Cooperative Innovation in the Commons:
Rethinking Distributed Collaboration and Intellectual Property
for Sustainable Design Innovation

by

Nitin Sawhney

M.S. Media Arts and Sciences, 1998
Massachusetts Institute of Technology

M.S. Information Design and Technology, 1996
B.E. Industrial Engineering, 1993
Georgia Institute of Technology

SUBMITTED TO THE PROGRAM IN MEDIA ARTS & SCIENCES, SCHOOL OF
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Signature of Author: __________________________________________ Program in Media Arts & Sciences
January 17, 2003

Certified by: _________________________________________________
Alex (Sandy) Pentland
Toshiba Professor of Media Arts and Sciences
Thesis Supervisor

Accepted by: _________________________________________________
Andrew B. Lippman
Chairperson
Departmental Committee on Graduate Students
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ABSTRACT

Addressing global design challenges in the environment and underserved communities requires a cooperative approach towards sustainable design innovation, one that embraces multidisciplinary expertise, participatory design and rapid dissemination of critical innovations in the field. How can a rural farmer in Botswana cooperatively develop appropriate solutions for his community with external research expertise? How can a doctor in Sao Paulo access a network of medical device companies to help manufacture her design innovation? While there is a great emphasis on large breakthrough R&D innovations, there is often little support for developing and disseminating small-scale, affordable, and locally sustainable designs.

The open source phenomenon has been influential in the software community, however distributed collaboration in engineering design requires awareness and sharing of physical artifacts, design tools and working environments as well as novel mechanisms to support social norms, communities of practice, and intellectual property rights for product innovations. ThinkCycle was created as a web-based collaboration platform with tools and shared online spaces for designers, domain experts and stakeholders to discuss, develop and peer-review evolving design solutions in critical domains. Over 2000 users worldwide access and contribute hundreds of concepts, resources, projects and publications on the site. ThinkCycle is emerging as a collaborative platform, open design repository and global community for innovations in sustainable design: [http://www.thinkcycle.org](http://www.thinkcycle.org).

Studies were conducted on the nature of design interaction, learning and intellectual property emerging from studio courses run at MIT in 2001-2002. Cooperative design is best understood when viewed as a “social process”, which is better sustained in online settings by peer-review from remote participants. There is a need for lightweight asynchronous interfaces with existing modes of communication like email. Social inquiry into notions of intellectual property reveal a typology of patterns with distinct forms of protection and disclosure, including patents and open source, adopted under different conditions. However, there is much ambiguity and conflict regarding how to deal with cooperative innovations as they evolve from being subpatentable learning experiments to functional and commercially viable solutions with potentially great social impact. The thesis provides a framework within which we can begin to explore these challenges.

Thesis Supervisor: Alex (Sandy) Pentland
Title: Toshiba Professor of Media Arts and Sciences
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Nitin Sawhney

Thesis Supervisor
Alex (Sandy) Pentland
Toshiba Professor of Media Arts and Sciences
MIT Program in Media Arts and Sciences

Thesis Reader
Bish Sanyal
Ford International Professor of Urban Development and Planning
MIT Department of Urban Studies and Planning

Thesis Reader
Mitchel Resnick
LEGO Papert Associate Professor of Learning Research
MIT Program in Media Arts and Sciences

Thesis Reader
Mark S. Ackerman
Associate Professor, School of Information and Electrical Engineering and Computer Science, University of Michigan
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APPENDIX
1 INTRODUCTION: COOPERATIVE INNOVATION IN THE COMMONS?

How should we create an environment that supports global interdisciplinary cooperation towards open design innovation in critical problem domains? This introduction begins with a strong argument for expanding the scope of cooperative R&D towards sustainable design innovation that supports, what I consider, Universal Human Rights. Lessons from the Appropriate Technology movement suggest the need for local and global cooperation in taking design innovations from concept to market, engaging a broader academic/research community and developing novel models for dealing with intellectual property rights. These three issues remain the core challenges and themes for the thesis: Cooperation, Community and Intellectual Property.

