Collective Systems for Creative Expression

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Abstract

This thesis defines *collective systems* as a unique category of creative expression through the procedures of micro and macro cycles that address the transition from connectivity to collectivity. This thesis discusses the necessary technology, context, and terminology, and provides a conceptual structure for the execution, discussion and evaluation of these procedures. This is supported through discussing the author's contribution to the OPENSTUDIO project and the Open I/O system.

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Collective Systems for Creative Expression

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Chapter 1

Introduction

With the rise of the Internet our culture has undergone a new change that has put the transformation of the post-industrial society into a new phase. The widespread adoption of networked personal computers and devices and the speed and the flow of information on digital networks have transformed existing value systems, ethics, power structures, production procedures, and creative processes. For a very long time, human tools for creative expression have supported the solitary creator. However, today we humans live in a world where ubiquitous connectivity transforms our abilities to sense, act, and delegate intention to large collections of machine and human actors. This thesis explores new creative processes, facilitated by new creative tools, that can and will arise in this new context. I call these tools – and the processes they support – "collective" systems.

Our networked informational milieu is also being dominated by the contemporary capitalism that is the continuation of the post-industrial society. Maurizio Lazzarato's definition *immaterial labor*[25], as the labor that produces the informational and cultural content of the commodity, is becoming more visible with the techno-cultural production in our electronically mediated society[25]. For Lazzarato the concept of immaterial labor combines two different aspects of labor:

> "On the one hand, as regards to the 'informational content' of the commodity, it refers directly to the changes taking place in worker's labor process... where the skills involved in direct labor are increasingly skills involving cybernetics and computer control. On the other hand, as regards the activity that produces

> 'cultural content' of the commodity, immaterial labor involves a series of activities that are not normally recognized as 'work'—in other words, the kinds of activities involved in defining and fixing cultural and artistic standards, fashions, tastes, consumer norms, and, more strategically, public opinion."[25]

This idea of immaterial labor has is rooted in the shift of work from factory to society[1]. Today, if we look at our everyday experiences, we can see that this theory is becoming more tangible. We use computers for both work and leisure. This situation not only transcends already the old dichotomy of "manual and mental labor", but also blends the division between work and leisure time. In front of a computer, our attention switches from work to leisure and back again in no time. During the day, in this blend of work and leisure, we not only browse things on the web but also actively contribute to various information aggregation systems from website statistics to search engines, increasing the value of advertising sales or the quality of search algorithms. We also post our ideas about a new product on our blog or forward them to our friends by adding our own comments and stories. We contribute to an *ideological sphere* for the products and consumers to live in. We produce cultural content as part of the immaterial labor, and this translates into value for the capital. But we do not get any return. With today's the electronic coordination of information flow, this exploitation of the techno-cultural labor generates more value than it has generated in the post-industrial capitalism of the late 20th century.

On the other hand, as open source development communities have been demonstrating, we can collectively create value independent from the capitalist control. For example, the Debian community develops an operating system consisting of a basic set of programs that work well, and are always evolving to meet various user needs. Hundreds of developers are patching and fixing bugs and this is generally considered better then a dedicated team of debuggers in a corporation. While the majority of open source software projects simply offer *free versions* of commercial software, there are innovative initiatives that leverage the collective sprit in the arts communities. For example, *Runme.org* software art repository is building a discourse for software art with the contributions of people

[1] This is also called the "Social Factory" by the Italian autonomists Paolo Virno and Antonio Negri.

from all over the world. Similarly the *Processing* development community builds software libraries for artists and designers, and teaches programming in the context of media arts.

While these projects are harbingers of a new transforming creative opportunity, how can we intensify and redirect our collective cultural production to a territory that is formed more by individual's free-will than capital? Acknowledging that the relation of the creative expression to social processes is as important as the materials, processes, and products, this thesis investigates the process of creative expression that comes out of immaterial production in electronically mediated social cycles.

1.1 Motivation

The concepts and experiments presented in this thesis as *collective systems for creative expression* emerged from the desire to experiment with new methods of expression that are relevant to current social, economic, technological, and cultural conditions. My strategy has been to view these as systems and to articulate the complex relationships among them. These relationships may then become contexts for building new systems for cultural production. I became interested in building systems that enable this collectivity for creative expression:

- by understanding the idea of art product as a system started in the 1960s and 1970s,
- inspired by the idea of openness of the work through interaction and participation,
- and examining today's electronically connected techno-cultural production environment.

Today, our contemporary machines are more abstracted than ever. On the Internet, we use multiple machines to store, process, and transmit massive amounts of information. As our everyday communications are increasingly mediated by the Internet and networked computers. People's activities woven into these processes and data in an unprecedented scale.

More than a century ago, Karl Marx identified the increasing importance of machinery in social organization as the *general intellect.* Cultural theorist Tiziana Terranova points out:

> "They [Italian autonomists] claimed that Marx completely identified the general intellect (or knowledge as the principle productive force) with fixed capital (the machine) and thus neglected to account for the fact that the general intellect cannot exist independently of the concrete subjects who mediate the articulation of the machines with each other. The general intellect is an articulation of fixed capital (machines) and living labor (the workers). If we see the Internet, and computer networks in general, as the latest machines–the latest manifestation of fixed capital–then it won't be difficult to imagine the general intellect as being well and alive today."[49]

This general intellect also corresponds to *collective intelligence* when its critical relation to capital is removed. The promise is that this electronically mediated environment can enable us to build a collective intelligence that will help us solve all the problems of humanity. However, as Terranova puts it "Knowledge labor is inherently collective, it is always the result of a collective and social production of knowledge. Capital's problem is how to extract as much value as possible out of this abundant, and yet slightly intractable, terrain"[49].

Existing systems for aggregating collective intelligence are more about creating this ideological environment / knowledge base for consumers and products and services of capital to rely on. Then, under these conditions, we can design custom collective systems that form alternative ideological spheres. But what are the qualities of these systems that involve social interactions? As Pierre Lévy puts it "How can we progress from the murmur of the crowd to a chorus?"[26]

1.2 Defining the Problem

Through further defining the concept of collective systems for creative expression, a foundation is constructed for discussion and evaluation in respect to current conditions and related disciplines. In this section, I will discuss openness and dynamics systems of collective systems.

1.2.1 Openness in Collective Systems

Today we leave traces of information through all our activities on the Internet. Most of these systems are built by corporations such as Google, Yahoo, etc. For example, every time we search something on a search engine, the search algorithm gets better because it is built to incorporate the data generated by activities. The aggregated information in these systems contributes to a big part in their overall revenue, either through direct advertisement or through the improvement in the quality of the services. For example, the aggregated data helps the Yahoo developers see the usage patterns and create better interfaces that filter and show the information based on users' identities. While these improvements are attracting more consumers, users that unknowingly contribute to this improvement just get another product or service to consume rather than a benefit. As discussed earlier, this exploitation is an important source of the growth of the capital of these corporations. Furthermore, in these capitalist systems, the data collected from people are not open for independent interpretation. The aggregated data that is only analyzed by companies themselves do not allow healthy synthesis of everyday human activities.

To better understand the openness of a system, I have created a scheme that guides the development. In this diagram openness has three main parts: spatial, temporal, and spatiotemporal. The spatial part corresponds to the openness of the source code or procedure of the technology. The temporal part corresponds to openness in time, that is systems that live and grow in time. The spatiotemporal part has three parts that correspond to openness of the aggregated and analyzed data, openness of relations with other systems, and openness in the modification of the system – copying, reusing, remixing, or mashing-up.

Creative expression through collective systems is, in a way, the expression of the "general intellect" that is described earlier. If we can free the general intellect from the closed systems, we can boost a radically new form of democracy and a public sphere that is directly opposed to political monopoly.

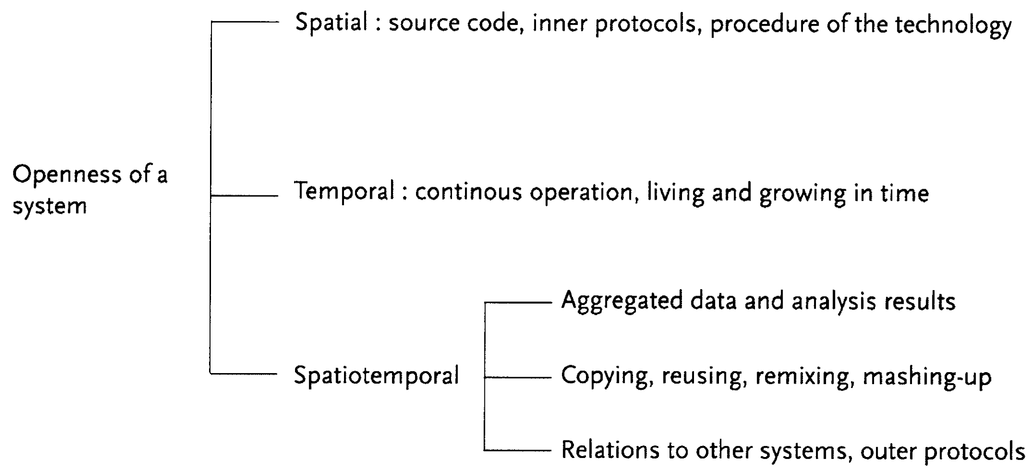

Figure 1-1: Openness scheme for systems

1.2.2 Dynamics of Collective Systems

In this thesis, I argue that to channel our everyday connectivity into a collective activity, two scales, *micro* and *macro* cycles, are needed that will synthesize our activities and cultural production. Collective systems in the context of this thesis combine two continuous cycles. These cycles address the transition from connectivity to collectivity.

Micro Cycle

The micro cycle happens amongst participants and the system. This cycle has five characteristic features: connectivity, activity, aggregation, analysis, and synthesis.

- *Connectivity* is at the core of the collectivity. People are connected to each other through computer networks.
- *Activity* happens when people communicate, exchange and so on. It can be synchronous or asynchronous.
- The interactions between people and the generated data from these interactions are *aggregated* in relational databases.
- The aggregated data is then *analyzed* and some patterns or meanings are extracted.

- Finally, these results are returned to people for reinterpretation and *synthesis*.

This whole cycle is called micro cycle because it happens in massive number of times in a short period of time. The qualities of this cycle first affect the motivation of the individual, and secondly the individual's synthesis of the information flow in the system.

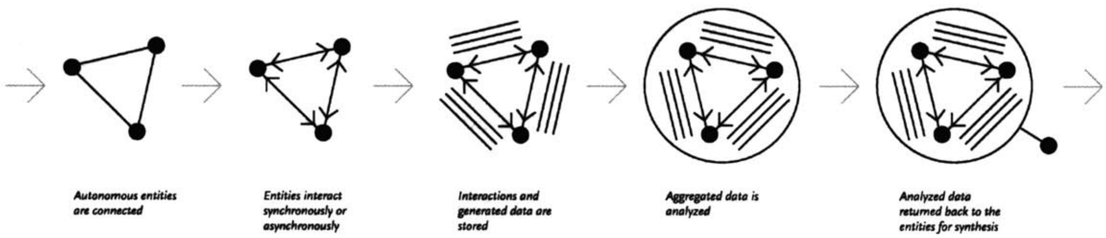

Figure 1-2: Micro Cycle

Macro Cycle

Macro cycle follows this procedure:

- Stay connected with loose activities.
- Let a goal emerge from these activities.
- Take collective action to accomplish this goal.
- When the goal is accomplished, relax and hold on to loose activities until you perceive another goal.

The macro cycle happens slowly in long period of time. Keeping loose connections enables people to be up to date with contexts, so helps them to easily concentrate on events and goals when a collective action is taken. The relaxation period is for digesting the results of the achieved goals. In a way, a macro cycle enables a slower and deeper synthesis. The features of the macro cycle determine the emergence of purpose through the activities. Qualities of the macro cycle are global properties that may or may not be directly perceived by the participants, but these qualities affect their behavior.

Micro and macro cycles together form systems for collectivity. These systems always need context for activities. In this thesis contexts are creative expression, economic relationships, and device compositions.

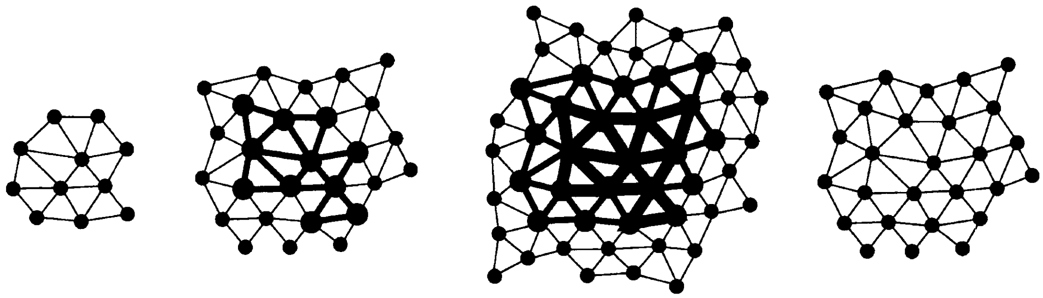

Figure 1-3: Macro Cycle

1.3 Summary of Contributions

The general methods of collective systems discussed in this thesis are extracted from the experiments I have done for the last two years.

- *A recipe for collective systems* — The procedures for micro and the macro cycles are extracted from the experiments as a guide for building and nurturing such systems.
- *OPENSTUDIO* — An actionable space for artists to experiment with the economy and the phenomenon of the immaterial labor. As an up and running system, OPENSTUDIO evolves, and its participants build an alternative ideological sphere.
- *Open I/O* — A combination of an Internet based peer-to-peer device communication application, a software service, and a database that enables programming, running, and maintaining device communications through social interactions.
- *Pinkie* — An electronics prototyping board for quick prototyping electronic compositions that are connected to the Internet and work in relation to the Open I/O system.

1.4 Thesis Structure

The rest of this thesis is divided into four primary sections: background, experiments, analysis and discussion, and conclusion. The purpose of the background section is to highlight the history for collective systems and creative expression. The experiments section reviews the path of my work from its origins in interactive software to more contemporary work in collective systems. This work is discussed and explained in relation to its concepts and implementation. In the discussion and analysis section, themes found in the diverse experiments are presented in relation to both the background and the concept structure of collective systems for creative expression. Both the system and perceptual critique of the work are discussed in this chapter. The conclusion reviews these topics and poses questions for the future.

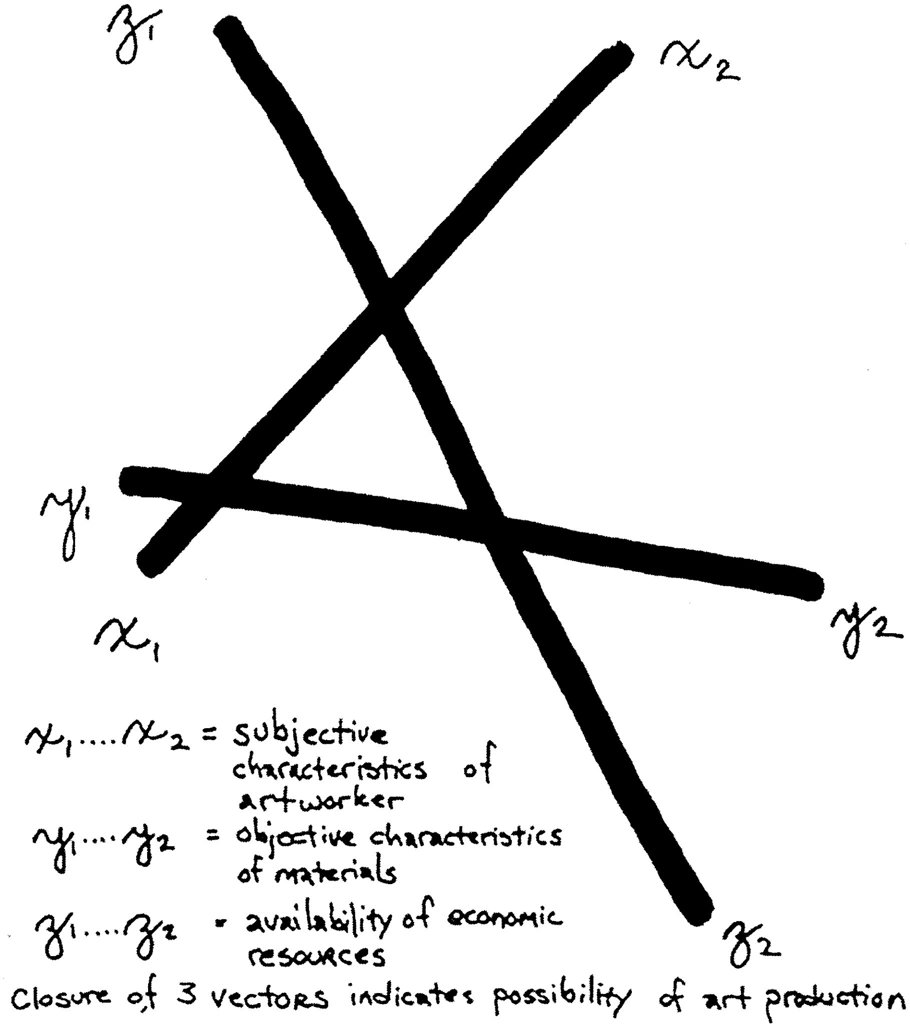

Figure 1-4: Carl Andre. *Three-Vector Model*, 1970

Chapter 2

Background

The concepts and technologies used in development of the projects in this thesis build upon many histories and disciplines. By looking at the transformation of the artistic production from the 1960s to today, we give a direct context in which to place the work presented in this thesis. From *complex systems*, we learn about the common structures of social, economic, and communication networks, and about analysis methods for these systems. From *collective systems*, we learn about advanced methods for creating systems that enable collectivity and about collectivity as a model for computer mediated communications and creative production. These areas utilize people, software, hardware, and communication technologies and give important perspectives to unify the idea of collective intelligence in creative process. Discussion and examples highlight concepts and objectives of each discipline.

2.1 The Shift of the Artistic Production

In this section, beginning from the 1960s, I will look at artists' products that are presented as aesthetic systems rather than objects, then I will focus on how interaction and participation lead to the idea of openness in the artwork, and finally I will look at the Internet and computer mediated artistic production to understand the qualities explored by net.artists.

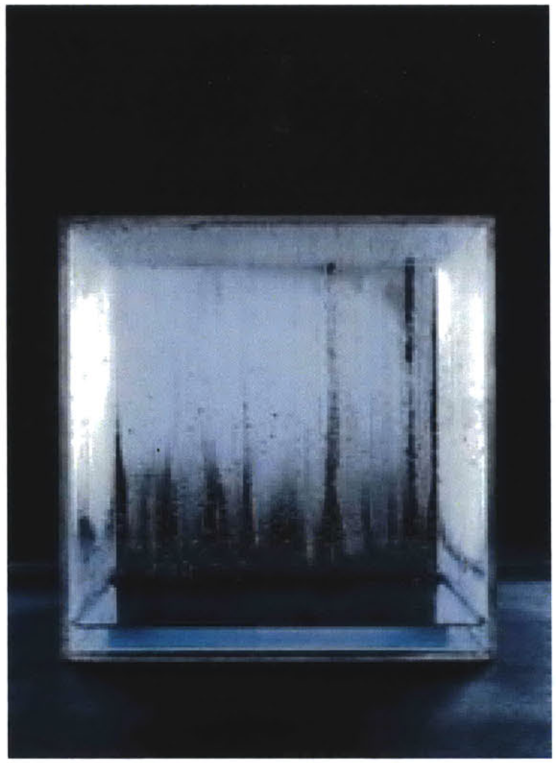

Figure 2-1: Hans Haacke. *Condensation Cube*, 1963

2.1.1 From Object to System

In the 1960s and 1970s, artists reacted against art's traditional focus on the object by adopting experimental aesthetic "systems" across a variety of media[42]. They moved out of the studio in an attempt to be more responsive to the world. Generative and repetitive systems were explored as a way of redefining the nature of representation. Artists started to view the work of art as equivalent for lived experience. They situated their work in real time and space, asking viewers to experience the artwork as something that could be perceived as an aesthetic system. In 1970 the art critic Jack Burnham wrote: "Traditionally, artworks exist in 'mythical time,' that is an ideal historical timeframe separated from the day-to-day events of the real world. Some systems and conceptual artists, such as Haacke, attempted to integrate their works in the actual events of the 'real world,' that is the world of politics, money-making, ecology, industry, and other pursuits."[12] In 1965 Hans Haacke created the *Condensation Cube* that continually changes and reacts to its environment. The movement in *Condensation Cube* is created by continual cycle of evaporation and condensation on the surface of the Plexiglas box. Haacke's *Condensation Cube* was just one of those works that combines technology and organic processes to make visible the order of nature.

2.1.2 Interaction, Participation, and Networking

Figure 2-2: Nam June Paik. *Exposition of Music Exhibition*, 1963

The 1960s and 1970s was also the beginning of the idea of openness in the work of art. In 1957 Marcel Duchamp asserted that every aesthetic experience assigns a constitutive role to the spectator, who in the process of viewing "adds his contribution to the creative act."[15] The notions and concepts of interaction, participation and communication were central to the artists of the time. With the *Exposition of MusicElectronic Television* festival staged in the German city of Wuppertal in 1963, Nam June Paik drafted a first blueprint for viewer interaction with the electronic television picture. Using devices such as a microphone or magnet, the several versions of *Participation TV* (1963 1966), which was

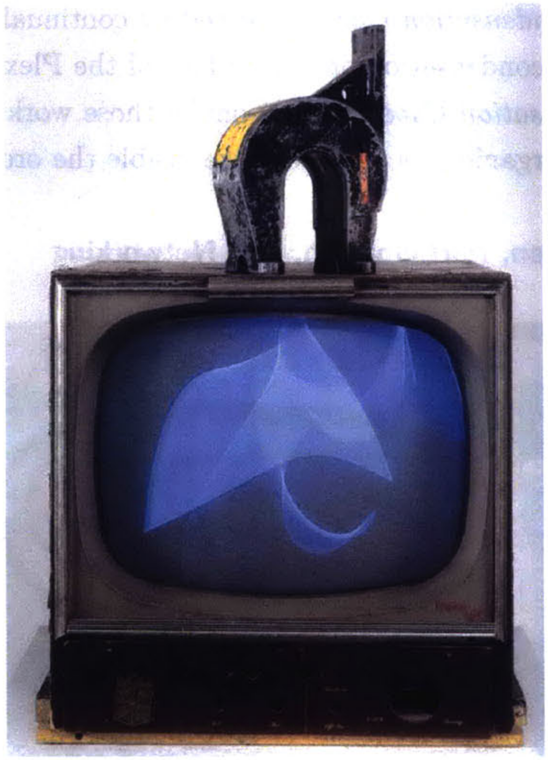

Figure 2-3: Nam June Paik. *Magnet TV*, 1965

first presented at the festival, and of the later *Magnet TV* (1965) allow the viewer to produce oscillating patterns on an electronically modified TV screen.[4] In the 1970s Douglas Davis, a pioneer in the artistic use of television and radio, aimed to establish explicitly dialogical communication situations through new telecommunications media. The goal of his action pieces was to overcome traditional, one-sided communication practices through personified interactions.

In these years, collaboration between artists was happening in various forms. When Jean Tinguely was installing his *Construction No 1 (Homage to New York)* in Museum of Modern Art in March 1967, he invited New York artists to contribute to sculpture that would destroy itself. Billy Klüver was finding all sorts of machines and bicycle wheels that Tinguely needed, Robert Rauschenberg for example contributed with his object called money-thrower[1]. This show "The Machine as Seen at the End of the Mechanical Age" was organized by Experiments in Art

[1]The Machine as Seen at the end of Mechanical Age. The Museum of Modern Art, 1986, New York.

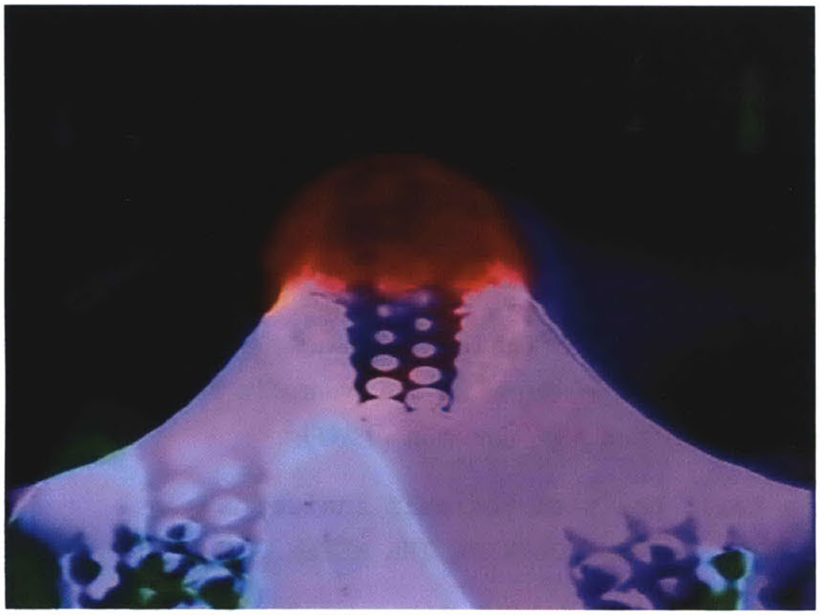

Figure 2-4: Nam June Paik. *Participation TV*, 1966

and Technology (E.A.T) that was founded in 1966 by engineers Billy Klüver, Fred Waldhauer, artists Robert Rauschenberg and Robert Whitman. This international organization's goal was to try to establish a better working relationship among artists, engineers, and industry. They were aware of the fast developing technology at the time, and they wanted to abolish the determinist notion that technology develops independent of the people who work with it[2].

