THE POLITICS OF DESIGN: NEXT GENERATION COMPUTATIONAL ENVIRONMENTS

Mark S. Ackerman
School of Information
and Dept. of Electrical Engineering and Computer Science
University of Michigan
Ann Arbor, MI 48108
ackerm@umich.edu

Abstract

This paper describes and analyzes two next-generation computational environments and their architectures: the Semantic Web and pervasive computing. Each of these necessarily carries with it political assumptions about how the environments will be used, and these political assumptions are reflected in the accompanying computerization movement's rhetoric. However, unlike "first growth" computerization efforts, both the Semantic Web and pervasive computing will result within a growing infrastructure that does not allow top-down design (or even overall design) but within which new designs must fit. The underlying assumptions for both environments are largely libertarian but with differing modalities of user control. This paper examines the libertarian assumptions, the promise of democratization in one but not the other, and the resulting conceptual tensions surrounding these two second-generation computerization movements.

1. INTRODUCTION

Computerization movements (CMs) carry with them hidden assumptions about the nature of political relationships, as Rob Kling pointed out (Kling 1991b). These assumptions include the nature of power and the political relationships among the major stakeholders in the construction, adoption, and use of the systems involved in the CM. For designers, these assumptions are often implicit and hidden; nonetheless, they are present.

In this paper, I describe and analyze two next-generation computational environments and their architectures:

- The Semantic Web. This is an attempt to add meta-data suitable for automatic inferencing to Web pages. Envisioned services include the automatic purchasing of goods (e.g., "what's the cheapest way to fly to Chicago") and the linked provision of information (e.g., "who wrote a good book on Social Informatics").

- Pervasive Computing. Pervasive or ubiquitous computing (ubicomp) presumes a future with hundreds or thousands of computational devices in everyday environments such as offices and homes. Envisioned scenarios include smart buildings, home shopping, sensor networks, and medical monitoring.

Each of these necessarily carries with it political assumptions about how the environments will be used. However, unlike "first growth" computerization efforts, both the Semantic Web and pervasive computing will result within a growing infrastructure that does not allow top-down design (or even overall design) but within which new designs must fit. The underlying assumptions for both environments are largely libertarian but with differing modalities of user control. This chapter, then, examines the libertarian assumptions, the promise of democratization in one but not the other, and the resulting conceptual tensions in the CMs surrounding each.

The chapter examines these two CMs through the writings of Berners-Lee and Weiser, the two founders of the CMs. It does so not to criticize per se, but rather to be critically realistic about the possibilities, issues, and tensions in these two technologies and these two CMs.

2. COMPUTERIZATION MOVEMENTS

In a series of papers, Kling and Iacono detailed their view of computerization movements. For this paper, of particular interest is Kling and Iacono (1994), where they defined a CM as "...a kind of movement whose advocates focus on computer-based systems to bring about a new social order." They saw, as signal indicators of a CM, the following five features:

1. Computer-based technologies are central for a reformed world. “CM activists often argue that computers are a central medium for creating the world they prefer. (Kling & Iacono,

1994)" This can include, however, merely productive organizations, leaving open an analysis of what constitutes a "reformed world".

2. Improved computer-based technologies can further reform society. "CM activists often define computing capabilities as those of future technologies, not the limits of presently available technologies. (Kling & Iacono, 1994)"

3. More computing is better than less, and there are no conceptual limits to the scope of appropriate computerization. State-of-the-art computing should become widespread.

4. No one loses from computerization. In Kling and Iacono's view, "Computer-based technologies are portrayed as inherently apolitical. While they are said to be consistent with any social order, CM advocates usually portray their use in a cheerful, cooperative, flexible, individualistic and efficient world. …Any short-term sacrifices … are portrayed as minor unavoidable consequences (Kling & Iacono, 1994)." While social power is better understood by technical designers, CMs are still often framed without sufficient regard to the issue.

5. Uncooperative people are the main barriers to social reform through computing. "In many social settings, we have found CM advocates arguing that poorly trained or undisciplined users undermined good technologies. …In short, people place 'unnecessary' limits on the complexity of desirable computer-based technologies...(Kling & Iacono, 1994)." Institutional barriers are now better understood by technical designers, but the point generally stands – people, whether by themselves or in collectivities such as organizations, institutions, or government, are the main barriers to reform through computing.

Despite the premise of feature three, Kling and Iacono's analyses of their five specific computerization movements all suggest that these CMs bring with them a view of the "proper" political relationships among system and stakeholders, technologists and users, and even workers, management, and society.

