parameters as configurable inputs and the newly added parameter *half incident angle* as the only output (Figure 56). The user can then run the model through the new run view.

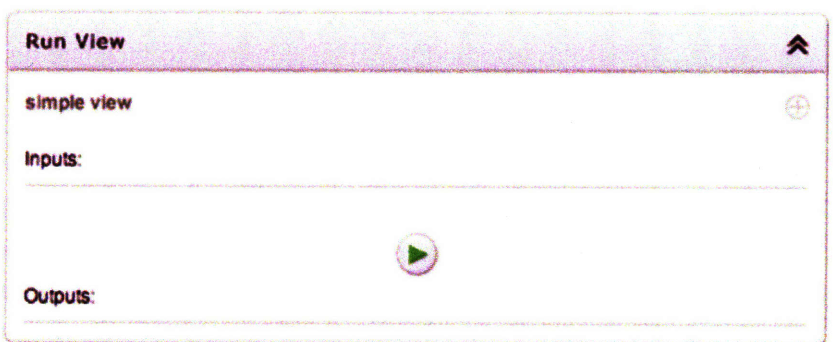


Figure 55 A new run view with no parameter.

Finally, the user can also share this newly synthesized model as a common on PEMS Web by using the *Share* menu item. An example of that action is described in the next subsection.

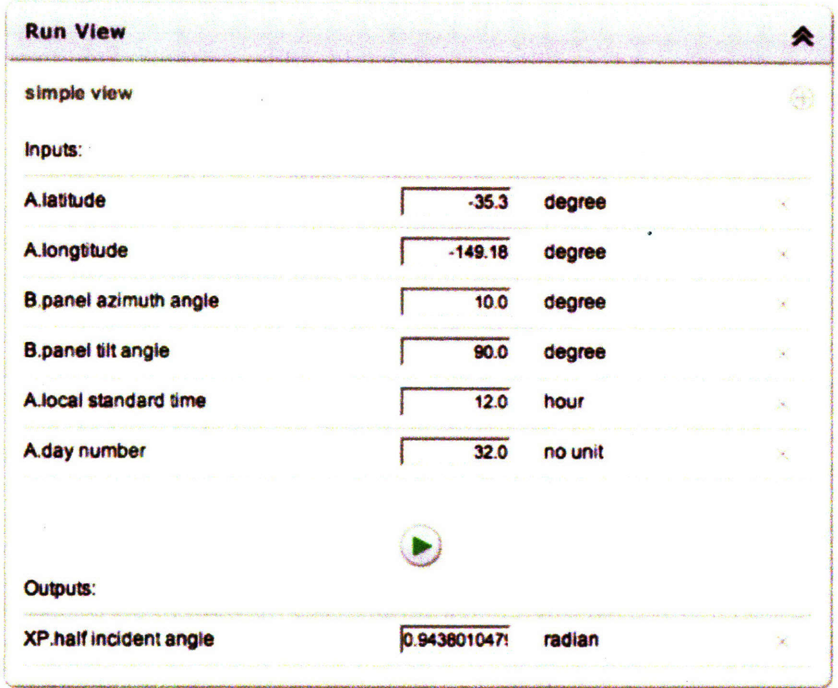


Figure 56 A new run view with selected parameters added.

Reasons why the infrastructure is designed this way: Two major design decisions are involved in the design of this infrastructure: to make the user interface interactive and look and feel like a desktop software application, and to use the DOME technology to facilitate model synthesis. Besides the reasons already discussed above as part of the description of how this infrastructure works, the following are reasons behind the design of the infrastructure.

The user interface has to be easy to use, in a simple form with which most people are familiar. Yet, it has to be intelligent and versatile – able to detect and appropriately respond to user actions and perform complicated operations – both computationally and graphically. The AJAX-style user interface has these needed capabilities. At the forefront the user interface is a normal Web page that can be viewed and operated in any normal Web browser. Yet, it is responsive and can perform complicated operations like a typical desktop software application.

In addition, having people perform syntheses right on pages of PEMS Web, instead of elsewhere like in a separate program on their computers, means that the syntheses take place at the site of commons. Consequently, after the syntheses are done, it is easy to make the synthesized information available as commons. In the case of model synthesis on PEMS Web, only a few extra clicks are required to make a synthesized model available as a common. No additional uploading or file transferring is involved. Thus, there is a better chance that synthesized information will be further shared to the community as commons.

The system to support commons-oriented model synthesis has to be flexible. The DOME technology enables integration of heterogeneous models. Model integration with DOME can also be done in an ad-hoc fashion, meaning that users can add links and mathematical relations between models as they see appropriate, without having to lay out a master plan of how everything will fit together upfront. In addition, users can integrate models without having to worry about the flow of executions. The solving mechanism of DOME ensures that individual models in an integrated simulation solve themselves at the right time. Thus, with DOME technology, users can focus on synthesizing a new model based on model commons without having to worry about the underlying complexities.

In summary, the infrastructure makes it possible for people to utilize commons for synthesizing new information. Especially, the infrastructure facilitates utilizing of model commons for synthesizing new information in dynamic forms.

People must be able to share their private and newly synthesized information as commons.

The importance of this design attribute: Allowing people to share information as commons is important for perpetual improvement and expansion of the commons. There are two main types of information that people can share: information that they privately own and information that they just create from syntheses.

The infrastructure designed to deliver this design attribute: The infrastructure for enabling sharing of information as commons works in conjunction with the commons-establishing infrastructure. There are two parts in the sharing-to-commons infrastructure: for sharing to multimedia commons and to model commons. The following are components of the infrastructure:

- A Web server
- User interfaces for sharing multimedia information as commons
- An interactive, Web-based user interface for sharing models as commons
- A user-interface controller, whose responsibilities are very much similar to the UI controller in the synthesis infrastructure. It is in charge of controlling the graphics on the user interface, based on detected user actions and information from the Web server. The controller is also in charge of formulating requests to send to the Web server, based on the user actions. Furthermore, it also manages data that is relevant to the display on the user interface.
- An asynchronous information transporter – for facilitating exchanges of small piece of information between the user-interface controller and the model sharer program.
- A model sharer program. It works with the DOME client application to execute model-sharing commands according to the requests received from the information transporter.
- DOME client application
- APIs for accessing the DOME client's model-wrapping and model-deploying functions

Enabling technologies of the infrastructure: The technologies used for this infrastructure are the same as those used in the other infrastructures of PEMS Web. The Java-based Tomcat Web server and DOME client application used in the other infrastructures are also used here. AJAX technology is used to enable interactivity in the user interface for sharing models as commons. Other user interfaces for sharing multimedia information as commons are JSP pages. The model sharer program is a Servlet, built similarly to the translator and builder programs in the other infrastructure.

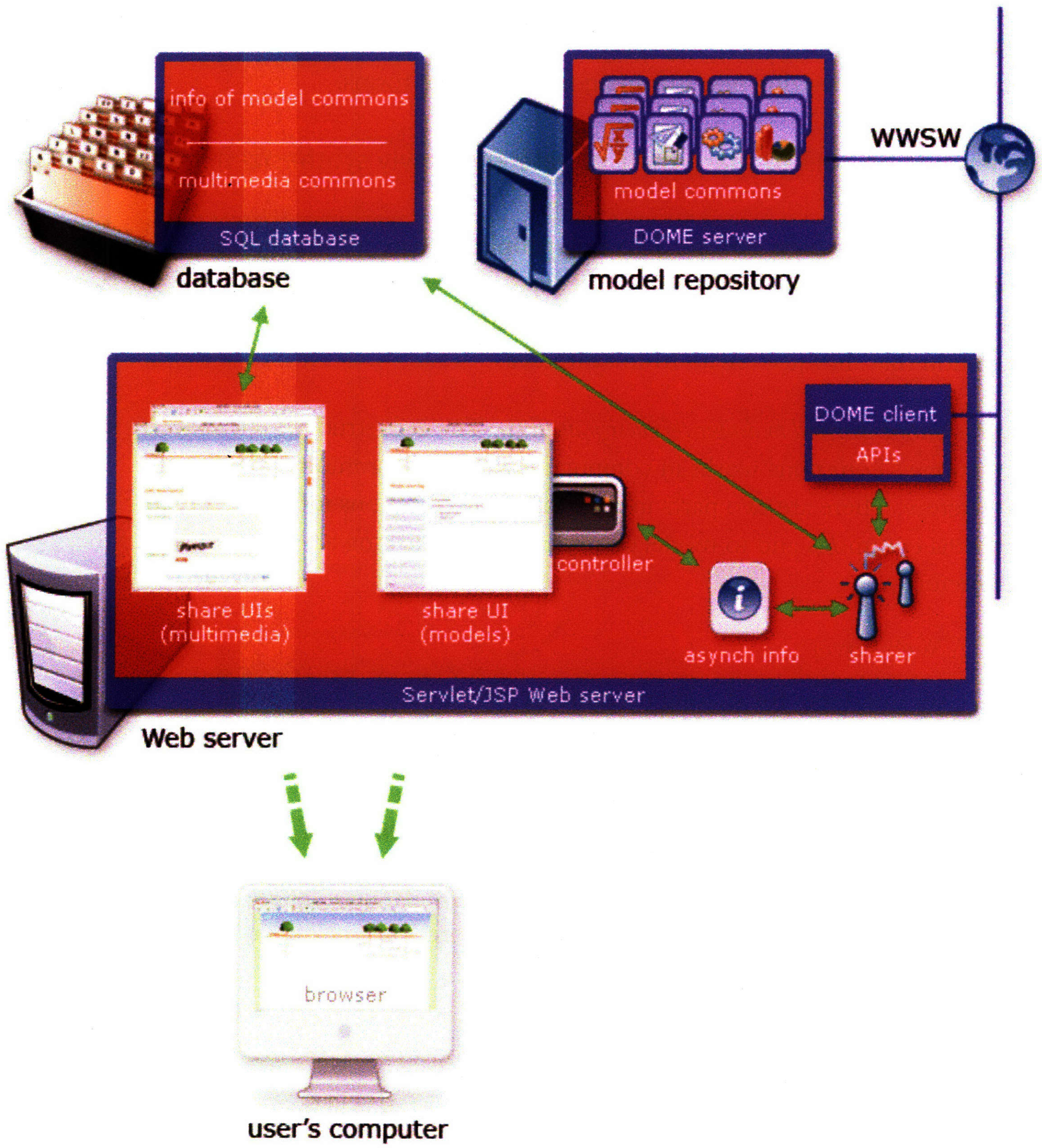


Figure 57 Infrastructure for sharing information as commons.

Initially, the DOME client application had no APIs for external access to its model-wrapping and model-deploying functions, so those APIs had to be designed and implemented together with this infrastructure. The diagram in Figure 57 illustrates this infrastructure. The blue boxes and lines signify that the components are readily adoptable technologies. The red boxes represent components that are custom designed and implemented for this infrastructure.

How the infrastructure works: an example use scenario and a look behind the scenes: In this example scenario, the user shares information as commons in many different ways. First, while browsing through the model commons, she finds a model about flat-panel solar collectors. She notices that the description of the model (Figure 58) is still a bit vague and thinks that adding some background information about flat-panel collectors to the description can make the model easier to understand and more educational. To edit the description, she clicks on the *help edit this description* link.

Figure 58 Description of a model common.

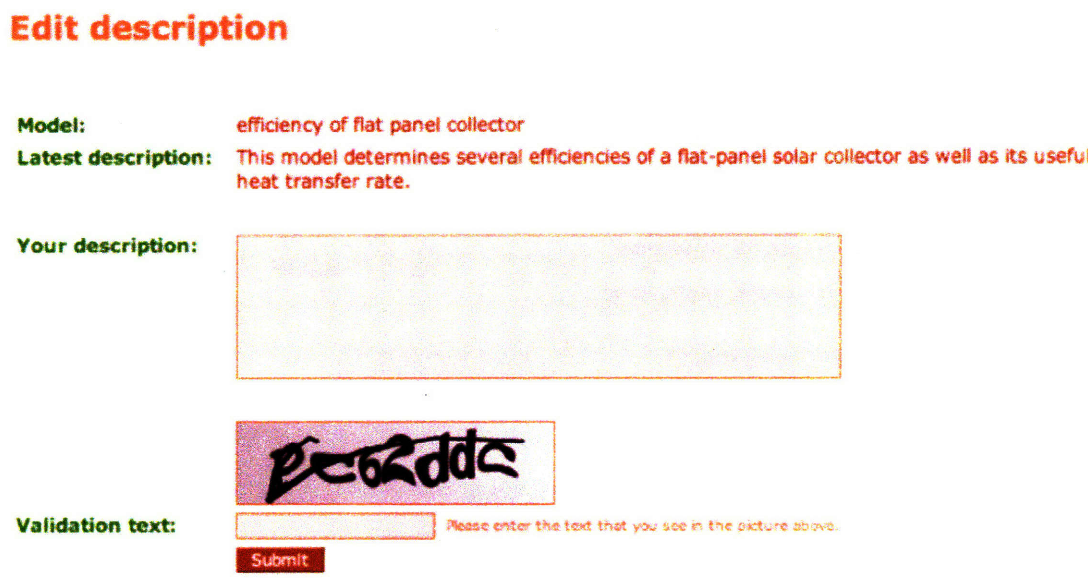


Figure 59 User interface for editing the description of a model.

Behind the scenes, the Web server dynamically creates a user-interface for editing the specified description (Figure 59). The server also queries the database for the latest version of the description and adds it to the user interface as a reference. To prevent false entries from spam bots, a CAPTCHA[23] graphic is also added. CAPTCHA is a challenge-response

[23] CAPTCHA stands for Completely Automated Public Turing test to tell Computers and Humans Apart.

test that can help detect whether the user is human or a program (Wikipedia contributors, 2007a). The selected CAPTCHA-generating code also adds an angled line across the letters to make it difficult for spam bots to make segmentations of the letters.

The user can add information about flat-panel solar collectors to the model's description. Behind the scenes, the Web server adds the new description to the database. All versions of descriptions are kept. A history of changes to a particular description can be viewed, by clicking on the *view description history* link (Figure 58).

Besides descriptions of models, descriptions of run views and parameters can also be edited. For run views, some background information may be more appropriate for a particular run view than others. The user notices that the description of a parameter can be improved as well. She clicks on the *help edit this description* link on the parameter's description area (Figure 60). Behind the scenes, the Web server dynamically creates a user interface similar to the one for editing a model's description (Figure 61) and displays it in a popup window on the user's browser. Web links and images can be included in the description.

Figure 60 Parameter's description with links to edit and view history of changes.

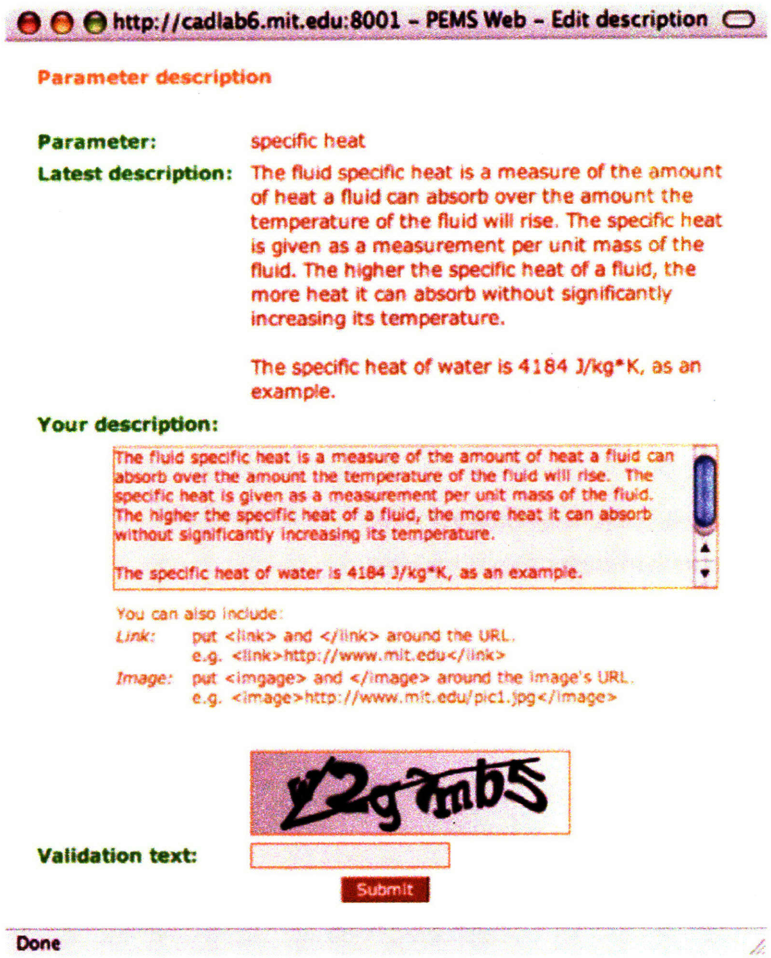


Figure 61 User interface for editing a parameter's description.

