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Open Design-Based Strategies to Enhance Appropriate Technology Development

J. Buitenhuis, Mathematics and Engineering Department, Queen's University
Ivana Zelenika, School of Environmental Studies, Queen's University
J. M. Pearce, School of Environmental Studies & Department of Mechanical and Materials Engineering, Queen's University

Abstract

The appropriate technology (AT) movement is being driven by inventors and innovators who are interested in designing technologies that are culturally, environmentally, and economically appropriate, and feasible to construct and use for people anywhere in the world. This paper examines how open sharing of designs, specifications, and technical information can enhance effectiveness, widespread use, and innovation of AT. This commons-based open design method has been highly successful for software development (i.e., open source), and has also begun to be used in other fields through unique partnerships and new information-sharing tools on the internet. This paper critically demonstrates key examples of open design successes that can be applied to development of AT. It also identifies potential barriers to open-sourcing AT designs, analyzes business models for open design in the context of AT, and outlines practical solutions with examples currently underway.

Introduction

In order to overcome rampant global poverty and create just sustainable development (Agyeman, Bullard, and Evans 2003) a growing number of organizations are concentrating on the application of appropriate technologies (ATs) (Appropedia 2009a). AT, first conceptualized in the 1970s (Schumacher 1973), is defined as those technologies that are easily and economically utilized from readily available resources by local communities to meet their needs (Pearce 2007a). In addition, AT must comply with the environmental, cultural, economic, and educational resource constraints of the local community (Pearce 2007b). As such, AT can be understood as a social movement that rejects the mainstream discourse of development through technology, which has resulted in a highly uneven distribution of advanced technology and wealth throughout the world (Pursell 1993). Countering the focus of large-scale technology implementation projects for economic development, AT focuses on small-scale, locally relevant, sometimes low-tech technologies in order to promote grassroots development and serve the world's underprivileged populations. Unfortunately, AT has not yet successfully scaled. The number of people around the globe suffering in poverty (Ferreira and Ravallion 2008) clearly demonstrates a need

for marginalized communities to have access to AT and thus a new way for designing and disseminating AT. As globalization has helped spread internet access even to the world's least developed countries, the commons-based open design method has promise to accelerate the development of AT (Pearce and Mushtaq 2009). This open source design, which has been highly successful for software development, is based around the publishing of software code openly for users to view, add to, and modify. This paper examines and demonstrates how open design principles could be used in AT development to produce better, more relevant technologies that communities can adopt and feel ownership over. Current open source appropriate technology (OSAT) initiatives are quantified and current barriers for the growth of the OSAT design community are identified. Then business models are provided to improve the uptake of OSAT, and the viability of OSAT design and development is discussed.

Background

Open source

Open source (OS) software refers to software code that is designed collaboratively and not published through proprietary means. Because the code is published freely, users are able to view it and make changes, as long as their additions are also published openly.[1] Beginning in the 1980s, OS provided an alternative to the linear hierarchical structure used to design software, using instead a distributed network of user-developed software (Mockus, Fielding, and Herbsleb 2002). The advantage of OS software is that since many users are able to contribute to the development of the code, the software is more robust and innovative (Raymond 1999). It also reduces research and development costs (Lakhani and von Hippel 2003), makes the software more relevant and reliable to the users (Kogut and Metiu 2001), and is able to compete with near-monopoly suppliers (Mockus, Fielding, and Herbsleb 2002). Despite these benefits, most OS software packages, such as Mozilla and Apache, have only a limited market, with the important exception of Linux (Hertel, Niedner, and Herrmann 2003). However, open source products are gaining popularity and continue to grow in market share (NetApplications 2009; Netcraft 2009; Taylor 2008).

While most OS projects are found within the software industry, there are some successful examples of hardware products that have been designed using open source methods. Arduino, an Italian microchip manufacturer, produces its hardware through open source means, publishing designs and schematics of its circuit boards on its website (Thompson 2008). Other examples include the Daisy MP3 player,[2] the WorldBike,[3] and the OS Car project.[4]

Open source appropriate technology

OSAT is AT that is designed in the same collaborative and open method as OS software, where the designs and specifications of the AT are published openly (Pearce and Mushtaq 2009). OSAT provides individuals with access to any or all of designs, specifications, photos, schematics, circuits, drawings, and bill of materials of an AT product in order to build it themselves. Following the rise of free sharing websites on the internet (e.g., Skype, Facebook, YouTube, Twitter), which bring communities together and enable every person to contribute, OSAT is also being developed on the internet (Pearce et al. 2008). The internet itself is therefore an open source medium for collaborative development of AT so that the AT truly meets the needs of the people who use it. Pearce and Mushtaq (2009) explain in detail that OSAT would improve the quality and relevance of AT, as well as increase the speed of innovation in the field.