Several global trends in the last decade including networked computing, increasing interest in sustainable development, emergence of the open source movement and rethinking of the "commons", present new conditions today for innovative approaches to solve problems. I believe the convergence of these trends led to the emergence of the ThinkCycle initiative for Open Collaborative Design at MIT, which I co-founded and use as a basis for this thesis work. I describe the primary vision and related initiatives, including the Design that Matters studio courses, development by design conferences and the online collaboration platform. The latter is the primary focus of the thesis, with an exploration of the technical and social challenges involved in developing the collaboration system, examination of its usage by students in studio design courses and the intellectual property issues emerging as a result of the cooperative design outcomes. I conclude the introduction by outlining the key research challenges for this thesis and summarizing the main chapters that follow.

1.1 Supporting Cooperative R&D to Ensure Universal Human Rights

The growing social and environmental impact of current industrial practices and inequity in the everyday lives of the underprivileged, creates a critical condition today for radical and innovative approaches towards sustainable development and design. Developmental economists Amartya Sen and Jean Dreze [1995] have pointed out that the central feature in the process of development should be the “expansion of human capabilities and freedoms”. In their studies in developing countries they have often observed that gains from economic growth are not always channeled into remedying the deprivations of the most needy or necessarily creating employment or social opportunities for all. Their economic theories have been adopted in recent developmental studies by organizations such as the United Nations Development Program (UNDP). The UNDP releases its Human Development Report¹ (HDR) each year, examining the comparative indicators of development in countries around the world as measured by the Human Development Index (HDI). These studies often demonstrate that despite similar income levels reported among many developing countries, factors such as life expectancy and adult literacy remain dramatically different (see figure 1.1). Hence, economic growth alone clearly does not assure human development, equitable access, rights and freedom among all citizens worldwide.

¹ http://hdr.undp.org/

Figure 1.1: This figure from the United Nations Development Program (UNDP) Human Development Report 2000 demonstrates that while two countries such as Vietnam and Guinea may have similar income levels (GDP), the rate of life expectancy and adult literacy may be dramatically different, leading to different levels of human development.
In my opinion expanding human capabilities and freedoms as Amartya Sen proposes, requires a conscious developmental approach that provides greater access to what I believe should be Universal Human Rights, such as clean water, clean air, affordable healthcare, primary education and political participation. These universal human rights can only be addressed effectively if we approach them with values that promote individual aspirations, equity, participation, better environment and socio-economic sustainability. In addition to broad community and developmental programs, I believe that ongoing research and practice towards Sustainable Design Innovation has a strong role to play in making such outcomes attainable in an appropriate and socially relevant manner. Hence, I feel that there is an urgent mandate today to expand the nature and scope of cooperative R&D among academia, industry, government, the nonprofit sector and grassroots innovators worldwide to better address Universal Human Rights.

One way to approach research and design in critical problem domains is by taking advantage of the unique experiences and expertise of individuals in diverse institutions and localized settings. Innovation may emerge by a nexus of individual and cooperative efforts, while distribution and access requires yet another range of mechanisms and channels. How do we ensure that there is sufficient awareness and dialogue among stakeholders, domain experts, researchers and field-organizations to make the design process participatory, the emerging concepts open to peer-review, and the outcomes sustainable and accessible to all? Under what conditions is cooperative design an appropriate means for approaching such challenges? How do we support distributed collaboration, peer-review, learning and dissemination among diverse participants worldwide? What systems, principles and design approaches support sustainable development and design? I now draw upon experiences and lessons from the Appropriate Technology movement and recent global trends, before describing the nature and emergence of the ThinkCycle initiative.

1.2 Papanek and Schumacher’s Vision and the Appropriate Technology Movement

The Appropriate Technology movement was initiated in the 1970’s, inspired by the pioneering work of visionaries like E. F. Schumacher and Victor Papanek. E. F. Schumacher’s seminal book “Small is Beautiful” [1973] provided a critique of the problems of Western economics and outlined his approach towards human-scale, decentralized, and appropriate technologies. Schumacher suggested that the current manner in which society pursued profit and progress promoted large organizations and increased specialization, leading to gross economic inefficiency, environmental pollution, and inhumane working conditions. He proposed a system of “Intermediate Technology” based on smaller working units, co-operative ownership, and regional workplaces using local labor and resources. He believed that ultimately products and capital should serve people rather than the converse, which was more prevalent at the time. His philosophy was often characterized as “economics from the heart rather than from the bottom line”. Schumacher’s book, which sold over 700,000 copies in multiple languages, had a tremendous influence on shaping ideas about self-sufficiency and commonsense economics for many generations.