By contributing to the description of a model, a run view, or a parameter, the user essentially shares her knowledge as an informational common.

In addition to sharing knowledge, the user can share her opinion as a common. She uses the *Share your experience* link toward the bottom of the model's page (Figure 62) to access the user interface for rating and sharing user experience of the model. The user-experience user interface (Figure 64) is part of the forum *Model blogs* in the *forums* section of PEMS Web. The user can write a comment and rate the model. When the comment and rating are submitted, behind the scenes, the Web server adds them to the database. People can view comments and ratings of a particular model in two ways: from the model's page (Figure 63) and in the *Model blogs* forum. All comments and ratings of each individual model are listed under the same topic.

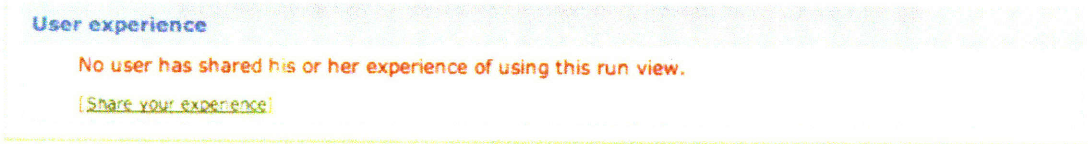


Figure 62 A link (from a model's page) to share user experience with a model.

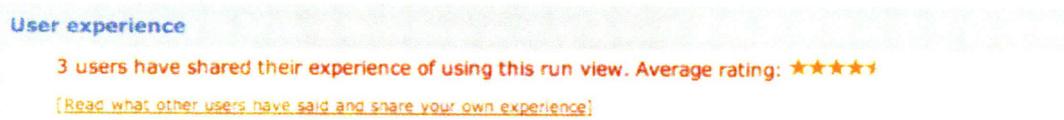
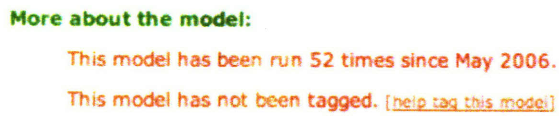


Figure 63 The User experience area in a model's page after people have shared their experiences.



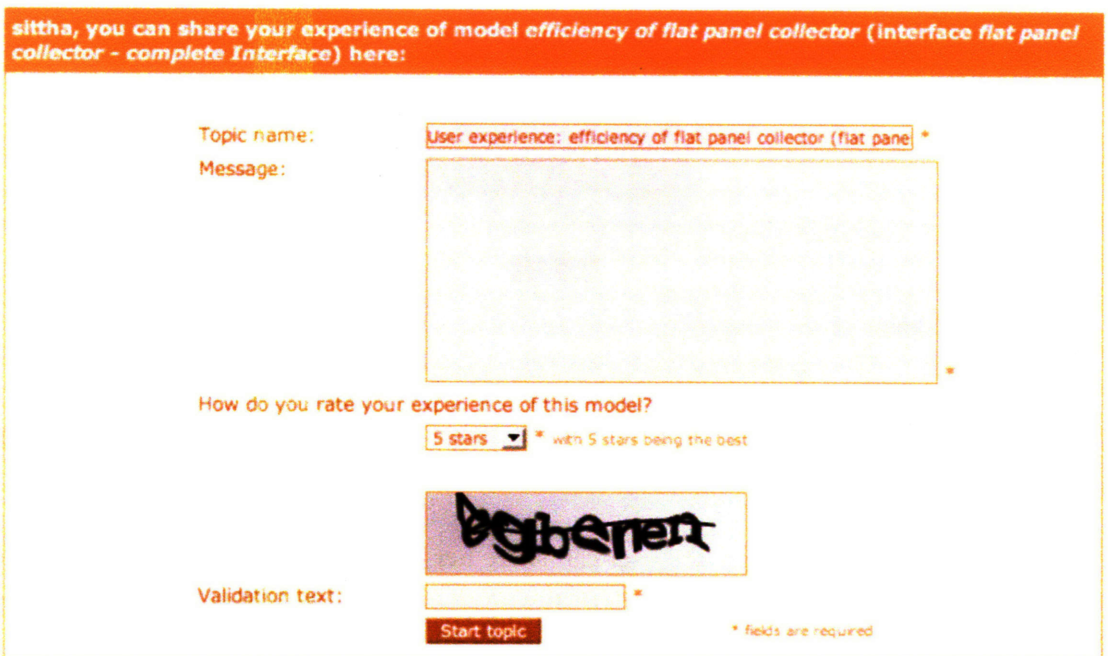


Figure 64 User interface for sharing user experience with a model.

In addition to sharing her knowledge of the subject related to the model and sharing her experience of using the model, the user can also help tag the model. Model tags can also be considered information commons in PEMS Web, as they constitute a set of information that represents collective cognition of the users.

Tags of each model are listed in the *More about the model* section toward the bottom of the model's page (Figure 65). The user can click on the *help tag this model* link to add more tags to the model. The Web server dynamically creates a user interface for tagging the specified model. All tags that are already applied to the model are queried from the database and displayed on the user-interface page for reference (Figure 66).

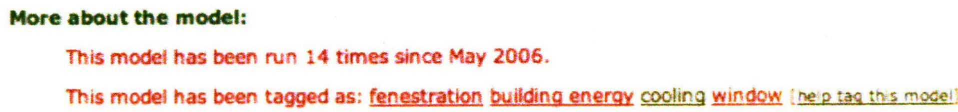


Figure 65 Tags of a model listed on the model's page.

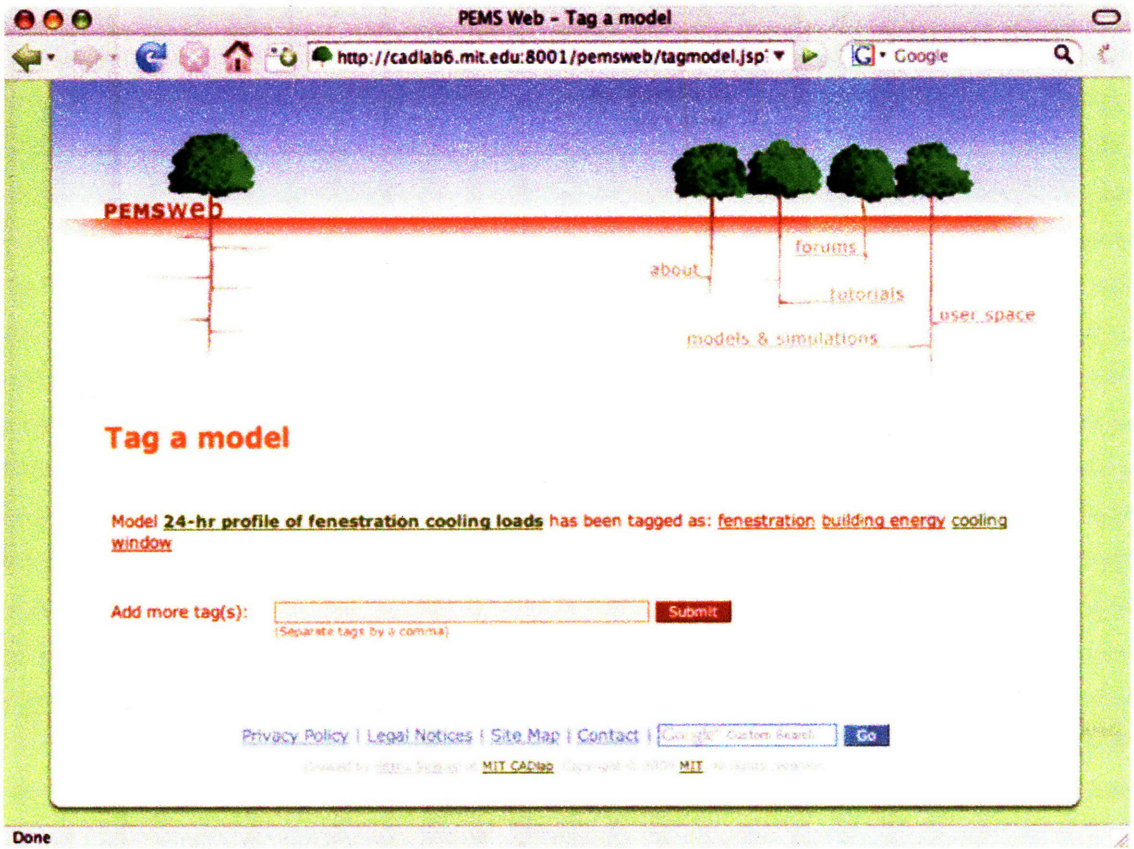


Figure 66 User interface for tagging a model.

It should be noted that, when the user shares information as a common, she also synthesizes it on the fly. For example, the user writes a parameter's description before sharing it as a common. Thus, the synthesis of the information occurs almost instantly before the sharing of it as a common. The syntheses of some information, such as a model's description, are likely based on the earlier shared versions of the information. Such syntheses are, therefore, commons-oriented. Thus, PEMS Web supports COIS of not only dynamic information (models) but also multimedia information (e.g. model descriptions).

To share models as commons, the user can use the interactive model-sharing user interface (Figure 67), which works similarly to the model-synthesizing user interface. Before being shared as a common, a model has to be wrapped, so that it can interoperate with other model commons. Currently, two types of models, Excel spreadsheets and Matlab m files, can be wrapped and shared as commons. Nonetheless, the infrastructure can be extended without difficulty to support other types of models.

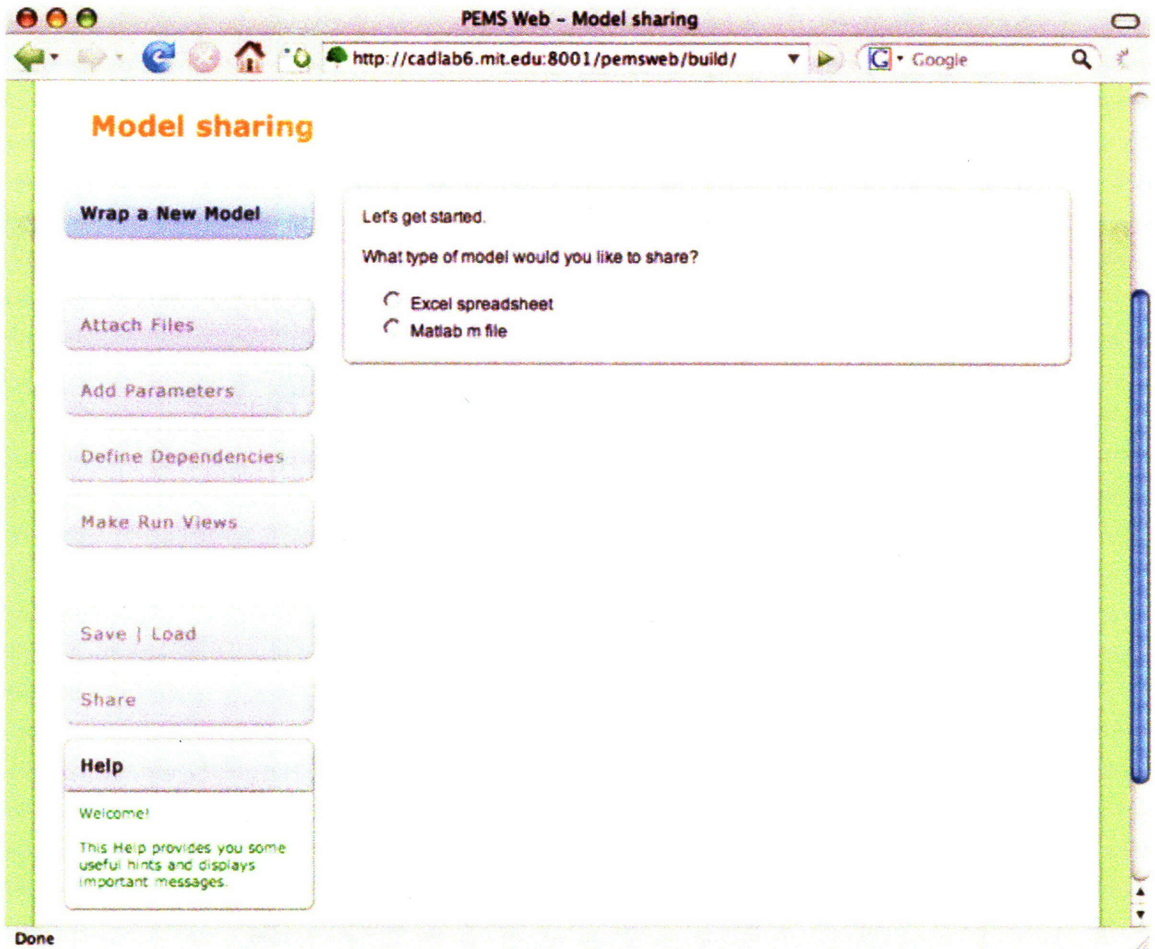


Figure 67 User interface for sharing a model as a common.

In this example scenario, the user wants to share an Excel spreadsheet for calculating the net present value of five payments spread over time (Figure 68). The user selects the *Excel spreadsheet* option on user interface. Behind the scenes, the UI controller detects the selection. Similarly to how it manipulates any other parts of the user interface, the UI controller updates the content of the main panel through the page's DOM. Based on the user's selection of the model type, the controller adds a brief outline of the wrapping process to the main panel (Figure 69). The controller also sends the information of the selected model type to the Web server, via the asynchronous information transporter (Figure 57). The sharer program receives the information and starts working with the DOME client application to prepare a proper wrapper model.

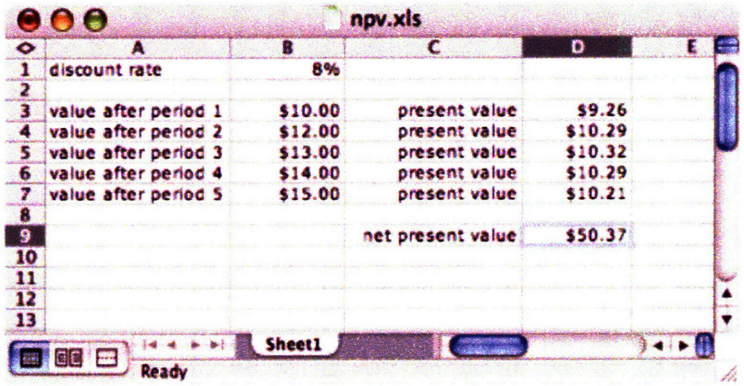


Figure 68 An Excel spreadsheet to be shared as a common.

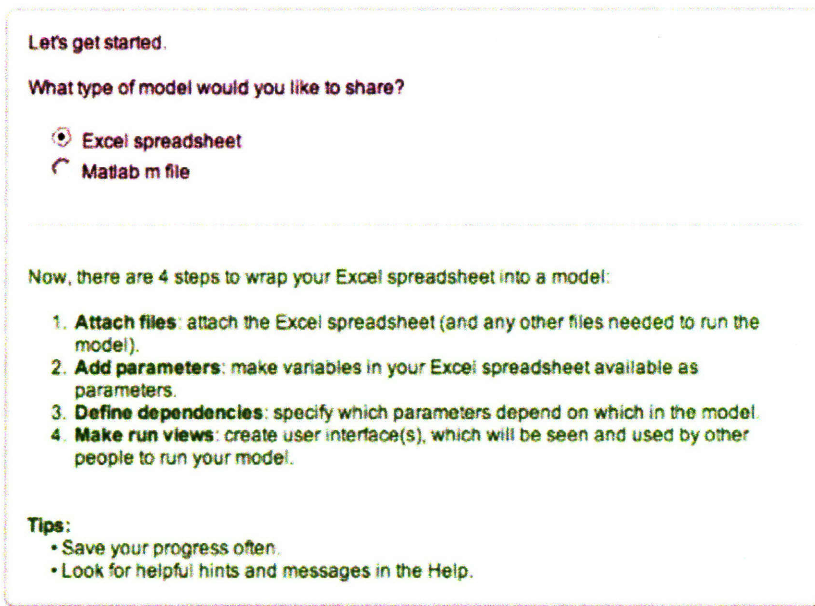


Figure 69 A message outlining the wrapping process.

The user clicks on the *Attach Files* menu button to proceed to the first step of the wrapping process. The UI controller changes the content of the main panel to reflect the menu selected (Figure 70). The user clicks on the *Browse …* button to select the spreadsheet file on her computer.