1This depends on the licensing used. For more information about OS licensing, see Lerner and Tirole (2002).
2 http://teuthis.com/daisy/index.html
3 http://www.worldbike.org/our-work
4 http://www.theoscarproject.org/

The Significance of OS in AT Design

The term "free" is often used to describe OS software, but it is important to distinguish between "free as in libre," where everyone has the right to view and modify software code, and "free as in gratuit," where there is simply no cost for the software (Dalle and Jullien 2003). In the context of international development, having the designs of an AT be both free-gratuit and free-libre is important, because it allows marginalized communities to have say and ownership over the technologies that they are using. Historically, international development projects dealing with large-scale technologies such as ports, dams, and highways were implemented on large scales. However, these projects made countries in the Global South dependent on Western ideas and experts for operation and maintenance (Escobar 1995). Now, more grassroots, small-scale projects that push for participation and collaboration are gaining momentum as they are founded on the idea that the poor should have an active role in any endeavor that is aimed at improving their lives (Bessette 2004). OSAT gives communities access and ownership to appropriate technologies that improve their quality of life. Ideally, community members feel empowered to develop this technology, and the traditional direction of flow of knowledge is reversed.

Participating in OSAT design can happen to varying degrees, depending on the needs, interests, and capacities of a person or group. Similar to three levels of OS software engagement (Bonaccorsi and Rossi 2003), participation in OSAT design can be broadly grouped into three categories. In each a user/developer (hereafter referred to as a creator) can access, contribute to, and collaborate on OSATs.

The first and most basic level of engaging with OSAT is open access. This engagement is unidirectional; the creator can access the designs and technical information regarding an AT in order to build it. Accessibility of design is affected by its cost, but also the literacy, socioeconomic status, and capacity of the community member. Even at this most basic level, the ability to access designs for ATs that a creator could build him or herself is empowering to that community member.

The second level of engagement involves the creator contributing to the body of OSAT designs. Creators not only build ATs in their own communities, but share information about how to enhance these technologies with other creators in their communities. At this level, the creator would likely contribute to the OSAT designs occasionally or as a hobby.

A successful OSAT development community would not flourish without the last and most engaged level of participation in OSAT design: the collaboration stage. Creators engaged in collaboration are highly involved with the OSAT design process. In OS software, people involved at this level are a unique community, often called the 'hacker community' (Bonaccorsi and Rossi 2003). This community is essential to the successes of OS software, as it creates a gift culture that incentivizes community members to contribute to the software code. The OSAT equivalent of the software hacker community would manage the body of OSAT design content and add improvements to OSAT designs based on their experiences. Such a community is needed to create a gift culture, and is therefore the most essential part of OSAT development. They would likely be involved in collaborating with OSAT designs weekly or even daily in a centralized location, the importance of which is described in a later section. Depending on the project, the community may be involved in controlling the quality of the designs.[5] The community would include many users who are also developers of ATs, and thus community members will understand the context of the designs, which is critical to the design process. Once this community is established, creators can choose to contribute at any of the three levels. Challenges to creating such a community are discussed in a later section.

5 For a discussion of quality control within OSAT design, see Pearce and Mushtaq (2009).

Current OSAT Developments

While there is a significant amount of AT design development around the world, AT has yet to reach the majority of the world's population. Some universities and colleges, both in the Global North and South have programs or options regarding ATs (Pearce 2009). There are also non-governmental organizations that deal with ATs, such as International Development Enterprises,6 which develops and markets ATs to improve rural livelihoods, and companies like Vestergaard Frandsen,7 which develops and patents technologies related to emergency health care and disease control. Of course, there are an unknown number of individual designers around the world creating AT for their communities that are not documented. Reaching and engaging them within the OSAT cooperative could have considerable benefits for sustainable development

All of these groups could participate in OSAT design. By far the most common way to make OSAT accessible is through the internet. Internet collaboration allows contributors to be in completely different locations, contribute at their convenience, and (depending of the method of collaboration) collaborate for free. In particular, the rise of Web 2.0 applications like wikis and online forums, which allow users to talk and share ideas in new ways (O'Reilly 2007), have the potential to change the way that all international development is done (Addison 2006), and make it possible for AT design to occur openly online (Pearce and Mushtaq 2009).