Victor Papanek has always been a strong advocate for socially responsible design of products and processes. In his book “Design for the Real World”, first published in 1969, he challenged industrial designers and industry to rethink existing design practices within the appropriate social, economic and environmental context, and reconsider their moral responsibility towards human-centered human-scale design. He believed that “the only important thing about design is how it relates to people.” Papanek had a strong background in anthropology as well as in architecture and product design. Papanek traveled around the world giving lecture about his ideas for ecologically sound design and designs to serve the poor, the disabled and the elderly. Papanek created products for UNESCO and the World Health Organization, and provided consultation to the governments of Nigeria, Tanzania, and Papua New Guinea. His declarations on the role of

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2 This terminology should not be confused with the Universal Declaration of Human Rights adopted by member states of the United Nations, in a resolution of the General Assembly on December 10, 1948. Universal Human Rights is a term I use to refer to universally applicable environmental and socio-economic capabilities, rights and freedoms for all individuals that goes beyond the typical Human Rights mandate. In this thesis, the notion of Universal Human Rights serves to motivate an urgent expansion of cooperative R&D initiatives in sustainable technology and design. However, one must recognize that this notion of a “universal” set of human rights in different cultural contexts must be carefully considered.
design in the modern era were based on well-considered explorations into the relationships between people and their tools, particularly among indigenous communities. Papanek believed that design should be "operative" throughout its value chain, i.e. in terms of how the entire process of design to manufacture to distribution is conceptualized in a manner that is socially and environmentally appropriate (using local resources and tools for example). In teaching design he wished to establish "design communes" where there could be greater peer learning across multiple disciplines. He felt that rather than exporting design and products to developing countries, local capacities should be developed by promoting indigenous designers through cooperative seed projects with western designers. Finally, Papanek also felt it was unethical to keep socially valuable design ideas protected, and discouraged patents in such areas.

Many of these principles of socially relevant design, local resources and manufacture, and the ethical spirit of disseminating design innovations were widely adopted by individuals and organizations working in developing countries, that came to be part of the so-called Appropriate Technology (AT) movement. While many design innovations emerged from this movement, it was not influential enough among industry and practitioners to successfully bring these innovations to market. Many feel that the AT movement declined due to a prioritizing of ideological principles over understanding of user needs and market dynamics [Donaldson2002]. For example, "decentralized production" which may have been a worthwhile goal would have been less cost effective or suitable in many areas with poor manufacturing capabilities and existing distribution networks. I summarize here three broad challenges within the Appropriate Technology movement, which I believe can be tackled differently today.

- **Seeking Local and Global Cooperation in Design to Market:** While design innovations may emerge in localized settings, there is a need to work closely with local and global partners in industry, government and the nonprofit sector to ensure production, distribution and deployment of products from concept to market. Many viable designs were never fully produced due to lack of funds and facilities to design, prototype and manufacture a product or dealing with regulations. Many innovations manufactured were not properly promoted, distributed or packaged as consumer products. While the AT movement rejected market-based values and practices, this led to an ignorance of sustainable business models, infrastructure needs, recognition of the complexities of the product lifecycle and the inherent forward/backward linkages over time. Hence, there is a need to support cooperation among diverse entities for venture funding, manufacture, distribution, testing, and marketing to ensure design concepts can be translated into successful consumer products and services operating throughout the value chain.

- **Engaging a Multidisciplinary Intellectual Community:** There has been a lack of engagement by practitioners with the academic and research community to conceptualize, review and rigorously test and evaluate ongoing design solutions. Specialized domain expertise and resources in critical areas can help in the design process, feasibility analysis, evaluation and implementation, particularly for complex products and processes. Novel techniques and materials can provide affordable and appropriate options not considered in field settings. While many AT innovations were sometimes documented in how-to manuals, they were rarely published in academic conferences or journals. Hence there was a lack of communication with researchers and lack of legitimacy given to these locally developed designs and practices, leading to poor dissemination, evaluation and adoption in the mainstream. Lessons learned and failures reported provide valuable insights for future work. Cross-pollination is needed among multi-disciplinary researchers and practitioners both at local scales and global networks.