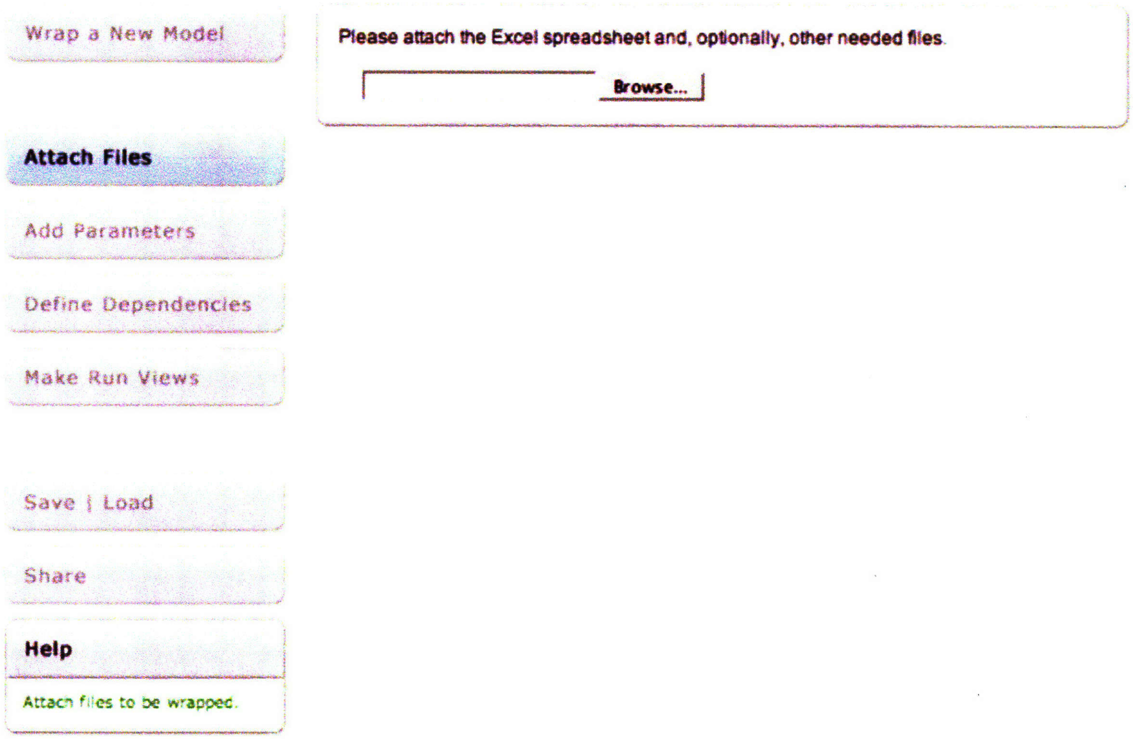


Figure 70 The model-sharing user interface with Attach Files menu selected.

Once selected, the location of the file is added to the memory of the UI controller, which also sets the main panel to display a list of the files that have been selected (Figure 71). The user can add more files, such as data files, if they are necessary for running the main model. In this case, only the spreadsheet is needed. Files that are selected can be removed from the list when the user clicks on the *x* button to the right of the file location. After the user has selected all the necessary files, she can click on *Attach selected files,* and the UI controller will then upload all the files to the Web server at once. This way, the user does not have to select and upload files one by one. Behind the scenes, the controller uploads the spreadsheet to the Web server. The sharer program receives the spreadsheet and attaches it to the DOME wrapper model. Once this is done successfully, a message is sent back via the asynchronous information transporter to the UI controller. The controller then updates the main panel of the user interface to show the list of attached files.

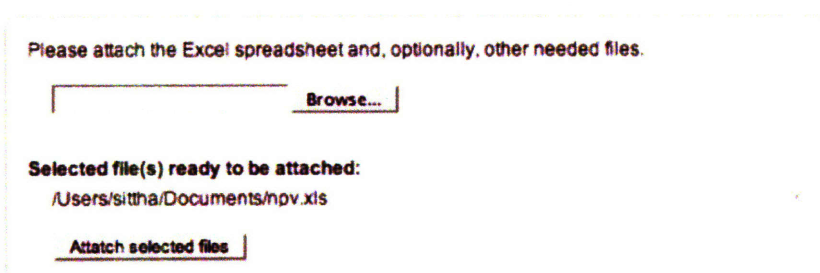


Figure 71 A displayed list of selected files to upload.

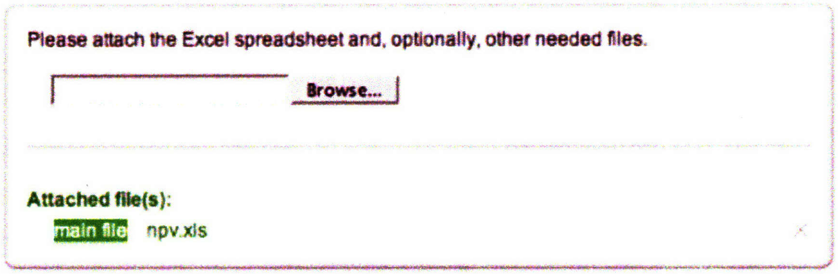


Figure 72 An updated list of attached files.

In the next step, the user adds input and output parameters to represent the values in the model, by using the *Add Parameters* menu item (Figure 73). For each parameter, the user enters the name, data type, default value, unit, and reference to the value in the model to be wrapped. For an Excel spreadsheet, a reference to a value in the model consists of cell and sheet names. For a Matlab m file, a reference to a value is a name of a variable. While the user types the unit of a parameter, the UI controller displays a list of possible auto-completions (Figure 73). When the user clicks on the green check-mark button to confirm the addition of the new parameter, the UI controller forwards the entered information to the Web server. The sharer program then works with the DOME client application to add the new parameter to the wrapper model. Once the addition is successfully done, the UI controller is notified and adds the information of the new parameter to the parameter list (Figure 74). Figure 75 shows the complete parameter list of the model after all the parameters that the user wants are added.

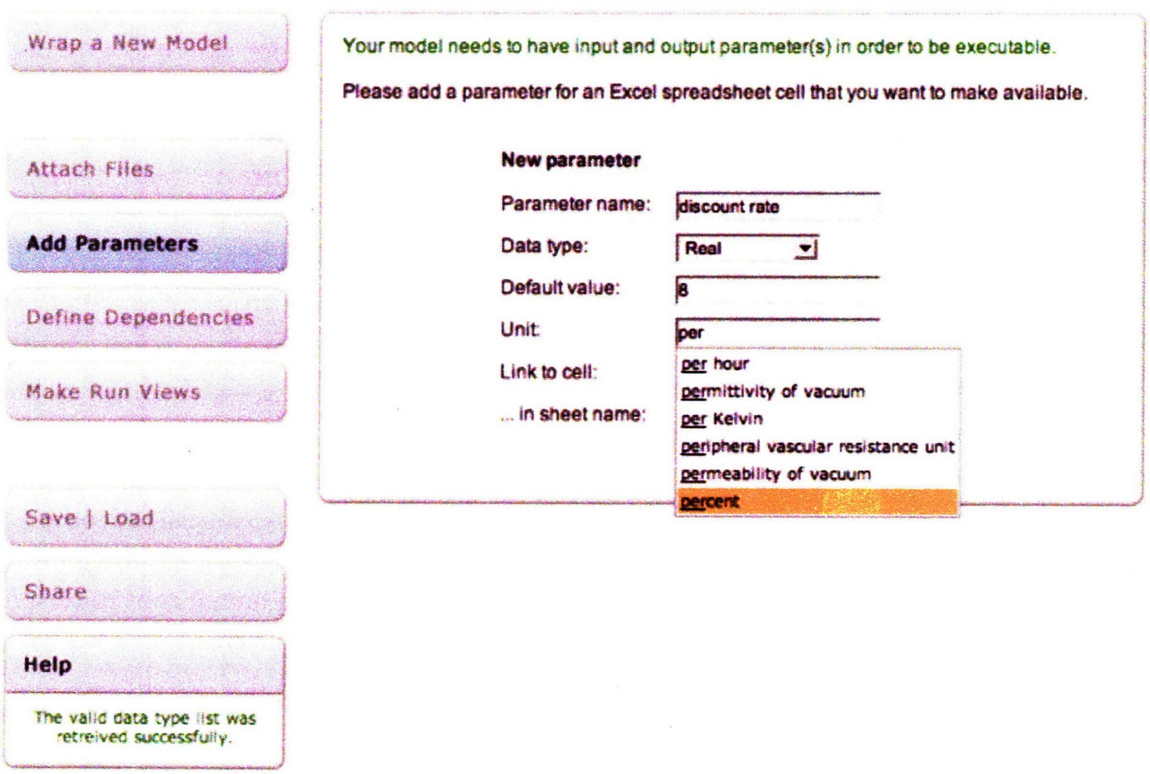


Figure 73 Add Parameters menu item.

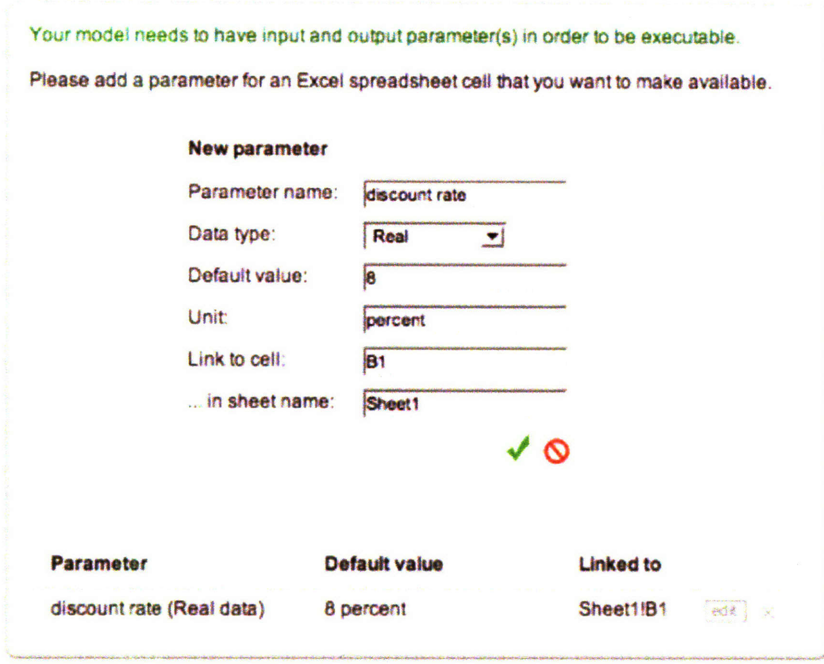
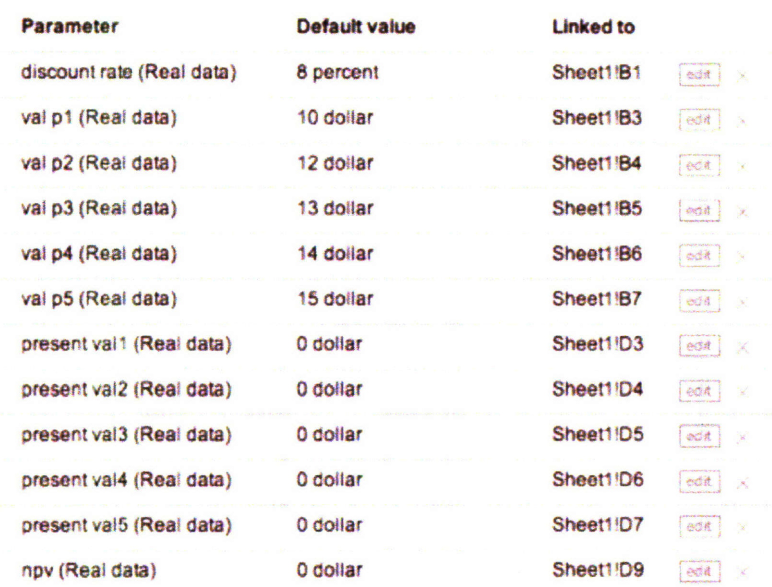


Figure 74 Information of a parameter that has been added.



Parameter	Default value	Linked to	
discount rate (Real data)	8 percent	Sheet1!B1	edit
val p1 (Real data)	10 dollar	Sheet1!B3	edit
val p2 (Real data)	12 dollar	Sheet1!B4	edit
val p3 (Real data)	13 dollar	Sheet1!B5	edit
val p4 (Real data)	14 dollar	Sheet1!B6	edit
val p5 (Real data)	15 dollar	Sheet1!B7	edit
present val1 (Real data)	0 dollar	Sheet1!D3	edit
present val2 (Real data)	0 dollar	Sheet1!D4	edit
present val3 (Real data)	0 dollar	Sheet1!D5	edit
present val4 (Real data)	0 dollar	Sheet1!D6	edit
present val5 (Real data)	0 dollar	Sheet1!D7	edit
npv (Real data)	0 dollar	Sheet1!D9	edit

Figure 75 A complete list of added parameters.

Note that the fields for entering information of a new parameter can dynamically adapt to user inputs. For example, if the user sets the data type to be *Matrix*, fields for inputting the matrix's size would appear (Figure 76). Then, when the user enters the numbers of rows and columns, the popup fields for inputting the matrix's elements would automatically adjust to match the matrix's size.

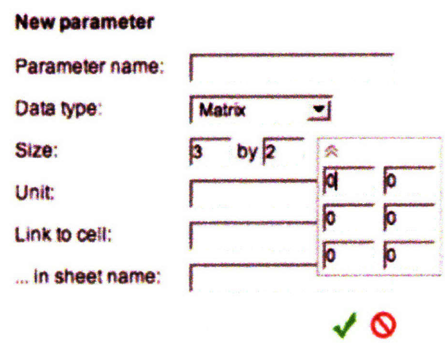


Figure 76 Auto-adapting fields for inputting information of a new parameter.

After uploading the model file(s) and adding parameters, the next step is to define dependencies between parameters. The dependencies of all parameter are crucial for the wrapper model to determine which parameters are inputs or outputs. In a complicated model that has many intermediate calculations and parameters, specifying which parameters are true inputs or outputs of the whole model can be confusing for users. Thus, users are only asked to specify the immediate dependencies of each parameter, and the system takes care of sorting out the overall causality of the model.

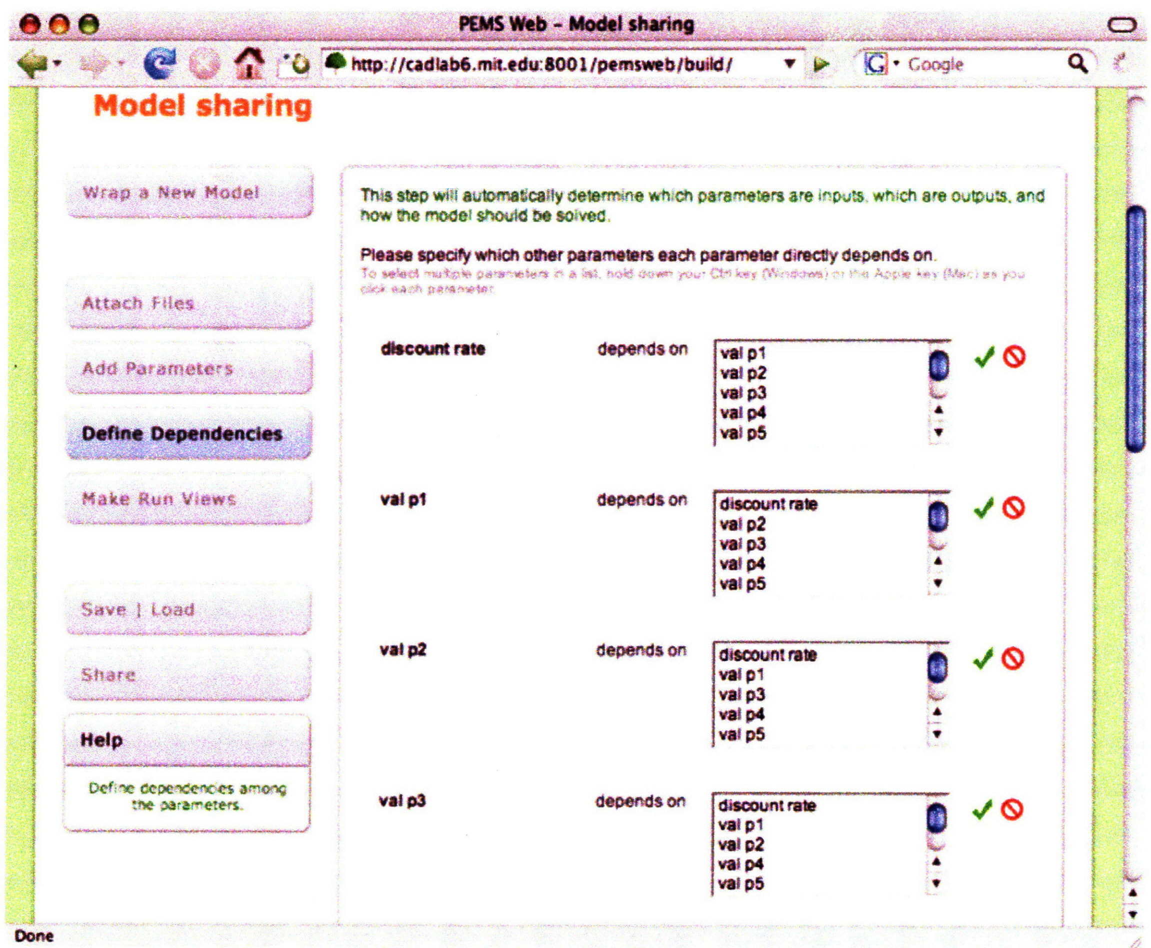


Figure 77 User interface for setting parameter dependencies.