Currently, the majority of AT projects are scattered around the internet on individual websites. Appropedia and Ekopedia are two related wikis, in English and French respectively, which aim to be a central resource and forum for collaboration regarding ATs. These sites focus on sustainability, poverty reduction, and international development through the use of AT (Appropedia 2009; Ekopedia 2008). On these sites, similar to other wikis such as Wikipedia, creators contribute to the website and make changes for no cost. The concept can be illustrated with an example of a person in Indonesia who can upload the design of an insulated oven made of clay, available for viewing by anyone using Appropedia. Then, a family in Chile can use the designs to build their own version of the oven. Any modifications made in order to make the oven more relevant to the local context and improve the device are then uploaded to Appropedia. This would be a more efficient design process and would likely result in a better clay oven than if the two groups had designed it separately. Appropedia and Ekopedia both have a number of low-tech designs or links to designs that users around the world can access, including solar cookers, hand-wash stations, biodigesters, and emergency shelters (Appropedia 2009; Ekopedia 2008).

Table 1 shows the size and usage of Appropedia and Ekopedia as compared to Wikipedia. Appropedia, despite having approximately the same number of page edits, registered users, and active users as Ekopedia, has >30% more content. It is also growing much more rapidly than its French counterpart, although both sites have grown continuously since their creation. In July 2009, Appropedia had 137% more visits, while Ekopedia had 24% more visits than they each had in July 2007.[8]

	Appropedia	**Ekopedia**[1]	**Wikipedia**
Founded	2006	2002	2001
Content pages	2,583 (out of >15,000 pages)	1,969 (all pages)	3,023,522
Page edits	72,827	72,877	330,727,319
Registered users	2,261	2,439	10,446,698

6 www.ideorg.org

7 www.vestergaard-frandsen.com

8 The authors conducted an analysis of the site traffic of Appropedia and Ekopedia based on data published on the Statistics pages of said sites, as well as the Google Analytics package.

Table 1. Data Regarding the Usage and Usership of Appropedia, Ekopedia, and Wikipedia[9]

It is useful to compare these sites to Wikipedia, the online encyclopedia and the most successful wiki, in order to gain some insight into the necessity of a critical mass of users. Appropedia and Ekopedia have been growing steadily, but Wikipedia has a much broader audience and its usage dwarfs both of the AT wikis. Outside Appropedia and Ekopedia, there are many individual internet sites that are home to specific AT projects. In order to achieve successful mass collaboration to develop AT, it is important to increase the active users and centralize the collection of AT information. It is interesting to note that at first the content on Wikipedia was developed by a small group of elites, but that as the site grew, larger groups of regular users became the main developers (Kittur et al. 2007). Further work is needed to determine if the AT wikis are following a similar trend.

The global usages of Appropedia and Ekopedia are shown in Figures 1 and 2, respectively. These figures show that while there is some usage of the sites in the Global South, the majority of visitors are located in the US for Appropedia and France for Ekopedia.

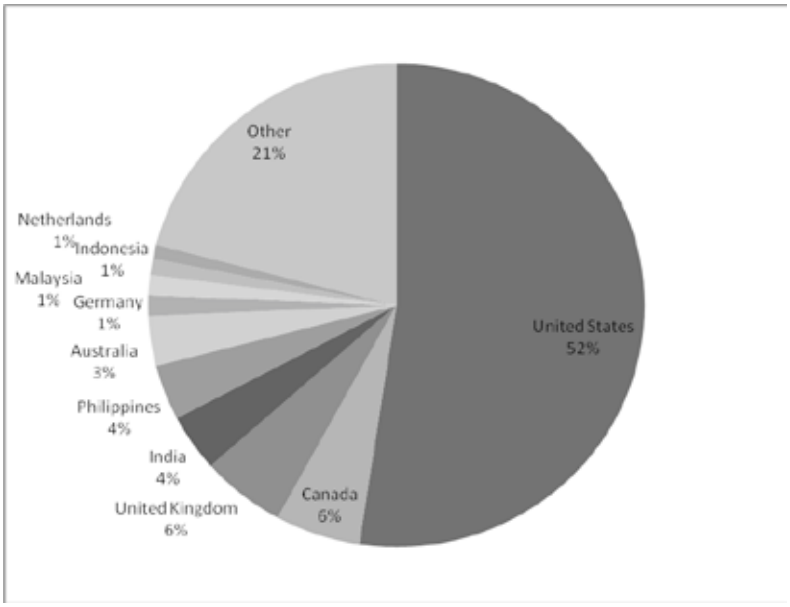

Figure 1. Top Ten Geographic Locations of Appropedia Visitors, by Percentage[10]