- **Rethinking Intellectual Property Rights to Ensure Production and Dissemination:** Most AT innovations have generally been subsidized and disseminated freely through how-to publications, however that has given little incentive to manufacturers for producing commercially viable products. One needs to consider what form of protection and
licensing is appropriate for different kinds of innovations, such that grassroots invention is rewarded while useful innovations are manufactured and made widely available.

While many new initiatives continue to emerge today such as Green Design, Eco-Efficiency and Sustainable Design, with somewhat revised principles and ideologies, I believe that the critical challenges outlined above need to be carefully addressed to ensure successful outcomes.

1.3 Revisiting Vannevar Bush’s Memex: Leveraging Emerging Global Trends Today

What if Schumacher and Papanek had met Vannevar Bush, would the Appropriate Technology movement have been more influential? Vannevar Bush a former MIT president and Director of the wartime Office of Scientific Research and Development wrote an article “As We May Think” in the Atlantic Monthly in 1945. In his article Bush urged scientists to turn their energies from war to the task of making the vast store of human knowledge accessible and useful. He also described a concept for a device he called the “Memex”, which operated not much unlike the Internet today:

“Consider a future device for individual use, which is a sort of mechanized private file and library. It needs a name, and, to coin one at random, "memex" will do. A memex is a device in which an individual stores all his books, records, and communications, and which is mechanized so that it may be consulted with exceeding speed and flexibility. It is an enlarged intimate supplement to his memory… If the user wishes to consult a certain book, he taps its code on the keyboard, and the title page of the book promptly appears before him, projected onto one of his viewing positions… It affords an immediate step, however, to associative indexing, the basic idea of which is a provision whereby any item may be caused at will to select immediately and automatically another. This is the essential feature of the Memex… Moreover, when numerous items have been thus joined together to form a trail, they can be reviewed in turn, rapidly or slowly, by deflecting a lever like that used for turning the pages of a book. It is exactly as though the physical items had been gathered together from widely separated sources and bound together to form a new book.”

Bush goes on to say, “Wholly new forms of encyclopedias will appear, ready made with a mesh of associative trails running through them, ready to be dropped into the memex and there amplified. The lawyer has at his touch the associated opinions and decisions of his whole experience, and of the experience of friends and authorities. The patent attorney has on call the millions of issued patents, with familiar trails to every point of his client’s interest. The physician, puzzled by a patient’s reactions, strikes the trail established in studying an earlier similar case, and runs rapidly through analogous case histories, with side references to the classics for the pertinent anatomy and histology. The chemist, struggling with the synthesis of an organic compound, has all the chemical literature before him in his laboratory, with trails following the analogies of compounds, and side trails to their physical and chemical behavior.”

Bush’s vision was a kind of precursor to the networked technologies of the Internet and far more. He predicted random access, association (linking), commenting, capturing, search and so on. Much of the Internet still remains a one-way broadcast medium, however with personalized and collaborative technologies it is beginning to be transformed into a true “memex”. Perhaps if Schumacher and Papanek had known about the memex, they might have considered a means to expand their vision to interconnected evolving knowledge thriving from a networked global community. In his article Bush remarked, “Science may implement the ways in which man produces, stores and consults the record of his race.” I believe this convergence of critical ideas from Schumacher, Papanek and Bush shaped the nature of the ThinkCycle initiative. Three global trends emerging in the 1980’s and 90’s provide what I feel are unique conditions today for novel approaches to the key challenges of Appropriate Technology mentioned earlier:

- Emergence of Distributed Online Communities and Networked Computing
- Increasing Global Dialogue on the “Digital Divide” and “Sustainable Development”
- Bold New Movements around Intellectual Property in the Public Domain

These ongoing trends (discussed in more detail in chapters 2 and 3 of this thesis), which implicitly highlight the key issues of cooperation, community and intellectual property, I believe led to the emergence of the ThinkCycle initiative at MIT in 2000-2002.
1.4 ThinkCycle: A Cooperative Culture of Socially-Conscious Design Innovation

How does one design better water filters for the 1.7 billion people lacking access to clean water, simplified IV treatment devices for cholera patients in refugee camps, low-cost prescription eyewear for communities in Africa or temporary shelters for disaster relief? How can a rural farmer in Botswana work with students and domain experts in universities like MIT to cooperatively develop appropriate solutions for his or her community? How can a doctor in Sao Paulo gain access to a network of medical device companies to help manufacture and disseminate his design innovations widely? While there is a great emphasis on large breakthrough R&D innovations, there is often little support for developing and disseminating small-scale, affordable and locally sustainable designs, which have impact in critical areas. In my view, it is possible to use networked technologies and distributed collaboration to improve the way existing market mechanisms, academia and government organizations address critical design challenges in underserved communities and the environment.