The user in this scenario clicks on the *Define Dependencies* menu item. The UI controller clears the contents in the main area and recreates it with a list of fields for setting parameters' dependencies (Figure 77). The user then specifies which other parameters each parameter depends on. For example, she specifies that *present val1* depends on *discount rate* and *val1* (Figure 78). After the user confirms the dependencies of each parameter by clicking on the green check-mark button, the UI controller forwards the dependency information to the sharer program on the Web server. The sharer program then sets the dependencies of the parameter in the wrapper model. When the parameter's dependencies are successfully set, the UI controller replaces the input field with text (the top part of Figure 78). Figure 79 partially shows the user interface when the dependencies of all parameters are set.

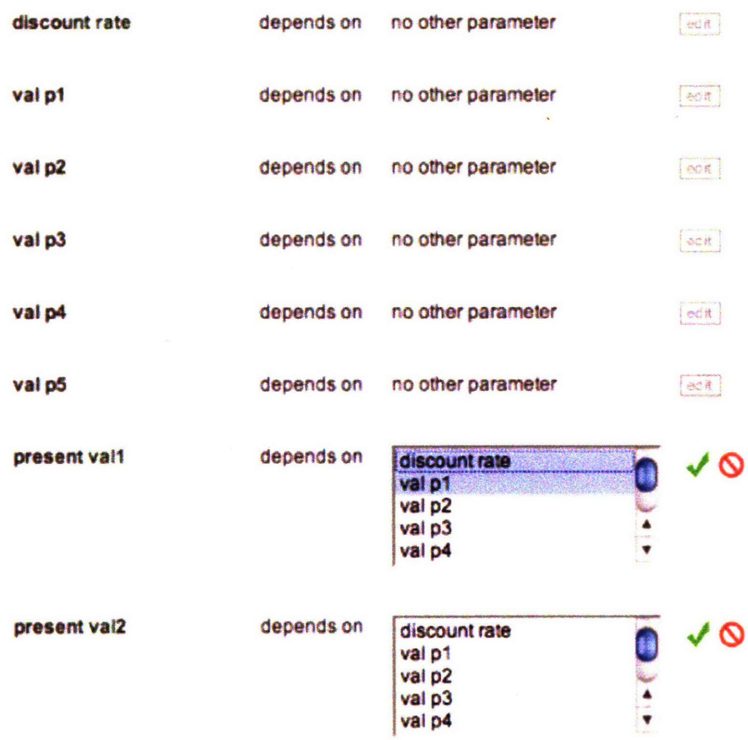


Figure 78 Dependencies of a parameter being specified.

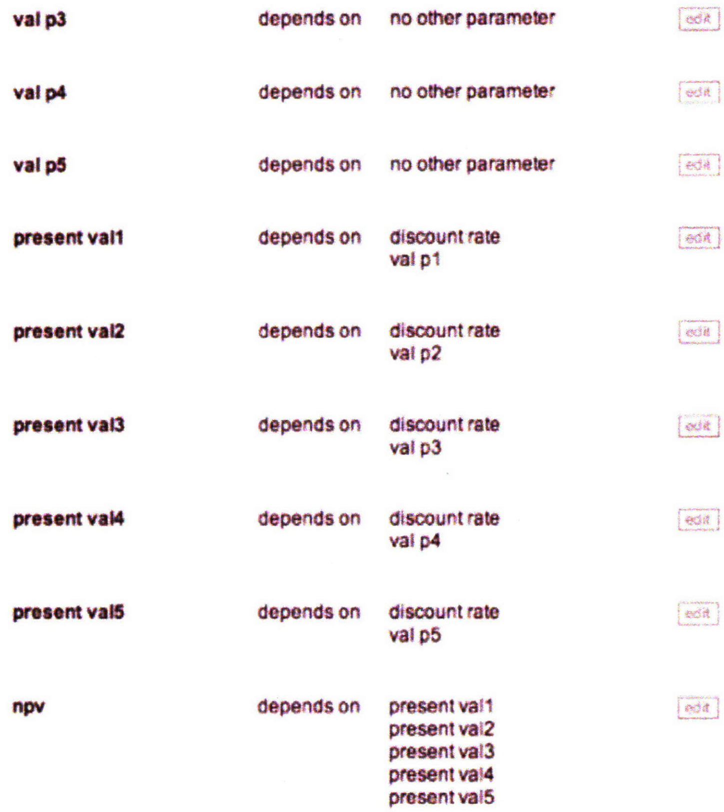


Figure 79 A partial view of specified parameter dependencies.

The forth and last step of wrapping a model is to create run view(s). Run views are used after the wrapped model is shared as a common. As illustrated earlier, run views are used as part of a model's user interface for utilizing the model. Run views are also used when people subscribe to the services of model commons in order to synthesize a new model.

The user can create as many run views, for the model to be shared, as she would like. When the user clicks on the *Make Run View* menu item, she sees that a default run view called *Default Interface* is already created (Figure 80). The UI controller asks the sharer program for lists of input and output parameters of the model, which the sharer determines based on the parameters' dependencies specified by the user in the previous step. Note that in the default run view only the absolute input and output parameters are included, while the intermediate parameters, such as *present val1*, *present val2,* etc., are omitted.

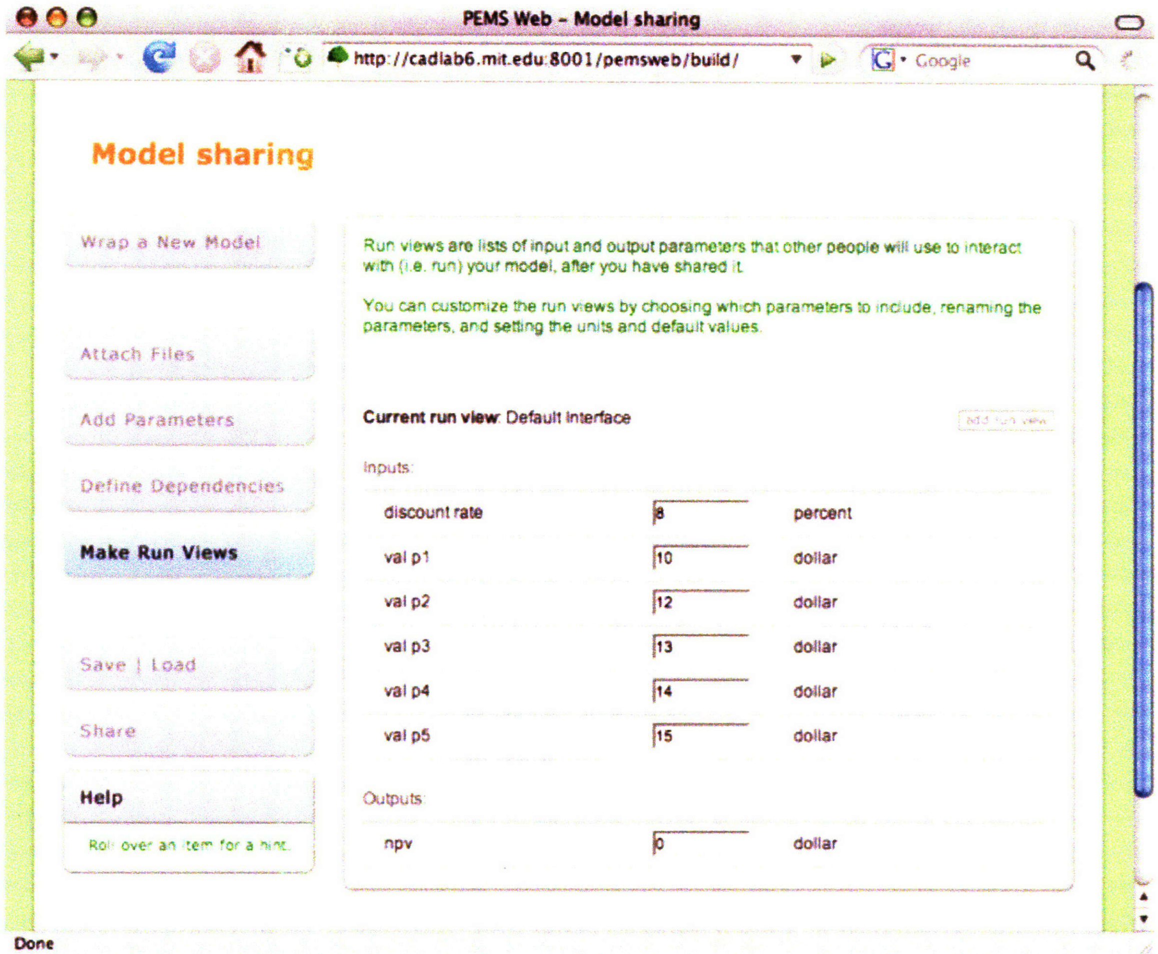


Figure 80 A default run view.

If the user is satisfied with the automatically generated default run view, she does not have to do anything in this step. Otherwise, the user can modify the default run view and create additional run views.

When the user double-clicks on a parameter's name, the UI controller changes the text to an input field and allows the user to change the name (Figure 81). The user can also change the unit of a parameter by double-clicking on the text; the UI controller replaces the text with a drop-down menu listing other compatible units (Figure 82). Any change that is made and confirmed by the user is sent to the Web server, so that the sharer program can update it in the wrapper model.

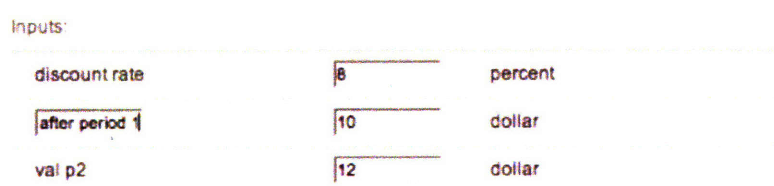


Figure 81 Changing of a parameter's name in a run view.

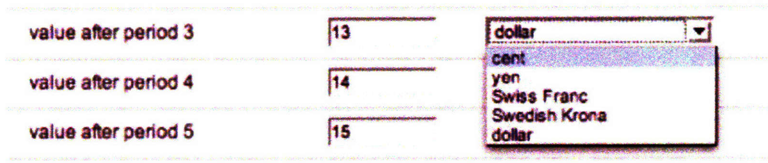


Figure 82 Changing of a parameter's unit in a run view.

To create an additional run view, the user can click on the *add run view* button, located to the right of the *Current run view* label. When the button is clicked, the UI controller adds a field to ask for the new run view's name (Figure 83). After the new run view's name is confirmed, the UI controller forwards the information to the sharer program and recreates the main area of the user interface to show the new run view, which is now empty (Figure 84). With the new run view, two buttons are added: *add parameter* and *switch run view*. When the user clicks on the *add parameter* button, the UI controller displays a list of the model's parameters that have not been added to the run view (Figure 85). The user can multi-select the parameters to add. The UI controller sends the list of parameters to be added to the run view to the Web server, and the sharer program adds them in the wrapper model. Figure 86 shows the new run view with all parameters added. The intermediate parameters are listed as outputs, since their values cannot be directly modified.

Figure 83 Input field for a new run view's name.

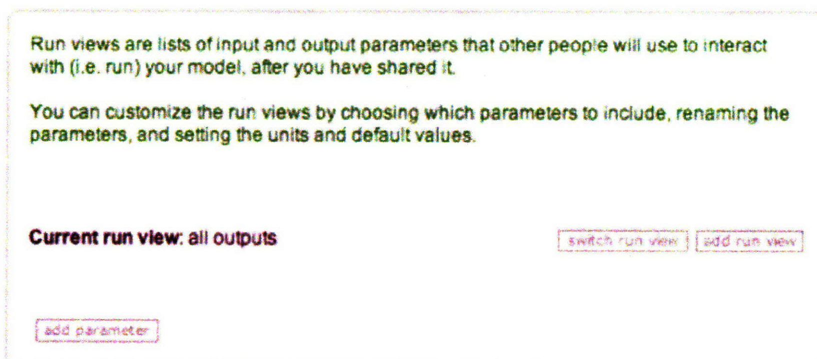


Figure 84 A new run view without parameters.

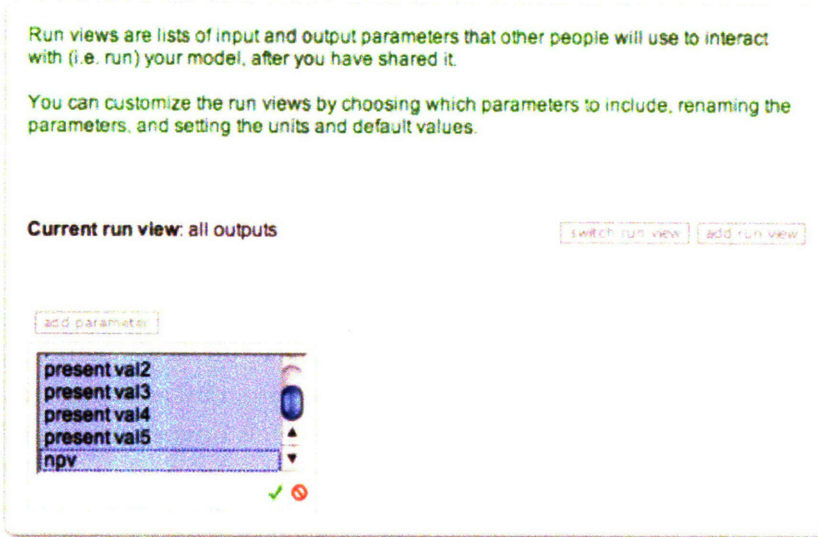


Figure 85 Adding of parameters to a new run view.

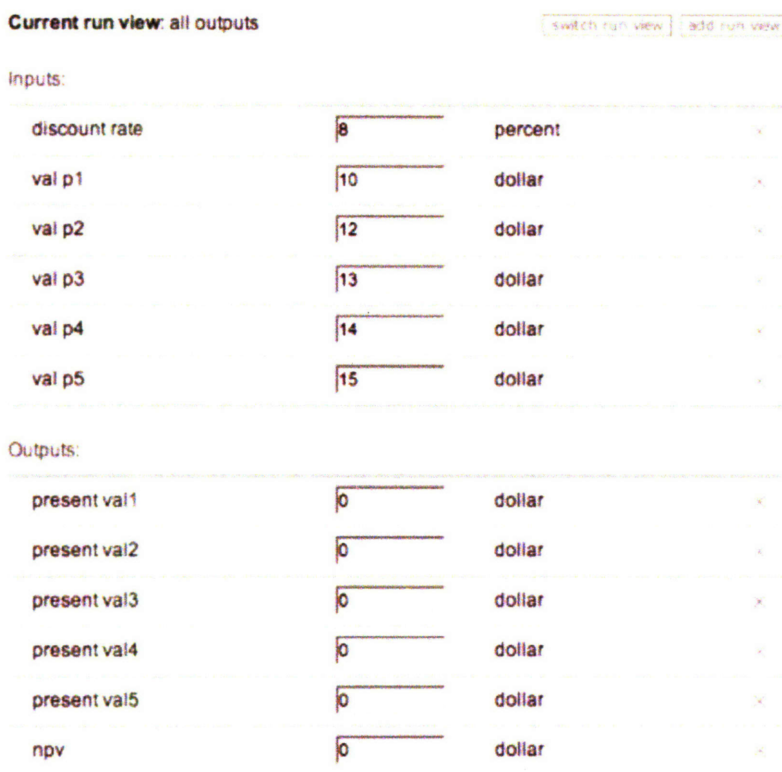


Figure 86 A new run view with all parameters added.