Fluxus, starting from early 1960s, has been a unifying movement for openness and participation in which artists in various ways associated themselves and did work in diverse media. Among its associates were George Brecht, Dick Higgins, La Monte Young, Nam June Paik, Joseph Beuys and Yoko Ono who explored media ranging from performance art to poetry to experimental music to film. They took the stance of opposition to the ideas of tradition and professionalism in the arts of their time. In his essay "Child's History of Fluxus," Dick Higgins mentions that in the beginning of the Fluxus, artists started to ask these questions: "Why does everything I see that's beautiful like cups and kisses and sloshing feet have to be made into just a part of something fancier and

[2]The Machine as Seen at the end of Mechanical Age. The Museum of Modern Art, 1986, New York.

bigger? Why can't I just use it for its own sake?"[3] Throughout the 1960s and 1970s artists close to the Fluxus staged "action" events, engaged in politics and public speaking, and produced sculptural works featuring unconventional materials. Unity of art and life was one of the key ideas that has been developed in the Fluxus movement. The conscious goal was to erase the boundaries between art and life. This is manifested in Beuys suggestion that "everyone is an artist" and with the term he coined "social sculpture"[4]. One of the important developments emerged from these ideas was to write recipes for the events. In 1961 Nam June Paik wrote the *Composition for Poor man (1961)*:[5]

```
Summon a taxi, position yourself inside,
request a long ride, OBSERVE THE METER.
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In the summer of 1961 Yoko Ono wrote the *Painting for the Wind*:

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Cut a hole in a bag filled with seeds of any kind
and place the bag where there is wind.
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The works associated with Fluxus contributed to the openness of the art work by not only making pieces or organizing events open to public but also encouraging everybody to make art by changing the perspective about high and unreachable art of that time. In this sense, mail art, art which uses the postal system as a medium is associated with the ideas discussed in the Fluxus circles. This idea of sending and receiving art through the mail system is probably still active today. Artists were experimenting with the communication technologies opening up the artwork by participation and interaction even before the Internet.

In the 1980s and 1990s, while the development of electronic communication technologies were enabling new experiments for participation and collaboration, it was also getting more complex and moving away from the artists as pointed out by the E.A.T earlier. Techniques and methods were in a way possible to discover but the inherent complexity of the technology was getting more abstract and invisible. Artists kept incorporating various technologies in their work

[3]Dick Higgins. A Child's History of Fluxus. First published in 1979 in Horizons: The Poetics and Theory of the Intermedia, 1979. http://www.artnotart.com/fluxus/dhiggins-childshistory.html

[4]http://www.artnotart.com/fluxus/kfriedman-fourtyyears.html

[5]Fluxus Archives at http://www.artnotart.com/fluxus/archives-alpha.html

and created pieces in which people can participate. The notions of telematics and telepresence began to gain importance for some artists in the late 1980s. Oliver Grau described the telepresence as something that allows the viewer parallel experiences in three different spaces at once:

> "(1) In the 'real' space in which the viewer's body is physically located; (2) per tele-perception in the 'virtual', simulated visual space reproducing a fictional or real, remote visual sphere; and (3) per tele-action at the physical location of the 'data' work or even of a robot controllable over one's movements or equipped with a sensory apparatus over which one can find one's bearings."[22]

Richard Kriesche's *telematic sculptures* are a good example of telematic projects. In 1993, Kriesche built a twenty-four-meter-long train track that is controlled by telephone calls. The number and information content of the calls determined whether or not the track would be pushed up against the wall. In 1995 at the Venice Biennial, Kriesche expanded his concept to produce *Telematic Sculpture 4 (T.S.4)*, in which the a train track is continuously moved by the data streams on the Internet. Each time somebody logged into T.S.4, the sculpture was temporarily brought to a standstill. The entire volume of data streams, and with them the concrete movement of the sculpture through the pavilion, was displayed on a monitor as status information.

These projects incorporate technological control in the artwork, and in a way the artist writes the parameters and lets the participants control them. Even though not technological, similar methods are used in the event recipes in Fluxus. For instance, Paik's *Composition for Poor Man* is written in natural language and can be performed by someone or some people. Also Sol LeWitt's separation of concept from the execution in his wall drawings has parallels to this idea of describing the processes beforehand and letting some entity execute it. For LeWitt this is a way of being objective[6]; in Fluxus the emphasis is on the idea of allowing anyone to write recipes or to execute them.

In the second half of the 1990s, new forms of participation and cooperation developed through the Internet. Participation in early

[6] Mark Godfrey. From Box to Street and Back Again. In Open Systems, TATE Publishing, 2005

telecommunication projects was confined to a small group of users. However, on the Internet, the possibilities of participation are far greater than in the time of the early telecom projects. As opposed to highly regulated telecom infrastructures, the open infrastructure of the Internet enables people to discover possibilities and to develop their own custom systems. When Tim Berners-Lee designed the Web, he did not ask anyone's permission[7]. Anyone can build a new application on the Internet, without asking to, Tim Berners-Lee, or the Internet pioneer Vint Cerf, or their cable company, or their ISP, or their operating system provider, or their government.

With widespread adoption of the Internet, artists started to build and use mailing lists, discussion forums, and newsgroups such as Nettime, The Thing, and 7/11. They stared to reach their audience and other artists instantly, globally, and directly. These tools enabled rich, technically savvy networked interaction and cooperation, and the increasing affordability of Internet access made participation possible on an unprecedented scale.

The Internet is increasingly becoming the dominant platform binding us; the qualities of this platform increasingly contribute to the shape of our contemporary culture. Beginning from the second half of the 1990s, artists have explored those inherently invisible and powerful qualities of the Internet. In these explorations, artists use browsers, or they write custom software using various programming languages and operating systems. In the next section, I will discuss how artists explore the qualities of the Internet as a creative platform using hardware, software, and communication protocols.

2.1.3 Internet/Software Art

The birth of the Net.art is usually tied to an email received by Vuk Ćosić in December 1995. This legend is written by Timothy Druckrey on his essay entitled *[...] J8~g#|;Net. Art{-s1 [...]*[14] and also posted to the Nettime email list by Alexei Shulgin:

[7] Tim Berners-Lee's blog post: "Neutrality of the Net" at http://dig.csail.mit.edu/breadcrumbs/node/132

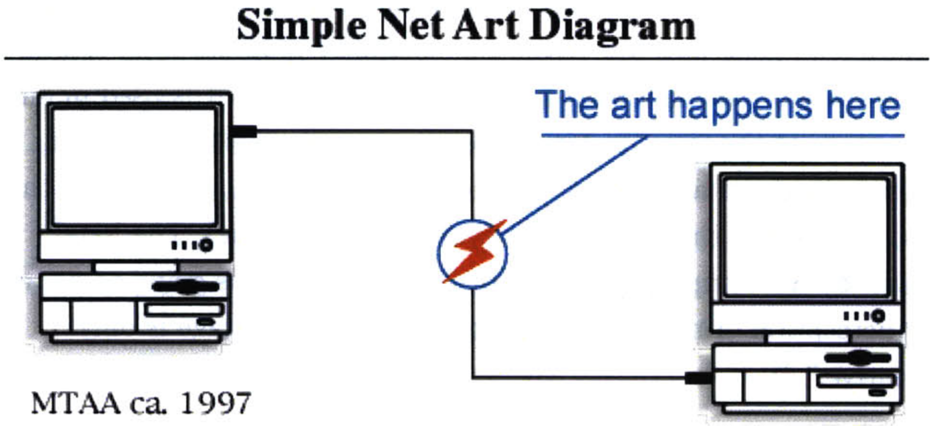


Figure 2-5: MTAA. *Simple Net Art Diagram*, 1997

> "I feel it's time now to give light on the origin of the term - 'net.art.' Actually, it's a readymade. In December 1995 (Slovenian artist) Vuk Cosic got a message, sent via anonymous mailer. Because of incompatibility of software, the opened text appeared to be practically unreadable ascii abracadabra. The only fragment of it that made any sense looked something like: [...] J8~g#|;Net. Art{-ŝ1 [...]" [44]

Net.art works are important for this thesis because they explore the qualities of the Internet as a creative medium. This does not mean art on web pages, but the cultural production that focuses on the structure and dynamics of the Internet itself, that is data transmission, communication protocols, hyperlinks, errors, and so on.

With his humorous and ironic style, Alexei Shulgin explored the Internet in various ways mostly by encouraging collectivity. His work *Refresh* (1996) consists of nothing but links between web pages. It involves many different organizations working together, using many different computers all around the world. In *Refresh* a chain of web pages is created. Shulgin describes the project as "A Multi-nodal Web-Surf-Create-Session for an Unspecified Number of Players" [8]. This work is seen as a public sculpture composed of links between computers.[9]

In his work Shulgin uses low-tech computers and elements such as midi, hyperlink, and HTML forms. His conceptual works are oppositional to previous forms of cultural production. For example, he uses famous

[8] http://sunsite.cs.msu.su/wwwart/refresh.htm
[9] Alexander Galloway puts it in the Internet Art section of his book Protocol, 2004

pop and rock songs as material in his performances, plays them through a midi system, generates low resolution computer graphics from sound, and on the stage or on the street, installs his computer as it is used in any office space at the time. In his performances with 386DX computer, Shulgin's program announces: "Ladies and gentleman, welcome to the world of 368 DX, the world's first cyberpunk rock band. The band consists of one computer, that's why nothing human is going to disturb your perception of music. The role of the human on stage is only decorative." [10]

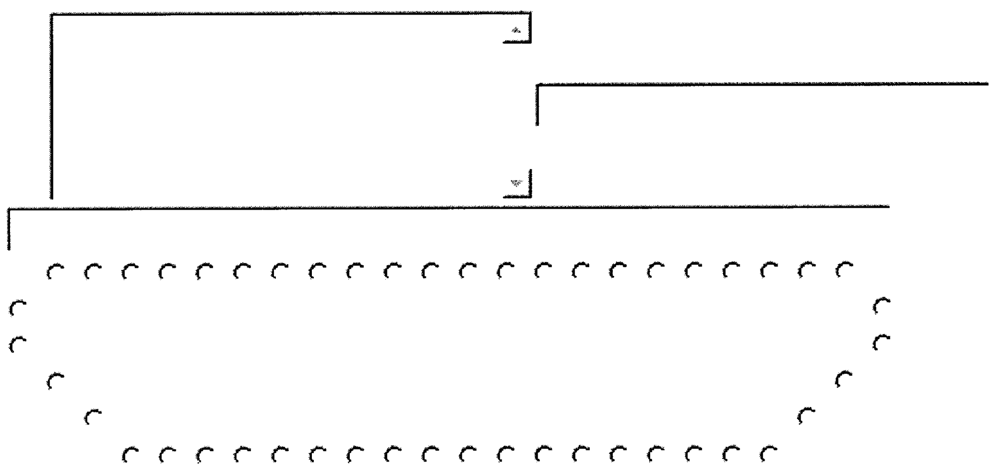


Figure 2-6: Alexei Shulgin. *Form Art Competition*, 1997

In 1997, Shulgin organized a Form Art Competition. Form Art refers to any Internet art piece that uses only HTML form elements such as radio buttons, pull-down menus, text boxes and so on. These are commonly used to control content on the web pages. While the Internet business and tons of personal web pages were taking off, this event and the pieces submitted to the competition exploited the aesthetic possibilities of the Web medium.

[10] Alexei Shulgin, 386 DX WIMP performance at Location One Gallery, New York in February 13, 2004

Shulgin's work criticizes the contemporary culture by incorporating existing content and media technologies such as midi, HTML form elements and hyperlinks. In a way, his work opens up the utilitarian and strict use of the Internet and breaks free from regularity.

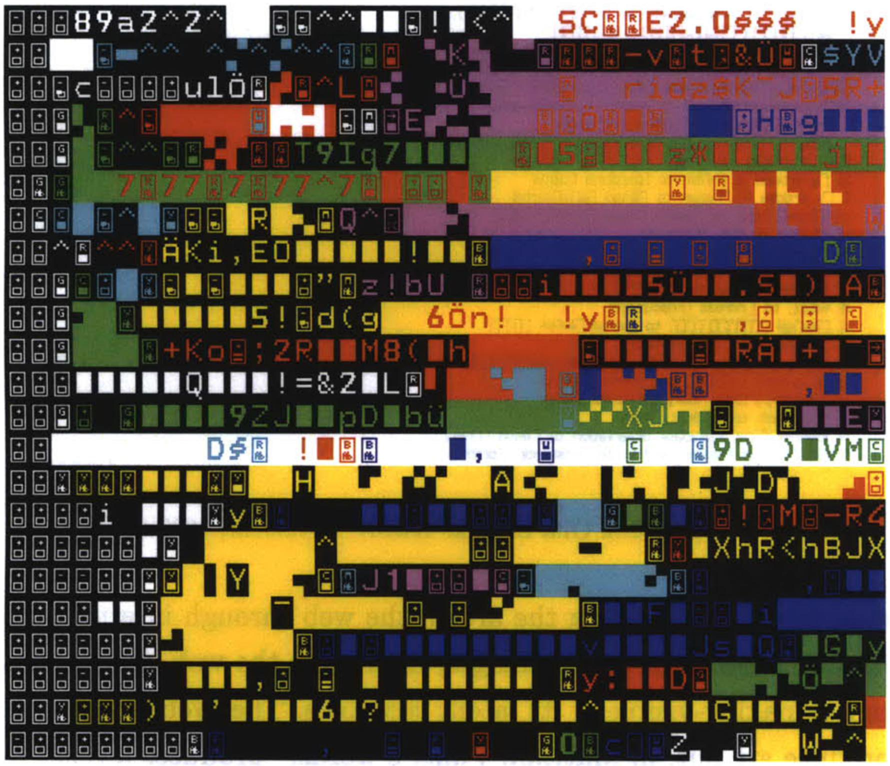


Figure 2-7: JODI. *938*, 2000

Heath Bunting is one of the earliest artists who focused on the total dissolution of the art product into the network. In his *_readme* project Bunting modified an article so that each word of written text becomes a hyperlink to itself[11]. For example, the word "is" links to www.is.com, "on" links to www.on.com, and so on. In his 1998 performance in Berlin, Bunting deliberatively attempted to load nonexistent web pages in a radical expression of solidarity with the network itself. Letting the artwork disappear was the very means by which the audience could experience the network protocols themselves[19].

Along the same critical lines with Bunting, the *Web Stalker* (1998)[12] browsing application have been critical for the very tools we use to surf

[11] http://www.irational.org/_readme.html
[12] http://bak.spc.org/iod

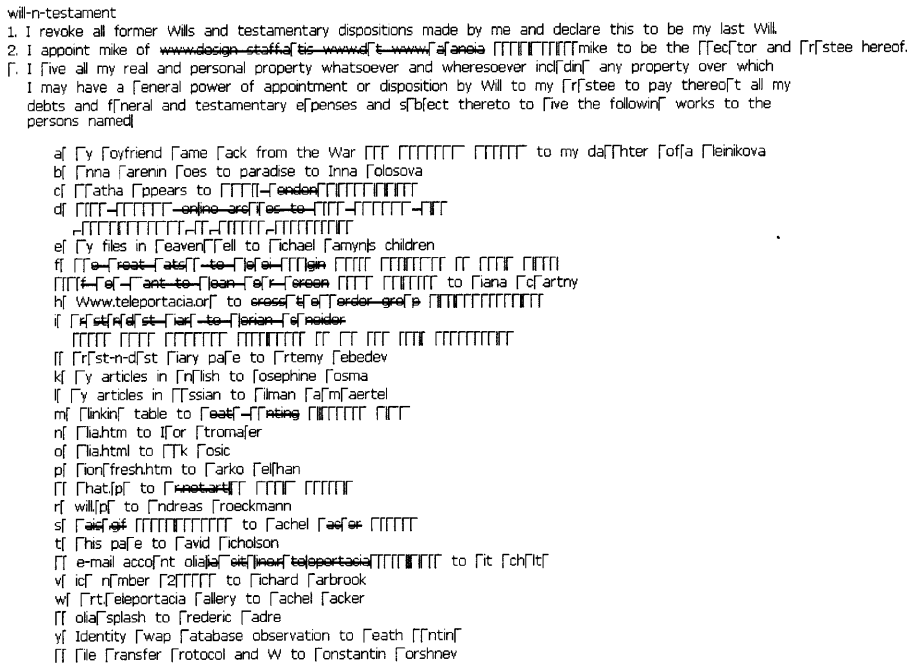


Figure 2-8: Olia Lialina. *Will-N-Testament*, 1998

the web. Instead of showing the art on the web through interpreting HTML and displaying in-line images, it exhibits the web itself as art through a making-visible of its latent structure. The Web Stalker does not produce art but, in Matthew Fuller's words, "produces a relationship to art". This idea positions the Web itself as a type of art object.

Another dissolution strategy comes from the Russian artist Olia Lialina. Lialina used the limits of the Internet such as the download time as a creative opportunity. Her piece *Will-n-Testament* is a digital poem, in which letters replaced with images[13]. Since the text loads slower than the images on the web, each letter loads separately and asynchronously. By making the download time part of the viewing experience, Lialina brings the Internet protocol itself directly into the art object[19].

The "file not found" 404 error code that is built into the HTTP protocol has inspired artists such as Jodi, Lisa Jevbratt, and Electronic Disturbance Theater (EDT). The European art duo Jodi, look at the computers and the Internet inside out, focus specifically on those places where computers break down, Jodi derives a new computer aesthetic by

[13] http://will.teleportacia.org/

THE TELEGRAPH, WIRED 50: Heath Bunting

Heath Bunting is on a mission. But don't asking him to define what it is. His CV (bored teen and home computer hacker in 80s Stevenage, flyposter, graffiti artist and art radio pirate in Bristol, bulletin board organiser and digital culture activist (or, his phrase, artivist) in London (is replete with the necessary qualifications for a 90s sub-culture citizen but what s interesting about Heath is that if you want to describe to someone what he actually does there s simply no handy category that you can slot him into.

If you had to classify him, you could do worse than call him an organiser of art events. Some of these take place online, some of them in RL, most of them have something to do with technology, though not all. One early event that hit the headlines was his 1994 Kings Cross phone-in, when Heath distributed the numbers of the telephone kiosks around Kings Cross station using the Internet and asked whoever found them to choose one, call it at a specific time and chat with whoever picked up the phone. The incident was a resounding success: at 6 pm one August afternoon, the are was transformed into "a massive techno crowd dancing to the sound of ringing telephones", according to Heath.

Figure 2-9: Heath Bunting. *Readme*, 1998

examining its point of collapse. All the elements that form a web page has been exaggerated with elements such as full-screen blinking text and images, wild animated gifs and HTML form elements[14]. In their interview with Tilman Baumgaertel, Jodi say that they are angry because of the seriousness of technology: "The computer presents itself as a desktop, with a trash can on the right and pull down menues and all the system icons. We explore the computer from inside, and mirror this on the net."[15]

In the early days of net.art, artists dealt with limited bandwidth and computer speed, and used these as qualities of their work. Later on with the rise of the Internet business and more advanced software tools and frameworks, artists such as Etoy and RTMark created works that are oppositional to the contemporary corporate driven net culture.

Etoy is a corporation founded in 1994 by a group of artists who use existing corporate systems as an actionable space for art. They call themselves a "corporate sculpture"[16]. For Etoy, the dramatic problems of globalization are not to be solved by simply rejecting global markets,

[14] http://www.jodi.org

[15] Tilman Baumgaertel "Interview with Jodi", Nettime, 1997. http://www.nettime.org/Lists-Archives/nettime-l-9708/msg00112.html

[16] http://www.etoy.com/fundamentals/

Figure 2-10: Etoy. *Etoy.HISTORY*, 2006

economic exchange, drive companies, culture, individuals and politics[17]. Etoy activities are inspirational for the experiments that are discussed in this thesis. After Etoy has started, they opened up their shares to people like a regular corporation, but as opposed to the business value of a corporation, these shares represent the cultural value of Etoy. When people invest in etoy.SHARES, they actually support the artists. etoy.SHARES represent participation in Etoy and cultural value generated by Etoy. Currently, Etoy is owned by its employees and the etoy.MANAGEMENT, by international art collectors (private and institutional investors such as museums, foundations etc.) and MICRO.investors such as TOYWAR.soldiers, etoy.FANS and etoy.BABY-AGENTS[18]. etoy.SHARES can be considered as a solution to the general problem of showing and archiving digital art. With etoy.SHARES Etoy actually distribute the original manifestations to the shareholders. The sum of all unique certificates assembles and owns the etoy.HISTORY[19]. The collective systems discussed in the context of this

[17]The statement at http://www.etoy.com
[18]etoy.SHARE description at http://www.etoy.com//fundamentals/etoy-share/
[19]http://www.etoy.com//fundamentals/etoy-share/

thesis benefit from this modularity of sharing and exchanging the value of activities. It is a way of synthesizing the art work and its metadata generated by the society.

Early net artists explored the aesthetics of the Internet by looking at its limits and opportunities (Heath Bunting, Jodi), discovered social and political implications of the digital networks (Vuk Cosic, Alexei Shulgin), formed communities (Nettime, The Thing, 7/11), and organized global activities (Read_me, Runme). Of course, today the Internet is everywhere, it is a core element in of our everyday life, everyday we invent more sophisticated ways of using networked computers. Massive accessibility of software that runs on the network of machines and the Internet based communication technologies create a new type of environment for creative production. As Pierre Lévy puts it, rather than distribute a message to recipients who are outside the process of creation and invited to give meaning to a work of art belatedly, the artist now attempts to construct an environment, a system of communication and production, a collective event that implies its recipients, transforms interpreters into actors, enables interpretation to enter the loop with collective action[26]. Collective systems promote the emergence of autonomous beings, regardless of the nature of the system or the beings involved (individuals, groups, work of art, artificial creatures). The creative production through collective systems enable us to exploit and enhance the veins of data, the capital of skills, and semiotic power accumulated by humanity.

In the age of the Internet, supporting creative and open production may seem like an easy task. But we are not only under the influence of corporate marketing systems, but also being encoded in the protocol level while using corporate driven systems. For instance, today we heavily rely on Google's Page Rank system for finding information on the web. We shop from Amazon.com and rely on rankings in our choices. The interfaces actually act as network protocols. We interact with them, and leave trails of data in the system, and this data is analyzed and used in the development of new interfaces/protocols towards some certain goal of the corporation. The access to the aggregated data should be a human right, but they are strictly guarded and rather come back as new products or services to consume. Under these conditions, new artistic strategies have to consider creating open actionable spaces for experimentation and collectively building humane meanings. Creation of such places and systems is the problem I am attacking with this thesis. From the experiments I have explored so far, I understand that creating loose connections and structures helps people engage, build interesting scenarios, and create personal ways of dealing with the system. For this reason, in the Complex Systems section, I will first look at the loose structure of the Internet itself that has been successfully scaling for more than 25 years. Then I will look at the field of Social Network Analysis for understanding naturally built social networks, and I will build a vocabulary to contribute to the analysis of the collective systems, then I will look at certain economical models in which massive amounts of people interact and exchange things, and finally I will look at the collective systems as living networks to understand their dynamics.

2.2 Complex Systems

The study of complex networks is an emerging field that provides a grand unified theory: networks made out of anything obey the same laws of growth and arrive at similar structures. For example, the chemical interactions in a cell, the network of routers and computers in the Internet, networks of business relations between companies, social network of acquaintances between individuals now can be described with similar unified structures. Most of the experiments in this thesis have structures based on graphs–nodes connected with links. These nodes are sometimes representations of a person's profile, sometimes an artwork, sometimes a device, sometimes a word. The links are sometimes business relationships between people, sometimes metadata similarities between artworks, sometimes data transactions between devices. The topology of these graphs are sometimes centralized, sometimes decentralized, sometimes a hybrid of both. These typologies are also can change when we change our point of view. For instance, in one of the systems in this thesis, people are connected to each other by their business relationships or invitations. These relationships often form a decentralized network since people decide whom to connect based on variety of reasons, they don't all connect to a particular person. But from the technological point of view, all the data is stored in the same centralized database, all the people who read and write data to the system are connected to a single server. The structures of the experiments in this thesis include systems from computer communications to social and economic relationships between people and they have several topological features. So it is relevant to look at complex network research that study non-trivial topological structure of the graphs in variety of contexts.

In this section, at first, I will look at the structure of the Internet since it sheds light to most of the experiments in this thesis. Then I will look at the core ideas in social networks analysis because the structural findings in these systems provide basic principles for the experiments developed in this thesis. Economic models are also relevant because various economic models have been used as organization systems in large experiments. Finally, the idea of living networks provides relevant context to understand the complexity of the projects developed in this thesis. Overall, looking at complex systems provide conceptual and technological insights for developing collective systems.

2.2.1 Communication Networks

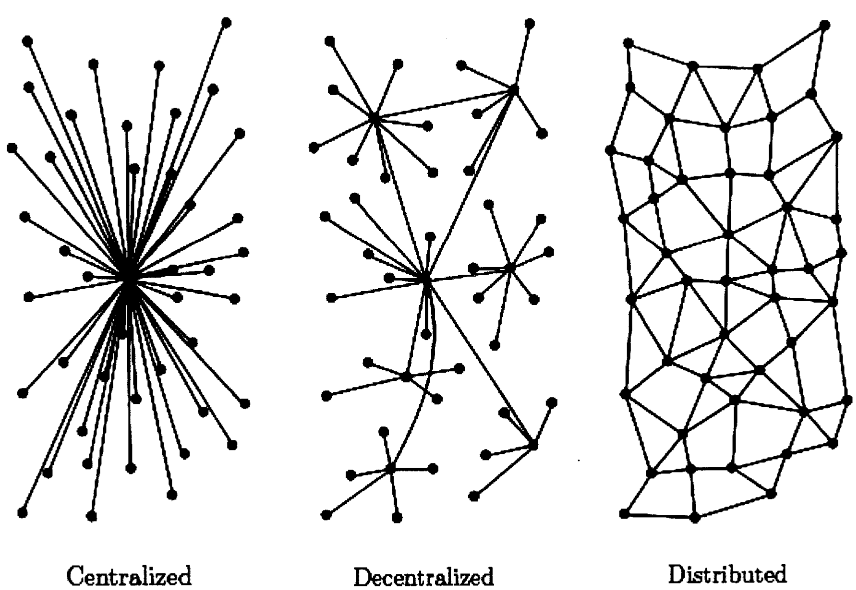


Figure 2-11: Paul Baran's network topologies.

Connectivity is a prerequisite for collectivity. Of course people can connect without technology, but communication technologies enable connection people that are far from each other, furthermore, with advanced infrastructures they provide rich interaction. Today with the extensive use of the Internet, we are able to send and receive digital media, movies, sound, and so on. People more often discover new ways of using this rich data transmission net, and the Internet has been emerging as the core platform for communication, collaboration, and organization, and network-enabled conversations are becoming a principal carrier of new ideas[37]. The experiments in this thesis are inspired by the design of the Internet and the communication layer of the experiments is based on the Internet. Therefore, the qualities of the Internet affect these experiments in various ways and understanding how the Internet operates provides a technical and cultural base for the work presented in this thesis.