1.4.1 Open Source and Distributed Collaboration

The networked medium of the Internet lowers the technical barriers for distributed collaboration, however there are many challenges for sustaining cooperative social enterprise towards product innovation across institutional boundaries. Recent trends in the “open source” movement suggest that many benefits can be derived from sharing design knowledge, and allowing an “open” evolution of design based on public peer-review and contributions from diverse participants. Eric Raymond [1997], in an article3 characterizing the evolution of open source software like Linux, pointed out the importance of a large base of distributed users who help improve the design outcomes much more rapidly but also become indispensable co-developers, if “properly cultivated” during the design process.

This “Bazaar view” of software development relies on the fact that each co-developer due to their unique background and interests, views the problem with a “slightly different perceptual set and analytical toolkit”. This approach is particularly valuable in complex problem domains where expertise cannot easily be found in any one institutional setting, and a wider design exploration of many simultaneous design alternatives and approaches is necessary. How should one support open source collaboration for sustainable design challenges in product engineering? Is it an appropriate approach in product innovation? While the open source phenomenon has been influential in the software community, distributed collaboration in knowledge-intensive engineering design requires widely accessible online design tools as well as novel mechanisms for supporting field deployment, intellectual property rights and product commercialization. In chapter 2 of this thesis I will re-examine the open source methodology in the context of both software and product design, and consider the challenges for transferring this notion of peer production to the design domains.

I believe that there is a genuine need for developing novel collaborative platforms while creating a culture of sustainable design innovation among institutions around such problem domains. Over a period of three years since 2000, I helped establish ThinkCycle4 as an MIT-wide initiative, which seeks to support Open Collaborative Design for sustainable solutions to challenges in the environment and underserved communities, with active participation of universities and organizations worldwide. In this thesis, I undertake a closer examination of these assumptions by evaluating the role of collaboration, learning and intellectual property rights for sustainable design initiatives.

3 http://www.tuxedo.org/~esr/writings/cathedral-bazaar/cathedral-bazaar/
4 http://www.thinkcycle.org
1.4.2 ThinkCycle and Design that Matters: A Brief History

In March 2000, along with several graduate students at the MIT Media Lab, I proposed ThinkCycle as an initiative to enable "open source problem solving" among university students everywhere and underserved communities. A key part of the initiative was to create an online database of well-posed problems and evolving design solutions. This would be designed to facilitate exchange, raise awareness and harness the expertise of students towards real-world and appropriate design of technology for their communities and the environment. However, it became clear that we first needed to encourage a culture of socially conscious design in the university.

In February 2001, in consultation with Media Lab professor Mitchel Resnick, we initiated a pilot design studio course at MIT appropriately titled "Design that Matters"\(^5\), as a novel experiment to devise a pedagogical approach that would seed challenges and design solutions for the initiative. The goal of the studio course was for students to solve "real-world" design challenges posed by non-governmental organizations (NGOs) working in underserved communities. The studio brought together students from across MIT and Harvard, with notable speakers from around the world to focus on problems like access to clean water, human generated power, bilingual language learning, low-cost health treatment and adaptive eyewear. Student teams built working prototypes with peer review from domain experts and documented their evolving designs using an experimental online collaboration platform. This studio was conducted at the MIT Media Lab in spring 2002, producing several award winning design outcomes\(^6\) such as a passive incubators for infants in Sri Lanka and ceramic/bio-sand household water treatment systems in Nicaragua.

In April 2001, I began development of the ThinkCycle online collaboration system built on top of an Oracle database and web-based platform. The system was iteratively designed with feedback from students in the course. An early version of the site was introduced in May 2001 for students to use in documenting their projects online. Over 16 months of development, the system has been extended with many collaborative features and performance improvements to make it a robust and usable online design platform. The system architecture, design and development is described in detail in chapter 3 of this thesis. As of January 2003, ThinkCycle has been used by over 2000 individuals in universities and organizations worldwide, to browse and contribute hundreds of design content/resources in over 45 critical topic domains. ThinkCycle continues to grow as a distributed community and open public domain site to support ongoing cooperative efforts, peer review and global dissemination of innovative ideas in sustainable design.