9 All data was collected on Sept 3, 2009, 17:40. (Appropedia 2009; Ekopedia 2009; Wikipedia 2009)
10 Data from Google Analytics analysis.

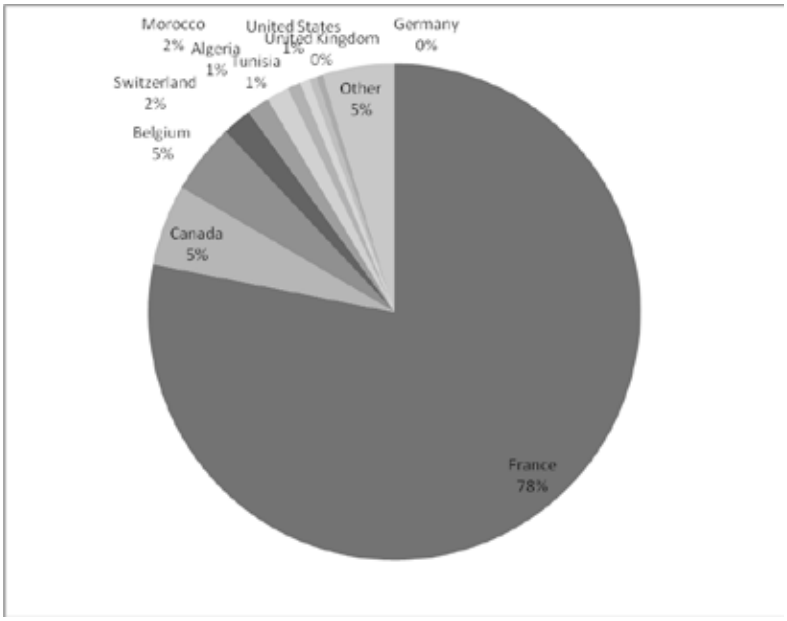

Figure 2. Top Ten Geographic Locations of Ekopedia Visitors, by Percentage[11]

Challenges and Barriers to OSAT Design

Widespread awareness, contributions to, and use of OSATs has not yet occurred. This section identifies barriers that prevent OSAT from being designed and used on a large scale.

Internet access

All levels of participation in OSAT design are limited by the amount of internet access available in the Global South. For example, 97% of all internet hosts are found in the Global North, which constitutes only 16% of the world's population (Petrazzini and Kibati 1999). In terms of users, while there are many more internet users in Asia than in North America in terms of absolute numbers, only 18.5% of the Asian population uses the internet, compared to North America's 73.9%, and in Africa, internet usage is much lower, at 6.7% (IWS 2009). In addition, computers represent a much smaller fraction of the average professional worker's salary in the north as compared to the south and thus hardware costs can also limit access to the internet (Petrazzini and Kibati 1999). If individuals in the Global South cannot access ATs, they will be unable to utilize them in their daily lives. If they cannot contribute to and collaborate on ATs, then the technologies are not likely to be as appropriate or relevant to them, nor will the concept empower people to take ownership over their own technologies.

One way to address this issue is to create spaces for OSAT design to occur without the internet. The role of cell phones in international development has been discussed significantly (see for example Kaplan (2006)). Through surveying, voice conversations, and text messaging, it may be possible to develop an OSAT community within cell phone users as internet access is being spread.

Language and culture

Language is another important barrier to the Global South that affects all three levels of engagement in OSATs. In Africa, for example, there are over 2,000 languages (Gordon 2000). Appropedia and Ekopedia focus on English and French, and although there have been some preliminary efforts to provide translations into other languages (Pearce and ter Horst 2009) there is considerable linguistic ground to cover. This is problematic, because OSAT designs will not be empowering to the poor if the designs are not accessible in their native language. Encouraging the development of ATs when the designs are only in colonial languages could be seen as perpetuating colonialism (Bgoya 2001).