In its physical form the Internet is a network of routers and computers connected by many physical or wireless links. The design of this massively extended communication system has roots in 1950s and 1960s academic and military culture. The Net was designed as a solution to vulnerability of the military's centralized system of command and control during the late 1950s[19]. The Internet was designed as a decentralized system because if there are no central command centers, then there can be no central targets, so the possible damage is reduced. In his memorandum for Rand Corporation, the Internet pioneer Paul Baran emphasizes: "Since destruction of a small number of nodes in a decentralized network can destroy communications, the properties, problems, and hopes of building 'distributed' communications networks are of paramount interest."[6] Distributed networks have no centralized command and control. The organization is possible through pre-agreed network protocols. For the Internet, protocols are written technical rules that are available in documents known as Request for Comments (RFC). Each RFC acts as a blueprint for a specific protocol, and instructs potential software designers and other computer scientists how to correctly implement each protocol in the real world.[19]

Computers attached to a network are defined as "hosts" in the RFC

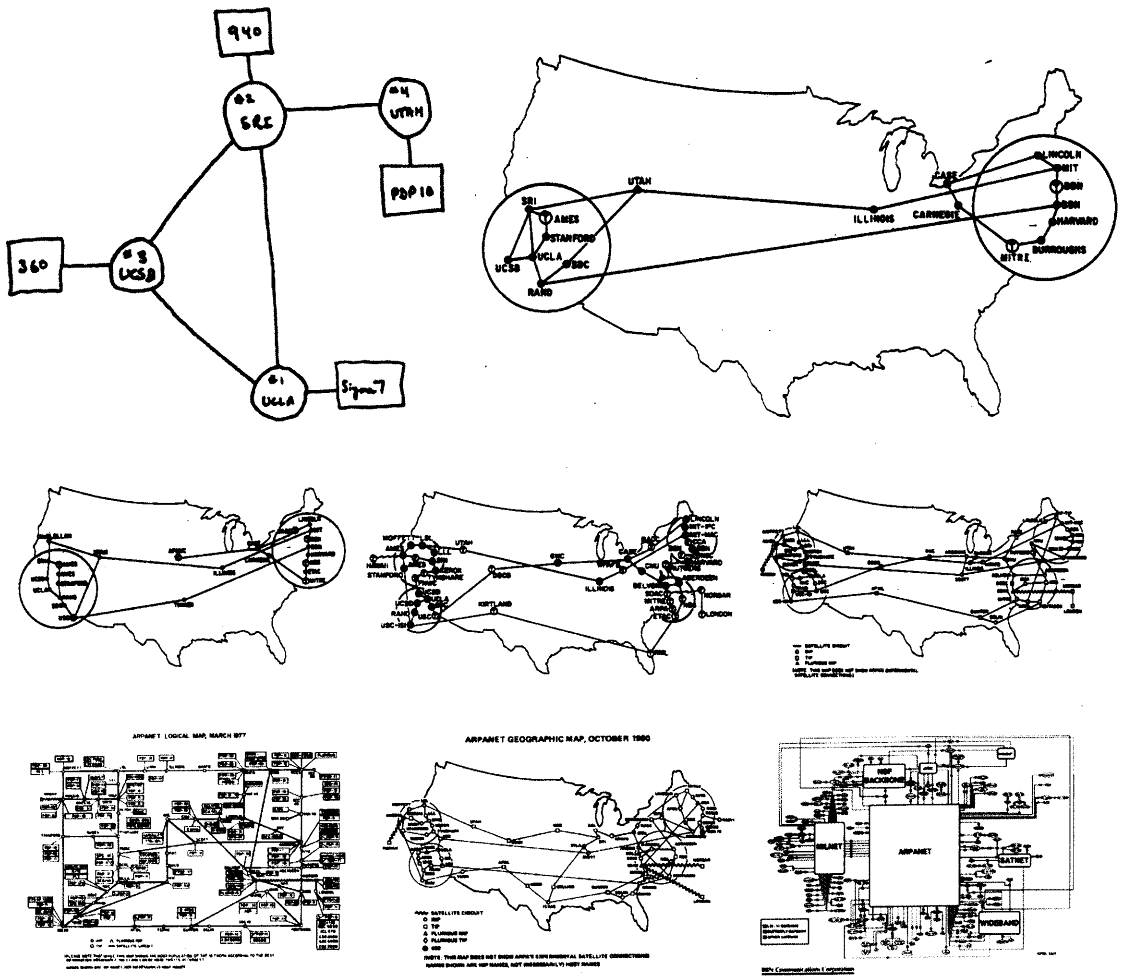


Figure 2-12: Evolution of the ARPA Net, 1969-1987

on Transmission Control Protocol (TCP) [20]. Hosts implement the entire Internet protocol stack that is combined by multiple layers. The RFC on "Requirements for Internet Hosts" defines four layers for the Internet suite of protocols: (1) the application layer (e.g., Telnet, FTP, HTTP), (2) the transport layer (e.g.,TCP, UDP), (3) the Internet layer (e.g., IP), and (4) the link layer (e.g., Ethernet, WI-FI). [21] These layers are encapsulated in each other in a nested way. This suite of protocols together form the sophisticated system of massive distributed control.

Another commonly used protocol is the Domain Name System

[20] Jonathan Postel, "Transmission Control Protocol", RFC 793, September 1981

[21] Robert Braden, "Requirements for Internet Hosts", RFC 1123, October 1989, http://www.ietf.org/rfc/rfc1122.txt

(DNS), which enables the translation of Internet addresses from names to numbers. [22] So while people can use and remember names (www.mit.edu), machines can use numbers (e.g., 18.85.23.255) easily. Domain name space is a tree of domain names. A domain name usually consists of two or more parts separated by dots. The rightmost part conveys the top-level domain. For example, wikipedia.org has the top level domain "org". The DNS consists of a hierarchical set of DNS servers. Each domain or subdomain has one or more authoritative DNS servers that publish information about that domain and the name servers of any domains "beneath" it. The hierarchy of authoritative DNS servers matches the hierarchy of domains. At the top of the hierarchy stand the root servers: the servers to query when looking up (resolving) a top-level domain name. The DNS system has a decentralized network topology and follows the chain of delegated authority.

With these protocols, the Internet has grown significantly without almost any central organization. Since the Internet is growing constantly, the complete map and analysis of the Internet is impossible. But there has been a study that could identify the general mechanisms by combining several databases capturing time evolution, topology and physical layout of the Internet. Barabási and his colleagues treated the Internet as though it were a natural phenomenon and found that the physical layout of nodes form a fractal set determined by population density patterns around the globe. The placement of links is driven by competition between preferential attachment and linear distance dependence[5]. So a router that has many links is likely to attract still more links and the Internet has more clusters of connected points than random graphs. These two properties give the Internet a topology that is scale-free, in other words, small bits of it, when suitably magnified, resemble the whole.

One of the central design principles of the Internet Protocol, the *end-to-end principle*, states that, whenever possible, communications protocol operations should be defined to occur at the end-points of a communications system[23]. Based on this principle, on the Internet, any

[22] Paul Mockapetris, "Domain Names – Implementation and Specification", RFCs 882, 883, 973, November 1987

[23] Jerome H. Saltzer, David P. Reed, and David D. Clark. End-to-end arguments in system design. ACM Transactions on Computer Systems, 1984. An earlier version appeared in the Second International Conference on Distributed Computing Systems, 1981

computer can send a packet to any other computer and the network do not look inside the data part of the packets. So who is organizing all these interconnections? The organizers of this complex network of autonomous entities are the protocols. Protocols enable the Internet to scale well. Protocols allow new Internet applications to be introduced and to evolve independently. A protocol is both an apparatus that facilitates networks and also a logic that governs how things are done within that apparatus.[24] As seen in the Internet development history, protocols are also designed through negotiation. This aspect is very important for this thesis work. Either through collective consciousness, social contracts, or state laws our complex relationships are organized in a way by high-level protocols that make sense to us. These shared protocols provide common ideological ground for members of a society, and ensure that members act in agreed-upon ways. Our communications are getting highly mediated by machines, and it becomes interesting when we think of the collective systems as people's activities woven to machines in the context of this thesis. This creates an interesting tension between machine protocols and human protocols. Today we can code social contracts into the software that works in between people through the Internet. So the protocols between machines and the protocols between people blend in a way. While building the experiments that involve individual and groups activities I came across with this situation where I switched from writing protocols for people to writing protocols for machines and vice versa. The important thing I've learned from these experiences is rather than directly coding the protocols into the software, one should let people debate and agree on the protocols as much as possible. This is not an easy task since connections between technology and social structures are often times arbitrary. However, systems can be nurtured to evolve in relation to the society. To nurture systems that can take shape with the society, we need to understand how social relationships evolve. Looking at psychology and sociology studies in detail would be relevant for this thesis, but they are so large that it is beyond this thesis timeline. But looking at the research in social networks analysis gives insight about the structure of general relationships between people.

[24] Alexander Galloway and Eugene Thacker. "The Limits of Networking", Nettime, 2004. http://www.nettime.org/Lists-Archives/nettime-l-0403/msg00090.html

2.2.2 Social Networks

Social networks have been an important part of the sociological studies. People are connected to each other through various social familiarities ranging from casual acquaintance to close familial bonds. Social network theory views these social relationships in terms of nodes (actors) and links (ties). There are number of different theoretical findings of social organization based on the structural approach. Tie strength and social capital will be relevant to my thesis, so I will introduce them in detail here.

Tie strength

In social network analysis relations are classified based on the *tie strength*. The measurement of tie strength between people can be calculated based on various factors such as the length of a relationship, time spent together, and amount of communication. The stronger one's relationship with another person is, the more likely it is that they have the same friends, and in turn access to the same social and physical capital. On the other hand, weaker ties connect individuals to a more variety of people and resources. Referred to by Mark Granovetter as a *bridging tie*, weak ties can provide more information than would be available through stronger ties[21]. Observing the dynamics of the tie strength is important while nurturing collective systems. It can show group formations in various levels of intensity. Measurement of the tie strength can also change based on the context of the connection. The other measures of Social Network Analysis also contribute to the weight of the tie strength.

Social capital

The concept of social capital is one of the most popular concepts in social network analysis. It has been used in terms of structural features: strong ties[27], weak ties and structural holes[13], and density[10]. Robert Putnam repurposed the term, instead of using social capital as a measure of *individual wealth*, Putnam considered it as a *collective wealth measure.*[39]

Social capital is an important concept for articulating collectivity and it can be used to organize activities and information flow in social networks. If we can place a value on the networks of individuals and communities, we can begin to explain the methods by which people can take advantage of their capital.[28]

There are numerous ways to measure social networks. The works in this thesis employ only computational methods of forming and gathering data about social networks. Once the data is gathered there are a number of different features that can be analyzed to translate the abstract graph into a richer understanding of the network. The following measures are relevant to this thesis:

Transitivity — If the edge (link) in between two nodes is bidirectional that edge is said to be *reciprocal.* For three nodes if there are bidirectional edges between each node the graph is said to be *transitive.* For example, a friend of your friend is likely also to be your friend. These measures can be calculated as a proportion over an entire graph and give a measure of how likely two edges are transitive. In terms of network topology, transitivity means the presence of heightened number of triangles in the network[34]. High transitivity also means broad communication channels within the network, so it causes high liquidity and so a rich network.

Degree — The number of edges connected to a node is defined as the *degree.* A directed graph has both an in-degree and an out-degree for each vertex, which are the numbers of in-coming and out-going edges respectively. In order to understand how a node relates to the rest of the network, the degrees of all other nodes should be considered.

Density — The density of a graph is the number of edges divided by the total edges possible. We can calculate the density for subgraphs in a graph, that is the edges of one node (person) and any edges connecting the node and its alters. This is typically called personal network density, and it is useful for understanding an individual's condition compared to his/her relationships. The average personal network density for the whole graph is called *clustering coefficient*[55].

Path — In social network analysis, the distance between two nodes is calculated by the shortest path. This path is called *geodesic* and it is one of the most well known structural property of a network is that which Stanley Milgram used to describe the "degrees of separation" between two people. If the paths are short in a collective system, it is more likely to be successful when a collective action is taken.

Centrality — The centrality of a node in a network is a measure of the structural importance of the node. This measure quantifies the prominence of an individual node among the other nodes in a network. There are three distinct measures: (1) *Degree centrality*, the in-degree for each node in the graph; (2) *betweenness centrality*, a measure of the probability that the given node lies on the shortest path between any two other nodes in the graph; (3) *closeness centrality*, the average distance from a given node to all other nodes in the graph. Centrality is an important feature for elections or collective decisions.

Structural Holes — Structural holes measure the extent to which an individual bridges various groups, or controls the communication between these groups[13]. It shows how much an individual controls the information spread to the entire network.

For collective systems in this thesis work one of the main processes is analyzing the relationships between people. These relationships are built in time by people as they use the system. To support collectivity, it is important to understand the macro meanings of these relationships and return them back to the people. These theoretical findings of social organization in social network analysis research help us to analyze relationships between many people. These relations are generally built around some context such as family, friendship, school, business etc. In today's Internet, a common practice of building relationships is by sending and receiving messages in systems such as mailing lists, social network systems, and blogging communities. Often times, our relationships in physical life are supported through these online systems.

People also build relationships through economic activities. Of course, these relationships differ from family, friends or any altruistic relationship by being "quid pro quo"[25] and by being measurable. Even though they are quid pro quo, they help us to build reliable relationships over time. This can be discussed deeply in various contexts but the relevant part for this thesis is the economic relationships also enable continuous activity among different people. These asynchronous but continuous economic activities are one way of creating loose connections and keeping them alive among the participants of a collective system. Also economic relationships are useful for organizing the information flow between individuals in a collective activity. Therefore, to better understand some certain economic structures I will look at the economic models.

2.2.3 Economic Models

In my set of thesis experiments, economic models are used in two ways. First, they are used to organize the information flow between individuals in a collective activity. Second, economic models provided context to create an actionable space for artists to experiment with the economy and the phenomenon of immaterial labor. The relevant economic elements to this thesis are the theory of value, the price mechanism, and the market system. Since the field of economics is very large and beyond the scope of this thesis, I will briefly discuss the theories and emphasize the organizational factors about these elements.

Theory of Value

The value of something in economics is how much a product or service is worth to someone relative to other things. Adam Smith defined "labour" as the underlying source of value, and later this idea is expanded by David Ricardo and Karl Marx.[29] The labor theory of value (LTV) holds that the value of goods or services is equal to the amount of labor required to produce them, including the labor required to produce the raw materials and machinery used in the process[29]. Marx used the labor theory of value as a tool for understanding the social relations between workers and

[25] Latin for "something to something", it can be understood as "a favor for a favor" or "tit for tat".

the owners of labor power and the owners of capital. Marx argues that for commodities to be comparable they must have a common element by which to measure them, and that labor is the only commonality[29].

This chain model of calculating values do not apply to cultural products because the value of ideas represented in the artistic work can not be calculated based on the labor measurement. This also means that cultural products cannot be bought and sold, and they belong to the public. In this ideal case, the creators of the cultural products should be supported in various ways and the resulting products should be open to public. Then the value translates to the links between supporters and the creator. In a collective system these links can be aggregated and can become a measurable social capital that a supporter deserves for its contribution to the culture.

Price Mechanism and the Market System

Most academic economists today begin with the premise that resources are scarce and that it is necessary to choose between competing alternatives. Choosing one alternative implies forgoing another alternative, and these decisions are made based on the price relationships. In market economies values are quantified by price relationships. The market incorporates all available information into price, and that so long as markets are open, that price and the value are one and the same. Prices abstract complex relationships and information to make right decisions[53]. According to Hayek, knowledge is dispersed in economy, and prices communicate the crucial information to individuals. Free market economy is based on these ideas, and applied in most part of the world.

Albert-László Barabási views the market as a directed network.[5] Companies, firms, corporations, financial institutions, governments, and all potential economic players are the nodes and links quantify various interactions between these institutions, involving purchases and sale, joint research and marketing projects and so forth. He points out that "the weight of the links captures the value of the transaction, and the direction point from the provider to the receiver. The structure and evolution of this weighted and directed network determine the outcome of all the macroeconomic processes."[5] This view of markets is helpful for building systems for collectivity in which individuals interact with each other independent from institutions. In today's electronically connected world, when appropriate tools and systems are provided to the individuals, they can handle the complexity that only an institution would handle. A market is relevant for collectivity, because it enables asynchronous but continuous activities, creates loose connections, keeps them alive, and organizes the information flow among the participants of a collective system.

Although this generalized view of the market as a complex network may be helpful for organizing the complexity in systems that have many autonomous entities connected to each other, it can not address the dynamics of the individual elements within the networks. This will be discussed in the next section "Living Networks".

2.2.4 Living Networks

Complex networks studies analyze the networks as static entities. However, individuals in a socioeconomic network can always change their state, and this can effect their connections (edges) to other individuals. As Eugene Thacker points out, much thinking about networks are based on Euler's mathematical paradigm, in which the dynamic qualities are spatialized and abstracted into a static pattern called *topology*[50]. While this paradigm of networks privileges the relation between things, rather than things-in-themselves (edges rather than nodes), it also cannot account for the dynamics within networks. Graph theory and network thinking are useful for certain problems (e.g. routing traffic on a computer network), but there are a range of other contexts that are much more than static networks such as distributed dissent, the self organization of insects, and patterns of infectious disease. These contexts are much more than static networks, for there are changes within individual nodes (change in political ideology, changes in environment, mutations in a virus), and between individual nodes, resulting in edges or relationships that create or change nodes (joining a cause, emergence of tasks, modes of transmission)[51].

Thacker modifies the Eulerian-Kantian network paradigm by deriving ideas from Bergson's notion of time-as-duration (things do not happen in time, but are rather constituted as duration) and builds an understanding of change in networks. Thacker's modifications to Eulerian-Kantian network thinking follows:[50]

> *Topological Layering* — Networks are not flat or uni-dimensional, but can overlap and co-exist; that is, networks can be layered, giving us *topological layering.* An biological network such as an infectious disease, is not just biological, but in the global context, it also participates in transportation networks (airlines) and communication networks (WHO website).
>
> *Topological Diversification* — Not all nodes are equal, just as not all edges are equal. Networks can display a *topological diversification.* An infectious disease is not the same at every local, but may display different rates of transmission and mutation in a food-processing factory, in an airplane, an in a densely packed urban environment.
>
> *Multigraph* — A network is really a *multigraph* exist in time. They don't need to have a single topology. An infectious disease network may start out as centralized pattern, radiating from a particular city, but then, due to its layering and diversification, it may change into a more decentralized network.
>
> *Topological Intensification* — A network existing in time is not just wide and extensive, a map of fixed nodes (things) and stable edges (relations); a living network is also intensive. Networks can intensify de-inensify, depending on the quality, force, resiliency, and flexibility of the relations. Topology is not an extensive mapping, but instead a *topological intensification*, culminating in a network effect.

These dynamic patterns are seen in the experiments developed in this thesis. These experiments are built using multiple layers of technologies from device communications to web services. The contexts of the experiments range from semiotics to economics, and they enable various relationships among people. These different networks overlap or work in relation to each other. For instance, one of the experiments, *Open I/O*, associates devices with people, and enables networks of devices that interact with the networks of people. Moreover, the same patterns seen in social networks can also be seen in device networks. Overtime, these different networks affect each other. A device group may fail because of people's decisions, or a person may suffer because of a device malfunction such as a server crash or an economic transaction loss. A person can change their political decision based on the group activities and this can affect a device composition, or the quality of a web service. Many people's sudden interest in a service may increase its value while the load may crash the server and disable the service. These different scenarios and patterns imply that these systems described in this thesis are in a way living systems, not by the force of nature, but by nurture—by collective activities of remotely dispersed individuals and machines.

In these living networks all entities are connected in various ways, but how does connectivity transform into collectivity? In the next section, I will discuss this issue and other contemporary systems that are relevant to collective systems, and finally I will look at the synthesis of physical inputs / outputs and collective activities for creative expression.

2.3 Collective Systems