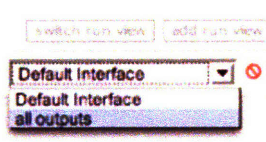


Figure 87 Switching run views.

When there are multiple run views, the user can use the *switch run view* button to see a specific run view. The UI controller creates a drop-down menu with the names of all run views listed from which the user can select (Figure 87).

After four short steps (uploading model files, adding parameters, defining parameter dependencies, and optionally making run views), the model is wrapped and ready to be shared as a common. The user can click on the *Share* menu item, and the UI controller checks to see if the user is logged in. If not, the user is asked to log in or create a user account (Figure 88). Figure 89 shows basic information that the user is asked to provide. The user has to provide the name of the model, pick which of the run views to make available, and specify whether the model can be open source.

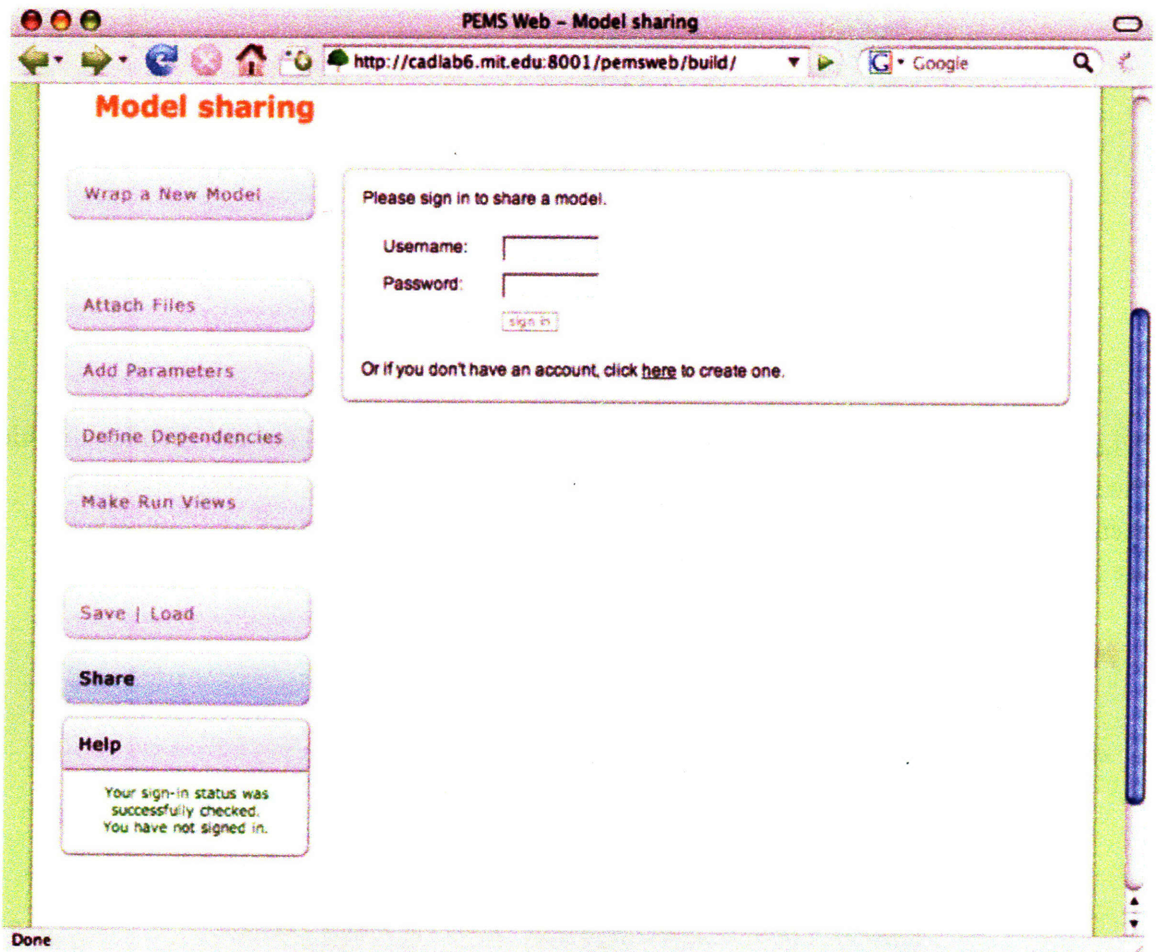


Figure 88 A log-in screen for sharing a wrapped model as a common.

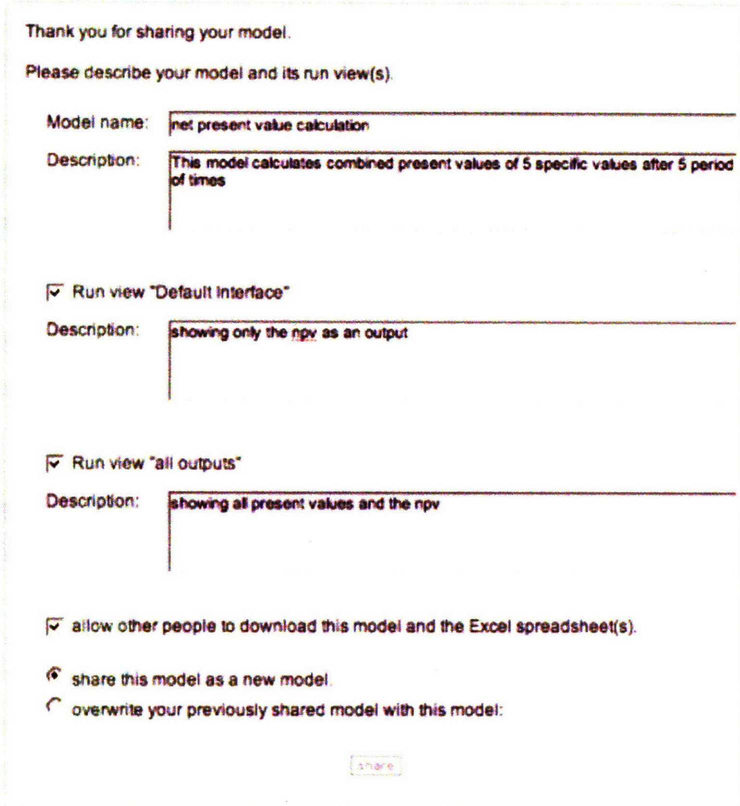


Figure 89 Information needed for sharing a model.

When a model is open source, people can download it (Figure 90). They can then look inside the model, e.g. view the actual Excel spreadsheet, and modify it. The modified model can then be further shared as another common. The Web server keeps track of all models that are derived from the same original models (Figure 91).

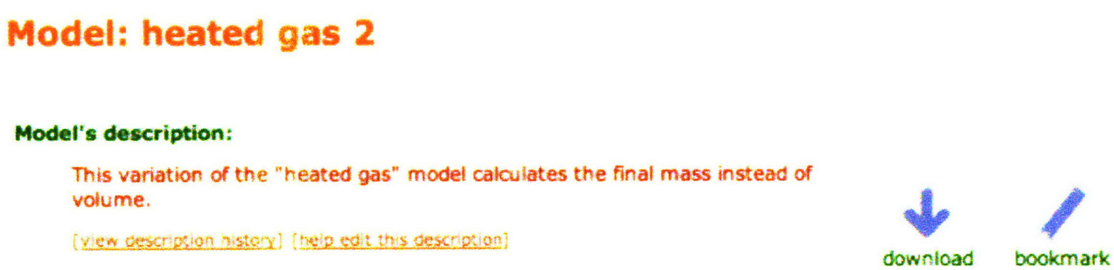


Figure 90 A button for downloading a model common that is shared open source.

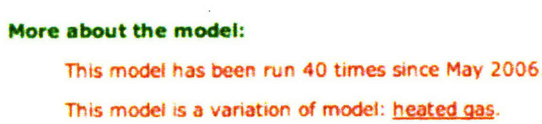


Figure 91 A note describing that the model is derived from another model.

At any point in the process of wrapping a model, the user can save it by using the *Save* menu item (Figure 92). The sharer program packages all the relevant files into a zip file and sends it back to the user interface for the user to download and save on her computer (Figure 93). She can later use the *Save* | *Load* menu item to load the progress of the model wrapping.

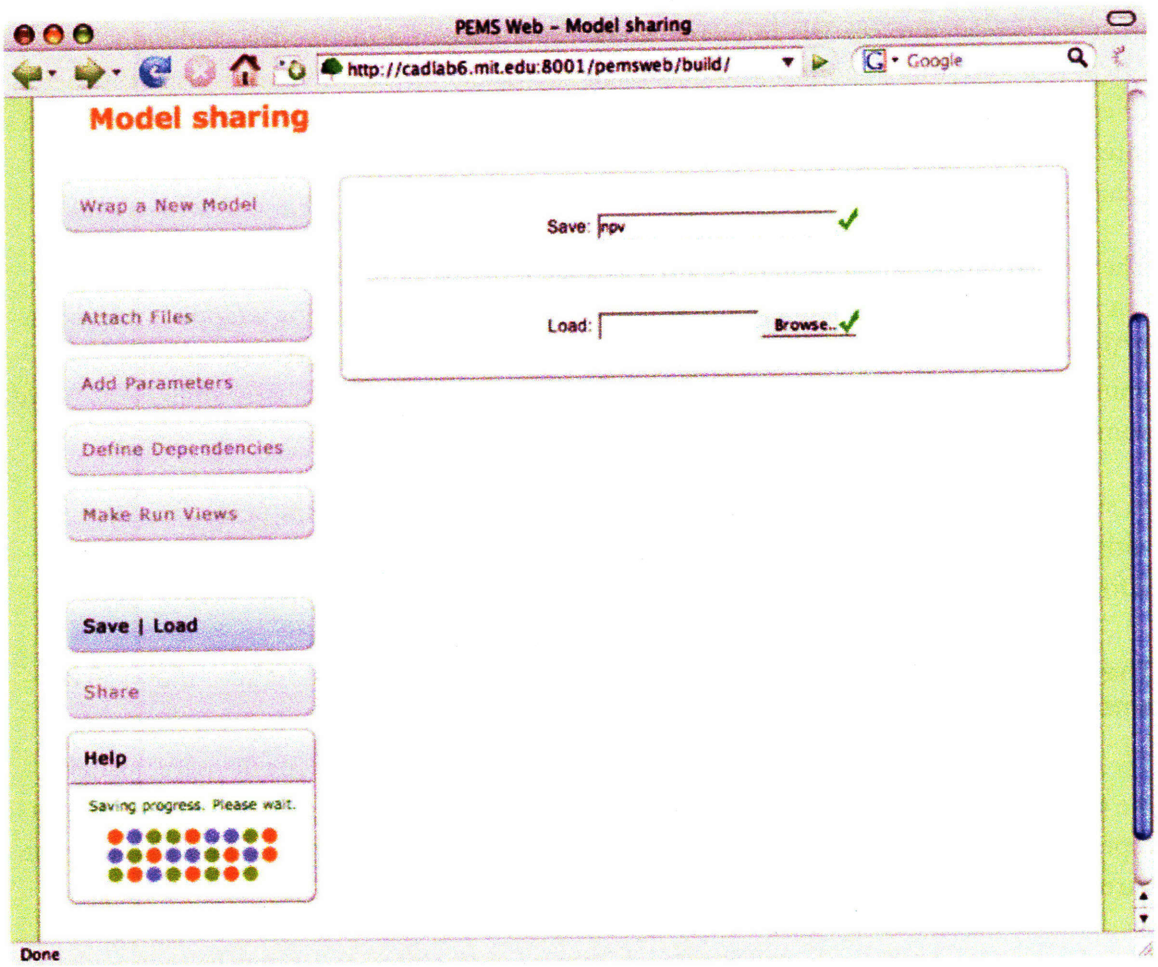


Figure 92 User interface for saving the progress of model wrapping.

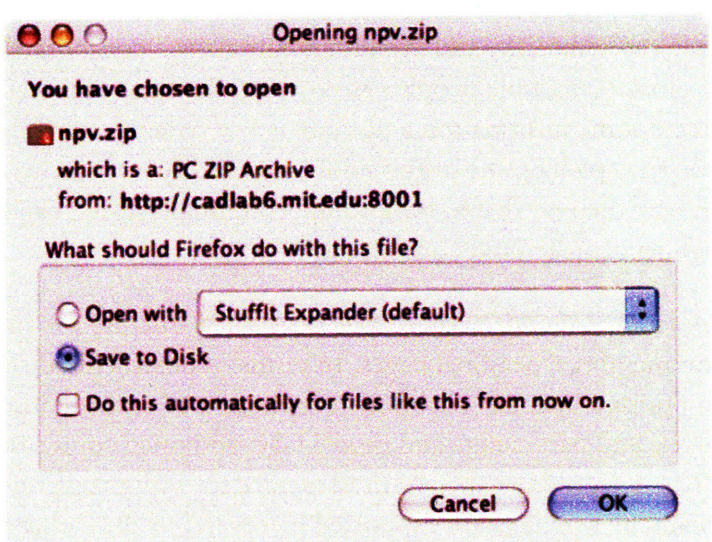


Figure 93 A zip file containing progress and relevant files of model wrapping.

Reasons why the infrastructure is designed this way: Various types of user interfaces are designed to support sharing of different types of information commons. Dynamically generated Web pages are designed for sharing of simple and mostly textual information, such as knowledge of subjects related to models and parameters, experience of using models, and model categorization. A more sophisticatedly designed, interactive user interface is used for sharing of complex information in forms of models. The user interface for sharing models is made interactive and responsive to users' inputs, so that the otherwise complicated process of sharing models can be enjoyable to the users.

The DOME client application is adopted as a technology for deploying models because it can wrap heterogeneous models into a uniform format and can deploy wrapped models on WWSW-compatible model servers. The reasons why having heterogeneous models in a uniform format is important is discussed earlier, and so are the reasons for utilizing WWSW-compatible model servers.

In summary, this infrastructure offers several user interfaces that allow people to share various kinds of information as commons on PEMS Web. Enabling people to share information helps keep the commons in PEMS Web perpetually improved and expanded.

The environment must support social networking and unstructured collaboration among the participants.

The importance of this design attribute: It is important that there are ways for the participants in the environment to socialize, in order to create a sense of community. Social networking is especially important in the case where the environment is virtual, e.g. PEMS Web, since the participants rarely get a chance to physically interact with one another.

It is also important that the environment supports unstructured collaboration among the participants, since structured collaboration can be hard to achieve when the participants hardly know one another, especially within a virtual environment. In an unstructured collaboration, people can indirectly, and even unintentionally, "collaborate". Over an unspecified period of time, multiple people can work on the same "project". For example, one person may create some information and share it as a common, and then, at some later time, another person may pick up the information and modify or improve upon it. The information, which may then be shared back to the community again, can be considered as having gone through an unstructured collaboration.

The infrastructure designed to deliver this design attribute: The infrastructure for social networking includes forums and members' personal pages. In terms of unstructured collaboration, the activities that are supported include collaborative authoring of textual information (such as descriptions of models and parameters and model tags) and open source development of model commons. There is no one explicit infrastructure for supporting unstructured collaboration. Instead, the activities are supported by several of the earlier mentioned infrastructures. Collaborative authoring of textual information and open source development of model commons are supported collectively by the infrastructures for making commons easily accessible and for allowing people to share information as commons.

Enabling technologies of the infrastructure: The infrastructure for social networking is made with JSP-based dynamically generated Web pages. The same Web server used in the other infrastructure serves the Web pages. The database that is part of the commons-establishing infrastructure is also utilized here. The diagram illustrating the infrastructure for social networking is shown in Figure 94.