Kling and Iacono demonstrate that the new, desired social order inherently conveys a set of political relationships, which the principal designers attempt to inscribe into their technology. Of course, it is not so simple; the path from inscription to use-in-practice is a winding one. People can adopt and adapt the systems as they wish, within some limits. A CM provides a set of "technological action frames" through which to view a technology. The frames structure public discourse, attempting to persuade organizational members to view this technology accordingly and so influence organizational practices. (In later work, Kling expanded organizational practices to societal practices as well.) In Iacono and Kling's view,

> Technological action frames shape and structure public discourse while public discourse shapes and structures organizational practices. …these relationships are non-deterministic, however. People's technology practices are usually much more complex than the more restricted public discourses about practices. For many practitioners, there is often a gap between their own discourse and practice. (Iacono & Kling, 2001)

It is open how much the inscription of political and social views into a system influences later use (Orlikowski, 2000). In any case, Kling and Iacono's contribution is largely in the explication of the technological action frames and the resulting public discourse, and this contribution is considerable. While CMs can differ widely (Kling and Iacono note mostly the varying maturity of different CMs, but other differences will be explored shortly below), CMs attempt to instill in their participants and in the public a sense of technological utopianism, hiding the political and social realities (Kling & Iacono, 1994). The following analyses hope to examine some current technological action frames and their attempts to structure public discourse.

Implicit in Kling and Iacono is that social movements have general theoretical features. Several issues are important to consider for the following analysis. First, any social movement of a significant size is a hubbub of social activity. There is a range of voices and power arrangements. Accordingly, it is important in understanding any given CM's implications to consider who gets to speak for a CM and who is listened to (and by what group). Second, any social movement is a collection of individuals embedded in a complex social milieu. As with any evangelical social group, a social movement will have a range of adherence and belief, goals and motives, as well as durations and trajectories of membership. It will be arranged within a social environment that has power relationships, and within the CM, there will be a similar network of power arrangements. That is, a social movement attempts to move a contested terrain towards a specific point of view. In Iacono and Kling's view, "…at certain points, within specific [i.e., within all given] social movements, master frames develop in their discourses. (Iacono & Kling, 2001)"

Finally, CMs have trajectories themselves, and these trajectories change over time. Initially, the different groups within a CM (and outside of it perhaps) are attempting to influence others, since technical frames are not yet codified and organizational practices have not yet become routinized. Only later will technical frames consider the nuances and tradeoffs of use. Here, we will largely consider two kinds of computational systems at the beginnings of their trajectories.

I next provide an overview and analysis of the Semantic Web project.

3. THE SEMANTIC WEB

The Semantic Web is partially a vision of a next-generation Web and partially a set of protocols and technologies that concretely instantiate that vision. I will largely concern myself with the vision here, but it is important to understand the technology and the history of the project.

The earliest conceptions of the Semantic Web are reflected in Berners-Lee 1998a and Berners-Lee, 1998b. As the web matured and the overwhelmingly furious pace of protocol design and development slowed, Tim Berners-Lee began to define his "what next" project. Taking time from his role as the director of the World Wide Web Consortium (W3C), he began sketching out a system whereby Web-based sites and intelligent agents could communicate about content. Early funding from DARPA was secured, and others began to work on the project as well. Thus, efforts to define a set of protocols and standards to define this communication and content markup lay partially within the W3C staff as a funded research project, partially within a DARPA sponsored program (with many university and defense vendor companies), and partially as a "regular" W3C project (with the usual mix of W3C coordination and industrial-sponsor participation).

The Semantic Web's purpose is to allow a "semantically" rich set of markup capabilities for Web content. This is to allow computers to be able to make inferences about the content and provide users with new, beneficial capabilities. At its simplest level, the Semantic Web might allow retrieval engines to retrieve sites that marked themselves up, for example, as selling airline tickets or particular machine parts. Retrieval engines would be able to distinguish between homonyms, and sites could be more specific about their contents and intent. As the Semantic Web advanced, agents would be able to make inferences on this data. For example, one might be able to ask for the cheapest airline ticket on an airline upon which the user has frequent flyer miles and that leaves after 4pm. I will return below to other scenarios, those heavily discussed in the master technical action frames for the Semantic Web.