Collectivity is a term that does not have a unified general theory, yet it can be placed in various axes between community and collaboration. With the widespread use of electronic communication technologies and the Internet, we are more electronically connected than anytime in the history. While this connectivity may be a prerequisite for collectivity, the reverse does not apply. Massive amounts of people can be connected – as it happens everyday on the web – without any aggregation or group phenomenon. Collectivity is an aggregation of individuated units in relation to each other, with the quality of the relations largely specified by the context[50]. Today, with the proliferation of online participatory environments and models, we see more people participate in community forums, message boards, mailing lists, blogs, social network services, media sharing systems, and knowledge bases. These systems are either very loosely (e.g., mailing lists) or very tightly (e.g., commonsense databases) structured. Incentives of participants also vary in a spectrum between altruism (e.g., wikipedia) to quid pro quo (e.g., micro jobs) and affected by the context, interfaces, and tools of the system. Activities in these systems also can vary from having one time participation (e.g., asking a question to a forum) to scheduled rules (e.g., collaborative text editing). Collective systems in the context of this thesis are situated in between these spectrums. Also collective systems typologically differ from communities and collaboration systems. Collective systems harvest intelligence from participants, analyze the aggregation, and feed back the results to people in a way that enrich the individuals. Collective systems place us with in a creative cycle, as Pierre Lévy puts it "it is a living environment of which we are always already the co-authors"[26].

It is apparent that we are building collective meanings by non-linearly contributing to many different systems from our linear time. Under these conditions, while multi-tasking in various activities, how do we focus on a collective goal? The problems collective systems try to address are pointed out in Lévy's writings: "How can a symphony be created from the buzz of voices? Lacking a score, how can we progress from the murmur of the crowd to a chorus?" [26] This can be possible through a two fold rhythm. The inner rhythm of feedbacks from the system to the people, and the outer rhythm of intensification and de-intensification of the network. How do we design collective systems that are always alive and can intensify to accomplish a goal and de-intensify to digest and relax and have loose activities until another intensification? The cycle of these two rhythms enables people to stay in the context and be effective for a duration to accomplish collective goals, and relax and digest until another intense action. This collective cycle can be considered as a swarm behavior, but in the context of this thesis, I prefer to consider this cycle a certain life style.

In this section, I will first describe the transition from connectivity to collectivity. Then I will discuss relevant examples from two emerging fields, social software and commonsense computing, to give background on the concept of harvesting intelligence. Finally, I will discuss the synthesis of physical inputs/outputs and collective systems to support the final project presented in this thesis.

2.3.1 From Connectivity to Collectivity

At the core of the collective action there is connectivity, but connectivity alone does not imply collectivity. How does the transition from connectivity to collectivity happen?

We are always connected via electronic networks but we are active only when we communicate with other people or interact with the systems. Today, the act of communicating is not only more frequent but also qualitatively better with the availability of rich tools such as chat, multimedia messaging, etc. These tools are rich in terms of the quality of transmission, but they don't aggregate data in some structured way. On the other hand, storing simple data such as plain text messages forms the community systems such as mailing lists, forums and so on. Aggregation not only enables asynchrony but also keeps people motivated. So connectivity moves a step towards collectivity.

The arts collective Critical Art Ensemble (CAE) defines this phenomenon while discussing their relationships with the Nettime mailing list in their seminal essay "Collective Cultural Action":

> "Nettime has no voting procedures, committee work, coalition officers, no markers of governance through representation. Hierarchy emerges in accordance with who is willing to do the work. For CAE the general policy for coalition maintenance is 'tools not rules'"[26].

Incorporating some more structure than storing and searching plain text enables a more structured activity. This is also where the tension begins in between people and in between system or system designers. Eugene Thacker writes "In this tension between collectivity and connectivity we also find a tension between politics and biology, between group phenomena considered as political phenomena, and some manifestation of 'life itself'" [50]. When the more structured activity is aggregated, analyzed, and fed back to the people we can have a synthesis that is open for evaluation. This feedback rhythm between people and the system motivates people in a particular scale. Together with this particular micro-rhythm, a macro-rhythm, intensification and de-intensification of the system depending on the relations in between entities,and enables the

[26] Critical Art Ensemble. "Collective Cultural Action". Variant. 2002

formation of the collectivity. However, collectivity is not something that lasts forever. It happens in a duration, it is a temporary event, in which people focus and together achieve a goal that emerges from the patterns of their loose activities. After the goal is achieved, they relax and digest whatever is achieved, and they become just connected or keep participating in loose activities until another purpose emerges.

2.3.2 Social Software

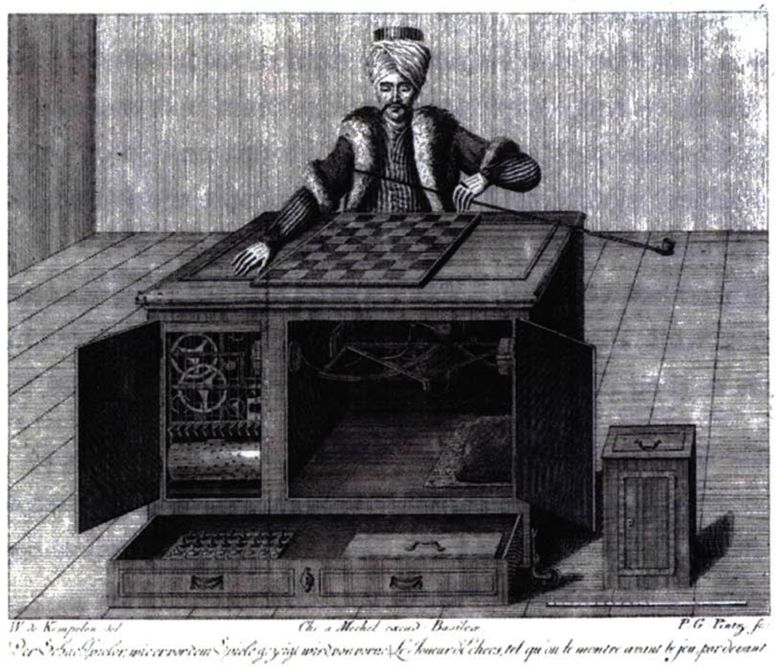


Figure 2-13: Mechanical Turk

In the early days of computer networks, electronic mailing lists were the first social software that made sense only with the people using them. Today wikis, multiplayer online games, and many commercial web services software are based on interactions of group of people within the software. This phenomenon of having people inside the machines is commonly described by reference to the Mechanical Turk, a chess-playing automaton invented by Wolfgang von Kempelen in 1769. This machine astonished Europe by defeating nearly every opponent it faced. In fact, the secret behind the mechanical Turk was a dwarf chess master cleverly concealed inside[36].

In social software people contribute to a mutual system and individuals take advantage of the aggregated information. Designing social software is slightly different than a regular software as Clay Shirky points out "The thing that makes social software behave differently than other communications tools is that groups are entities in their own right. A group of people interacting with one another will exhibit behaviors that cannot be predicted by examining the individuals in isolation, peculiarly social effects like flaming and trolling or concerns about trust and reputation. This means that designing software for group-as-user is a problem that cant be attacked in the same way as designing a word processor or a graphics tool"[43] For this thesis work, it is important to understand common patterns in various types of social software. There are many online services that can be considered as social software, and I will focus on a few typical examples and highlight the common patterns.

Social Network Services

Today social network services mostly provide tools for connecting people in some context. They are highly focused on providing tools for creating rich profiles. Main activities in these systems are posting messages, adding other people as contacts, and browsing profiles.

Friendster[27] provides a general purpose social connection service between people. It is one of the earliest and most well known social networking system. One of the main activities in this system is browsing through people's connections until one gets bored. People are represented with small thumbnail images, and they express themselves in this 75x75 pixel image. There is no action other than message posting and browsing people's profiles. Friendster is interesting because it very quickly inspired many other systems and more improved social networking systems have been developed such as Tribe, Myspace, and so on. Most of these systems added simple group tools and possibility of using rich media (larger images, videos, and sound).

Myspace[28] provides more freedom to users to customize their profile pages. These profile pages are highly expressive and people post all sorts

[27] http://www.friendster.com/
[28] http://www.myspace.com/

of images, icons, videos, links from all over the place on the Internet. These pages usually have a simple structure. A very long single page with general community links on the top, some tools (send message, add to favorite, rank user, etc.) on the left bar, information about the profile in the center of the page, flashy images or patterns at the background of the whole page, tons of messages with images and videos from the community members and social network of the that profile. Usually music bands have fan pages with URLS such as “myspace.com/modonna”, “myspace.com/dntel”, and so on. There are tons of icons, banners, buddy icons, links for buying CDs, DVDs, T-shirts, posters, all the merchandise one can imagine. These pages often end up being *hyper-kitsch* websites–collection of people’s random desires linked to all sorts of other random places. Myspace.com is now one of the most popular social network website[29]. This massive amount of people using the Myspace.com service are just connected through social networks, there may be shared interests as it is seen in star fan pages, but a collective activity is not really visible.

Linkedin[30] business networking service, provides profile pages for people and detailed information about a user’s connections like any other social network service. For example, this author has 15 first degree connections and 800+ second degree connections and so on. Linkedin is focused on providing tools for people to create detailed business profile, it reminds if the profile is not complete and so on. The common business terms such as CEO, SVP, GM, CTO etc. are used all over the website. Like any other social network service it has advanced search tools for finding people, but following business links seems more interesting and useful. Additionally, a job search tool is provided, and job search results show the relationship to the job poster besides the regular job information. Usually networks are formed by adding contacts from the real world connections. For instance, most of my contacts are from the MIT Media Lab. These kinds of systems are probably replacing the traditional card swapping in business relationships. Linkedin does not aggregate extra data except for the links between people. Of course, it is a flat reciprocal system for people to extend their business relationships,

[29]According to the Alexa traffic rankings in 2006.
[30]http://www.linkedin.com/

the focus is not on groups or collective activity.

These social networking services commonly have very general contexts and usually people involved in these systems have just connections representing that they know each other. There is no structure that would help them build mutual meanings. Generally these social networking systems store second or third order links between people. This is an important filter for accessing information, and can be used in collective systems for organizing the information flow between people.

Social Bookmarking

For the last couple of years, social bookmarking has been a typical activity for organizing hyperlinks on the Internet. Bookmarking hyperlinks started with the early web browsers, with tools that enable storing and naming urls for future reference. Today with these bookmarking services, we are able to store the web addresses we like to a central server and share them with other people.

With its simple interface, *Del.icio.us*[31] has been one of the most popular social bookmarking services. In Del.icio.us, a bookmark is identified by a URL and supported by three metadata - description, notes, and tags. A person can enter multiple words as tags and different bookmarks can be tagged with the same words. Over time, more used tags emerge and define the main categories for a person's bookmarks. These weighted tags are commonly represented as tag clouds in which the weight is assigned to the font size of the word. This is very helpful because as people browse other people's bookmarks they can easily see both the major and minor interests of a person. There are many bookmarking websites that mainly operate in similar ways. Additionally, some of them have ranking, some of them have tag suggestion and so on.

Social bookmarking is important because the Internet is a massive source of information and search engines are mostly useful for finding "popular" information. Whereas with social bookmarking, people can easily focus on particular websites and information based on their interests and friends' interests. This type of social aggregation of

[31] http://del.icio.us/

information is very useful for focusing on specific contexts in collective activity.

Media Sharing

Today picture, video, and music sharing have become very easy and popular with the simple tools that media sharing websites provide. Massive amount of people post media to these websites, they annotate any picture, video, or audio, and post messages to people based on these media. They contribute to a massive collection of media and metadata based on their own interests. There are many websites providing similar media sharing services, I will look at the patterns in the three most popular ones: Flickr for picture sharing, YouTube for personal video broadcasting, and Last.fm for music sharing.

Flickr[32] is a simple picture sharing service. Usually people upload images from their computer, give titles, write descriptions, and tag with relevant words. Other people post comments about the images and leave notes to particular areas on the images themselves. Since the images have rich meanings, there are various stories being developed in the system. Some people post images from events, some of them collect images of particular objects, some of them make self portraits, some of them make photo-diaries and so on. People also group images in sets or specific categories, this feature kind of matches the traditional the idea of albums. People create social networks through adding contacts to their profiles, and moreover people can subscribe their friends' image feed and get updated when there are new images form their network. In Flickr, people communicate through images about various contexts. Most of the time a bad picture posted by a friend is more important than any glossy image. This happens mostly because the story or the meaning created by a friend is more relevant than any general interesting image. Overall, the medium of photography is so rich and manageable that massive amount of people from all over the world speaking different languages can figure out how to use this system. The emerging ways of usage is the most relevant to this thesis. In Flickr, the data structure is fairly simple and data objects are loosely connected to each other. In such a system, people discover new

[32]http://www.flickr.com

ways of using these loose connections. Besides creating interesting stories with the regular tools, they further analyze the system based on the semantic metadata (title, tags etc..) attached to the images. For instance, a user (brevity) wrote a program to blend Flickr images which share the same tags such as sunset, flower, eye, mountain, Eiffel Tower, soup etc. The resulting images are interesting because the common cultural understanding of icons becomes visible. So just opening the information lets people to explore various dynamics of the system. These feedback mechanisms are powerful strategies for collective systems, they motivate people and create incentive for contribution to the collective actions.

YouTube[33] is another media sharing system that enables people to broadcast their personal videos about almost anything: a person singing a song, parts from a TV show, an urban ninja jumping around buildings, cartoons, web cam girls, music videos, game recordings, how to videos, and so on. People make movies by shooting with their cheap video cameras or web cams, by recording screens, by remaking music videos, by editing all of them in various ways, and sometimes they mash up what ever clip they find on the web. As seen in other spaces such as myspace.com, this media mash up culture is exploding. YouTube has common rating, tagging, commenting, add to favorite, and grouping tools like many other social media services. Additionally, the playlist tool enable people to create playlists out of videos about particular contexts. The interesting thing about YouTube is any video can be linked outside of the YouTube system. YouTube also provides a video player so people are able to embed the videos to their blog posts and personal web sites. This helps to spread the videos on various interest networks of people. The aggregation system of YouTube does not go further than simple tagging, rating, view counts, and comments. YouTube leverages the wide spread adaption of the video recording tools by providing a social environment for sharing personal recordings. In a way, this system increases the moving image literacy in the society. This is important because people figure out ways of expressing themselves with moving images. This example is relevant for this thesis, because it shows how people are engaged with the media as a producer when a social

[33] http://www.youtube.com/

environment is provided. They get motivated and inspired from each other, figure out a way to create and edit videos, and show it to other people. Video has a great potential for creating stories and this potential is exploded with YouTube's social environment. This strategy, providing a social environment for a particular media type, can be applied to many different areas such as electronics compositions to explode the creativity on that medium.

Last.fm[34] is a music sharing service. It is based on the Audioscrobbler Plugin for media players (iTunes, Winamp etc..) which sends the name of every song played on a user's computer to Last.fm. Over time, this list of songs grows larger and larger - you can see the personal listening charts on the user pages. Last.fm automatically finds people with a similar taste, and generates music recommendations. It has all the simple aggregation tools (tagging, comments, friend network etc.) mentioned earlier in other services. The interesting side of this system is users collaboratively build stations by tagging music they like with the keywords. And of course as they listen, their profiles update accordingly. The cycle of aggregating the usage data, analyzing, and returning back to the users is a useful strategy for collective systems.

There are also other systems for sharing digital media that do not aggregate metadata but have very important role in the formation of an open culture. One of the most important one is the Independent Media Center (Indymedia)[35], in which people from all over the world report about activism and resistance events in various languages. This is very important because it provides an independent information source opposite to the politically biased and manipulated information from the mass media channels. It would be very useful for the society at large, if these efforts would have been more structured with open databases and software.

Another aspect of the social software is the apparent explosion of the personal news and diaries. People in all ages have been adopting all sorts of blog publishing software. These simple free tools and services enable people to easily publish text and visual media. Furthermore, the syndication formats such as RSS and ATOM and various news readers

[34] http://www.last.fm/
[35] http://www.indymedia.org/

help us synchronize with the development and news about our interests. For example, today, scanning more than hundred personal news feeds in an hour is an everyday common task for me and my friends at my laboratory. Also, people rewrite stories while forwarding them to their friends or publishing on their blogs. This personalized distribution of the news adds a deeper social layer on everyday information transactions. However, while this reinterpretation is easy with text, editing photo or video to add personal perspectives is not an easy task yet. This is mostly because of the low literacy of these media types (compared to text) rather than the limitation of the technology.

More and more people consume media through their social connections. This is an important transition in general media consumption. Possibly in the near future, wide adoption of similar systems can replace existing authoritative media distribution systems such as the commercial TV channels and huge media distribution monopolies. Media sharing and media literacy are very important for collective activities, they together enable rich communication between people.

All the services mentioned in the social software section have web services Application Programming Interface (API). By using these interfaces people programmatically access the aggregated information, manipulate it, mash it up with other services. For example, Google Maps are mashed up with the classified advertisements website Craigslist and created an application that dynamically locates available houses on the city map. This is another dimension in consuming these media services. Probably in marketing terms, web services APIs enable early adapters to build applications and generate content for the late adapters and so on. But this is also a new type of cultural development, our collective knowledge and aggregated experiences are being mashed up like no time in the history. Similar strategies can also be used for creative expression. For this thesis work, besides being an inspiration in terms of technology, these systems show how massive amounts of people can participate to an aggregation with different contexts. These new conditions provide important insight for collective systems development.

Massive Collaboration

There are also important contemporary examples for massive collaboration with shared goals or objectives. Wikipedia is the most obvious one, but there are also visual collaboration examples that are relevant to this thesis. Also, open source software development communities have structured methods that are relevant to collective systems development.

Wikipedia is the most adopted collaborative editing typology. Today, people contribute to this massive knowledge base by manually entering new information and editing the existing articles. In Wikipedia, people's shared goal is to build a complete and clear article about the given topic. Since Wikipedia is completely open, people can maliciously change texts or delete articles. In these cases the history of the activity in articles enables recovering the data. Overtime, precise and clear information emerges from these activities.

Editing text is an easy task for almost any person, but collaboratively creating visuals is a little more challenging. However, there are few attempts such as *The Smaller Picture* and *Swarm Sketch*. These projects provide a canvas, and a drawing tool. Most of the time users are given specific or general goals to accomplish collectively. For example in *The Smaller Picture* website, goals are specifically defined such as "create a spider", "create an umbrella", or "create a heart" and in the *Swarm Sketch* website, goals are more thematic such as sketching "village people", "shark attack", or "the bachelor". In these systems, the synchronous collaboration is more visible compared to other text based environments. People may login to the system at the same time and change things while other people are also working on the same visual elements. This real-time feedback motivates people for participation.

Runme.org software art repository, launched in January 2003, is an open, moderated database in which people submit projects they consider to be interesting examples of software art[36]. It is conceptualized and administrated by Amy Alexander, Olga Goriunova, Alex McLean and Alexei Shulgin, and developed by Alex McLean. Every year they organize software art festivals based on the collective data aggregated from