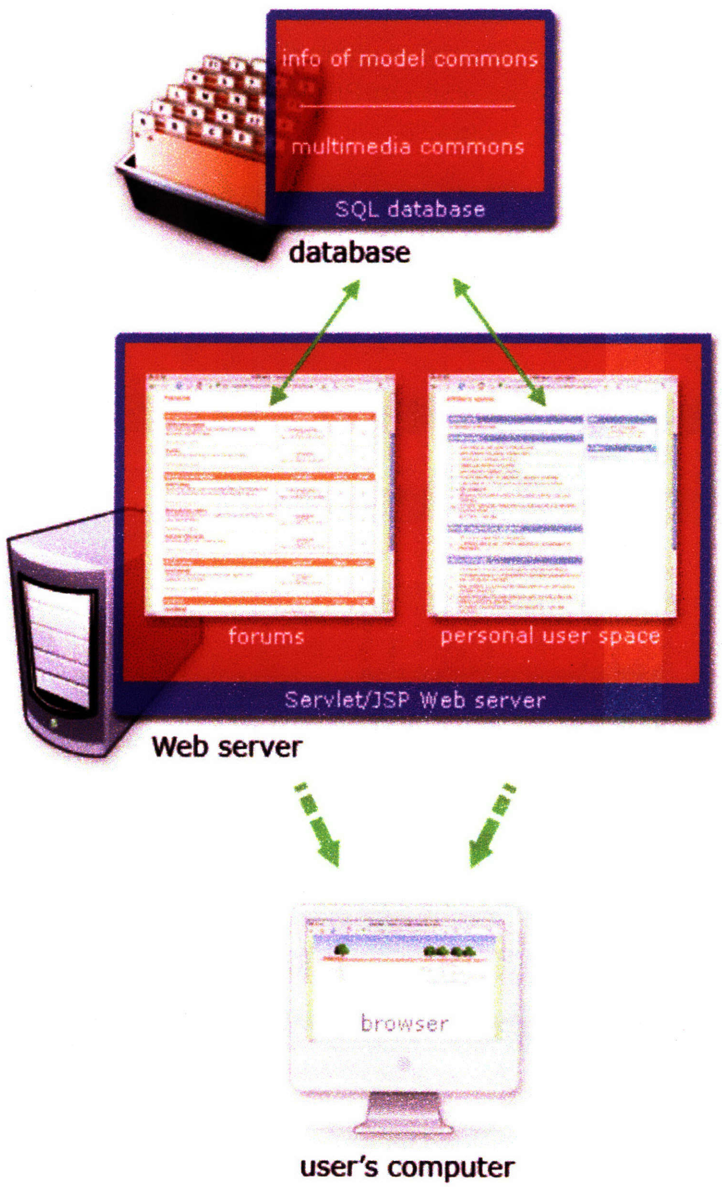


Figure 94 Infrastructure for social networking.

How the infrastructure works: an example use scenario and a look behind the scenes: In this example scenario, the user takes part in both social networking and unstructured collaboration. First, the user updates her personal space, through which she can let other people learn about herself and her interests. She uses the main menu of PEMS Web to go to the *User space* section and clicks on the link *Manage your space.* Once she has logged in, the user enters the *Your space* page, showing her basic personal information and lists of models she has bookmarked and shared. The information on the *Your space* page is queried from the database and dynamically added to the page. While editing her basic personal information, the user can write a blurb to describe herself and topics in which she is interested. She can also choose whether to let other people view her list of bookmarked models, her full name, etc. The edited and submitted information is stored in the database. Other people can then visit the user's personal page and learn more about the user. Figure 95 partially shows a user's personal page. The *User space* section of PEMS Web is essentially a simplified version of a social networking site like Friendster.

Figure 95 A user's personal page.

Another way that the user can socialize with other users of PEMS Web is to use the forums. Instead of directly adopting an open source forum technology, a forum program is custom designed and implemented for this infrastructure. The custom-implemented forum can be smoothly integrated with the format and style of PEMS Web, but, more importantly, it can perform PEMS-Web-specific functions. For example, while writing a message that is related to particular models, the user can use her bookmarks to quickly add references to the models in the message (Figure 96). When the message is submitted, the forum program automatically translates the bookmark information into links to the models' pages (Figure 97). Other people can then click on the links to go to the models that are referred to in the message directly. In addition to the customized functions, conventional functions such as *quote* and *flag as inappropriate* are available.

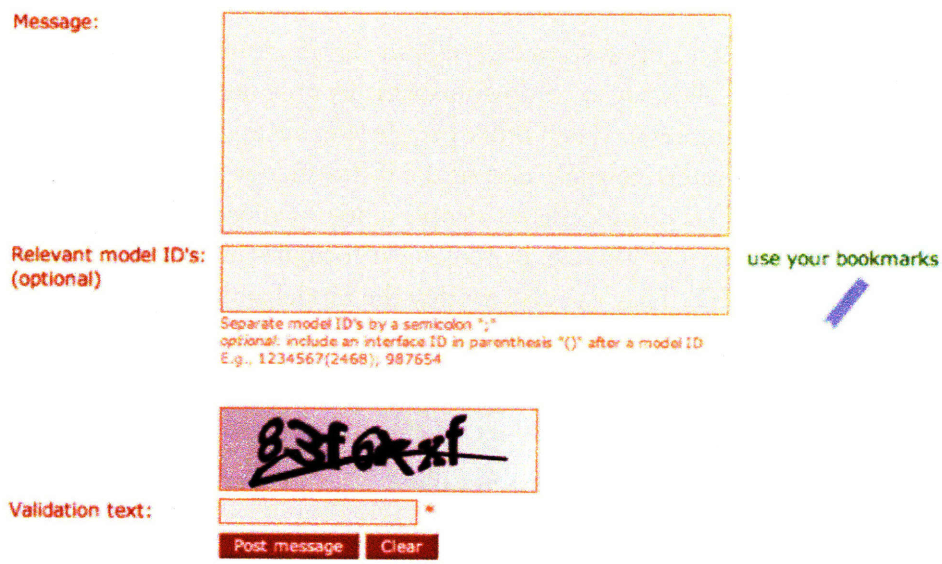


Figure 96 Using model bookmarks to add references to models in a message.

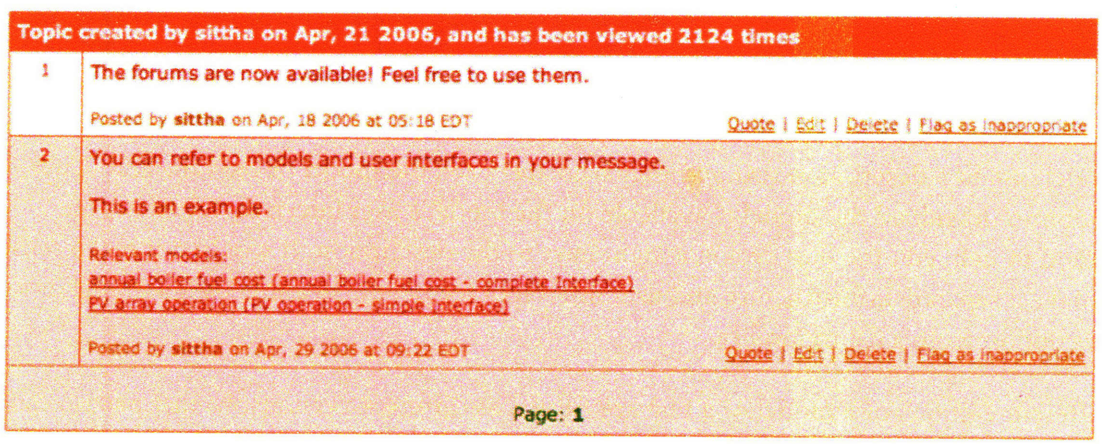


Figure 97 Hyper-linked references to models in a forum message.

Multiple forums are created to help users communicate with one another in regard to different subjects, including announcements (PEMS-Web-related and upcoming events), models (reviews, requests for models, and general discussion), communities (local issue discussions), and feedback (guestbook and troubleshooting).

As mentioned earlier, collaborative authoring of textual information commons, such as descriptions of models and parameters, takes place via multiple infrastructures. In this example scenario, the user can read the current version of a description of a model or a parameter on a user interface of a model (part of the infrastructure for accessing commons). Then, she can help write a new version of the description and also share it through one of the user interfaces for sharing descriptions (via the infrastructure for sharing information as commons). The revising process can keep on going over time by actions of different people. The history of changes of a particular text is kept and can also be viewed through a user interface of a model (via the infrastructure for accessing commons).

Unstructured collaboration, or open source development, of a model common starts when a user shares her model and allows it to be downloadable by anyone (via the infrastructure for sharing information as commons). When other people later access the shared model common through its user-interface page (part of the infrastructure for accessing commons), they can see that the model is downloadable. People who download the model can see inside the model and learn of how it works, e.g. by looking at formulas in the Excel spreadsheet or the code in the Matlab m file. They can also modify the model and share the modified model back with the community as a new common (via the infrastructure for sharing information as commons). The open source modification process of models can also keep going by actions of different people over time.

Reasons why the infrastructure is designed this way: Both forums and personal user spaces are provided as means for social networking, so that people can choose between two degrees of socialization. Some people may prefer to actively converse with others through forums. Other people may prefer to passively introduce themselves to others through a personal page.

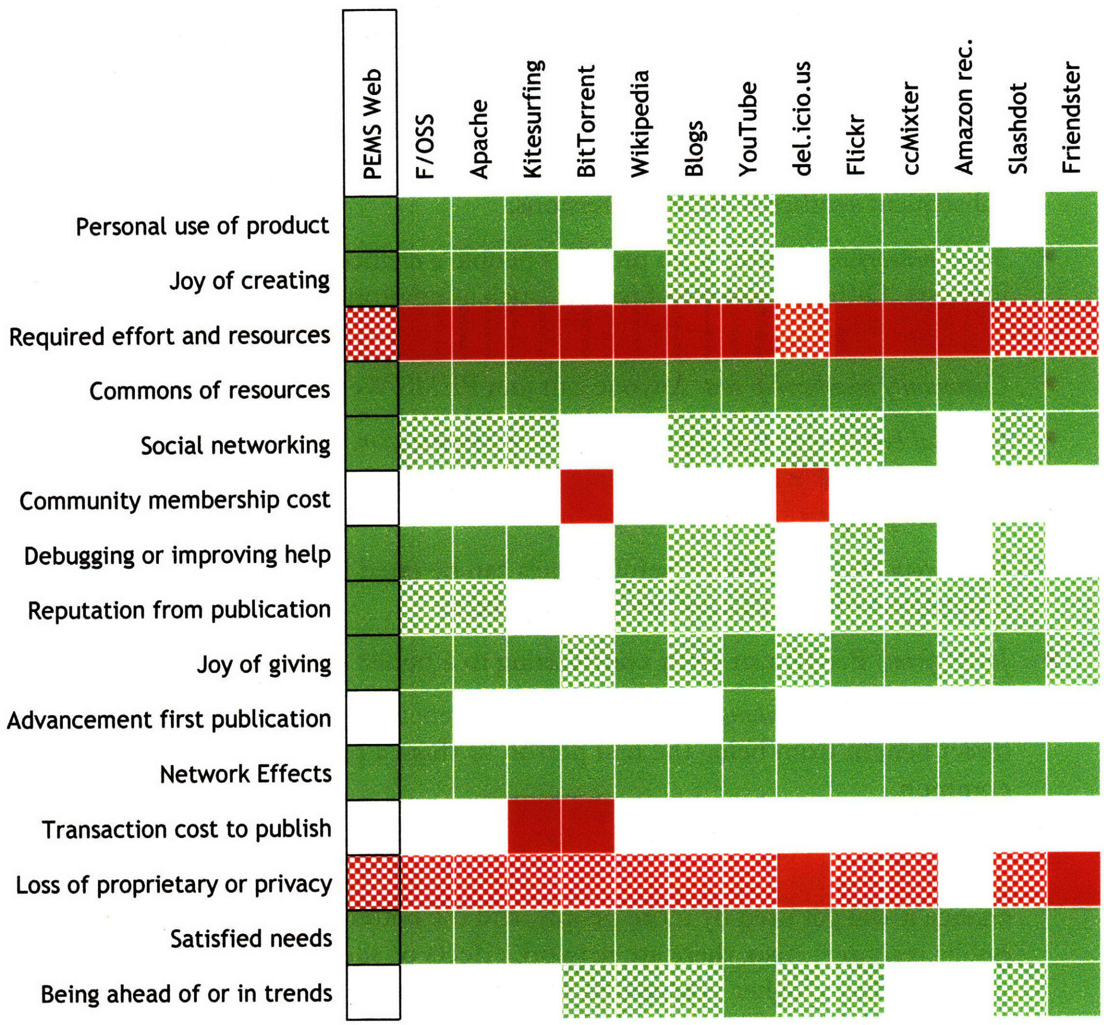
Unstructured collaboration is assisted through multiple infrastructures so that each step coexists with a related process. Specifically, people would likely want to help improve upon a model or edit a description text *after* they have just used the model or read the text. Thus, the option to download the model is available on the model's user interface. Likewise, the option to help edit the description is right next to the description. It would not make sense to have a separate infrastructure and user interfaces for people to come pick a model or a description from a list to modify.

Different editions of a model or a text are treated as different versions, so that people can freely modify or improve upon others' works without overwriting them. This way, changes can also be rolled back. In addition, histories of changes are kept and published, so that anyone can see the evolution of the commons. The histories of changes help highlight the norms of sharing, reusing, and building upon the commons.

6.2.4 Consideration of the Prospective Benefits and Costs of Commons-Oriented Information Syntheses and the Perception-Influencing Mechanism

The design of PEMS Web takes into consideration the prospective benefits and costs of COIS. That is, the design aims to highlight the prospective benefits and minimize the costs, in order to draw people to engage in COIS in PEMS Web.

Table 3 Summarized relevancies of perspective benefits and costs of COIS in PEMS Web, compared to selected examples of creation activities



The following describes how the prospective benefits and costs of COIS, as summarized in Table 3, are considered.

- *Personal use of synthesized information.* People can benefit from personal use of synthesized models. Especially, they can perceive that integrated simulations – the products of COIS of models – can be beneficial for answering their what-if questions.

- *Joy of creating and other side benefits.* While exploring what-if scenarios, people can enjoy putting models together to answer questions and altering different configurations of inputs to see the outcomes. People can also enjoy expressing their knowledge when they write descriptions of models, parameters, etc. as well.
- *Required effort and resources for creation.* Writing a description in PEMS Web is similar to writing an article in Wikipedia. That is, it requires knowledge of the related subjects, but not too much effort. Synthesizing a model requires a basic understanding of the subject. This understanding, which can be helped by the descriptions of associated models, is helpful for figuring out what models to use as starting points or ingredient. Nonetheless, no programming skills are required.
- *Commons of information resources and shared cultural context.* Benefits of commons in PEMS Web are easily recognizable. Many model commons are readily available to be utilized in new model syntheses. Existing descriptions are also readily utilizable for subsequent syntheses of newer versions.
- *Social networking.* PEMS Web provides people a chance to meet others with similar interests. Different groups of people, such as environmental researchers, enthusiasts, and local communities' stewards, can socialize and exchange ideas.
- *Community membership cost.* Anyone can join PEMS Web free of charge.
- *Potential help debugging or improving synthesized information.* Synthesized descriptions and models that are shared open source can potentially benefit from later improvement by other people.
- *Reputation from publication.* Useful models can be rated highly, leading to good reputations for the sharers among their peers.
- *Joy of giving.* People can enjoy contributing to a public resource for the greater good.
- *Advancement from making first publication.* This benefit is not highlighted. There is no direct benefit from being the first person to share a particular model or text as a common.
- *Network Effects.* Model commons have network effects, in the way that the more times a model gets used, the higher it is ranked in terms of popularity, the higher chance it will get used by more people, and the better the model can perform as a public resource. Also, there are network effects of site. As PEMS Web attracts more visitors, it has a higher potential to benefit the society. Prospective engagers can think that if they contribute to PEMS Web, there is a good chance, due to the network effects, that their contributions can continue to become greater and more gratifying.
- *Transaction cost to publish synthesized information.* There is no cost to share synthesized information as a common in PEMS Web, neither in a monetary form nor as a computer resource.
- *Loss of proprietary and privacy information.* Descriptions that are shared as commons are general knowledge, without proprietary value. Models that are freely shared as

commons may be perceived as loss of proprietary information, but there is an option for the owners to share only the service, not the codes, of the models. Moreover, sharing of models that are synthesized based on PEMS Web's model commons would be perceived as contribution back to the community, not as a loss.

- *Satisfied needs.* Synthesis of models can help satisfy people's needs to answer what-if questions. Also, synthesis of descriptions, as well as models, can help satisfy people's desires to contribute knowledge for the greater good.
- *Being ahead of or in trends.* This benefit is not emphasized in PEMS Web.

Furthermore, the four mechanisms that can influence how benefits and costs of COIS can be perceived by people are also considered as part of the design of PEMS Web.

- *Open content licensing.* PEMS Web supports *open* use of models and other multimedia information. In particular, models and various descriptions can be freely used, built upon, and further shared.
- *Pioneering work.* Contributions by early participants can help improve PEMS Web in many respects for later participants. Particularly, the models shared by early participants function as seeded commons for later participants to build upon. The early participants can also help seed tags for categorizing models and start dialogues in the forums.
- *Communal taxing.* The communal taxing in PEMS Web is mild, since it does not incur high private costs on the participants. One communal taxing scheme is for collecting model usage information. Every time someone accesses and uses a model common, the activity is recorded. Records of all models' usages are compiled and used to determine which models are popular. The records essentially reflect the wisdom of all the participants, since they collectively, albeit inadvertently, filter through the entire commons to pick the ones that they "prefer". The records can be considered a privacy loss for the participants, but they are done anonymously, so the privacy loss is nearly negligible.
- *Power-member status.* Even though this mechanism is not adopted yet, power-member status can be used as an incentive for PEMS Web participants to contribute more to the community. People who have shown dedication and contribution to the community can be awarded power-member status, such as an administrator status, that comes with special capabilities and responsibilities, such as moderating the forums or verifying the qualities of model commons.