1.4.3 “development by design”: Towards a Global Design Network

On the heels of the ThinkCycle initiative, I co-organized an international workshop at MIT called development by design\(^7\) (dyd01) in July 2001, which brought together experts in developmental innovation and sustainable design from all around the world. This was established as a peer-reviewed workshop with technical papers submitted online by all participants in diverse domains of interest, ranging from design of appropriate technologies, novel educational models, environmental solutions, open source innovation in rural settings, low-cost mobile/internet technology and so on. All papers were submitted, peer-reviewed and archived in a digital publication library developed on ThinkCycle. With over 100 participants from US, Europe and developing countries such as India, Brazil, Kenya and Nepal, the workshop provided a unique forum for a critical discourse on sustainable design and technology.

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\(^5\) http://www.media.mit.edu/~nitin/thinkcycle/
\(^6\) http://www.mit.edu/~ideas/winners.html
\(^7\) http://www.thinkcycle.org/dyd
The 2\textsuperscript{nd} event, \textit{development by design 2002}\textsuperscript{8} (dyd02), was established as an international conference in Bangalore, India, December 1-2, 2002, in conjunction with Media Lab Asia, the MIT Alliance for Global Sustainability (AGS), Indian Institute of Sciences and Srishti Schools of Art, Technology and Design. It was held in cooperation with the ACM SIGCHI, ICSID, Infosys Technologies and Concept Labs. I served as the program co-chair for the conference, ensuring that we could develop a strong and compelling technical program. Over 120 papers were submitted and peer reviewed online on ThinkCycle, by an international program committee as well as the general public.

Nearly 200-300 participants from around the world attended the conference in Bangalore, along with invited experts and panelists. The 3-day event included pre-conference workshops, panel and paper sessions as well as informal participative events. Printed proceedings for the conference will be released in 2003 with selected papers, workshop summaries and thematic editorials. The next dyd conference will be held in Sao Paulo, Brazil in 2004. Hence the conferences continue to expand to develop a community of interest among academia, industry and the nonprofit sector. I believe such forums are critical to maintain genuine interest and establish greater legitimacy for design innovation in emerging areas of research and practice.

Both the \textit{Design that Matters} studio course and dyd events have both emphasized that the critical challenges of sustainable development and the environment must continue to be addressed by meaningful collaboration among various institutions. Expanding the pedagogical emphasis for sustainable design is critical among universities everywhere. In 2002 we encouraged faculty and students at several universities around the world to develop similar design studios, run in conjunction with the MIT Design Studio. Faculty in Bangalore, Lisbon, Sao Paulo and Nairobi proposed to conduct their own Design that Matters courses. Each studio would be run in a unique manner with participation of local organizations and potential collaboration among the schools. The following initiatives were setup as part of the \textit{Global Design Network}\textsuperscript{9} in 2002:

\begin{itemize}
  \item \textit{Design that Matters (DtM02)}\textsuperscript{10}, Cambridge, USA
    Massachusetts Institute of Technology
  \item \textit{Learning from Grassroots Innovators}\textsuperscript{11}, Bangalore, India
    Srishti School of Art, Design & Technology, Indian Institute of Sciences (IISC), and National Innovation Foundation
  \item \textit{Collaborative Design Studios}\textsuperscript{12}, Lisbon, Portugal
    GASA-FCT-UNL, New University of Lisbon and IST, Technical University of Lisbon
  \item \textit{Engineering Design for Development}\textsuperscript{13}, Nairobi, Kenya
    University of Nairobi with Numerical Machining Complex (NMC) Ltd.
  \item \textit{Social Design Studio}\textsuperscript{14}, Sao Paulo, Brazil
    University of Sao Paulo with network of local organizations
  \item \textit{ThinkCycle Student Initiative}\textsuperscript{15}, Pittsburgh, USA
    University of Pittsburgh and Carnegie Mellon University
\end{itemize}

\begin{figure}
\centering
\includegraphics[width=\textwidth]{logo.png}
\caption{The logo for the 2\textsuperscript{nd} international “development by design” conference. The logo was designed by Surabhi Prasanna in Bangalore.}
\end{figure}