11 Ibid.

In the move towards large-scale use and implementation of OSATs, language is actually part of a larger barrier of cultural differences in the contributors to OSAT. The gift culture that OS software development utilizes is difficult to create, but important to the success of OS projects. Creating a gift culture within the OSAT community is particularly challenging because it must be created between people with different geographies, cultures, and socio-economic statuses. Wiki sites like Appropedia are not neutral; the development of knowledge on sites depends on a person's culture and identity (Pfeil, Zaphiris, and Ang 2006). It is important, then, that infrastructures set up for sharing OSAT designs address these challenges.

Funding

A difficulty that affects OSAT development most acutely in the Global North is the lack of commitment from universities, governments, private industry, and funding bodies to support research affecting the world's poor. While 10% of the global population lives in sub-Saharan Africa, this region accounts for only 0.5% of the world's gross investment in scientific research (Pardey et al. 2006). Only 1% of drug discoveries by pharmaceutical companies are for tropical diseases (Trouiller and Olliaro 1999), even though the majority of the world's population lives in areas affected by these diseases. If research and development priorities were shifted in order to reflect the needs of the majority of the world's population, the number of researchers in the Global North developing ATs would obviously increase.

Collaboration infrastructure

Even with a shift toward more research regarding AT, the infrastructure in place for sharing and modifying designs affects the ability of a collaborative culture to exit. The first challenge for the current OSAT infrastructure comes in the need for a centralized location. Although the biggest cause for success of open source lies in its widespread diffusion and decentralization, which allows for a free flow of information and integrated collaboration, even software such as Linux/GNU, Apache, and Sendmail would not have materialized so quickly and successfully had there not been a clearly defined set of goals, leadership, and organization (Lerner and Tirole 2002) within a select database to get the projects underway.

This principle is even more important for OSAT, because currently most of the information on AT is scattered without one website or organization standing out as a leader in size and scope. There is clearly a need to integrate all this knowledge into a centralized location which would serve as a "go-to" place where people have the highest probability of accessing and collaborating in the true sense of open source. One of the ways to achieve the critical mass of OSAT participants, as well as raise awareness, is to integrate existing knowledge into one database. This database would serve as the solid base of available knowledge on the topic of AT with an indexed list of projects and data available, as well as projects that need to be developed. Most importantly, its size and scope would allow AT to step out of obscurity. This process of integration could happen through collaboration between currently existing organizations, or develop as a project initiative within a service learning or similar educational enterprise where information can be gathered and classified by students and researchers working on OSAT related projects.

Appropedia hosts the largest collection of OSAT designs and can be examined as the potential database described above. Though it is growing, as discussed above, between 2007 and 2009, the average amount of time that a visitor spends on a page per visit has decreased by 38%.[12] While more users are viewing Appropedia's pages, there are not necessarily more contributions and collaborations occurring. This is consistent with anecdotal evidence that while users are accessing designs on Appropedia, communication, contribution, and collaboration often happen external to the site through email or other online tools.[13] This is similar to Wikipedia, since almost all the content of Wikipedia exists elsewhere and has been organized

12 It should be noted that as the density of useful content on a site increases, the average visit time may decrease because users can more quickly find what they need.
13 Correspondence with C. Watkins, an administrator of Appropedia.

and tabulated for the use of the public. This implies that while Appropedia may serve as a good resource to interested creators, it may not serve the user/developer community in the way that is needed. A space to present new ideas, modify designs, discuss improvements, and monitor other contributions is needed in order to create a gift culture conducive to OSAT design. As discussed above, the community aspect is integral to the success of OSAT. Changes that would make Appropedia more creator-friendly include both trivial changes such as improving aesthetics, as well as deeper changes such as improving applications to upload and modify AT designs.

Business Models for OSAT Development

One way to develop the design content of the OSAT community is to encourage businesses and non-governmental organizations to adopt OS practices when designing ATs. Some view OS design and profit-making to be mutually exclusive. However, examples of successful OS business models exist within the software industry and, to a limited extent, in hardware. These new methods of profit-making can be applied to businesses that create ATs, as well as non-governmental organizations that focus on designing and building ATs.