6.3 Chapter Summary

This chapter discussed the design and implementation of a prototypical COIS environment: PEMS Web. PEMS Web is a Web environment that helps people access, utilize, share, and synthesize environmental information. The environmental information is in forms of multimedia (texts and pictures) and simulation models and can pertain to environmental knowledge, principles, designs, guidelines, or policies. The environmental information shared on PEMS Web constitutes the site's publicly accessible commons – the key components around which most activities in PEMS Web revolve.

An important goal of PEMS Web is to test the feasibility of creating an environment to foster COIS. Many Web 2.0 sites, such as Wikipedia, ccMixter, Flickr, etc., already demonstrate that environments for fostering commons-oriented syntheses of information in multimedia forms can be achieved. Thus, PEMS Web focuses more on the feasibility of creating an environment to foster commons-oriented syntheses of information in forms of simulation models.

PEMS Web demonstrates that it is feasible to create an easily accessible environment that can

- Establish common resources. Multimedia and models of various formats can be made into interoperable commons.
- Make the commons publicly accessible. All commons, whether multimedia or models, can be freely accessed and utilized through a normal Web browser. The commons can be presented in Web-page-style user interfaces with which most people are familiar. Several mechanisms can be added to help people locate and understand the commons.
- Make the commons utilizable for synthesis. The model commons can be utilized in syntheses of new models. An interactive Web-page user interface can be designed and implemented to enable people to perform model syntheses via a normal Web browser, without any programming. Dynamically generated Web pages can also be created to enable people to utilize multimedia commons in syntheses of new information.
- Help people share information as commons. An interactive Web-page user interface can be developed to enable people to share their models, of any kind, as commons. Models that are synthesized using PEMS Web's model commons can also be shared as commons right away. Similarly, dynamically generated Web pages can be created to let people share their knowledge, opinions, and experiences as multimedia commons.
- Support social networking and unstructured collaboration. Various means, such as forums and personal user spaces, can be created to facilitate social networking among participants. Different components of PEMS Web can be utilized to support unstructured collaboration. In particular, model commons can be developed in open source style, and multimedia information can be created through collaborative authoring.

Furthermore, the design and development of PEMS Web demonstrates that an environment to foster commons-oriented syntheses of information can be done with innovative adaptations of and building upon existing technologies, even when the information involved is in complex forms like simulation models.

Additionally, PEMS Web helps illustrate how the potential applications, proposed in the previous chapter, can be achieved.

- *Information synthesis by common people.* PEMS Web shows how a COIS environment can be created for attracting common people to engage in information synthesis. The environment must be designed so that common people can easily access it via a simple means, such as an Internet browser. Also, the prospective benefits and costs of COIS must be considered in the design of the environment, so that as many benefits as possible are highlighted, and as many costs as possible are circumvented. Particularly, when dealing with complex information, the environment must provide appropriately designed tools and user interfaces to eliminate or help common people overcome technical difficulties, such as programming. In addition, several perception-influencing mechanisms, such as pioneering work and open content licensing, can be used, to make it even more attractive for common people to engage in COIS.
- *Knowledge diffusion.* PEMS Web shows that a similar environment can be created as a channel for diffusing knowledge. The environment can be used for exchanging knowledge within a community, whether within an organization of experts or a group of common people. A similar environment can also be developed for transferring knowledge across communities, such as from developmental or educational agencies to the public.
- *Design development and concept exploration.* An environment like PEMS Web can be used to facilitate commons-oriented design development and concept exploration. In particular, a COIS environment like PEMS Web can facilitate the design-evaluate-redesign processes. Designers can access the common resources of the environment and utilize them to explore new concepts or develop new designs. The designers can then share their newly synthesized designs or concepts as commons of the environment. Other designers or beta-testers can join the environment to access and help evaluate the shared designs or concepts. Additionally, other designers can also help further develop the shared designs or concepts, in an open source fashion.

Finally, PEMS Web itself is more than just a prototype for the COIS study. It can serve as a tool for meaningful, practical applications. PEMS Web can be:

- A public resource of dynamic environmental information. Common people can access the environmental models in PEMS Web and utilize them to answer what-if questions, such as "how much energy can be produced if a solar panel is installed at my location?" or "what effects would the proposed policy have on the emissions in my town?"
- An educational tool for environmental subjects. Models in PEMS Web can be used as teaching aids for helping students explore what-if scenarios.
- A space for contributing environmental knowledge. Anyone, from major environmental agencies to individuals, can help contribute to the public commons in several ways.

- A potential of new dimension to environmental journal publication. In addition to publishing papers, researchers can also publish the simulation models from which the results and conclusions in the papers are derived. If such models are published on PEMS Web, readers can play with the models while reading the papers and potentially gain more insights. Also, if the models associated with the papers are published on PEMS Web, peer researchers can use the models as additional means to review and validate the findings of the papers. Furthermore, PEMS Web can help promote the works of the researchers, as the reputations of high-quality models would likely be amplified by the wisdom of PEMS Web's crowds.

As of January 2008, the model commons on PEMS Web have been utilized more than 1,500 times.

7

Conclusions

Overall summary, future work, and contributions

7.1 Overall Summary

Recently, creation activities by non-experts have emerged and are increasing rapidly. More and more lead users design products to get precisely what they want by themselves. On the Web, a skyrocketing number of common people generate their own content and share it with one another. This phenomenon is intriguing because it reflects the convention-defying change of roles of non-experts, from passive users or audiences to active creators. Moreover, most creation activities by non-experts are even done without any substantive or financial incentives.

The phenomenon of user-driven creation activities shows that under certain circumstances, typically passive users can become active creators. And, under those circumstances, creation activities are not just isolated do-it-yourself activities of individuals; instead, people build on one another's creations and further share their own.

This work recognized the potentials of the phenomenon of user-driven creation activities and endeavored to understand its underlying drivers and essential elements. Such understanding can provide a foundation for constructing environments in which user-driven creation activities can be induced and fostered. Such environments can benefit many areas, including design and knowledge transfer processes in product development, engineering education, sustainable development, and academic communities.

To understand the underlying drivers and essential elements of the phenomenon of user-driven creation activities, this work analyzed the creation activities by non-experts in the following environments: BitTorrent, Wikipedia, blogs, YouTube, del.icio.us, Flickr, ccMixter, Amazon recommendations, Slashdot, and Friendster (in Web 2.0 area); free/open source software development, Apache, and kitesurfing equipment (in product design area). The analysis was done based on literature reviews and direct experience with the individual environments.

The analysis showed that the creation activities by non-experts, in both product design and Web 2.0 areas, share many similar traits. The following are the major traits:

- Information is the essence of the creation activities. For product development, the essence is design information, and for Web 2.0, multimedia information.
- The acts of creation performed by the non-experts are essentially acts of information synthesis.
- The non-experts do not only engage in creation; rather, they engage in creation, participation, and publication, as integral processes.
- The creation activities take place in communities and highly involve the communities' commons.
- Prospective outcomes from creation are not the only reasons why non-experts engage in the activities. Rather, the non-experts are attracted by combined prospective benefits of the integral processes of creation, participation, and publication. That is, the activities are not just do-it-yourself creations, but also social connections through which people can relate, communicate, and express themselves to one another.
- The communities have norms of sharing, reusing, and building upon commons.

Based on the results of the analyses, a model of commons-oriented information synthesis (COIS) was formed. The model describes a special kind of information synthesis, which revolves around common resources. The commons are often in reusable forms, so an individual's use of commons does not decrease, but rather often increases, the benefits available to others. In this special kind of information synthesis, the creation of information is not the sole process. Instead, creation takes place in conjunction with participation and publication. All three processes are oriented around commons. The prospective benefits, as well as costs, of the three processes integrally influence people's decisions of whether or not to engage in the synthesis. The engagers value not only the end results but also the processes, as COIS is about creation as much as social relations, communications, expressions, and experiences.

The COIS model applies not only to commons-oriented creation activities by non-experts, but also to commons-oriented creation activities by experts as well. In other words, anyone can engage in COIS. However, not all creation activities can be considered COIS. Some creation activities, even if done by non-experts, do not involve commons and are, thus, not COIS. Nonetheless, virtually all creation activities in Web 2.0 by common people, and many in product design by lead users, are describable by the COIS model.

People are likely to engage in creation activities that are in the form of COIS because they can likely perceive not only the potential benefits from creation alone, but also the added benefits from participation and publication as well. The costs of participation and publication are typically small, compared to the added benefits. Fifteen prospective benefits and costs of COIS were identified:

- Personal use of synthesized information
- Joy of creating and other side benefits
- Required effort and resources for creation
- Commons of information resources and shared cultural context
- Social networking
- Community membership cost
- Potential help on debugging or improving synthesized information
- Reputation from publication
- Joy of giving
- Advancement from making first publication
- Network Effects
- Transaction cost to publish synthesized information
- Loss of proprietary and privacy information
- Satisfied needs
- Being ahead of or in trends

Some prospective benefits or costs of COIS are more easily perceivable than others. Varying from environment to environment, the combinations of benefits and costs that are easily perceivable depend on the mechanisms that the environments have in place. Four established perception-influencing mechanisms were identified: open content licensing, pioneering work, communal taxing, and power-member status. Each mechanism influences how people perceive the prospective benefits and costs of COIS in different ways.

The COIS model provides insights into the essentials of COIS, the motivations of COIS engagers, and the implications of COIS. Based upon the insights from the model, potential applications of COIS can be derived to benefit the following three major areas:

- *Information synthesis by common people.* Common people are more likely to engage in creation activities that are commons-oriented, such as Web 2.0 activities, than activities that are strictly about creation. In this regard, the COIS model can be a recipe for creating an environment that invites and fosters information synthesis by common people. Two noteworthy applications in this area are: to attract common people to engage in customer co-design in mass customization (in the area of product development), and to get citizens involved in a community's policy drafting.
- *Generative diffusion of knowledge.* Some information can be considered knowledge. Information, or knowledge, synthesized in COIS can be socially efficient. Information synthesized by a member of the community can be shared as a common, so that other members can reuse or build upon it, saving collective effort and resources of the community. Additionally, in COIS environments where commons are publicly accessible, synthesized information that is shared as a

common can reach and potentially benefit many people. Furthermore, commons can be used in more syntheses, so the shared knowledge can seed further knowledge generation. Thus, the COIS model can be a recipe for socially efficient and far-reaching knowledge diffusion.

- *Design development and concept exploration.* When designs are synthesized in a commons-oriented way, they can continue to evolve through open, unstructured collaboration – in an open-source style. The COIS model can be an approach to foster perpetually evolving open design development and design concept exploration. In addition, COIS can also facilitate the design-evaluate-redesign cycle. For "design", commons can be a library of ingredients, starting points, references, and inspirations. For "evaluate", COIS provides test beds in which other designers and the public can evaluate designs that are shared. For "redesign", COIS facilitates open-source-styled improvement as well as unstructured collaboration.

The implications of COIS in all three areas can be enhanced by use of models as live representations of dynamic information. Furthermore, access to the increasingly ubiquitous Internet can also help broaden the impacts of COIS.

Finally, a prototypical COIS environment, called PEMS Web, was designed and implemented. PEMS Web is a Web environment that helps people access, utilize, share, and synthesize environmental information. The environmental information, which makes up the commons of PEMS Web, can be in forms of multimedia (texts and pictures) or simulation models, and can pertain to environmental knowledge, principles, designs, guidelines, or policies.

One important goal of PEMS Web, as a prototypical COIS environment, is to test the feasibility of creating a system design environment to foster commons-oriented syntheses of information, especially when the information is represented in forms of simulation models. PEMS Web demonstrates that it is feasible to create an easily accessible environment that can: establish common resources, make the commons publicly accessible, make the commons utilizable for synthesis, help people share information as commons, and support social networking and unstructured collaboration among users.

Additionally, the development of PEMS Web demonstrates that a COIS environment can be created by innovative adaptations of and building upon existing technologies. Furthermore, PEMS Web illustrates that a COIS environment can be structured to achieve applications in the areas of information synthesis by common people, knowledge diffusion, and design development and concept exploration. Lastly, PEMS Web is a functional tool that serves meaningful, practical purposes, such as a public resource of environmental information, a potentially new dimension to environmental journal publication, and an open-source design environment for alternative energy systems.

7.2 Future Works

There are two overall future directions for this work: to further explore the proposed potential applications, and to further improve the simulation-infrastructure technologies that can be used to support COIS environments.

7.2.1 Pilot Studies

Pilot studies can be set up to further explore the potentials of the proposed applications. A COIS environment can be set up, in a similar fashion to PEMS Web's, for each application.

An environment can be implemented as part of an ongoing study of customer co-design in mass customization, such as a study set up at Adidas Salomon AG (F. T. Piller & Walcher, 2006). In such a setting, an empirical study of the impacts of COIS on the customer co-design process can be conducted.

Likewise, a pilot environment can be implemented in a research community, to study how COIS can affect dissemination and syntheses of knowledge among researchers. Potential target research communities include academic societies and journal publication groups. A related application is to use a pilot COIS environment as a platform to support dissemination and syntheses of knowledge among researchers in a developing country, like Thailand, where a formal platform for such applications is still lacking.

Similarly, a pilot COIS environment can be deployed in a design group, in order to study the effectiveness of COIS as a tool for unstructured collaboration in design workplace.

7.2.2 Improvement of Simulation-Infrastructure Technologies

Further work can be done to improve the technologies used in infrastructures for supporting model commons in COIS. For instance, a redundant model repository technology can be introduced. When an open model is shared, the technology can make a duplicate of it and store the duplicate in a backup repository. Then, whenever the original model is offline or corrupted, the duplicate can be used instead.

A model that is used as an ingredient or built upon to synthesize a new model may be changed after the synthesis. If that happens, people who use the model should be notified of the change. An infrastructure can be implemented to support this. The infrastructure will need to be able to keep track of which (upstream) models are used in the syntheses of which (downstream) models, to look out for changes in the upstream models, to notify the users of the downstream models of the upstream changes and ask if they want to use an updated version of the upstream models instead.

The above examples show that there can be several improvements or additions to enhance the infrastructure technologies for supporting use of model commons in COIS. The best approach to identify the needs for these improvements is through pilot applications of COIS environments.

7.3 Summary of Contributions

The major contributions of this thesis, as listed below, are related to the COIS model and PEMS Web, the prototypical COIS environment.

First, this thesis contributes a model (the COIS model) that can be applied to describe commons-oriented creation activities by non-experts within different domains in a unified way.

Second, this thesis contributes propositions, as part of the COIS model, of factors and mechanisms that attract non-experts to engage in commons-oriented creation activities. In other words the COIS model can explain why non-experts engage, or do not engage, in creation activities.

Third, this thesis contributes recipes for approaches to creating environments that can foster COIS. Furthermore, this thesis identifies three major areas (information synthesis by common people, knowledge diffusion, and design development and concept exploration) that can benefit from COIS and proposes how potential applications of COIS in these three areas can be achieved.

Forth, this thesis contributes a prototypical environment (PEMS Web) that demonstrates the feasibility of implementing a COIS environment and illustrates how potential applications of COIS may be achieved.

Fifth, this thesis contributes PEMS Web as a functioning public environmental information system – a platform for synthesizing and disseminating dynamic environmental knowledge among academia, local communities, and the general public. PEMS Web also serves as an open-source design environment for alternative energy systems.