The technology of the Semantic Web consists of a number of markup languages and protocols. The details are not important here, but it is important to understand how the technology is structured. When the Semantic Web began as a project, Web-based documents were primarily restricted to HTML, the Web's display markup language, and XML, a language allowing a set of generic markup tags. Neither was very structured, allowing too much ambiguity for easy handling by computers. HTML merely marks up whether a paragraph is to be normal, outlined, or numbered, or whether text is bold, plain, and so on. No description of the content itself is easily possible. For example, one cannot say that "This paragraph is the introduction." (This is a step backward from SGML, the early markup language from which HTML was constructed.) XML allows markup of content, but the markup is flat in that no relationships between parts of the document can be specified. Without a centralized and authorized dictionary, both for vocabulary and relationships, it is not possible to automatically infer relationships between two different documents produced in two different places. For example, the same tag might mean different things, and even if they meant exactly the same thing for the two authors, the relationship of that specific content might be very different to other parts of the document.

To correct these problems, a number of new standards were proposed. The first, RDF (Resource Description Framework), allows relationships to be demarked. RDF allows authors to write "ontologies", or precise definitions of the relationships between terms. RDF allows authors to create tuples consisting of a name, relationship, and target URI (or Web identifier). For example, one might create “Mark Ackerman” is “an author of” “this document”. RDF depends on XML; or rather, the standard allows XML to be one of the languages in which RDF can be expressed. (There are alternative syntaxes.)

RDF was in progress before the Semantic Web effort started; it was required by digital libraries and other content providers. In addition to RDF are the efforts started within the Semantic Web project. For brevity, I skip RDF-S, which adds capabilities for handling subclassing in ontologies. The next major standard is OWL, or Ontology Web Language. OWL comes in three “sizes”, depending on the needs of the Web service. The most minor version of OWL provides the ability to markup descriptions of Web services; the most complete version allows full Artificial Intelligence (AI) ontologies. The middle version, which will be discussed here, is not complete from an AI perspective: Some inferences cannot be done, and reasoning is not guaranteed to finish. It is, however, quick and suitable for most Web requirements. OWL adds additional ontological capabilities, such as cardinality, property typing, class relationships, and so forth. Recently, work has continued with rule-based inferencing.

This analysis depends largely on the Scientific American article about the Semantic Web (Berners-Lee et al., 2001). Published in 2001, by Tim Berners-Lee, James Hendler (at the time, the DARPA program manager and a prominent AI researcher), and Ora Lassila (at the time, a W3C staff member with AI training), the article is an explanation and invitation to the informed public. This is supplemented with (Berners-Lee, 1998a; Berners-Lee, 1998b; Berners-Lee & Miller, 2002).

The Scientific American article’s initial page is a graphic of a computer monitor with ones and zeros as well as the words “i [sic] know what you mean.” The article itself begins with "A new form of Web content that is meaningful to computers will unleash a revolution of new possibilities.” Even this phrase is interesting - "new" entices the reader, the promise is "Web content meaningful to computers" (which perhaps hints of the importance of this new form and invokes AI images of smart machines).

It is worth repeating the opening scenario for the American Scientific article at some length:

> The entertainment system was belting out the Beatles' "We Can Work It Out" when the phone rang. When Pete answered, ...His sister, Lucy, was on the line from the doctor's office: "Mom needs to see a specialist and then has to have a series of physical therapy sessions. Biweekly or something. I'm going to have my agent set up the appointments." ... Lucy instructed her Semantic Web agent through her handheld Web browser. The agent promptly retrieved information about Mom's prescribed treatment from the doctor's agent, looked up several lists of providers, and checked for the ones in-plan for Mom's insurance within a 20- mile radius of her home and with a rating of excellent or very good on trusted rating services. It then began trying to find a match between available appointment times (supplied by the agents of individual providers through their Web sites) and Pete's and Lucy's busy schedules.
>
> ...In a few minutes the agent presented them with a plan. Pete didn't like it—University Hospital was all the way across town from Mom's place, and he'd be driving back in the middle of rush hour. He set his own agent to redo the search with stricter preferences about location and time. Lucy's agent, having complete trust in Pete's agent in the context of the present task, automatically assisted by supplying access certificates and shortcuts to the data it had already sorted through. (Berners-Lee et al., 2001)

In this scenario, machines automatically and efficiently take care of laborious tasks. This is reminiscent of selling domestic appliances (Cowan, 1983). The words "promptly" and "automatically" indicate the efficiency of the machine, but more importantly, the scenario strongly implies that the machines are themselves trustworthy and capable. The scenario jumps over a number of intermediary steps, such as rating the medical providers and understanding medical requirements. The beginning and end of the scenario, as presented here, implies cooperation and consent. No conflict, glitches, or competition are mentioned.