[36] Runme.org description on http://www.runme.org/about.tt2

people's uploaded art and the keywords that form the metadata. They also manually filter and manipulate the words and subcategories. This is a good example of collective cultural production not well structured but becomes meaningful with people's moderation.

Open source software development communities have been inventing various ways of collaborating on the software projects. Besides the general communication tools such as IRC chats and instant messengers, bug trackers and code repositories are the main tools that enable collectively developing software. Developers document projects using wiki and report news on the blogs. They subscribe to RSS feeds of the changes, new commits, and logs in the code repository software (e.g., CVS, Subversion). There are various elements that motivate people for contribution. Developers mostly benefit from the mutually tested upstream code [37] and save time and cost in their projects. Contributers maybe mostly motivated with the ideas of the project itself. On the FreeBSD organizational document it Joseph Koshy summarizes: "The factors that motivate individuals are complex, ranging from altruism, to an interest in solving the kinds of problems that FreeBSD attempts to solve." [38] Besides the internal development of the project, there is another type of collaboration in open source software development: the collaboration between projects, also known as "forking". Projects fork from one project, develop differently, and later may meet with the root. For example, the operating system Ubuntu has forked from the Debian project and later some of those code reused to patch the Debian. [39]. In many open source development projects a core team manages the repository commits. This also a hierarchical structure where supervisors review the selected contributers' code. Developers can only contribute through these sponsors. People organize elections for reviewing teams. Projects usually start in some way and people reconfirm the review teams as they go. [40] They also review significance of the contribution. Today, Debian has thousands of members and around 500 contributers. Ubuntu has several hundreds of members worldwide and around 30 contributing

[37]Tested stable source code
[38]http://www.freebsd.org/doc/en_US.ISO8859-1/articles/building-products/index.html
[39]Interview with Benjamin Mako Hill, one of the Ubuntu developers. MIT Media Lab. April 25, 2006
[40]Ubuntu when it started two years ago in 2004.

developers. According to Hill, this type of structure keeps a consistent vision and assure the quality. The structured development in the open source software development communities is relevant because with those structures they can keep large projects running for a long period of time. This robustness is very important for collective systems. Even though the resulting product is as complex as a computer operating system, in a way these projects keep living in parallel to people's life.

2.3.3 Harvesting Collective Intelligence

Besides the commercial systems that collect information from people, there are other academic approaches that acquire and analyze knowledge from people to give "common sense" to computers. Common sense computing has emerged as an important field in the artificial intelligence community. One of the earliest projects *Cyc* has started in 1984 by Doug Lenat to assemble a comprehensive ontology and database of everyday common sense knowledge with the goal of enabling Artificial Intelligence applications to perform human-like reasoning[41]. The other well known effort is the *Open Mind Common Sense (OMCS)* initiated by Push Singh in 1999 with a goal to build a large common sense knowledge base from the contributions of many thousands of people across the Web[42]. Both of these systems use custom template languages for entering information to their knowledge bases. These semantic templates enable collecting structured data from people. Some examples of items collected by *OMCS* templates are "Every person is younger than the person's mother", "People generally sleep at night", "If you hold a knife by its blade then it may cut you", etc. While the *Cyc* language has very strict rules, *OMCS* relies more on information extracting from text so the information entry interfaces are more easy to use through the natural language.

In these projects there is not much incentive for people to enter data into the system. Louis von Ahn approached this situation by creating games that collect human knowledge. In his web based games *ESP* and *Peekaboom*, people play the game because of its entertainment value, as a

[41] D.B. Lenat, A. Borning, D. McDonald, C. Taylor, S. Weyer. Knoesphere: Building Expert Systems with Encyclopedic Knowledge. In Proc. of the 8th International Joint Conference on Artificial Intelligence, Vol 1, pp 167169, Karlsruhe, Germany, August 1983.

[42] Push Singh, Thomas Lin, Erik T. Mueller, Grace Lim, Travell Perkins and Wan Li Zhu (2002). Open Mind Common Sense: Knowledge acquisition from the general public.

side effect of them playing, systems collect valuable image metadata, such as which pixels belong to which object in the image. The collected data could be applied towards constructing more accurate computer vision algorithms, which require massive amounts of training and testing data not currently available[43]. *Peekaboom*'s unique interface captures information from two individual's interaction. In the game, while one person is revealing parts of an image, the other person guesses what his/her partner is revealing with words. With this interaction, this system collects information about "How the word relates to the image", "Pixels necessary to guess the word", "The pixels inside the object, animal, or person", "The most salient aspects of the objects on the image", "image-word pairs that can be eliminated"[44]. This is a powerful approach because two people confirm the accuracy of the knowledge in their interaction. As I discuss in this thesis document, aggregating the information generated by people's interactions is one of the core methods for collective systems.

Commonsense inference is rooted in the assumption that there exists a set of unspoken knowledge that is shared by most people. Having such knowledge then becomes an important prerequisite for computer applications which aspire to higher levels of understanding. These projects are focused on building intelligent machines, which is a very broad goal. In this thesis, I am only inspired by the methods invented in these systems, and focused on returning the aggregated and analyzed information from people's activities back to the people. This cycle enables a synthesis through people and empowers the individuals who are participating in collective activities.

2.3.4 Synthesis of Physical I/O and Collective Activities

The research in the field of ubiquitous computing promises to digitally connect all the objects and environments around us. This utopian dream started with the Xerox PARC researcher Mark Weiser's vision to describe the future in which invisible computers, embedded in everyday objects,

[43] Luis von Ahn, Ruoran Liu and Manuel Blum. Peekaboom: A Game for Locating Objects in Images. In ACM CHI 2006

[44] Luis von Ahn, Ruoran Liu and Manuel Blum. Peekaboom: A Game for Locating Objects in Images. In ACM CHI 2006

replace PCs[45]. Weiser raised new questions in his famous essay titled "The Computer for the 21st Century": How does technology disappear into the background? How do all these objects around us interact? What would it be like to live in a world full of invisible widgets?[59] This dream was later followed by many projects such as Smart Dust[46], and MIT's Project Oxygen[47]. In the vision of these large projects the computer is pervasive, it is embedded, it is adaptable, and eternal. However, as the technology gets invisible, it also becomes closed. As it becomes more closed, it becomes more authoritarian. By being invisible, these technologies promise to increase the "quality" of our life, but they also get closed and enable a kind of social control mechanism for regulators of these technologies. Today's glossy electronic objects and services that offer

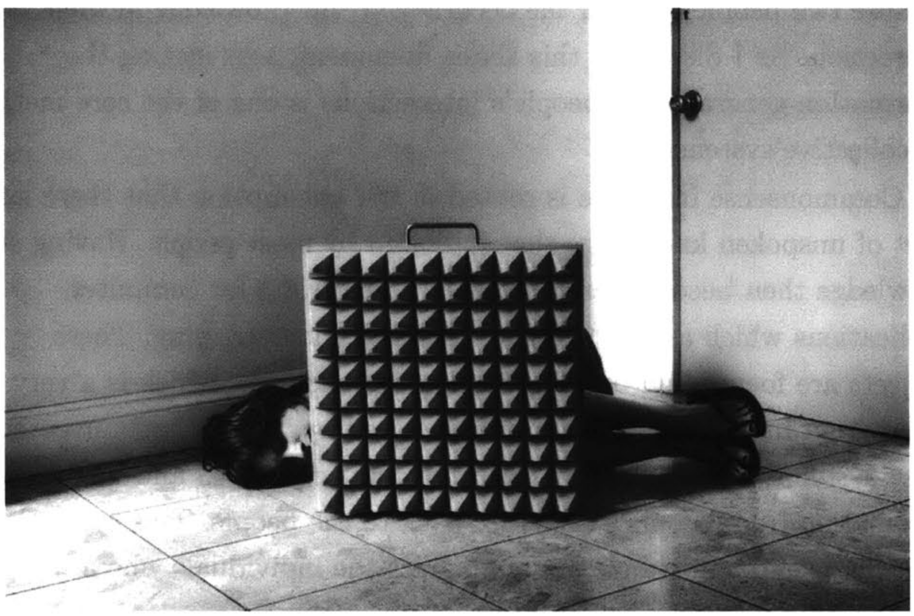


Figure 2-14: Anthony Dunne & Fiona Raby. *Electro-draught excluder*, 2001

futuristic lifestyles are also well criticized by Dunne&Raby in their book *Design Noir* (2001). They point out the parallelism between the glossy electronic products and the Hollywood blockbuster movies that both reinforce how things are now and conform to cultural, social, technical,

[45]See Mark Weiser's famous essay "The Computer for the 21st Century", reprinted from Scientific American, 1991

[46]Smart Dust: Communicating with a Cubic-Millimeter Computer, Brett Warneke, Matt Last, Brian Liebowitz and Kristofer S.J. Pister, IEEE Computer, 2001.

[47]http://www.oxygen.lcs.mit.edu/

and economic expectation[16]. Dunne&Raby offer an alternative genre for electronic products that focuses on how the psychological dimensions of experiences offered through electronic products can be expanded. In their approach, they look at the misuse and abuse of the consumer products, where desire overflows the material limits and functions of everyday objects. They propose a new product design genre that addresses the darker, conceptual models of need[16]. With their design, for example the *Compass table*, the *Electricity drain*, and the *Phone table*, they underline the importance of asking carefully crafted questions that make us think, as an alternative to design that simply solves problems or finds answers. This perspective becomes more important in the design of connected electronic objects and spaces because these connected things are not always passive, on the contrary, as discussed as the vision of invisible computing, they are active, reactive, responsive, adaptive things and are taking more part in our daily lives as they are embedded everywhere.

The quest to make the connected products invisible is based on a specific world view, an ideology, or way of understanding reality. There can be other perspectives that are more critical and humane. If we are moving into a world where electronic objects and spaces are digitally connected, what we need are dialogues at the stage of designing these electronic objects. These dialogues do not mean the communication between people through the end products, but they mean participation in the design process of these products and services. I argue that design of connected objects and spaces should be based on a consensus; the level of visibility or invisibility should emerge from participants' collective decisions. When products and services emerge from collective activities, the collective consensus embeds the social, technological, cultural, and economical values within the resulting products. This way of building connected electronic objects and services with a consensus contributes to the openness of products and services that are going to be embedded in our lives.

Artists working with technology and building things that work on their own also generate digital data through their craft. At the same time, we not only communicate online and send and receive all sorts of digital data, but we also generate data through our relationships with other people. A synthesis of artists' craft and their relationships is possible when things are represented as digital data. This synthesis is meaningful if people together mix and mash up the data generated by their electronic objects with the data generated from their relationships in collective activities.

The final thesis project Open I/O, discussed in the next chapter, contributes to this vision by enabling artists and designers to share and exchange the data of their electronics prototypes in collective activities. It is designed to easily create electronics prototypes that are accessible through the Internet. In doing so, it opens up a new way of collaboration through physical devices between artists and designers that reside in different parts of the world.

Chapter 3

Experiments

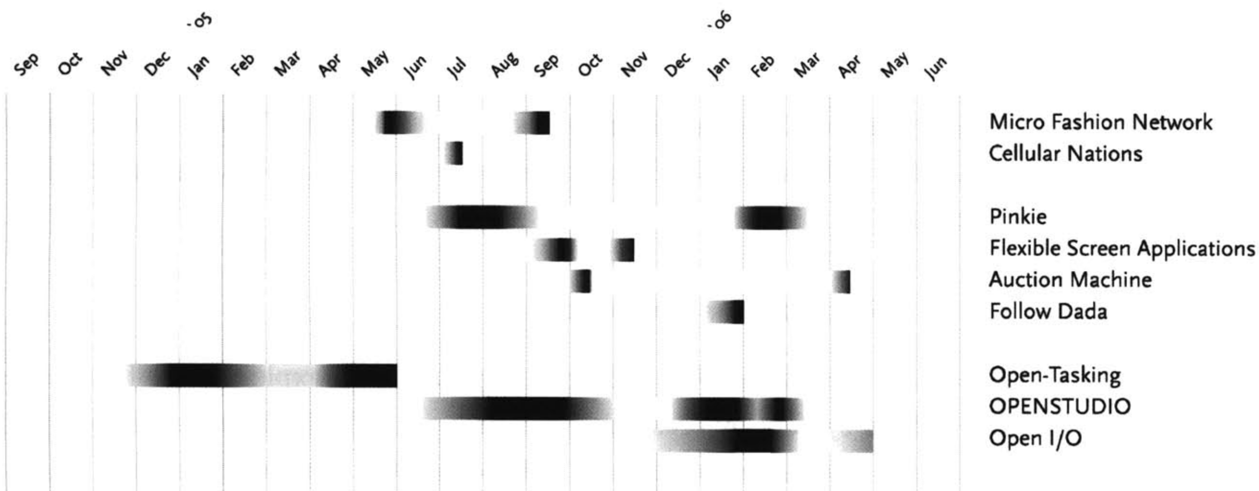


Figure 3-1: Experiments Timeline

This section includes a partial range of experiments from visualization of systems to physical interaction systems for collectivity. Although this thesis focuses on systems that enable collectivity, it discusses supporting projects to facilitate a richer understanding of their dynamics. The supporting experiments address the problem of representing the dynamics of complex systems that are abstract and can only be experienced by using them. So with these experiments I also explored how to represent various complex systems in order to show and observe their dynamics. One method that emerged from these experiments is to show the instances of the whole system, implying the global dynamics and giving clues about the experience while the system is being used by people.

These experiments progress roughly in parallel, from developing collective systems to exploring the ways to represent them (fig. 66). The desire to create collective systems with physical inputs emerged naturally from the process of building systems that include people and machines and from a frustration of screen-based form and interaction. The common thread in this work is the study of large systems, composed of high-level social and economic relationships and low-level physical interactions, as a means of supporting and altering these high-level social interactions.

3.1 Visual Systems

The experiments in visual systems section are created because of the desire to show and observe the dynamics of complex systems. These experiments are reactive systems that receive and process input as a means of generating and altering visual compositions. These systems are composed of basic visual forms, images, software, and data from certain contexts.

3.1.1 Micro Fashion Network

Micro Fashion Network is a hybrid application to explore the effects of the fashion system by creating a network with the basic elements of color and time. The system of fashion is based on the continuous change of styles and speculations about the future tastes in clothing that are represented through mass media and networks of individual expression. Understanding the relationships that form the fashion system can be a very complex task, but placing a camera in a public space and capturing the clothing of pedestrians is one way to look at these complex relationships. *Micro Fashion Network* reduces the relationships of styles to colors by capturing only the colors from people's clothing. Also the view of the camera is fixed on a certain location on the street, so it only scans a certain slice in the flow of the crowd. With these simplified focus, this project departs from an analytical observation of the fashion system and becomes a subjective exploration of a micro-system. This project emphasizes the unique ways of looking at the un(fore)seen relationships in the society. *Micro Fashion Network* not only captures and represents

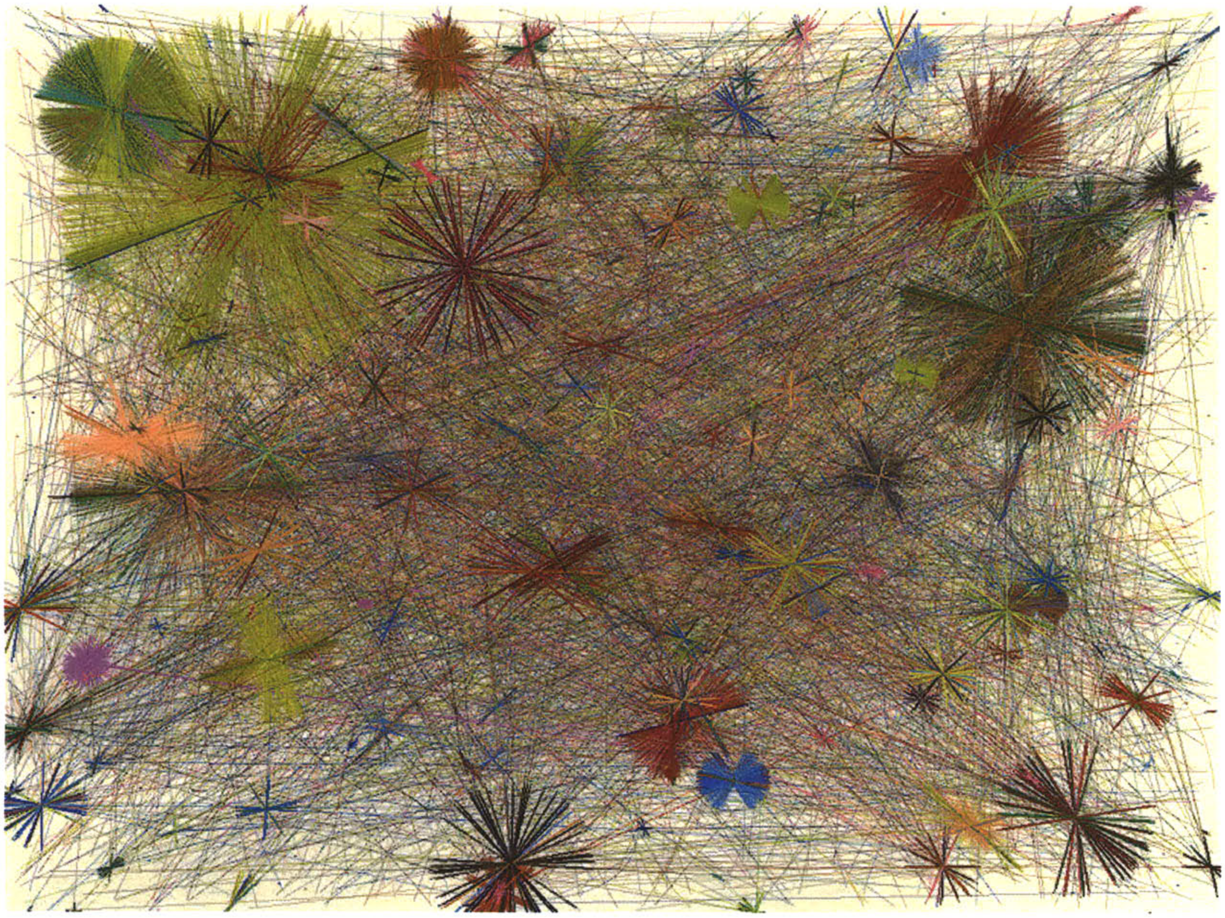


Figure 3-2: Micro Fashion Network

the color similarities between people's clothing, but also explores the function of time in the structure of networks. By continuously scanning a slice in a flow and detecting features, we can build a graph based on the relationships between these features (fig: slicing). *Micro Fashion Network* applies this idea by using a fixed camera and custom software that processes and stores dominant colors of moving people in a busy Cambridge neighborhood. Similar color data connects to each other and, over time, form a large color network. The program is designed so that as the network grows, the new vertices are connected to existing similar colors. Because of this preferential attachment[1], in the resulting network, most color nodes have only a few links, held together by a few highly connected color hubs. These color hubs mean that the connections in this

[1] Barabasi found the preferential attachment behavior in complex networks.

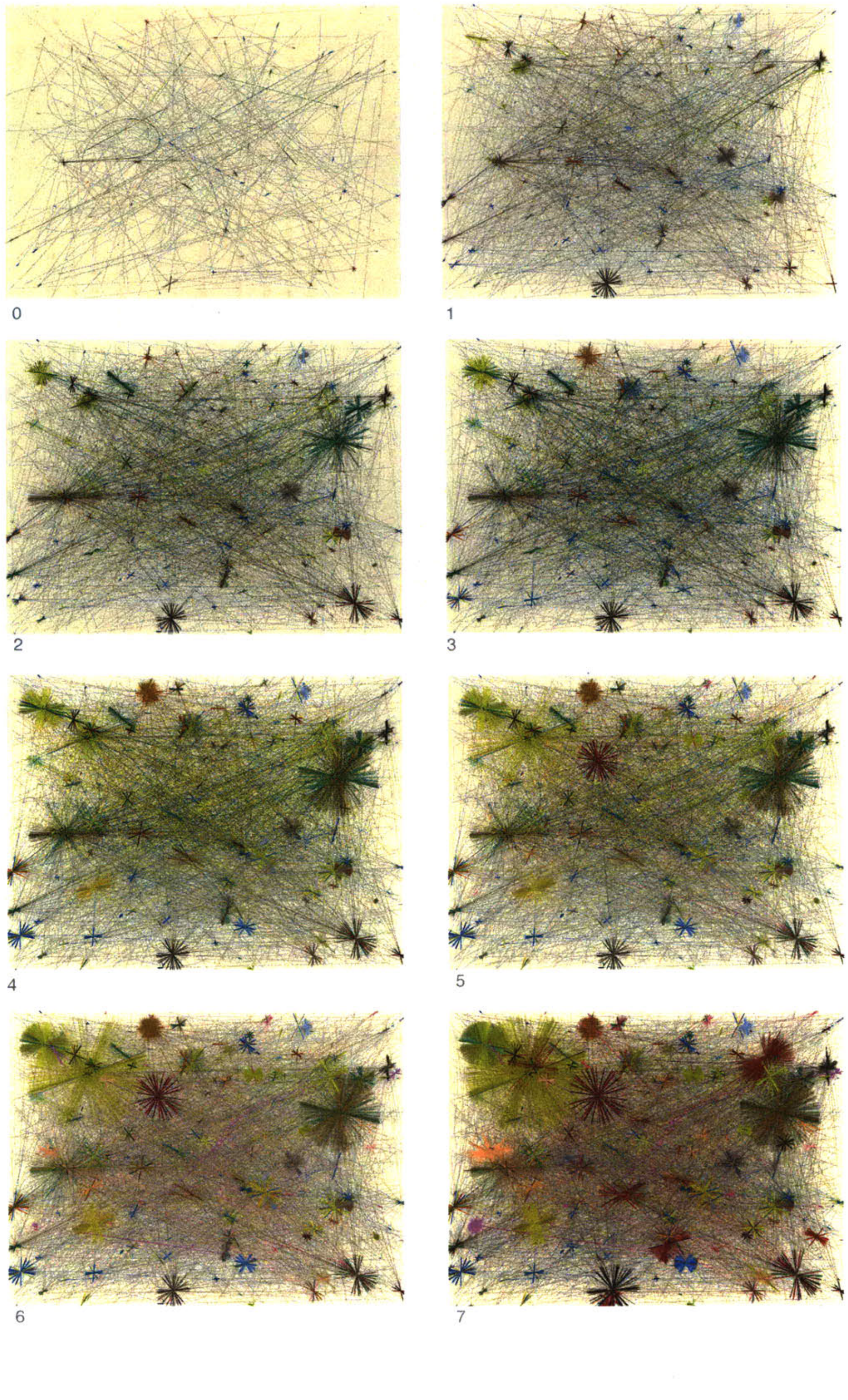


Figure 3-3: Micro Fashion Network. Color clusters emerge in time.

color network follow a power law degree distribution[2], which shows that at a certain point in the city, color similarities between people's clothes are far from random. The technical foundation of *Micro Fashion Network*

Figure 3-4: Micro Fashion Network. Camera capturing view, abstract color blocks, and the network visualization.

is its ability to capture dominant colors of moving objects from a scene. The software written for image capturing extracts the moving pixels from the static pixels, quantizes the colors of the extracted region, clusters through a k-means clustering algorithm, and finally returns the three dominant colors. If no motion occurs in the scene, the program captures nothing. Moreover, the program captures data at a certain threshold of change in the scene, that is the human walking speed. When the program captures the colors, it writes them into a database with their timestamps. If a new color matches any color in the existing database, the program creates a link in between.

The visualization program reads a network of color nodes from a database. It iterates through the nodes based on their timestamps. When a node is read, it shows up at a random position on the screen and moves towards the node that matches itself. As the nodes move, they leave tracks on the screen and paint the canvas. As a result we see a mash-up of color hubs and the trails of the colors.

Micro Fashion Network is exhibited in the Collision Eight Exhibition[3] in the form of three different artistic representations placed side by side: captured human figures, color information as abstract boxes, and the complex network of colors.

[2]The power law probability distribution was found by the economist Vilfredo Pareto. It can be observed in a large number of real-world situations.

[3]The Collision Eight Exhibition took place at Art Interactive Cambridge, in September 2005

3.1.2 Cellular Nations

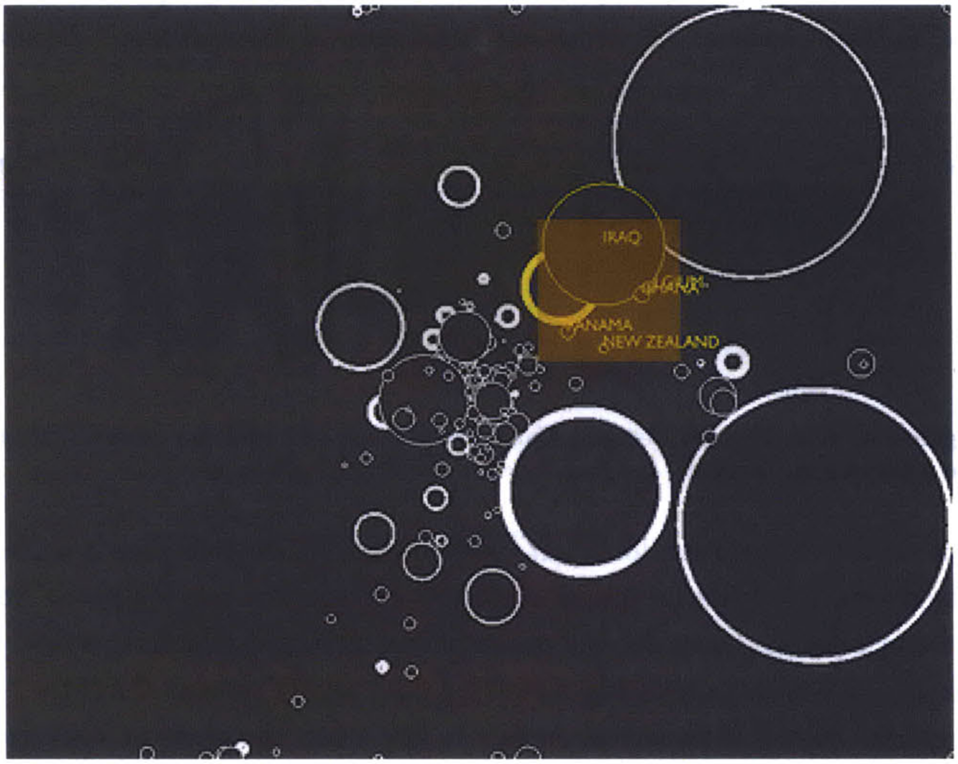


Figure 3-5: Cellular Nations

Cellular Nations is a program that maps global economic information to a dynamic visual system. It offers an alternative way of looking at the relationships between nations. Usually a good way to understand information is to make comparisons. A richer way to do this is to visualize information in a way that enables visual comparison. But comparing the static visual elements does not always help us understand the effects of the data. *Cellular Nations* allows us to compare the ever changing effects of the relationships in the data set by creating a dynamic visual system. Here the data is not literally tied to static visual elements as it is in pie charts, bar graphs, and so on. The data is rather mapped to a dynamic visual system in which visual elements interact with each other and relax over time. This enables us to observe the effect of the relationships in the data set.

Two studies focus on the representation of two hundred and thirty-two world nations with visual cells. The data is parsed from the

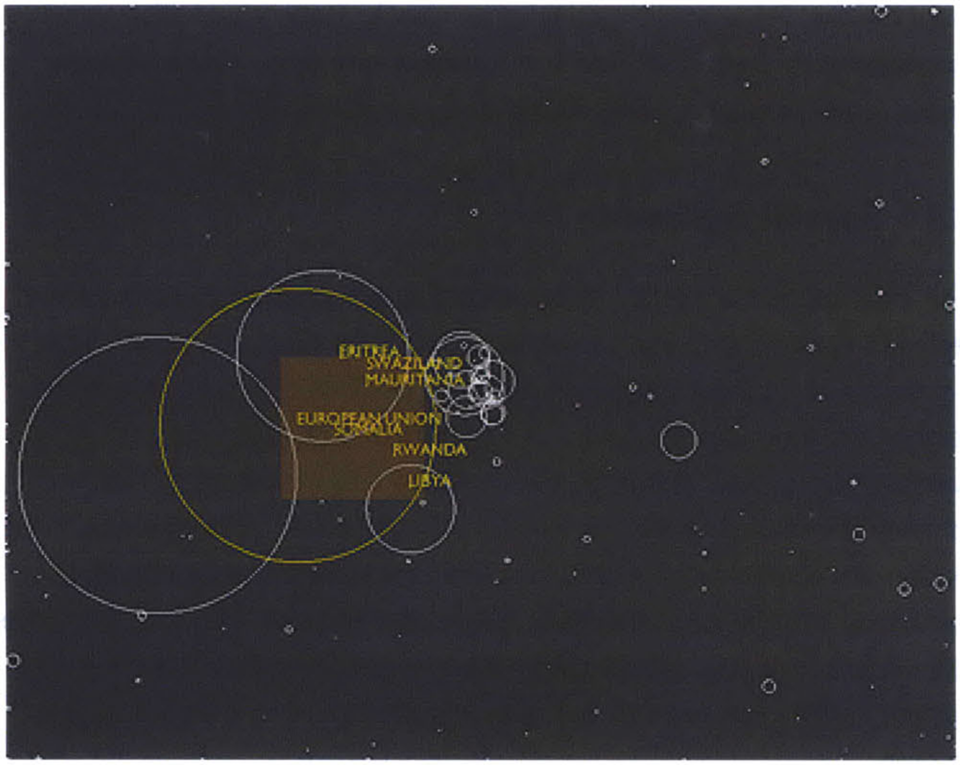


Figure 3-6: Cellular Nations

CIA World Fact book[4] and mapped to the visual elements in the program. Economic information - GDP, GDP growth rate, inflation rate - is mapped to the geometry and speed of the circles. The physical power relationship between the cells simulates the military power. In Study 1, the size of the circles represents the GDP (Gross Domestic Product) for countries, the thickness of a circle represents the GDP Growth Rate, and the speed represents the Inflation Rate. In Study 2, the size of the circles represents the GDP (Gross Domestic Product) for countries, the pushing force represents the Military Expenditure. If the touching circles have similar military expenditure values, they stick together.

Viewers can control a magnifying glass-like square element by dragging it to see certain areas on the screen. When circles appear under this square, their names become visible. This occurrence enables the viewers to observe a particular region while allowing them to explore the overall change. Study 1 shows countries who have high inflation rates

[4] http://www.cia.gov/cia/publications/factbook/

(e.g., Latvia, Peru, and Nigeria) move clearly faster than others and countries with high GDP and low inflation rate (e.g., United States, Japan, and Germany) move slowly and visually dominate the screen.

3.2 Spatial Systems

The experiments in spatial systems section are created because of the desire to connect physical interactions to larger digital systems. Today it is possible to connect microprocessors to the Internet, and so various devices, sensors, and actuators can become online and take part in our everyday online life. However, the qualities and meanings of these connections are primitive and needs to be improved. The systems in this section are composed of electronics, microprocessors, sensors and actuators, RFIDs, microprocessor programs, software services, protocols, and certain materials. With these experiments, I explored various qualities of the connections between physical space and larger digital systems.

3.2.1 Pinkie

Pinkie is a network based electronics prototyping board developed in collaboration with Vincent Leclerc as a precursor to building large networked systems around physical devices. It has been designed to easily compose sensors and actuators that reside at different locations. *Pinkie* boards work in relation to a suite of software services and interfaces in order to program and run distributed physical media, and to exchange data and functionality of devices over the Internet. Pinkies are inherently invisible, they hide behind the structures and only serve as facilitators to interface the physical world to the digital network.

The main component of the *Pinkie* board is an AVR family microprocessor (ATMEGA32) with 8-channel 10-bit ADC (Analog to Digital Convertor) and 16 digital I/O channels. The board accommodates two MOSFET chips to drive high-voltage components such as DC motors, solenoids, and speakers. In addition to these basic functions, there are two LEDs, one of them indicates that the board is on, and the other is a general purpose output for quick testing. Finally, the XPORT component

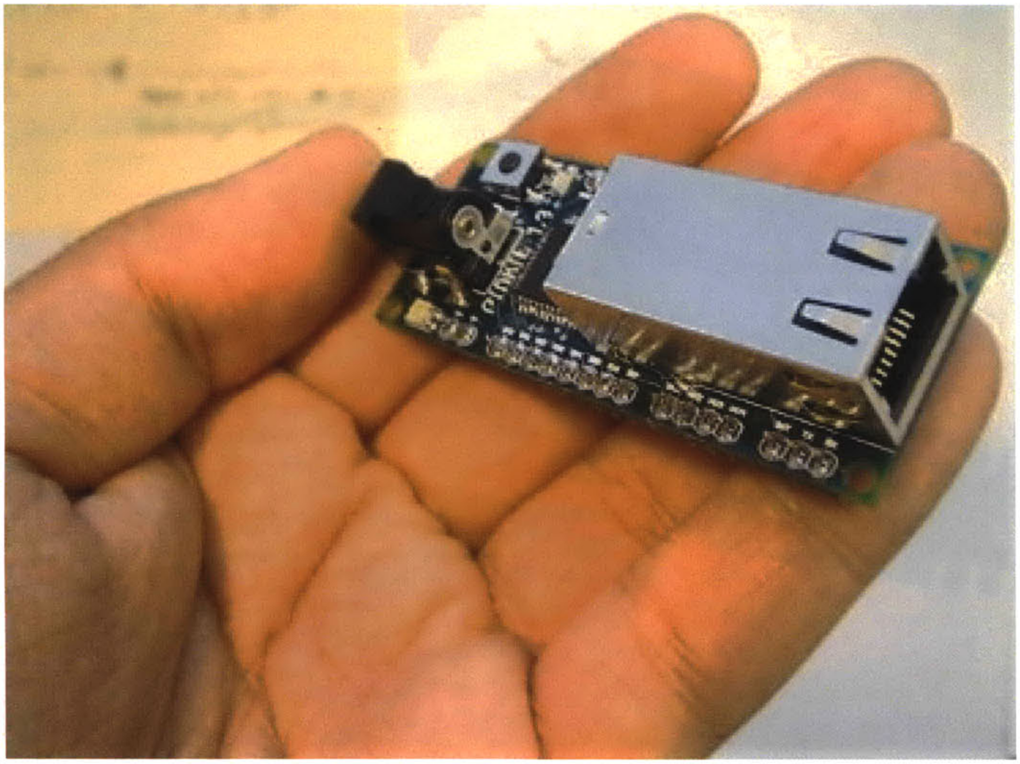


Figure 3-7: Pinkie

connects the board to the Internet by converting outgoing serial data to TCP packages and incoming TCP packages to serial input. The XPORT is also used for addressing and communication. It automatically gets an IP address when started. When a special message is broadcasted, the XPORT replies with its IP and mac address. Then this data is used to globally access the *Pinkies*. The combination of a software service and a dispatcher manages the communication between multiple *Pinkie* boards globally. The details of this part is described in the *Open I/O* section.

Pinkie boards had various iterations, current version is the most stable one and its size is 1x2.5 inches. By using the header pins, *Pinkies* can be mounted to a breadboard for quick prototyping. Then a very simple electronic composition such as blinking an LED becomes globally accessible. For more complex compositions, *Pinkie* boards can be used as the main controller board not only to control the system but also to make composition available to the world.

A C library has written to simplify the programming on the *Pinkie*

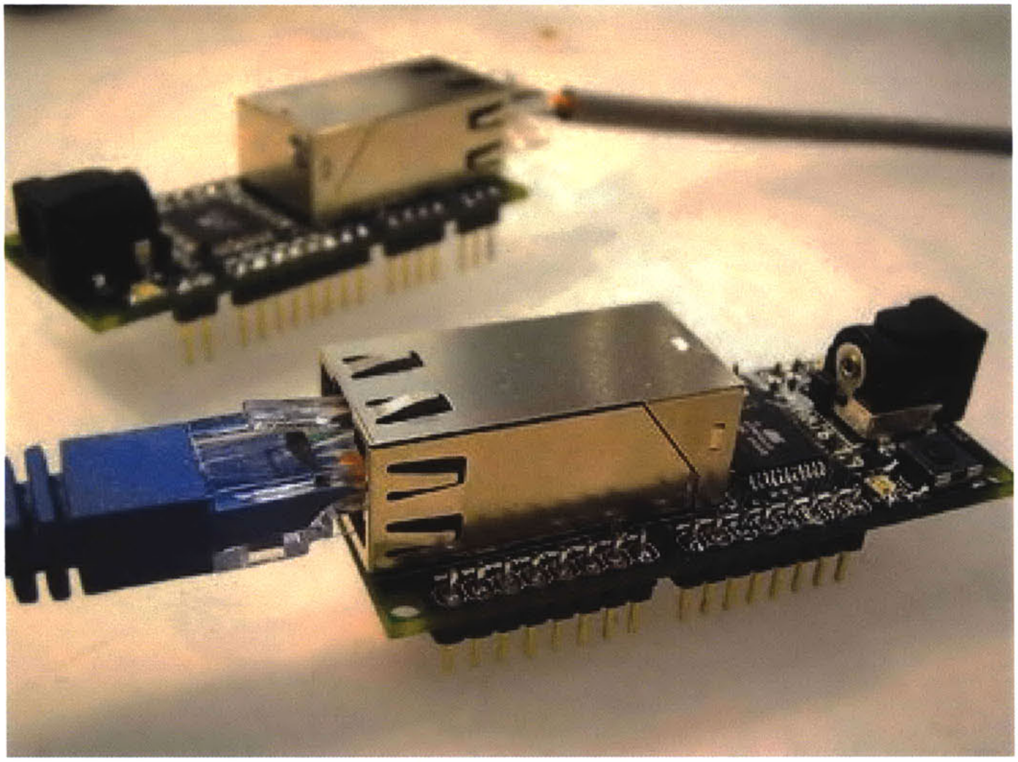


Figure 3-8: Pinkie

microprocessor. Artists and designers who are not tech savvy can easily program the *Pinkies* by using the simple interface of this library. This simple interface provides an understanding of how these systems operate and becomes a step for more complex programming modes. Basically, there are three ports on a *Pinkie* board: Analog-to-digital convertor (AN), Digital input-output (IO), and High Voltage (HV). The programming interface has four control methods that use those ports:

```
setIO(pin, value); Set digital i/o pin to the given value
setHV(pin, value); Set high voltage pin to the given value

getIO(pin); Read the digital value
getAN(pin); Read and convert the analog value to digital
```

And three communication methods:

```
serialAvailable();  Return true if there is data in the serial pin
serialRead();  Read the serial input
```

`serialWrite(value); Write the given value to serial pin`

Pinkies provide a platform for artists and designers to easily prototype tangible media with the context of networks. This enables the realization of new ideas about product design and architecture in the context of networks.

3.2.2 Flexible Screen Applications

Flexible Screen Applications are a series of experiments with flexible screens developed by one of the sponsors of the MIT Media Laboratory. Because this technology is a new medium in between paper and screen, the challenge is to create meaningful experiences that are richer than the combination of both conventional media types. I've created four applications that leverage the properties of this new medium. Flexible

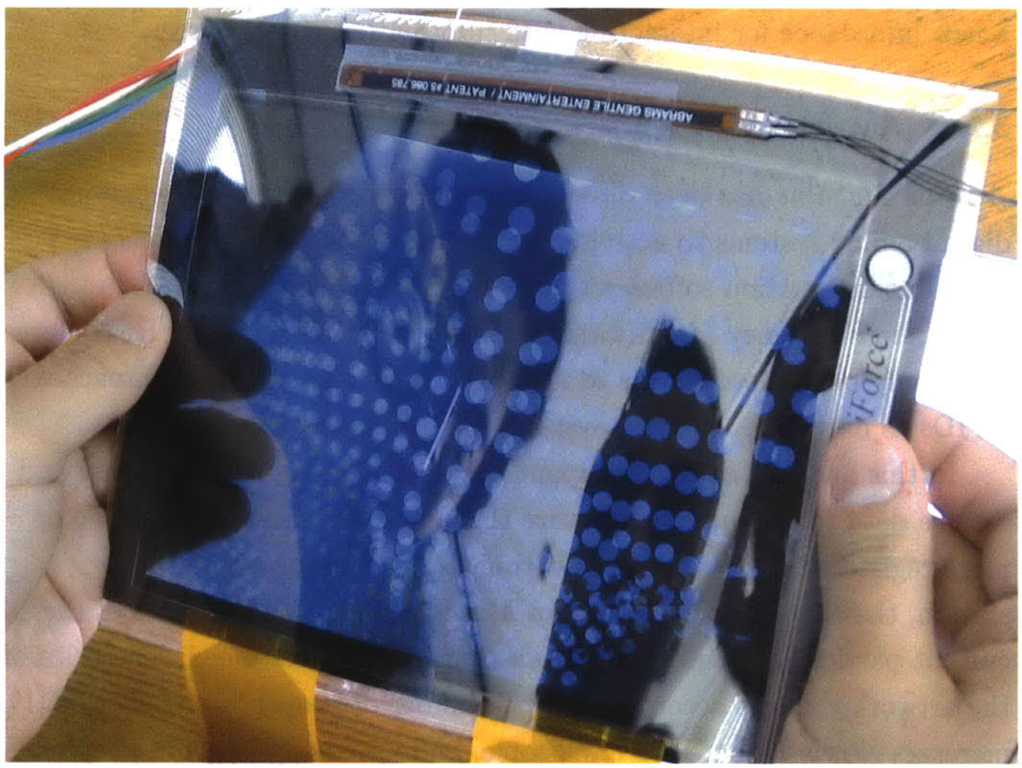


Figure 3-9: flx.scape

Screen Applications *flx.maps*, *flx.movie*, *flx.scape*, and *flx.treemap* combine two bending sensors and a force sensor working in relation to the software that both handles sensor communication and the dynamic graphics. Sensors in these applications are used with the Pinkie boards. In *flx.maps*, two bending sensors control the zoom to maps and force sensor points a position on the map. In *flx.movie*, two bending sensors control the movie to play in forwards or backwards, and the force sensor controls the speed. In *flx.scape*, there are abstract data points on the screen and two bending sensors control the positions of the data points in a virtual 3d space. The force sensor changes the sliding speed of the data cloud. *Flx.treemap* is a treemap visualization application, in which bending sensors control the scale of particular rectangles among all the rectangles of the treemap. Force sensor controls the opacity of the squares and makes them visible or invisible. In all these applications, the activity between the sensors and the software organized in a way that a person using the screen experiences a unified experience. By unifying sensors, graphics, and the materiality of the screen, this new hybrid screen-interface defines a new affordance for interacting with information on the screen.

3.2.3 Auction Machine

Auction Machine has been developed as an experiment for connecting digital online systems to activity in physical space. *Auction Machine* is an online art auction software that works with *OPENSTUDIO* through the Radio Frequency Identification (RFID) technology. While RFIDs are commonly being used as IDs to identify things, this project approaches RFIDs as interfaces to larger systems, distributed in physical space.

In this auction, each participant has an RFID tag that can send and receive data to the auction software through radio signals. After two or more registered participants are within the radio range of the base station, the auction starts. *Auction Machine* displays the names of the current participants and the artwork that is to be auctioned. The price of the artwork changes according to the number of people in the auction. It increases slowly if there are few people, and speeds up as more people join the auction. People stay connected if they think that the art piece is worth the price, or, if not, they leave by turning off their RFID tags. At the end, the last person who stays in the auction automatically gets the artwork and pays the price. When the artwork is sold, all the related

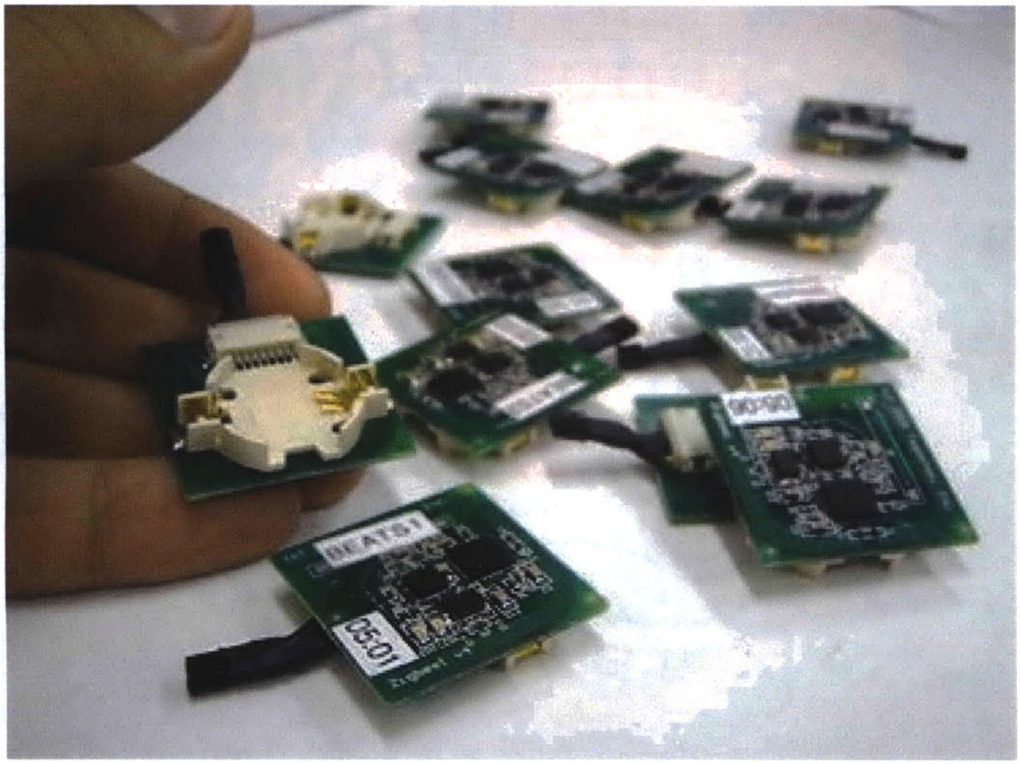


Figure 3-10: Auction Machine RFID Tags

information in the database gets updated, and the sale becomes visible as a regular online transaction in the *OPENSTUDIO* online micro-economy. *Auction Machine* connects the virtual *OPENSTUDIO* system to the activities of multiple people in physical space. Such an interconnected environment creates new types of scenography and spatial continuity that fundamentally affect the way we understand and use space.

Auction Machine can be set up on any computer that has Internet connection, and its surrounding environment becomes an electronic auction space. *Auction Machine* has been used by approximately 20 people (10 people in the same session simultaneously) during the Media Lab Sponsor Week in Fall 2005.

3.2.4 Follow Dada

Follow Dada is an interactive installation that investigates the relationship between information density, physical distance, and intuitive human acts. It is composed of two software projections on the wall and

Figure 3-11: Follow Dada

floor, and a sensor system that captures the proximity of the viewers. The visual information projected on the wall is responsive to the proximity of the viewers. As the viewer gets closer, the rectangular body of the information gets divided into smaller pieces, becoming more detailed. When the viewer moves back, the information is altered to become less detailed.

3.3 Collective Systems

Collectivity is a term that does not have a unified general theory, yet it can be placed in various axes between community and collaboration. With the wide spread use of electronic communication technologies and the Internet we are more connected than any other time in the history. While this connectivity may be a prerequisite for collectivity, the reverse does not apply. Massive amounts of people can be connected -as happens everyday on the web- without any aggregation or group phenomenon.

Collectivity is an aggregation of individuated units in relation to each other, with the quality of the relations largely specified by the context[50]. People also contribute to various communities and collaborate with others every day. These communities have very loose structures. For example, people usually post messages to a forum without any organization toward some agreed-upon action. They also collaborate with other individuals with very strict rules and goals. For example, together they edit a text to create a certain document. In these systems inputs are stored as plain lists that are just viewable and searchable. However, collective systems harvest intelligence from participants, analyze, and give feedback to people in a way that enrich the individuals. Collective systems place us with in a creative cycle, as Pierre Lévy puts it "it is a living environment of which we are always already the co-authors"[26]. The problems collective systems try to address are pointed out in Lévy's writings: "How can a symphony be created from the buzz of voices? Lacking a score, how can we progress from the murmur of the crowd to a chorus?" The quality of collective systems depend on many things from the loose protocols between participants to the evolving shape of the environment. These qualities are explored in the experiments described in this section.

3.3.1 Open-tasking

Open-tasking is a web service that enables people to create and manage tasks that can be altered by other people to include more detail. In *Open-tasking*, people collectively design vertically deep or horizontally wide projects based on other people's skills. The distributed and open architecture of the *Open-tasking* system enables a person to manage his or her own complexity, so a worker becomes a manager and vice versa.

In *Open-tasking*, a person takes the responsibility of a task, articulates it, and defines subtasks. Then the person who is assigned to the subtasks does the same thing. Eventually, tasks get more granulated. This tree structure regulates a top down hierarchy between the tasks. While the growth of tasks has a hierarchical structure, the relationship between people has a decentralized topology. The contract system is designed so that the person who is executing the subtasks of a root task can create new subtasks and hire the person who has started the root task. So in

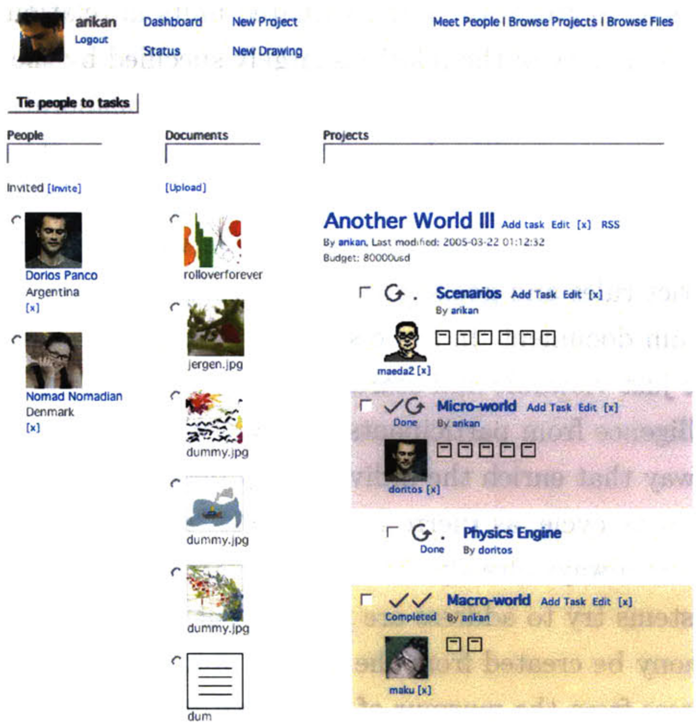


Figure 3-12: Open-tasking

Open-tasking, while the network of people grows as a directed graph, tasks evolve in a hierarchical structure. This hybrid system as the core of *Open-tasking* lets people discover interesting scenarios in the system.

The tasks in *Open-tasking* are primarily defined by a title and description. The other data about the task are starting date, duration, budget, status (pending, done, etc.), link to parent task, and responsible people who are creator and executer. The contracts between people are loose rules that enable people to explore various scenarios that meet their needs. By using the Treehouse Projects suite of digital creation tools people are able to create and to store documents online, and use them in their tasks. Besides the task operations, the *Open-tasking* system is supported by a virtual bank implementation that enables people to get paid when they are done with their task. So the relationships between people have been developed in both a social and economic sense.

The main design goal of the *Open-tasking* system is to let people use their existing tools rather than to introduce new ones. For this reason,

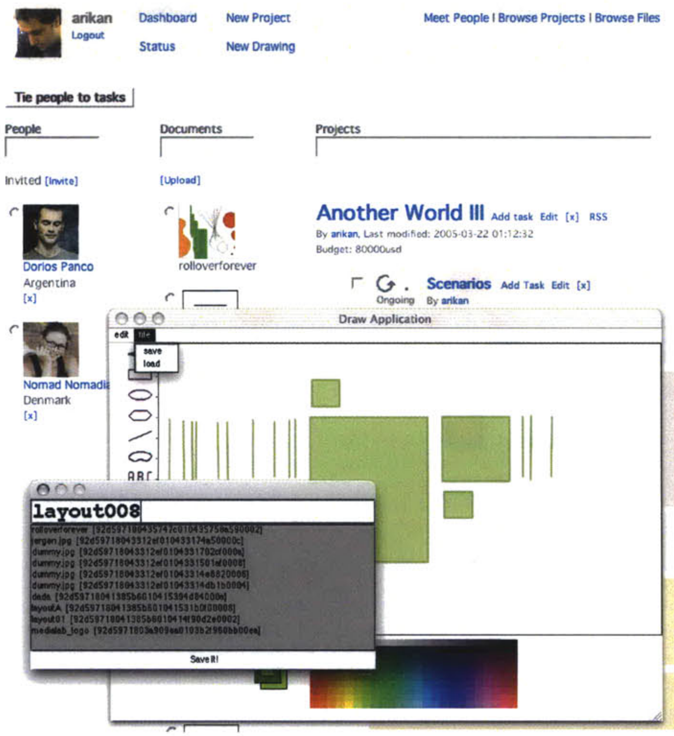


Figure 3-13: Open-tasking

the Simple Project Syndication (SPS) scheme has been created to easily syndicate the tasks and the related data outside of the *Open-tasking* system. SPS is a dialect of XML and it organizes the information flow in an online work environment where people, documents, and tasks are distributed in a network. It also enables people to subscribe to their project's SPS feed and get updated as it is executed.

With its hybrid structure formed by the distributed network of people and their connections to a hierarchical order of tasks, *Open-tasking* is an alternative model to centralized institutional management systems of our time.

3.3.2 OPENSTUDIO

OPENSTUDIO is an online marketplace of digital art created by the Physical Language Workshop at the MIT Media Laboratory. The software combines free creative tools, flexible network infrastructure, and an open web services API to create a powerful community-based economic system