\textsuperscript{8} http://www.thinkcycle.org/dyd02
\textsuperscript{9} http://www.thinkcycle.org/global-dtm
\textsuperscript{10} http://www.thinkcycle.org/dtm
\textsuperscript{11} http://cpdm.iisc.ernet.in/dtm.htm
\textsuperscript{12} http://gasa.dcea.fct.unl.pt/thinkcycle/index2.asp
\textsuperscript{13} http://www.thinkcycle.org/global-dtm/edd_abstract.pdf
\textsuperscript{14} http://www.cidade.usp.br/sds/
\textsuperscript{15} http://www.pitt.edu/~mab77/tcyclepgh.htm
Of these initiatives, the studio courses at MIT and Bangalore were formally conducted in 2002. The design studios conducted at MIT in 2001 and 2002 have been evaluated (described in chapter 4), along with learning outcomes and usage patterns of the ThinkCycle platform.

1.5 Thesis Research: Cooperation, Community and Intellectual Property

The key research challenges for this thesis work can be summarized as follows:

A. Architectures for Distributed Cooperation: What is the role of online collaborative platforms for distributed design and problem solving in critical domains? How should an online platform be developed to support diverse geographically dispersed communities, with distinct cultural and social norms or varying levels of bandwidth and connectivity? How can a platform be structured to deal with diverse problem domains and communities of interest, and made robust and scaleable for thousands of participants worldwide? It has been challenging to develop a comprehensive online system and design appropriate interaction mechanisms for distributed collaboration. In chapter 2, I describe the rationale for considering distributed collaboration and the open source approach, as well as the potential limitations. In chapter 3, I describe the design evolution of the ThinkCycle platform and closely examine the technical and social challenges for developing and sustaining it. In chapter 4, I examine the nature of online design collaboration, usage patterns and social issues emerging on ThinkCycle, based on a study I conducted.

B. Supporting Communities of Practice: While an online system and collaborative tools provide the “infrastructure” for cooperation, productive social interaction emerges when the appropriate incentives, norms and conditions are in place. What are the social and technical conditions that support distributed communities? What is the nature of social interaction in online settings like ThinkCycle? Do participants interact as a unified “community” or diverse “social collectives” with distinct and often conflicting interests? How do communities of practice in physical settings differ from those emerging online? What is the nature of social incentives and peer learning in online cooperative design? I examine these questions in chapters 2 and 3, while discussing the open source movement and existing online communities. I also examine the nature of community interaction and social norms emerging on ThinkCycle in chapters 3 and 4, based on my experience developing the online platform and from surveys and interviews conducted.

C. Rethinking Intellectual Property Rights: The outcomes of individual or cooperative design may yield intellectual contributions that are beneficial to disseminate. During two years of studio projects and online interactions on ThinkCycle, several design innovations have been documented and continue to evolve with ongoing peer review. What is the manner in which participants deal with their intellectual property rights (IPR) in terms of sharing, protection and dissemination of individual or cooperative efforts? Under what conditions do innovators adopt open source, patents, public or proprietary disclosure of ongoing designs? What social incentives and online mechanisms support diverse forms of IPR solutions? I examine prior work on IPR in chapter 2 and discuss results from a sociological inquiry with participants engaged in projects on ThinkCycle in chapter 5.

Thesis Summary: The thesis begins with a discussion of the nature of distributed cooperation and property rights (chapter 2), particularly for sustainable design innovation in online settings. I then describe the development and design of the online collaboration platform (chapter 3), and social and technical lessons learned in the process of development. I discuss the results of a study (in chapter 4) conducted with design courses in 2001 and 2002, examining the nature of design cooperation, learning and usage of the online collaboration platform. I also describe a follow-on study conducted on intellectual property rights (chapter 5), which examines the sociological rationale for innovators and teams in negotiating the nature of protection and dissemination of their design innovations. I suggest several recommendations and concrete mechanisms for dealing with diverse approaches to intellectual property in online settings. Finally, I conclude (in chapter 6) with the key challenges, lessons learned and research directions for future work.