But, even the possibilities of this scenario are not final. Berners-Lee and Miller suggest

> The most exciting thing about the Semantic Web is not what we can imagine doing with it, but what we can't yet imagine it will do. Just as global indexes, and Google's

> algorithms were not dreamed of in the early Web days, we cannot imagine now all the new research challenges and exciting product areas which will appear once there is a Web of data to explore.
>
> The Semantic Web starts as a simple circles-and-arrows diagram relating things, which slowly expands and coalesces to become global and vast. The Web of human-readable documents spawned a social revolution. The Semantic Web may in turn spawn a revolution in computing. In neither case did a change occur in the power of one person or one computer, but rather a dramatic change in the role they can play in the world, by being able to find out almost anything virtually immediately. (Berners-Lee & Miller, 2002)

All of this sounds like the CM for Artificial Intelligence (AI) in the 1980s. However, this CM is quick to distance itself from AI. Berners-Lee notes, "The concept of machine-understandable documents does not imply some magical artificial intelligence which allows machines to comprehend human mumblings. (Berners-Lee, 1998b)" Indeed, the explanation of the Semantic Web is prosaic in its technicality:

> The Semantic Web addresses this problem in two ways. First, it will enable communities to expose their data so that a program doesn't have to strip the formatting, pictures and ads from a Web page to guess at the relevant bits of information. Secondly, it will allow people to write (or generate) files which explain - to a machine - the relationship between different sets of data. For example, one will be able to make a 'semantic link' between a database with a 'zip-code' column and a form with a 'zip' field that they actually mean the same thing. This will allow machines to follow links and facilitate the integration of data from many different sources. (Berners-Lee & Miller, 2002)

In the Scientific American article, the authors explain:

> Further markup on the page (not displayed by the typical Web browser) uses the ontology's concepts to specify that Hendler received his Ph.D. from the entity described

> at the URI http://www. brown.edu/—the Web page for Brown. Computers can also find that Hendler is a member of a particular research project, has a particular e-mail address, and so on. All that information is readily processed by a computer and could be used to answer queries (such as where Dr. Hendler received his degree) that currently would require a human to sift through the content of various pages turned up by a search engine. (Berners-Lee et al., 2001, p. 41.)

The authors go on:

> In addition, this markup makes it much easier to develop programs that can tackle complicated questions whose answers do not reside on a single Web page. (Berners-Lee et al., 2001, p. 41).

The authors explain that the Semantic Web is different from AI in two significant ways. First, it is merely a layer above the existing Web. It does not require extensive changes, although it does require additional labor. Second, it is decentralized. As Berners-Lee and Miller explain, "The ability for 'anyone to say anything about anything' is an important characteristic of the current Web and is a fundamental principle of the Semantic Web. (Berners-Lee & Miller, 2002)" Earlier AI efforts, such as CYC, were monumental and centralized; the Semantic Web preserves the radical decentralization of the Web in its structure. The Semantic Web allows many ontologies to exist simultaneously, and Semantic Web agents must deal with potentially dissimilar ontologies and rules.

Despite this prosaic description of the technology, visions of the Semantic Web are quick to swing back towards machine intelligence. (One might note that AI itself has largely abandoned its early goal of creating a synthetic human intelligence.) For example, the Scientific American article describes simple agents and goes on to say:

> The consumer and producer agents can reach a shared understanding by exchanging ontologies, which provide the vocabulary needed for discussion. Agents can even

> “bootstrap” new reasoning capabilities when they discover new ontologies. Semantics also makes it easier to take advantage of a service that only partially matches a request.
>
> A typical process will involve the creation of a “value chain” in which subassemblies of information are passed from one agent to another, each one “adding value,” to construct the final product requested by the end user. (Berners-Lee et al., 2001)

Indeed, article ends with

> The Semantic Web is not “merely” the tool for conducting individual tasks that we have discussed so far. In addition, if properly designed, the Semantic Web can assist the evolution of human knowledge as a whole. (Berners-Lee et al., 2001)

and

> The Semantic Web, in naming every concept simply by a URI, lets anyone express new concepts that they invent with minimal effort. Its unifying logical language will enable these concepts to be progressively linked into a universal Web. This structure will open up the knowledge and workings of humankind to meaningful analysis by software agents, providing a new class of tools by which we can live, work and learn together. (Berners-Lee et al., 2001)

In all fairness, one must realize that to do their job of convincing a reader, the authors must avoid visions of AI, since there are many AI dysutopias in the media as well as a popular disappointment in the AI hype and craze of the mid-1980s. At the same time, to mobilize support, the authors must promise the new. It would be interesting to speculate on what drives Americans' fascination with the future and the new (as well as the lingering pervasiveness of technological utopianism and economic greed in predicting the future), but for this paper's purposes, it is merely necessary to note that the authors tap into this never-ending fascination and yet are wary of it.