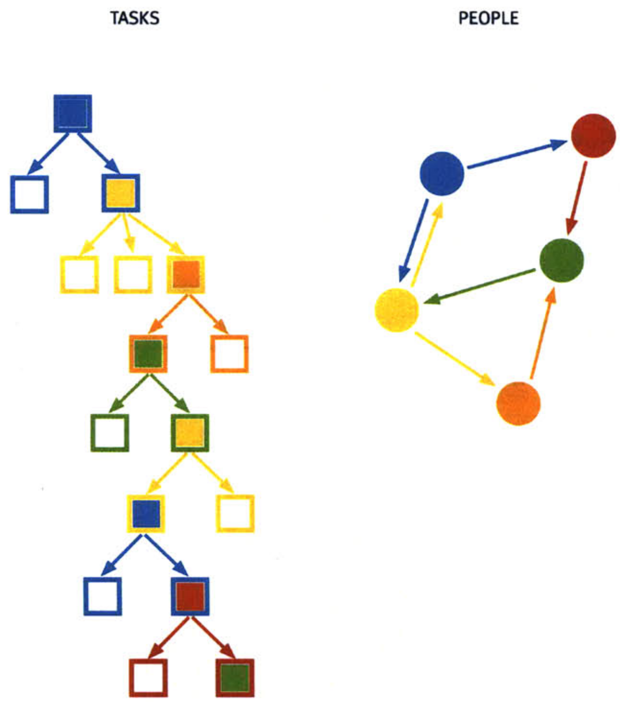


Figure 3-14: Open-tasking Diagram

in which participants create, buy and sell artwork. The *OPENSTUDIO* project is an evolving synthesis of creativity, community, and capitalism.

OPENSTUDIO is centered around a creative application suite that is free, networked and community driven. Each participant authors and edits her work using the project's light-weight tool, Draw, a java web-start application that seamlessly integrates a simple and approachable user interface with a flexible communication protocol known as SMPL[40]. Draw uses this protocol to save created art pieces directly to participants' inventory in the *OPENSTUDIO* document server.

Once an artist saves her piece, it is available in her private inventory on the *OPENSTUDIO* website, and can be either kept private, displayed in the gallery, or put up for sale. Any piece for sale can then be purchased by another member. People can collect other artists' work to show or sell in their galleries. These individual transactions cumulatively reveal community structure and values. *OPENSTUDIO* currently uses a virtual currency to lower the barrier of buying and selling activity, and in the

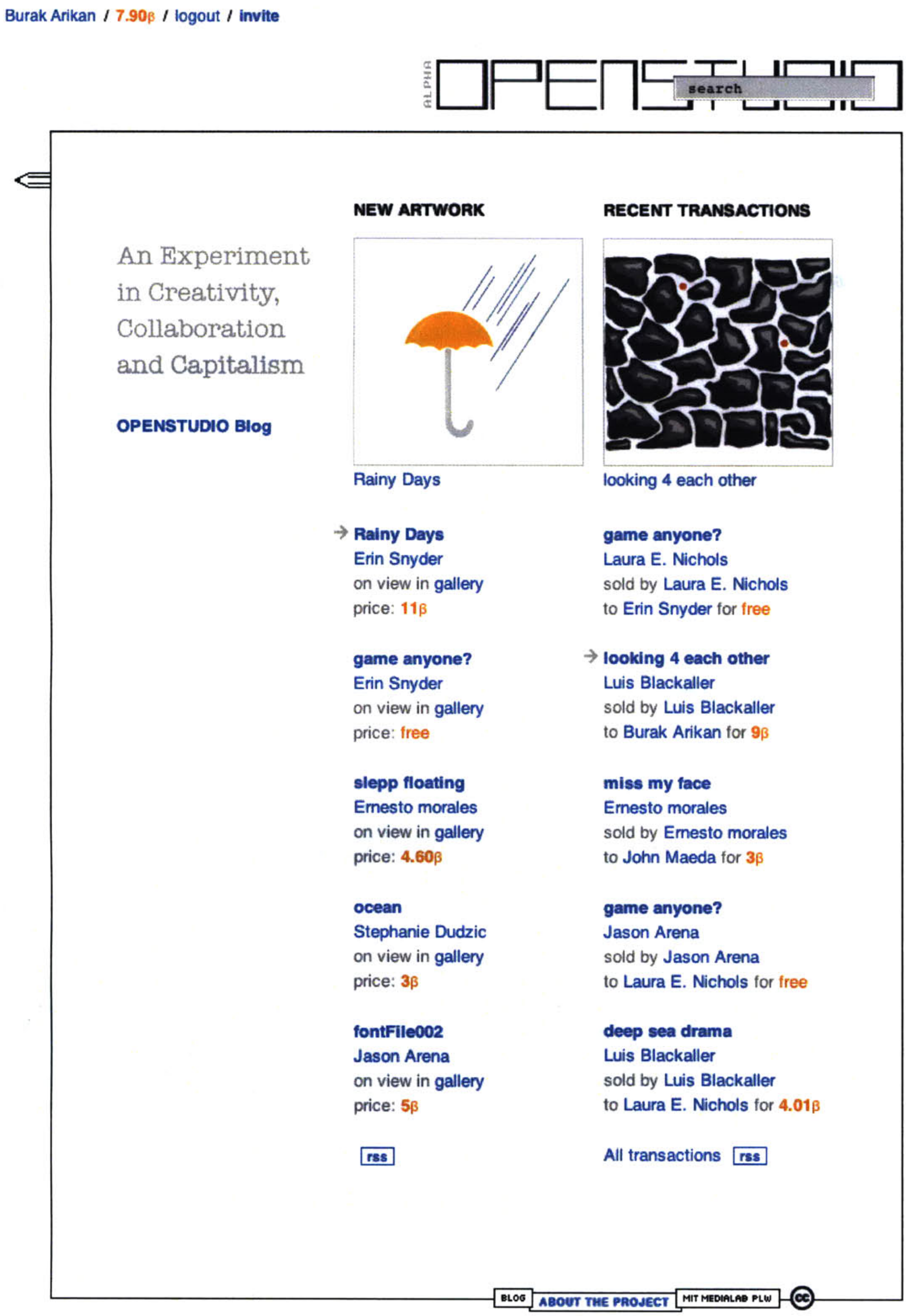


Figure 3-15: OPENSTUDIO Website Homepage. May 19, 2006

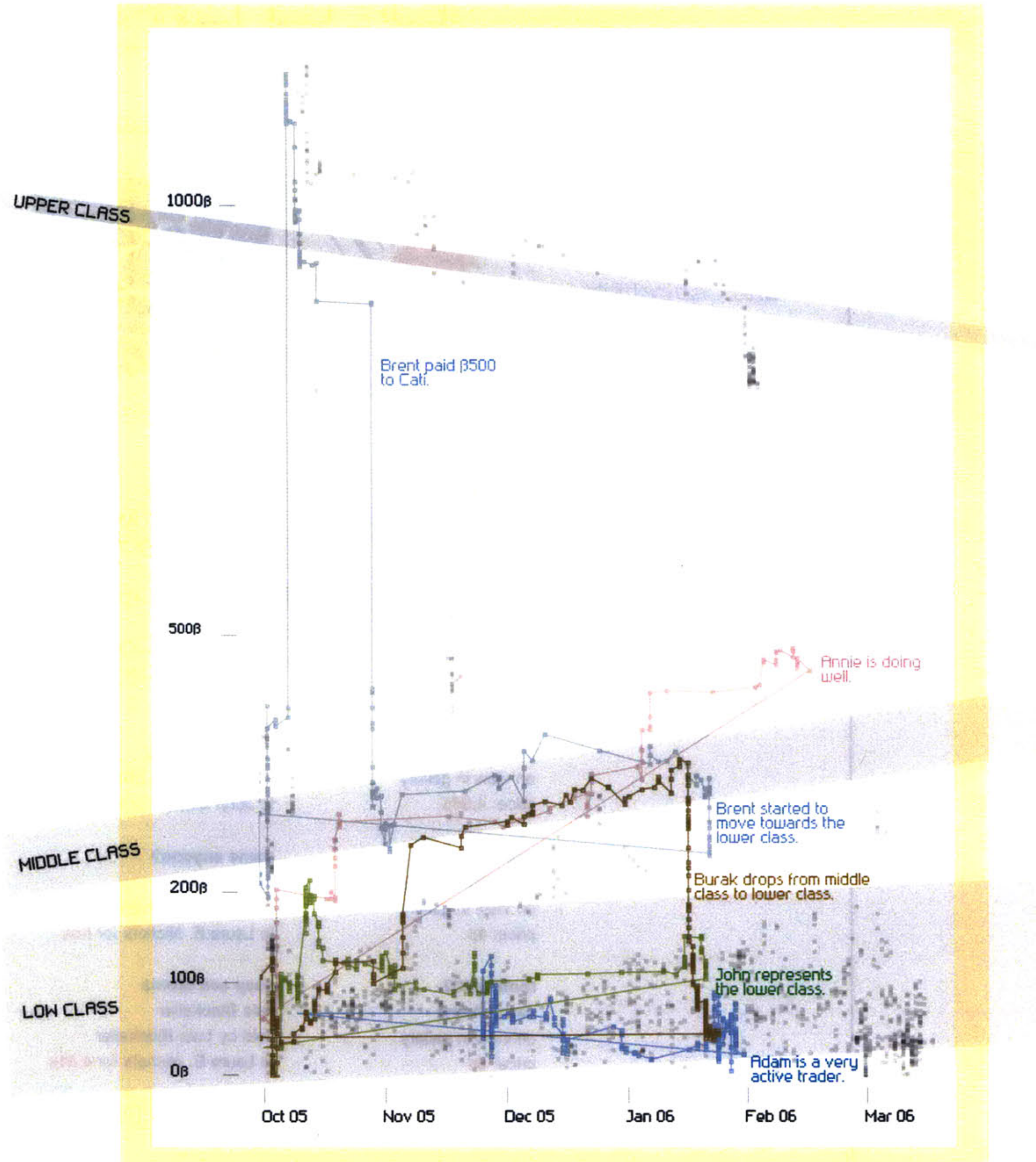


Figure 3-16: OPENSTUDIO Classes. All balance distribution over time. We see three dominant areas: 0-100, 200-400, and around 1000.

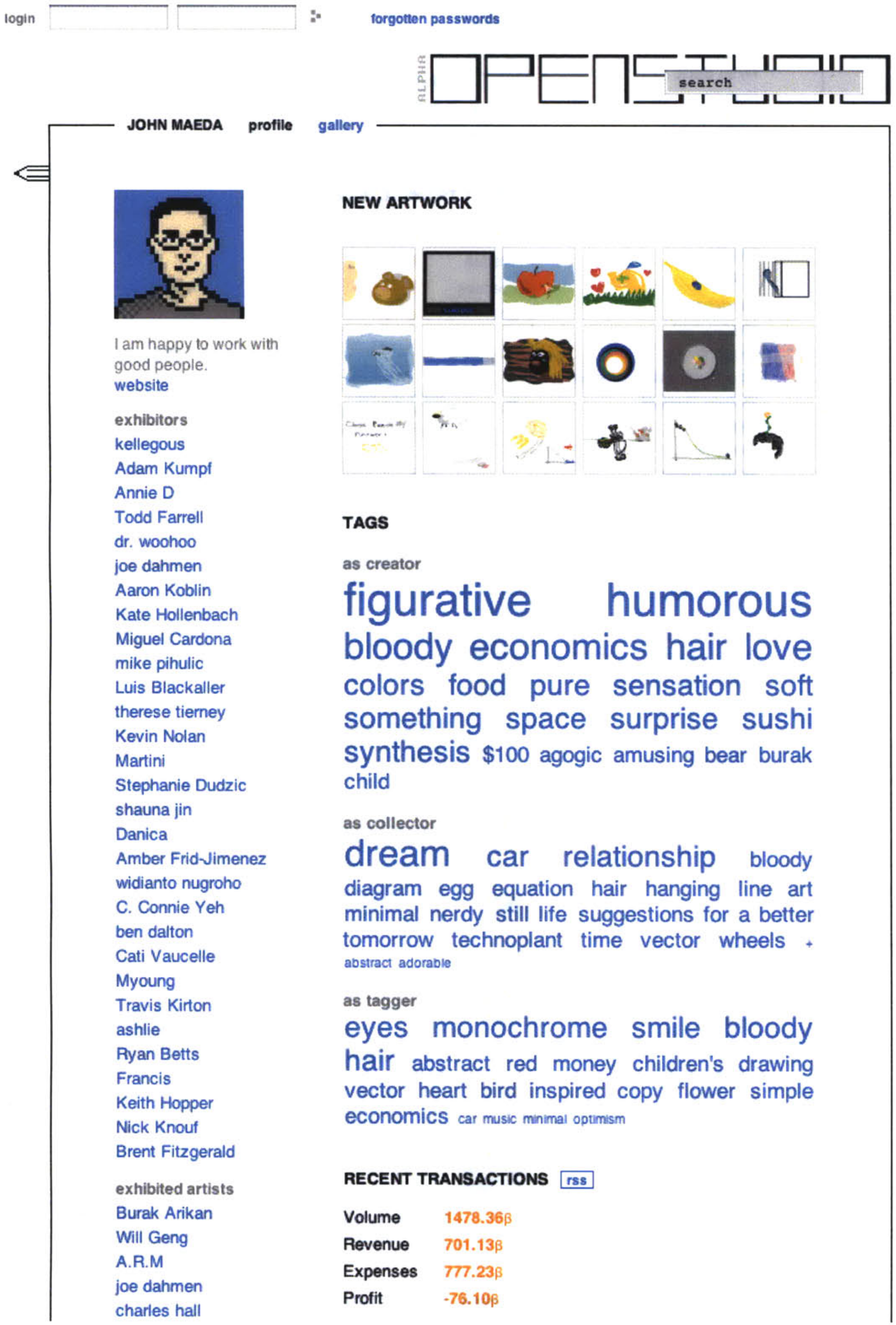


Figure 3-17: OPENSTUDIO Profile Page. May 20, 2006

Figure 3-18: OPENSTUDIO Profile Transactions. May 20, 2006

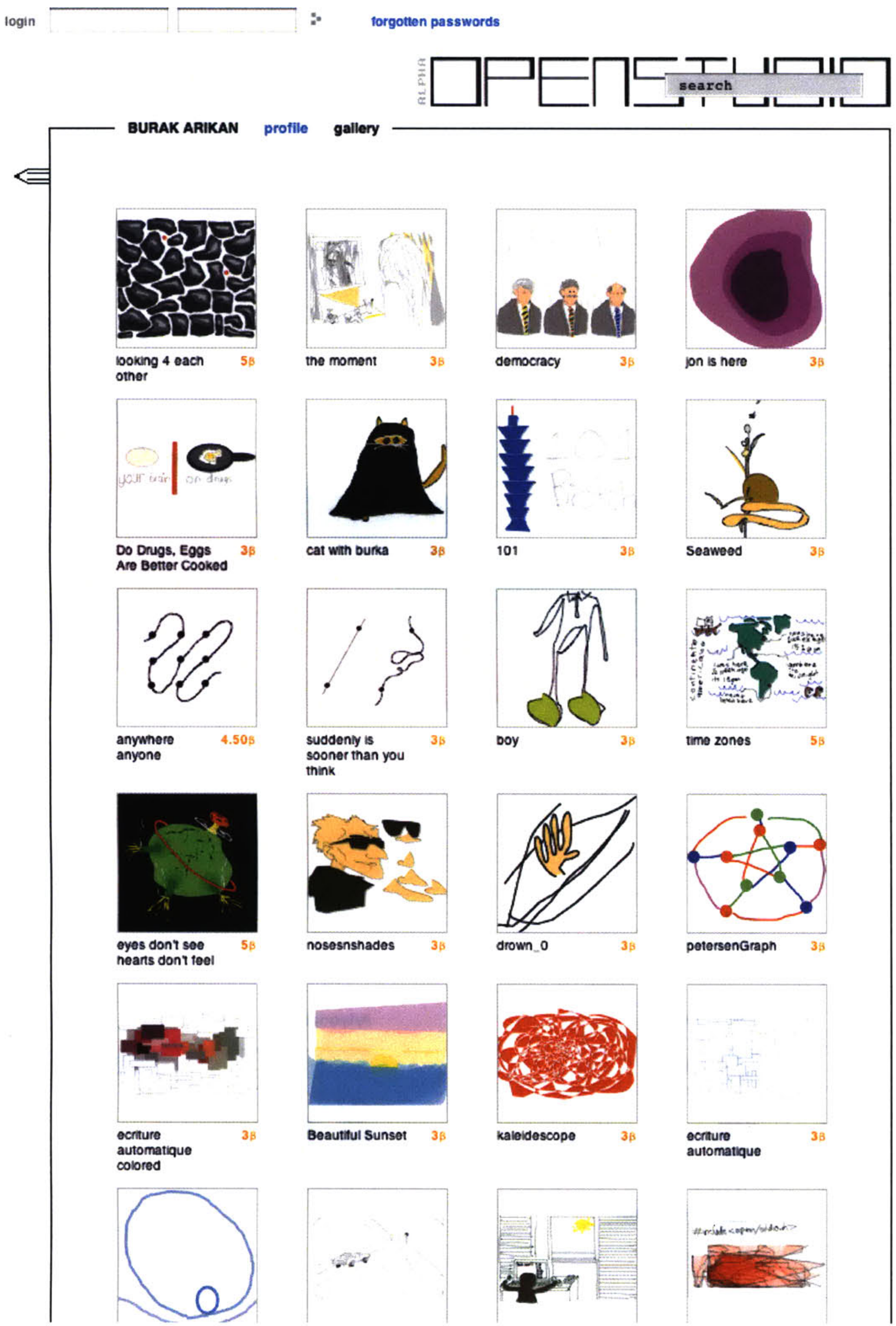


Figure 3-19: OPENSTUDIO Gallery Page. May 20, 2006

Figure 3-20: OPENSTUDIO Piece Page. May 20, 2006

future the project aims to tie this virtual currency to existing markets.

All publicly traded artwork in *OPENSTUDIO* is subject to an informal community-based organization system called the Artsonomy. Using the Artsonomy members classify an art piece with words or phrases that they feel characterize the image, collectively forming an emergent semiotic network. These associations stay attached to documents through business transaction. When tagging an art piece, a person must think about how her characterization affects the value, meaning and standing of the piece within the community. Within the rich Artsonomy tag space artists can coordinate and spawn new movements, critics and observers can label and critique, and art investors can watch for semiotic market trends.

As the *OPENSTUDIO* community continually creates, exchanges, and edits artwork, individual actions generate trails of authorship that cumulatively form a rich genealogical network. Every version in the evolution of a piece is preserved in the *OPENSTUDIO* document server, creating a rich process history. At a basic level, this Art Genealogy serves as a version control system. It is also fundamental to the workings of *OPENSTUDIO*'s attribution system. When multiple authors are working on pieces within the same genealogical tree, each of these authors can be given proper attribution for their work. Openly exposing this information gives greater meaning to the interpersonal ties within *OPENSTUDIO* because authors become connected by artwork genealogy, linked by their creative endeavors.

3.3.3 Open I/O

Open I/O is a suite of software services and applications for composing and running distributed physical media in a way that enables people to exchange data over the Internet. By using this system, artists and designers can contribute to a collective activity and take advantage of high-level social and economic information while creating low-level physical interactions.

Usually people (artists, designers, hobbyists, students, researchers, etc.) solitarily build electronic systems and explore electronic arts and tangible media in a closed and isolated way. Most of the time these

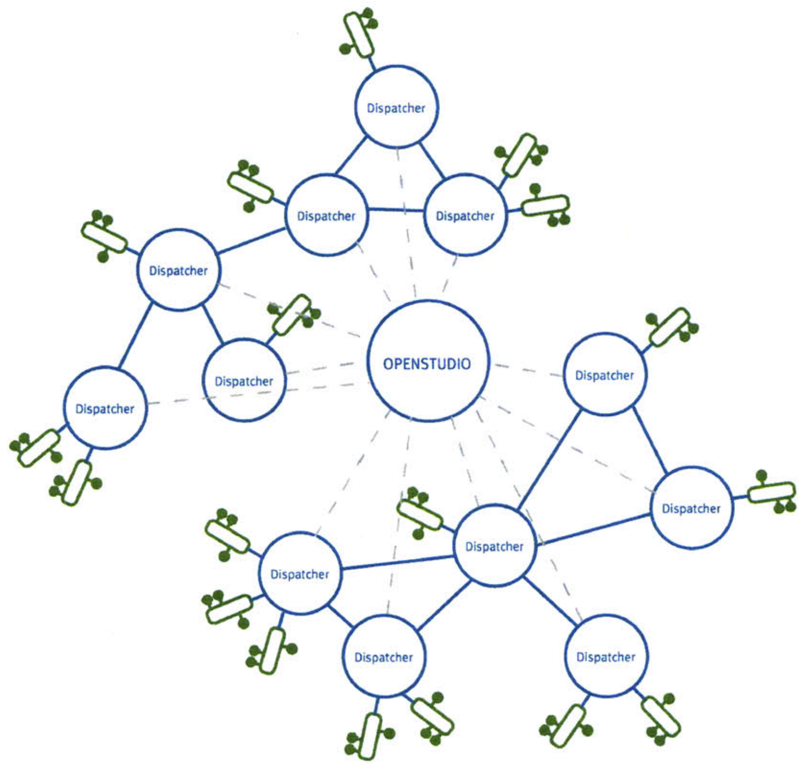


Figure 3-21: Open I/O topology

systems work on their own, very specific to a context, and are not connected to any other system. However, the Internet has been emerging as the core platform for communication, collaboration, and organization. Moreover, network-enabled conversations are becoming a principal carrier of new ideas[37]. Systems for collectively creating and manipulating knowledge are not only bound to the virtual world, but are also getting close to our physical world with the widespread adoption of network capable devices, sensors, and actuators. In this contemporary conditions, *Open I/O* provides a hybrid system for people to build device compositions relevant to collective contexts.

Structure

The core of the *Open I/O* (OIO) system combines a standalone dispatcher software, *OIO Dispatcher*, and a device service software, *OIO Server* and a relational database that runs on the OPENSTUDIO server. Currently, the devices that work with this combination are only the *Pinkie* boards.

OIO Dispatcher facilitates communication between Pinkies. It starts from the web as a Java Web-start Application and runs on a personal computer. When it starts, it finds the available Pinkies on the local network and reports itself and the found Pinkies to the *Open I/O Server*. *OIO Server* writes the list of available *OIO Dispatchers* and Pinkies to a database. In this system, *OIO Dispatchers* are identified by the IP addresses of the machine that they run on and Pinkies are identified by their IP and MAC addresses. *OIO Server* initiates the communication between the *OIO Dispatchers*. When they are connected, *OIO Dispatchers* facilitate the data transmission between Pinkies globally.

Also, *OIO Server* enables people to find each other's devices in all over the world. The people who use *OIO Dispatchers* should be registered to *OPENSTUDIO* so that they can coordinate their communication with other people. In the database, every person is associated with a *OIO Dispatcher* which is associated with one or more Pinkies. *OIO Server* not only initiates communication between *OIO Dispatchers*, but also serves the list of available compositions which are described by the authors of the Pinkies. *OIO Server* also keeps the history of interactions between *OIO Dispatchers* and finally this data helps people to evaluate compositions.

Open I/O has a hybrid topology that combines centralized and decentralized systems and so enjoys the advantages of both. While decentralization is contributing to the extensibility and fault-tolerance, partial centralization makes the system more coherent than a purely decentralized system.

Addressing & Discovery

In *Open I/O*, addressing and discovery is similar to the Internet infrastructure. IP addresses and the hostnames are the core of the addressing and communication. *OIO Dispatchers* have IP addresses since they work on Internet enabled computers. They are associated with people in the database, so a dispatcher's hostname is actually a person's username. The IP of the dispatcher can change depending on the Internet service that the computer is connected to, but a person has always a unique username associated with the changing dispatcher IP. While

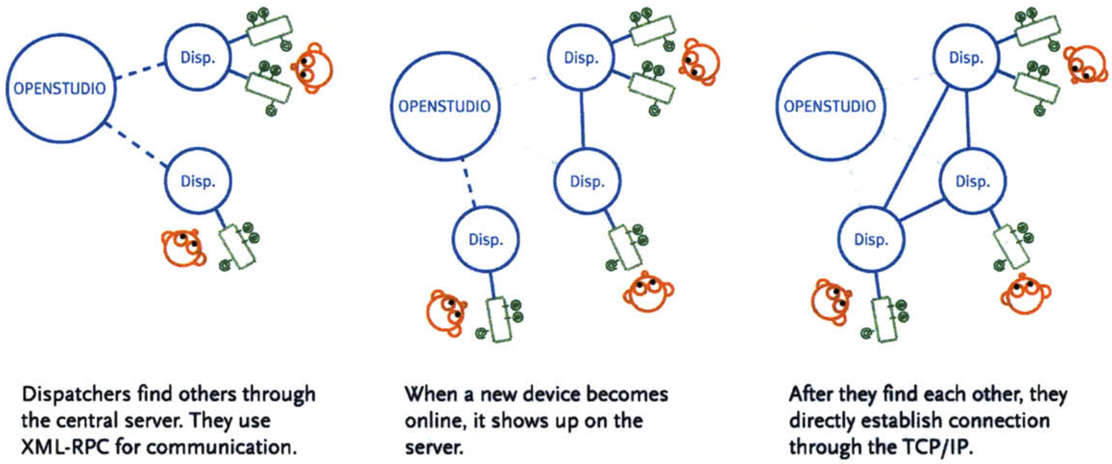


Figure 3-22: Open I/O Addressing and Discovery

Pinkies are referenced by their IP and MAC addresses in the system, people can give them names and refer them easily. It is also convenient because when the IPs change, the hostname-address relationships are automatically updated both in *OIO Dispatcher* and *OIO Server*.

To discover the *Pinkies*, *OIO Dispatcher* broadcasts a special message in the local network, then the *Pinkies* reply with their MAC and IP addresses. *OIO Dispatcher* stores these IP and MAC addresses in a list in the runtime. Again, *OIO Dispatcher* reports its list to the central server so that *Pinkies* become accessible to the world.

With this addressing and discovery system, from the OPENSTUDIO website, people can check if a person on OPENSTUDIO runs a *OIO Dispatcher*. As a result, people can find each other's electronic compositions and connect world wide.

Runtime

Open I/O enables connection and communication between multiple Pinkies and software running at different locations. After the Pinkies are programmed and they are online, they send and receive data between each other through the *OIO Dispatcher*. In the runtime *OIO Dispatcher* dispatches the incoming and outgoing data to corresponding addresses. Pinkies send out their data using the UDP protocol, *OIO Dispatcher* reads the data and sends it to a corresponding address based on the configuration, which is going to be discussed in the next section. Similarly

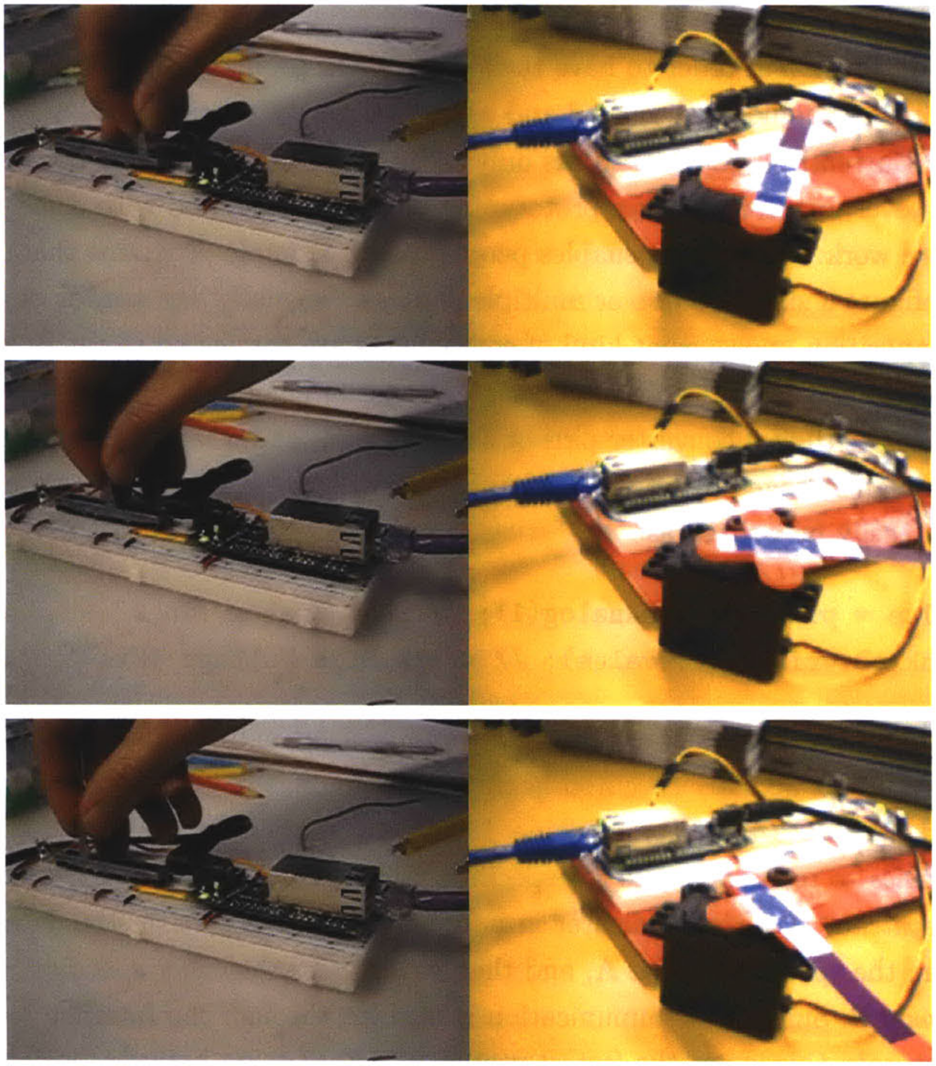


Figure 3-23: Open I/O Slider-Servo Example

OIO Dispatcher directs the incoming data to the corresponding Pinkies in the local network through UDP protocol. Pinkies receive anything they get through the UDP as serial input.

Composing & Programming

At the core of composing multiple devices there is the design of *protocols*. While a single person designing a composition with multiple elements, he/she can define what to send and receive among the devices and build the system accordingly. For people reside in different locations, connecting compositions is only possible if they agree on the communication protocols. They decide what to send and receive based on their device attributes. So in order to have their system run properly, these low-level protocols should be discussed and agreed by all the participants.

Currently, *Open I/O* works only in relation with the *Pinkie* boards. However, other electronics prototyping boards can be used with some more work. The system enables people to write simple programs that configure a single *Pinkie* or multiple *Pinkies*. Normally, the author of the composition knows what kind of components are connected to the board. For example, there can be an infrared sensor in one of the analog-to-digital converter pins of the *Pinkie* A, and a motor in one of the high-voltage pins of the *Pinkie* B. Then the configuration program can easily be written as:

```
value = pinkieA.readAnalog(1); // read analog pin 1
pinkieB.writeHV(1, value); // write High Voltage (HV) pin 1
```

This program is written from a web interface, and through *OIO Server*, it is actually executed in three computers, two *Pinkie* processors and the *OIO Dispatcher* machine. It first automatically programs the *Pinkies* to read and write the specified pins, and starts to run on *OIO Dispatcher* as a communicator in between *Pinkies*. It receives the data from the specified *Pinkie* A, and then writes it to the other specified *Pinkie* B. Since the communication is enabled through the Internet protocols, this is not the fastest way of communication between devices, but it enables global communication. The network connectivity and having another computer in between cause a time lag, but over time people adapt to this lag and this distraction in the communication becomes reasonable.

In this program, one of the *Pinkies* may be authored by another person in another location. In this case, the code does not change, but the authors must know what their device compositions are going to send and receive. This is called service description in *Open I/O*. Each author describes its service and the attributes of the composition in plain text in the OPENSTUDIO website. They find each other through *OPENSTUDIO* and they read the service description. Then if they want to create a composition together and their *Pinkies* are available, they can program their composition. For example, say person A in San Francisco has an infrared sensor connected to his *Pinkie*'s ADC pin, and person B in Cambridge has a servo motor connected to the digital I/O pin of his *Pinkie*. They both have their description on the *OPENSTUDIO* website. When they find each other and decide to run their compositions together, one of the people, for instance, person B in Cambridge can write the same code above from the web interface and let the *OIO Server* execute it. Then the *Pinkies* in two different locations will be automatically programmed and the two dispatchers in the computers of the authors will start to run as the communicators in between. After this moment, the composition becomes live. The data is transmitted in between Pinkies through the *OIO Dispatchers* that are directly connected to each other through a TCP socket. As a result, the measured proximity from the sensor in San Francisco controls the rotation of the servo motor in Cambridge.

Creating a composition that resides in three different locations authored by three different people is not very different than this example. More devices and authors can join the composition if they can manage to agree on protocols. *Open I/O* can scale well in terms of technology but the real challenge is having many people agree on common protocols.

With *Open I/O* a person not only designs a system for particular use, but also creates a system that is part of other systems. With this collectivity in mind, artists and designers can explore new qualities for Internet enabled electronic objects and physical environments. *Open I/O* lets creative people think about designing protocols. This not only causes an awareness and understanding of these protocols in our everyday life, but also enables creative people to find roles in this process of designing protocols that regulate our relationships with electronic and digital systems.

Exchange

Open I/O is designed to enable many distributed devices to be composed by multiple people. When there is a multitude of compositions and people, the information flow between devices and relationships between people can become complex. So, to organize this complexity, the

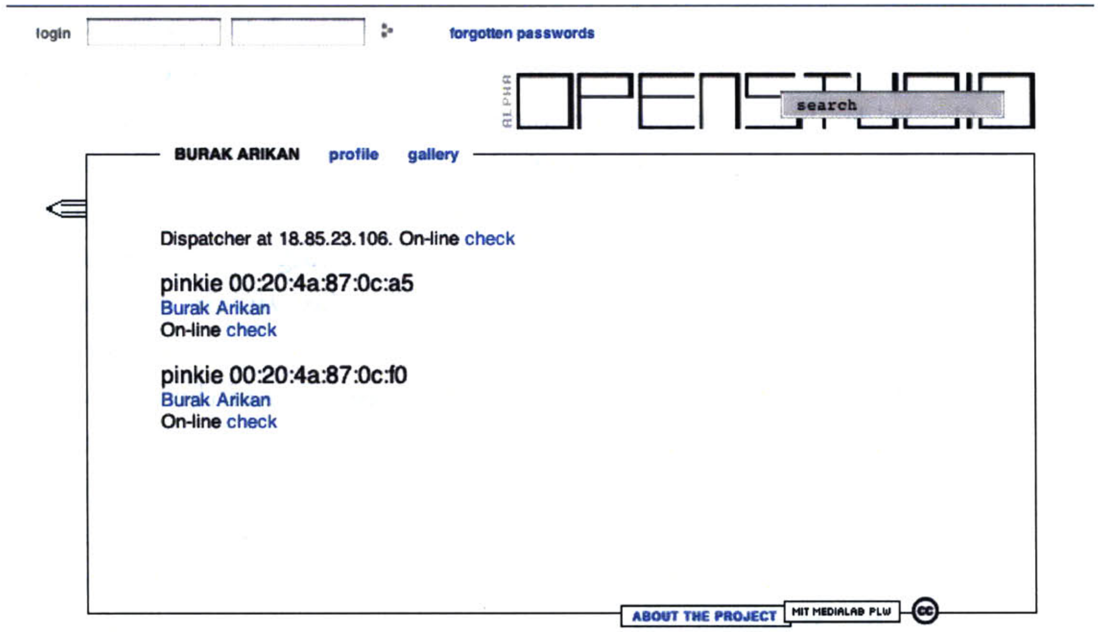


Figure 3-24: A prototype of Open I/O Server showing the Pinkies on the OPENSTUDIO website.

OPENSTUDIO marketplace system and virtual currency can be used for device compositions. Using these economic systems, people can rent services of the device compositions. The price mechanism and exchange not only help people to evaluate the values that come out of the compositions, but also help people to manage their time and their composition's time. The economic system promotes valuation, marketing, and exchange of creative electronics compositions.

After setting up the composition, the author describes the service and gives it a price. Then other people find this composition on the OPENSTUDIO website. They not only look for compositions they want to integrate in their own system, but they also check out if the service is worth integrating. This simple scheme organizes the information exchange and lets people create low-level electronic compositions based on these high-level social and economic information.

Such an interconnected environment reveals new types of scenography and spatial continuity that would fundamentally affect the way we understand and use space and electronic objects. Rather than adopting existing social, cultural and political values, the outcomes from this collective environment can reveal how limited choices are usually hard-wired into electronic products for us. As a result, *Open I/O* provides an actionable space for artists and designers to collectively create electronic media that is relevant to social contexts.

Given the thesis timeline, *Open I/O* has not fully opened to public yet. The schemes described here only used by my self, my collaborator Vincent Leclerc, and a few other students in the MIT Media Laboratory. After completing this thesis, *Open I/O* will be released to public for its real-world evaluation.

Chapter 4

Discussion and Analysis

There are accepted methods for discussing and analyzing traditional artistic production in terms of materials, processes, and products, but how do we evaluate systems in which creative results emerge from collective processes? Within the context of MIT Media Laboratory, it is appropriate to discuss both the technical and humanist merits of this thesis.

4.1 System

Today I woke up at 7am, had a shower, left my apartment, got some cash from an ATM, took the T (Boston subway), came to the MIT campus, opened the doors with my student card, came to my office, turned on my computer, checked my emails, replied a few of them, watched a new movie trailer on the web, looked for meaning of some English words from an online dictionary, had a chat with my lab mate Amber about her new audio project, she recorded a sound sample from me for her project, then I kept working on my thesis. In this day, I have participated in various human made systems consciously or unconsciously. When I had a shower, the amount of water I spent was recorded in the city water system, I contributed to the credit card company's transaction and ATM usage stats, the subway system counted one more passenger for that time of the day, the MIT card system counted which buildings I used to get into my office through my RFID enabled student ID card, the mail server logged the emails I got, read, and replied, I incremented the counter of the website I visited for watching the new movie trailer, I changed the stats of the most looked up English words in an online dictionary, I gave a sound sample to Amber's sound aggregation software and so on. We leave traces in various systems that we interact every day. Sometimes these traces are associated with our identities, sometimes we are anonymous, sometimes we are not aware that we are leaving traces, sometimes we get immediate feedback from the system, sometimes periodically an utilities bill in the postbox shows us how much energy we spent. These systems help us organize our life or let us wield some hegemonic power structure, in any case, their capability of storing, analyzing, and reusing the information alters our life. Most of these systems run for years and combine many elements such as interfaces that we use, machines that store and process data, and humans that make decisions. These systems can also be referred as infrastructures, and this view of system is different than a system that refers to a single machine not only because it combines many machines and materials but also it involves people. This difference is important for the context of this thesis, because the systems that enable collective activity are similar more to an extensive infrastructure of a city than a monolithic machine. However, a collective system can not be thought as a subway system or a credit card system, because it involves social relationships. Furthermore, when we consider a system that involves people, it can be thought as a form of social organization that do not include any machine. In this thesis, collective systems also differ from this view because they include both machines and people. It must be stated, though, abstracting social structures and coding them into machines is becoming a highly relevant process in today's electronically connected society. Overall, in this thesis, a system is referred to something that combines machines, people, data, processes, many-to-many relationships of these entities.

Humans interpret sensations and information in regard to our past experience. When we see a red heavy image it may trigger a recent memory or make us feel warm. Also when we read a joke forwarded in an email, we may find it funny or not funny based on our prior knowledge about the context of the joke. Every person has a unique history through which she/he interprets new experiences and we perceive these experiences in relation to each other. We may say "I don't use cash so much", "I call to my parents in Turkey once in a while", or "subway is faster than the bus on my way to go home", but as we interact with systems they store precise information about our past experiences, no person can know that she or he uses the ATM in Cambridge two times a week in the mornings, her/his international calls are 960 min, national calls are 1056 min a day, or the average speed of the busses are faster than the subways. As humans we can't keep track of these absolute information but build an intuitive knowledge about our experiences. A human view is unique to the individual, while the system view is objective and consistent. When we experience the world through the mediation of these systems and have an understanding of the system view, our perception of the environment is altered.

4.1.1 System categories

A scheme for discussing the work presented in this thesis is shown in Figure 4-1. This scheme has six categories which describe the work from a system view. These categories together enable a collective system. This scheme assumes that a system initially has entities that can connect to each other. There are many art works that are just depicted as connection of elements. *Connectivity* is used in Alexei Shulgin's *Refresh* to create a sculpture in the form of websites linked to each other, it is used in Ben Fry's *Valence* to visually connect words, or in Hans Haacke's *Shapolsky et al.*, which includes charts that showing connections between Shapolsky's companies [1]. A system that has interactions among its elements is in the *activity* category. Mail art, art which uses the postal system as a medium, fits into this category since it is a system in which individuals all over the world send messages and art to each other. In the *aggregation* category, the data generated by the interaction of entities are stored. The picture sharing service Flickr is an example of a system that fits into this category. As the Flickr users tag their or others' pictures the keywords are stored on the Flickr servers. The *analysis* category includes systems where the aggregated data is analyzed to find emerging patterns

[1] Hans Haacke made this piece by investigating the records of the financial activities of the landowner Harry Shapolsky who possessed more slum properties than any other landlord in New York as of 1971.

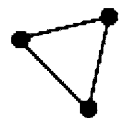
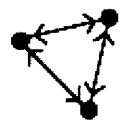
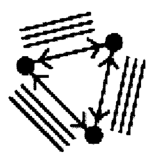
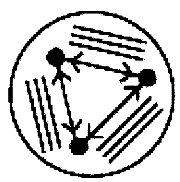
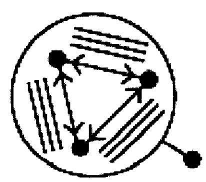
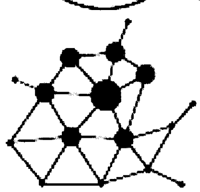
	Diagram	Properties	Examples
Connectivity		Links between entities.	*Shapolsky et al. Manhattan Real Estate Holdings, Real Time Social System, as of May 1, 1971*, Hans Haacke *Refresh*, Alexei Shulgin *Valence*, Ben Fry
Activity		Entities interact synchronously or asynchronously.	Mail art works
Aggregation		Interactions and generated data are stored.	Flickr photo sharing
Analysis		Aggregated data is analyzed to find emerging patterns.	*ConceptNet*, Hugo Liu
Synthesis		The analyzed data is returned back to the entities.	*OPENSTUDIO*, Physical Language Workshop
Governance		Entities live within a consensus.	*Meta-Wikipedia*, Wikimedia Foundation *Ubuntu Development*, Ubuntu

Figure 4-1: System Categories

and to infer knowledge. A good example for this category is *ConceptNet*, developed by Hugo Liu, is a toolkit that works with a knowledge base in the form of a semantic network and supports textual reasoning about various concepts. The knowledge base is generated from the Open Mind Common Sense database that is built by the contribution of over 14,000 authors on the web[2]. *Synthesis* category includes systems in which entities reuse the results of the analysis of the data generated in the system. This feedback loop enables synthesis and this is essential for collective activity. For example, in *OPENSTUDIO* we calculate the profit of a person from her/his transactions and show it in each person's profile page. This affects people's buying and creation patterns. Similarly, the weights of the aggregated keywords are visible in a person's profile, and these word clouds affect people's behavior in the creation process, in selecting the words to criticize other people's work, and in buying art pieces in the system. The *governance* category includes systems where many people live within a consensus. No experiment in this thesis is in such a complex stage yet, but there are systems such as Meta-Wikipedia or large open source software development projects such as Ubuntu or Debian. In these systems, at some point, deliberation and agreement has to be backed up by a stronger structure, if a group is to take significant action. In Meta-Wikipedia, people collectively decide for changes about the Wikimedia Foundation's projects. For example, they propose to close an article in the Wikipedia, they request for permissions, organize open meetings, vote for changes and so on. Similarly, in the Ubuntu development community, people regularly organize elections for sponsors who control the code commits to the project repository [3].

4.1.2 System Analysis

Most of the work presented within this thesis falls within the connectivity and activity categories. While *Micro Fashion Network* is just formed by connectivity of color data, OPENSTUDIO is more complex and includes all the categories except for the governance. A complete system analysis follows:

[2] http://web.media.mit.edu/ hugo/conceptnet/
[3] Interview with Benjamin Mako Hill, one of the Ubuntu developers. MIT Media Lab. April 25, 2006

Micro Fashion Network	*connectivity, aggregation*
Cellular Nations	*connectivity, activity*
Pinkie	*connectivity, activity*
Flx Series	*connectivity, activity*
Auction Machine	*connectivity, activity*
Follow Dada	*connectivity, activity*
Open-tasking	*connectivity, activity, aggregation*
OPENSTUDIO	*connectivity, activity, aggregation, analysis, synthesis*
Open I/O	*connectivity, activity, aggregation, analysis*

It is possible to have a system in the activity category without computation. People already interact with each other in all sorts of ways as seen in the mail art movement. The works in connectivity and activity categories in this thesis are created using computers for experimenting with various aspects of these systems. In *Micro Fashion Network*, color data connect to each other based on their similarities. Also the connected nodes attract each other and over time, highly connected color hubs become more visible. In *Cellular Nations*, world nations are the autonomous entities represented with circles floating in a rectangular screen space. They are not literally connected but they interact when they touch each other. In any given time the military expenditure ratio of touching nations is used to calculate pushing power of the circles. For example, when USA and Cuba circles touch, Cuba is pushed away because of this ratio. The spatial experiments combine sensors, actuators, electronics, and physical human interaction. The *Pinkie* electronics prototyping boards are designed to connect sensors and motors over the Internet, and to enable people to exchange data of their devices. In this work, devices are the entities connected through the Internet, and they interact by exchanging data of their sensors. Flexible Screen Applications include four applications *flx.maps*, *flx.movie*, *flx.scape*, and *flx.treemap* that combine two bending sensors and a force sensor that work in relation to each other. In *flx.maps*, two bending sensors control the zoom to maps and force sensor points a position on the map. In *flx.movie*, two bending sensors control the movie to play in forwards or backwards, and the force sensor controls the speed. In *flx.scape*, there are abstract data points on the screen and two bending sensors control the positions of the data points in a virtual 3d space. The force sensor changes the sliding speed of the data cloud. *Flx.treemap* is a treemap visualization application, in which bending sensors control the scale of particular rectangles among all the rectangles of the treemap. Force sensor controls the opacity of the squares and makes them visible or invisible. In all these applications, the activity between the sensors and the software organized in a way that a person using the screen experiences a unified experience. In *Auction Machine*, people are connected to an auction software with their RFID tags and they control the auction software by turning on or off these tags. The only activity is between people and the central software, but everybody can see the overall connectivity and response based on other people's actions. In *Follow Dada*, three sonar proximity sensors are connected to a microprocessor and they all communicate with a software that runs on another computer. The data sensed from the sensors control the visuals on the screen. Multiple people synchronously interact with the system by changing their position in relation to the sensors. The experiments that include more than connectivity and activity are more complex than the others. Open-tasking is the earliest experiment that connects people, documents, and tasks, and aggregates data generated by the activities of the people. In this system, people interact with each other through the tasks. Their decisions, messages, and created documents are all aggregated in relation to tasks. However, there is no analysis for the aggregated data, the stored data is just visible and shared by the people. *OPENSTUDIO* is the largest experiment among all the works discussed in this document. It enables interconnections between people, art pieces, and tags. The activities between these individuals such as economic transactions or the document creation based on other person's drawing are stored on the *OPENSTUDIO* database. These stored data then analyzed and presented back to people on the website. For instance, we calculate the profit of a person from her/his transactions and this affects the behavior of the people. Similarly, the weights of the aggregated keywords are visible in a person's profile, and these word clouds affect people's behavior in the creation process, in selecting the words to tag, and in buying documents in the system.

4.2 Participation & Perception

How do we measure a participant's perception of a collective system? Because a participant's interaction with a collective system is a long process, his/her quality of perception is constructive. It is like a relationship with a friend, we build stronger ties over time. A participant's perception of a collective system is affected and its qualities are constructed by both his/her interaction with the system itself and his/her relationships with other participants mediated through the system. Collectives can be formed around various contexts, and the incentive of a participant can be defined by many things including the his/her goals, moral and so on. It can be subjective and can be affected by the community. Economists research how incentives are get built or how to design incentives, but in this thesis I will just consider simply if an incentive is altruistic or quid pro quo[4]. Analysis of incentives are beyond the scope of this thesis.

4.2.1 Categories for the Qualities of Collective Systems

As a person participates in a collective system his/her perception is affected by macro and micro cycle of the system. His/her perception of the qualities of these behaviors develops and changes over time. Qualities of the macro cycle are *extensity*, *density*, *diversity*, *transitivity*, *openness*, and *Extensive responsiveness*. Qualities of the micro cycle are *perception of control*, *amount of information*, *noisiness*, *perception of events*, *trust among participants*, and *unpredictability*. While the qualities of the macro cycle contribute to the emergence of purpose through the activities, the qualities of the micro cycle affect people's synthesis of the aggregated/analyzed information flow in the system. Although some of these qualities can be measured and numerically represented, they can only be intuitively perceived by the people.

Macro *Extensity*
Diversity
Transitivity
Resilience
Openness

[4]Latin for "something to something", it can be understood as "a favor for a favor" or "tit for tat".

Extensive Responsiveness

Micro *Perception of control*
Amount of information
Noisiness
Perception of events
Trust among participants
Unpredictability

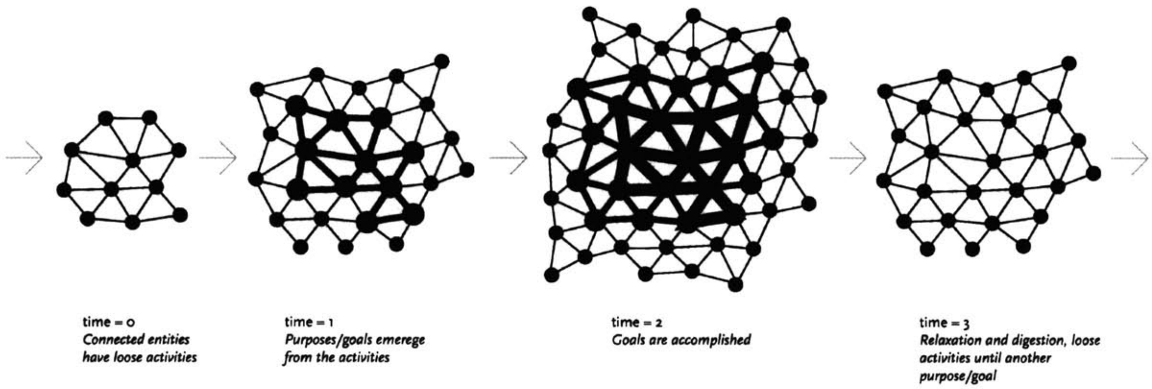


Figure 4-2: Macro Cycle

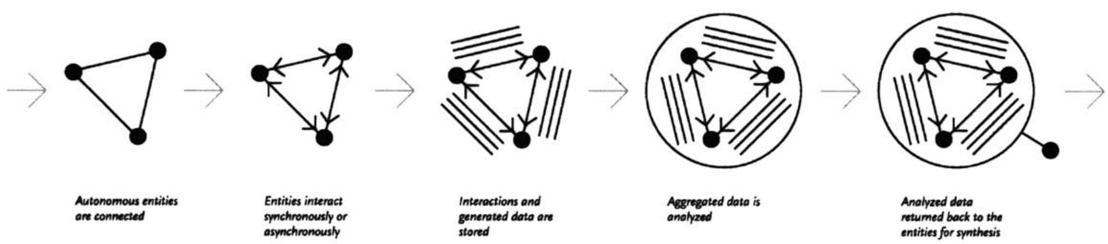


Figure 4-3: Micro Cycle

4.2.2 Analysis of the Qualities of Collective Systems

Macro qualities of the system is about its global properties that may or may not be directly perceived by the participants, but they affect their behavior. Qualities of the micro cycle are perceivable by direct interaction with the system.

Qualities of Macro Cycle

Extensity — How large is the number of entities in the system? It gives an idea about the scale of the system.

Open-tasking	*Many entities*
OPENSTUDIO	*Many entities*
Open I/O	*Few entities*

Density — The density of a graph is the number of edges divided by the total edges possible. This is useful for understanding an individual's condition compared to his/her relationships.

Open-tasking	*Moderate*
OPENSTUDIO	*High*
Open I/O	*Moderate*

Diversity — How many different types of entities are there in the system?

Open-tasking	*Moderate*
OPENSTUDIO	*High*
Open I/O	*Moderate*

Transitivity — Transitivity refers to the presence of heightened number of triangles in the network. High transitivity means broad communication channels within the network, so it causes high liquidity and so a rich network.

Open-tasking	*Low*
OPENSTUDIO	*Moderate*
Open I/O	*Low*

Resilience — If vertices are removed from a network, the connectivity decreases, and typical paths between pairs of vertices get longer. Ultimately vertex pairs become disconnected and communication between them through the network become impossible.

Open-tasking	*Low*
OPENSTUDIO	*Moderate*
Open I/O	*Moderate*

Openness — How open the spatial, temporal, and spatiotemporal features of the system? The spatial part corresponds to the openness of the source code or procedure of the technology. The temporal part corresponds to openness in time, that is systems that live and grow in time. The spatiotemporal part has three parts that correspond to openness of the aggregated and analyzed data, openness of relations with other systems, and openness in the modification of the system – copying, reusing, remixing, or mashing-up.

Open-tasking	*Semi-open*
OPENSTUDIO	*Open*
Open I/O	*Semi-open*

Extensive Responsiveness — How fast can the system expand and contract, intensify and de-intensify?

Open-tasking	*Moderately*
OPENSTUDIO	*Moderately*
Open I/O	*Moderately*

Qualities of Micro Cycle

Perception of control — The control of the interaction (depending on the amount of feedback from the system) appears to either within the control of the system, within the control of the participant, or within the control of other participants.

Open-tasking	*Participant, Other participants*
OPENSTUDIO	*Mutual*
Open I/O	*System creator*

Amount of information — How much information a participant deals with?

Open-tasking	*Moderate*
OPENSTUDIO	*High*
Open I/O	*High*

Noisiness — How much noise a participant gets from the system?

Open-tasking *Noisy*
OPENSTUDIO *Moderately Noisy*
Open I/O *Moderately Noisy*

Perception of events — Do individuals participate in the activities synchronously or asynchronously?

Open-tasking *Asynchronous*
OPENSTUDIO *Asynchronous*
Open I/O *Synchronous, Asynchronous*

Trust among participants — How much trust are there in the interactions of the participants?

Open-tasking *Low*
OPENSTUDIO *Moderate*
Open I/O *Moderate*

Unpredictability — How much balance are met between chaos and unchanging reactions of the system?

Open-tasking *Predictable*
OPENSTUDIO *Unpredictable*
Open I/O *Moderately predictable*

4.3 Artistic Production as Collective Cycle

There are two successes of collective systems in terms of artistic production. First, it enables people to create relationships by creative expression. Relationships formed in this way help people explore patterns over time. Then these patterns become purposes for collective achievement. Second, these relationships determine the dynamics of the actionable space that is discussed earlier in this thesis. Creative people test ideas and form alternative ideologies in this actionable space. Furthermore, in the *Open I/O* system, people collectively design low-level device communication protocols as an alternative to authoritative protocols that exists in current electronic products.

The shortcomings of collective systems discussed in this thesis are mostly the temporal issues. Collective systems cannot instantaneously become useful. They make sense as people us them and leave trails of data. Since they reach to a critical number of people in a long period of time, the success and shortcomings cannot be instantly evaluated. This also determines a certain development style for these systems, they are not designed authoritatively from the beginning, but nurtured in time.

4.4 Materials & Tools

The systems I have been creating in this thesis are computer programs written in C, Java, Python, Ruby, and SQL that run on high-end servers, desktop computers, and microprocessors. I began creating screen-based compositions and web based systems using common input devices, and I am currently building larger complex systems that are synthesis of computer and communication networks, sensor and actuator networks, and social and economic networks. These systems operate with the network of programs, devices, and people. The common thread in this work is the connection of large systems that are composed of high-level social and economic relationships and low-level physical interactions. The topology of the systems are either, centralized, decentralized, distributed, or hybrid of them. Practically hybrid systems are robust in real life conditions, they show powerful scalability and extensibility while retaining some of the coherence of centralized systems.

Chapter 5

Conclusion

This thesis presents the concept of collective systems for creative expression within the context of immaterial labor in the age of the Internet, complex systems, and shifting form of artistic production. Experiments created by the author leading up to the *Open I/O* system are discussed and analyzed in relation to these related ventures. Methods for critiquing and discussing collective systems have also been presented and explained. It is my hope that in the near future, collective systems presented in this work will inspire new generation of artists to build their alternative systems and develop new visions that are necessary to challenge cultural assumptions. As networks of machines become more essential in the organization of our social life, we need to understand the critical stages in the process of emergence from a multitude of interactions amongst people and machines. In such an environment products themselves are byproducts of activities. So in a multitude of electronically mediated social interactions, to challenge the cultural assumptions, one strategy is to focus on creating new relationships by creative expression and free-will. These strategies builds new "ideological" environments to live in and reproduce in parallel to current capitalist systems. But as these experimental ideological environments are created with an open collective consensus, they will always be in continuous transformation that is relevant to our social lives.

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