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Appendix

A. Roles of Prospective Benefits and Costs of Commons-Oriented Information Syntheses in Selected Creation Activities by Non-Experts

Prospective Benefits and Costs related to Creation

Personal use of synthesized information

Engagers in the following activities highly value personal use of synthesized information:

- F/OSS – software programs, part of the "private" incentive of programmers (E. von Hippel & von Krogh, 2003)
- Apache – Web server software
- Kitesurfing – kite designs
- BitTorrent – files
- del.icio.us – bookmark collections
- Flickr – photo collections
- ccMixter – music
- Amazon recommendation – trained, personalized product preferences
- Friendster – connections

Some of engagers in the following activities value the personal-use benefit:

- Blogs – when blogs are used as means to document life (Nardi et al., 2004)
- YouTube – when videos are produced primarily for personal use

Engagers in the following activities rarely value the personal-use benefit:

- Wikipedia – articles are not for contributors' personal use
- Slashdot – shared news stories are not for contributors' personal use

Joy of creating and other side benefits

Engagers in the following activities value the joy of creating and other side benefits:

- F/OSS – besides the joy of software programming, engagers also value the learning and the sense of ownership as side benefits of programming (E. von Hippel & von Krogh, 2003)

- Apache – same as F/OSS
- Kitesurfing – designing kites is part of the fun (E. von Hippel, 2005)
- Wikipedia – contributors value the "fun" and learning from article writing (Nov, 2007)
- Flickr – the joy of photography
- ccMixter – the joy of remixing and composing is one of the biggest pros in decision-making
- Slashdot – contributors enjoy sifting through materials on the Web and coming up with news stories
- Friendster – the joy of making connections with new people

In the following activities, some engagers value the joy of creating and other side benefits:

- Blogs – some bloggers enjoy writing blogs and being able to their express emotions through writing (Nardi et al., 2004)
- YouTube – e.g. creating home videos for fun
- Amazon recommendation – some people enjoy rating and writing comments on products (Grossman, 2006a)

Engagers in the following activities rarely value the joy-of-creating benefit:

- BitTorrent – people enjoy the end result but rarely the downloading process
- del.icio.us – making bookmarks and tags are trivial

Required effort and resources for creation

This cost is a major factor that engagers in many activities have to consider, including:

- F/OSS – time, effort, and programming ability and tools
- Apache – also time, effort, and programming ability and tools
- Kitesurfing – time, effort, building tools, and knowledge of kitesurfing
- BitTorrent – time and sharing of files to satisfy the "tit-for-tat" system – in this case, publication of personal resources as commons is a cost that has to be paid, in order for creation to operate effectively
- Wikipedia – time, effort, and knowledge of subjects
- Blogs – time and some effort
- YouTube – time, effort, and videotaping or video-editing equipment[24]
- Flickr – time, some effort, and photographing equipment

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[24] Note that simply reposting videos made by others is not considered creation and is, thus, non-COIS.

- ccMixter – time, effort, and musical abilities and instruments
- Amazon recommendation – time and some effort

People may sometimes consider required effort and resources for creation costs in the following activities:

- del.icio.us – minimal time and effort required to make bookmarks and tags
- Slashdot – time and effort required in the case of originally written news articles
- Friendster – minimal time required, but some effort may be needed to create a connect to certain people

Prospective Benefits and Costs related to Participation

Commons of information resources and shared cultural context

The benefit of commons is highly valued by engagers in all of the following activities:

- F/OSS – commons of software codes and libraries, and pools of beta users
- Apache – core modules
- Kitesurfing – commons of kite designs
- BitTorrent – commons of files and file bits
- Wikipedia – existing articles and reader base
- Blogs – all contents and personal "information", e.g. opinions, and readers in the blogosphere
- YouTube – existing videos and the viewer base
- del.icio.us – a large collection of bookmarks and tags, representing collective cognition of all users
- Flickr – photo collections and viewer base
- ccMixter – commons of music and listener base
- Amazon recommendation – product ratings of other people with similar interest, amounting to item-to-item collaborative filtering
- Slashdot – reader base and expert opinions from readers
- Friendster – commons of connections and bundled opportunities

Social networking

Engagers in the following activities highly value the social-networking benefit:

- ccMixter – socializing with fellow musicians and music enthusiasts

- Friendster – social networking is the biggest benefit, overlapping with the main objective

Some people who engage in the following activities value social networking:

- F/OSS – with fellow programmers
- Apache – with fellow developers
- Kitesurfing – with kitesurfers and fellow kite designers
- Blogs – some bloggers socialize through blogs (Nardi et al., 2004)
- YouTube – within community channels (Garfield, 2006)
- del.icio.us – tags can lead users to meet other like-minded people who have bookmarks of similar interests
- Flickr – among fellow photographers and to connect with friends
- Slashdot – conversations through threads of stories and comments

Engagers in the following activities rarely value the social-networking benefit:

- BitTorrent – no direct user interaction
- Wikipedia – social networking is not a strong incentive of contributors (Nov, 2007)
- Amazon recommendation – people rarely interact with one another through product comments

Community membership cost

The membership cost is a major factor in the following activities:

- BitTorrent – BitTorrent software is required for managing torrent connections, and downloading and uploading file bits
- del.icio.us – a small plug-in to a Web browser is required for accessing personal bookmark collections and for the instant creation of a bookmark for the Web page currently being viewed

On the other hand, the membership cost is not a factor that the engagers in the following activities have to consider at all:

- F/OSS
- Apache
- Kitesurfing
- Wikipedia
- Blogs
- YouTube
- Flickr

- ccMixter
- Amazon recommendation
- Slashdot
- Friendster

Prospective Benefits and Costs related to Publication

Potential help on debugging or improving synthesized information

Engagers in the following activities highly value the potential-improving-help benefit:

- F/OSS – revealing software codes is one of the main characteristics of free/*open source* software
- Apache – also an open source software program
- Kitesurfing – kite designs are revealed to invite suggestions and improvements
- Wikipedia – receiving further corrections or modifications to articles is part of collaborative authoring
- ccMixter – feedback and reinterpretation of music by other people are welcome

In the following activities, the engagers sometimes value the potential-improving-help benefit:

- Blogs – when bloggers write to solicit opinions of others
- YouTube – comments from viewers, albeit usually unconstructive, are welcome
- Flickr – when engagers look for comments on their photos
- Slashdot – comments from readers, especially experts, are important in the case of open source journalism

The potential-improving-help benefits are unimportant or irrelevant to the engagers in these activities:

- BitTorrent – shared files and file bits are "final" and do not get improved by other users in the swarms
- del.icio.us – bookmarks require no improvement
- Amazon recommendation – product comments and ratings do not get improved
- Friendster – connections do not get improved

Reputation from publication

Some engagers in the following activities value the reputation benefit:

- F/OSS – some programmers want to earn good reputations from users and fellow programmers, sometimes as part of their career objectives (Chance, 2005)
- Apache – similar to F/OSS, but an Apache programmer can earn a good reputation from only fellow Apache programmers, not end-users of the program
- Wikipedia – some contributors want to be known as part of their career objectives (Nov, 2007)
- Blogs – some bloggers want to be famously known
- YouTube – many engagers in YouTube want to be famous; nonetheless, if videos are not specifically about the engagers themselves, viewers would know of the famous videos but not of the videos' creators
- Flickr – some may want to show off and be known for their photos
- ccMixter – some may want to be recognized for their music
- Amazon recommendation – those who have written good reviews can earn "Top Reviewer" badges (Linden et al., 2003)
- Slashdot – in the cases where the news stories are original pieces or when the engagers are affiliated with the links they suggest
- Friendster – engagers can be known for having many connections

The reputation benefit is irrelevant or not valued by engagers in these activities:

- Kitesurfing – reputation is not an objective of participants
- BitTorrent – publication is anonymous
- del.icio.us – people do not pay attention to the creators of tags or bookmarks

Joy of giving

In the following activities, engagers highly value the joy-of-giving benefit:

- F/OSS – making free/open source software available to the public is the "collective" incentive (E. von Hippel & von Krogh, 2003)
- Apache – also a free software
- Kitesurfing – kitesurfers enjoy sharing their new designs with one another
- Wikipedia – the "value" of contributing knowledge (Nov, 2007)
- YouTube – sharing of videos is one of the primary objectives
- Flickr – sharing of photos is influenced by the community's setting of an open-content license (discussed in section 4.2.1)
- ccMixter – sharing of music is also influenced by the community's setting of an open-content license
- Slashdot – engagers enjoy sharing interesting news stories

Some of the engagers in the following activities value the joy-of-giving benefit:

- BitTorrent – some people enjoy sharing their files
- Blogs – some people blog to share their opinions (Nardi et al., 2004), while some enjoy blogging in order to function as media to the public (H. Jenkins, 2006b)
- del.icio.us – some people enjoy sharing their personal collection of bookmarks with others
- Amazon recommendation – while some people rate products just to train the site of their preferences, many enjoy sharing their comments on products with other potential buyers
- Friendster – some people enjoy sharing their networks of friends

Advancement from making first publication

The first-publication benefit is valuable to some engagers in the following activities:

- F/OSS – early and free software programs can attract many users and additional developers and can eventually become unofficial standards. For example, the following F/OSS have become the unofficial standards of the Web's infrastructure: Linux, Apache, MySQL, Perl, PHP, and Python (O'Reilly, 2005).
- YouTube – publishing of videos with novelty can be beneficial, such as the make-believe lonelygirl15[25]

On the other hand, the first-publication benefit is irrelevant or not valued by engagers in the following activities:

- Apache – even though the early developers of Apache gained benefit from making Apache available as one of the first free and open-source Web server software applications; in the context COIS within Apache itself, developers do not gain benefit from being the first to release a bug fix or to deploy an add-on
- Kitesurfing – no benefit from being the first to share a particular kite design
- BitTorrent – no benefit from being the first to share a file
- Wikipedia – since the knowledge shared in Wikipedia articles is not new, there is no benefit from being the first to write about a subject that presumably some other people also know about
- Blogs – being the first to blog about something is not a motivation; in fact, bloggers often repost blogs of others
- del.icio.us – no benefit from being the first to bookmark a certain Web site

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[25] Lonelygirl15 is a massively popular video series on YouTube about a teenage girl named Bree, whose YouTube username is "lonelygirl15." The series is presented through short, regularly updated video blogs posted by Bree. Lonelygirl15 attracted international attention when suspicious viewers found out that Bree is in fact a fictional character played by an actress and the videos are produced in Hollywood.

- Flickr – technically, all users are the first to share particular photos, since different people are unlikely to share to same photos; there is no benefit from being the first to share a photo
- ccMixter – similar to the case of Flickr
- Amazon recommendation – being the first to rate or review a product is not an advantage
- Slashdot – no benefit from being the first to recommend a news story
- Slashdot – users who are not the first user cannot technically be the first to share connections

Network Effects

In the following activities, engagers personally benefit from the information they synthesize, *and* the synthesized information performs better with more users. So, the engagers in the following activities value the improved-performance network effect:

- BitTorrent – the more people sharing and downloading the same file, the more effective and more robust the torrent becomes
- Blogs – when a blog is used as a conversational means, the more people conversing through the blog, the more effective the blog becomes
- del.icio.us – shared tags become more useful (i.e. can lead to more links), when more people use it to index their bookmarks
- Flickr – similar to del.icio.us in terms of the use of tags
- Friendster – the more people using a shared connection, the more friends of friends emerge

Some engagers in the following activities value the reputation from making their synthesized information available, *and* the synthesized information has an improved-reputation network effect:

- F/OSS – the more users of software programs, the more popular they can be; and some programmers value reputation from their published programs
- Wikipedia – an article can be more famous after more people have read it; some contributors value the reputation from their articles
- Blogs – blogs can be more famous with more readers; and some bloggers want to be famously known
- YouTube – YouTube videos can become more famous by words of mouth of more viewers; some engagers in YouTube who make videos about themselves may want to be famous through their videos
- Flickr – photos can also become famous by word of mouth of viewers; some engagers in Flickr want to show off and be known for their photos

- ccMixter – likewise, music can become more famous with more listeners; some engagers may want to be recognized for their music
- Amazon recommendation – when more people read a particular product review, there is more chance that it will be rated as a "helpful" review. Engagers who have written good reviews can earn "Top Reviewers" badges (Amazon.com Inc., 2007a). Some engagers may care for that reputation.
- Slashdot – news stories can become more popular with more readers; in some cases, the engagers may want to earn reputations from having written famous articles

The commons in the following activities can benefit from improved-site network effects:

- F/OSS – improved software commons
- Apache – improved module commons
- Kitesurfing – better and added kite designs
- BitTorrent – richer file swarms
- Wikipedia – articles of increased number and quality, and more readers
- Blogs – more readers and content in blogosphere
- YouTube – more videos and viewers
- del.icio.us – more capable collective bookmarks
- Flickr – bigger overall collection and more viewers
- ccMixter – more listeners and larger selection of music to remix
- Amazon recommendation – better collective filtering of products
- Slashdot – increased readers
- Friendster – more people and bundled opportunities in network

Transaction cost to publish synthesized information

This publication-transaction cost is a major factor in the following activities:

- BitTorrent – memory resource of a computer has to be dedicated to making files available
- Kitesurfing – a computer server or Web site may be needed to personally host kite designs

On the other hand, engagers in the following activities do not have to worry about publication-transaction costs at all:

- F/OSS – a Web site for promoting F/OSS such as SourceForge.net provides free service to make F/OSS programs available
- Apache – no cost to publish modules
- Wikipedia – free to contribute

- Blogs – most blog services, such as Blogger.com, are free
- YouTube – free to share videos
- del.icio.us – sharing of bookmarks and tags is automatically taken care of by the system free of charge
- Flickr – sharing tags is also taken care of automatically by the system; minimal computer resources and time are required to upload photos
- ccMixter – free to share music through the Web site
- Amazon recommendation – sharing of ratings and reviews are automatically taken care of by system
- Slashdot – free to submit news stories
- Friendster – sharing of connections is automatically taken care of by system

Loss of proprietary and privacy information

A loss of privacy is an important factor that engagers in the following activities have to consider:

- del.icio.us – sharing of bookmarks entails a loss of privacy
- Friendster – sharing of connections can be considered a loss of privacy to some people; nonetheless, many engagers do not mind this loss, as they make their profiles publicly accessible

In the following activities, a loss of proprietary or privacy information can be a concerning cost to some engagers:

- F/OSS – programs have proprietary values, but the functionalities can sooner or later be duplicated by other programmers
- Apache – software modules have proprietary values
- Kitesurfing – kite designs have proprietary values
- BitTorrent – some files are personal or originally created
- Wikipedia – written articles have proprietary values
- Blogs – blogs may entail some privacy loss
- YouTube – originally produced videos have proprietary values
- Flickr – photos have proprietary values
- ccMixter – music has proprietary value
- Slashdot –originally written news stories have proprietary values

On the other hand, loss of proprietary or privacy information is not a factor in the following activity:

- Amazon recommendation – product reviews hold little proprietary value

Prospective Benefits from Creation, Participation, and Publication Combined

Satisfied needs

Engagers in all of the following activities value the satisfied-needs benefit:

- F/OSS – needs for specialized software programs and collaborative programming
- Apache – Web server software and collaborative programming
- Kitesurfing – special kitesurfing equipment and collaboration with other kitesurfers
- BitTorrent – files or file distribution
- Wikipedia – to contribute to collaboratively written online encyclopedia
- Blogs – to write or to share thoughts or writings with someone (the readers are usually unknown)
- YouTube – to make and share videos with online audience
- del.icio.us – online personal bookmark collections that can be enhanced by others
- Flickr – online photo management and sharing
- ccMixter – creative music composition
- Amazon recommendation – to share opinion of products and to train personalized product recommendations
- Slashdot – to share news stories, and sometimes to invite expert opinions on news stories
- Friendster – to make new connections and acquire bundled opportunities, and to keep in touch with acquaintances

Being ahead of or in trends

Engagers in the following activities highly value the trend benefit:

- YouTube – most engagers in YouTube want to be part of a shared cultural context (H. Jenkins, 2006a)
- Friendster – being in trend is a strong motive for engagers in Friendster

Some engagers in the following activities value the trend benefit:

- BitTorrent – some view BitTorrent as a new, trendy way to share files
- Wikipedia – some contribute in Wikipedia because of the trend
- Blogs – some blog just to be trendy

- del.icio.us – many use del.icio.us as a trendy way to share bookmarks
- Flickr – some find it trendy to share photos online
- Slashdot – submitting a news story and having it published can be trendy

Yet, trend is rarely valued by engagers in the following activities:

- F/OSS
- Apache
- Kitesurfing
- ccMixter
- Amazon recommendation

B. PEMS Web's Database Tables

Related to Model Commons

- Information about models (e.g. names, IDs, locations on servers)
- History of descriptions of models
- History of versions of models
- History of descriptions of parameters in models
- Information about run views of models
- History of descriptions of run views of models
- Descriptions of customized run views of models
- Model tags and their associations with models
- Log of model runs
- Log of model downloads
- User reviews of models and run views
- Integration logics of synthesized models
- Temporary information about models

Related to Forums

- Individual messages' details
- Individual forums' descriptions (A forum is a thread of messages.)
- Details of forums that are directly related to models
- Description of forum topics (A forum topic is a category of related forums.)
- List of permission types on forum topics
- Permission settings on forum topics
- Descriptions of groups of forum topics (Related forum topics are grouped.)
- List of moderators

Related to Users

- Information about users
- Temporary information about users (while awaiting identity confirmation)
- Lists of personal model bookmarks
- Temporary passwords

- List of account security questions
- List of user types
- Information about user groups
- User group assignments

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