Service-based model

Some companies focus on a service-based profit-making model. A company may sell a product that was designed openly and make little profit from the sale of the product itself. However, the company then provides technical support and assistance to the users regarding the product. This would require the firm to build recognition in the market. Red Hat is example of such a company; it gives support to the users of the free OS operating system Linux. Although the OS nature of Linux gives users the opportunity to learn about the system themselves, they might not all be proficient in computer programming. These users can rely on Red Hat to provide technical support (Young 1999). Arduino, the microchip manufacturer, is an example of this OS business model outside of software (Thompson 2008). For both of these businesses to be successful, the company must development a "brand" that users trust. The user must be willing to pay the extra money for a service that would provide them with much more value for less time and energy than the user would be able to commit (Thompson 2008). This might present a challenge when the business model is applied to businesses and NGOs that work within AT design in international development.

Franchise model

Geographical boundaries could also be used to promote OS design of technologies. Small companies frequently work in competition with each other, often researching the same topics, hoping to be the first to make an economically relevant discovery. The efficiency of research could be greatly improved if companies opened their research and shared their ideas, thus preventing redundancy. In order to maintain profitability, companies would agree to only sell products within a certain geographic area. Because each firm would have a guaranteed market in which it could sell its products, it would be willing to collaborate with other firms with which it would otherwise be in competition. This is similar to any franchised business, for example the Subway franchise, which gives a start-up Subway geographic exclusivity in exchange for a franchise fee paid to the franchisor. It the case of AT, one large firm could act as the franchisor, or all firms could contribute to a pool of money in order to 'buy in' to the sharing of ideas and designs with other firms, much like a patent pool. This model would be challenging to implement because it might remove incentive for companies to do research and could also be difficult to set up appropriate geographical boundaries that would be profitable for each firm.

Altruistic model

Some firms do not need an alternative method of profit-making. An altruistic model of technology development would involve developers creating technologies that are commercially viable, publishing

the designs openly with no patent, and manufacturing them to sell. The technology in question would be aimed at marginalized groups, so it would be most important for the designer that the products get to the people they are trying to serve at the lowest cost possible. It is then in the designer's altruistic best interest for other firms to use the designs and produce the product for a lower price. This altruistic model may work in some cases, such as non-profits, profit-not-for-profit hybrids, as a public relations mechanism for for-profit companies, and governmental organizations. It could also work in a university setting, where the individual or group receives credit through publishing the work. However, it is not a financially suited for many businesses.

Pure open model

It is important to note that the amount of "openness" that a business uses to design its products is completely dependent on the type of product, the industry, and the market in which it is being sold. Most businesses will likely have a medium amount of open sharing and collaboration within their business strategies and developments, or a mix of some OS development and some closed (Bruns 2001). Some companies may not open much of their IP at all; others may openly publish designs and specifications that are non-essential to their product, but keep their most valued IP private.

The other extreme would be to move a particular industry into a completely open design system. There would be no intellectual property (IP) or trade secrets; companies would share all IP. It is possible that the software industry is shifting in the direction of only OS development (Fitzgerald 2006), and so the possibility of such a shift in other industries could be examined. However, this would require a shift in the way that companies make profits. It would likely require that the industry be heavily government-funded. This strategy would probably need to ensure that public opinion enabled the government to make ATs a priority.

Conclusions

Twenty-five years after the conception of the AT movement, the need for better, simpler, and smarter technology is just as prevalent. However, with the rise of the internet, open source design methodologies, and eco-friendly consciousness, OSAT finally has the right tools and resources to be successfully integrated throughout the world. Combined with the fast and ever improving exchange of information, growth of internet communities, and a global drive for just sustainability, it is clear that OSAT has the potential to be one of the major tools of sustainable development. This paper has shown that both widespread OSAT development and OSAT communities face a number of obstacles to large-scale deployment. However, these can be resolved step by step as the communities interested in such resources begin to gather and share information through specific and reliable centralized sources such as the Appropedia and Ekopedia websites. The critical mass of internet traffic can be accelerated for OSAT to become self-sustaining and scaled following Wikipedia's example, through the use of business models outlined in the paper, which utilize the concepts of service, franchise, altruism, or pure collaboration to drive OSAT development. Further work is needed to assist in implementation of these models in order to rapidly improve the information quality, quantity, and diversity of OSAT knowledge.

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(Footnotes)

1 All data regarding Ekopedia pertain to the French Ekopedia, http://fr.ekopedia.org, the largest of seven language Ekopedia sites in total.