In any case, the Semantic Web articles are noticeably lacking in any discussion of the social world. The vision is limited to allowing separate language worlds to communicate and assuming they will want to do so. Questions of who controls the ontologies, which relationships are expressed and which are not, and how ontological categories come to be matched are not discussed (Bowker & Star, 2000). Even questions of how ontologies or statements are maintained and supported over time are not discussed. It is assumed that the development of ontologies is open to all, and in fact, many attempts will be made. As with current Web sites, however, it is entirely possible that ontologies or rules will become the province of large corporate or institutional entities with the financial and programming resources to support them. It is also possible that such entities might not want to openly share or cooperate with others.

The Semantic Web offers a vision of radical libertarianism, with all of the political concerns that such libertarianism suggests. Nonetheless, the Semantic Web offers the technology to allow such a libertarianism to succeed. Any given person, organization, group, or society, even in the face of corporate or institutional restrictions, can place its own ontology and rules onto the Web. Just as any entity is free to offer any Web page about any topic and with any slant, the Semantic Web also offers that capability.

I will show next that Pervasive Computing, while arguing for the same libertarian decentralization, does not offer this capability.

4. PERVASIVE COMPUTING

Pervasive computing – sometimes called ubiquitous computing or pervasive environments – is often touted as the next generation of computer architectures. The idea is simple: Processors will be so cheap and high-bandwidth networks so available that there will literally be computers everywhere. Sensors will be ubiquitous. A building's rooms may have dozens of embedded computers, a person may have implanted medical systems, and even clothing may have computational or display elements. Hundreds or thousands of computationally-based services may be processing data and providing applications. As Weiser's seminal 1991 paper begins:

> The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it. (Weiser, 1991)

There are hundreds of pervasive computing papers published every year, as with the Semantic Web. Relatively few still are industrial or marketing articles; the market is still nascent. Here we will consider largely Mark Weiser's papers, as he was the founder of the area. Much of his vision has been kept by researchers in this field, although they have been more mechanical and less concerned with the socio-historical. Again, I do not expound Weiser's point of view to be sharply critical; I merely want to explore the CM's points of view. Weiser set the tone for the entire pervasive (ubiquitous computing) CM; his words were deeply influential on researchers and practitioners alike. While he died unexpectedly in 199, the field has continued on, and as one might expect, over time, numerous voices have tried to influence the CM. Some more recent researchers, especially those influenced by the field of Human-Computer Interaction, have acknowledged some of the problematic issues raised by the technology (e.g., Abowd et al., 2002; Abowd & Mynatt, 2000) or acknowledge the social requirements (e.g., Kindberg & Fox, 2002; Langheinrich, 2002). These researchers, nonetheless, are still optimistic about the technology and its possibilities. Others are more instrumental, focusing on the technical problems. However, many continue the predominant themes of Weiser, perhaps even accentuating the positive (e.g., Dertouzos, 2001; CMU Project Aura, 2000).

Pervasive computing, at its core, attempts to reconcile computers and everyday life by attempting to make the computer as easy to use as any everyday experience:

> Silicon-based information technology, in contrast, is far from having become part of the environment. ...the computer remains largely in a world of its own. It is approachable only through complex jargon that has nothing to do with the tasks for which people actually use computers. The state of the art is perhaps analogous to the period when scribes had to know as much about making ink or baking clay as they did about writing. (Weiser, 1991)

Weiser's work reflects the dominant concerns in PARC, the research center in which he wrote. His reflection of everyday activities echoes ethnomethodologically-inspired emphases:

> ...only when things disappear in this way are we freed to use them without thinking and so to focus beyond them on new goals. (Weiser, 1991)

This is also a criticism of classical AI, less muted than that of the Semantic Web:

> No revolution in artificial intelligence is needed--just the proper imbedding of computers into the everyday world. (Weiser, 1991)

The scenarios Weiser paints are often broad-brush and historical – technologies that have changed over time and become more common-place. Socio-historical transitions are, at best, minor:

> How do technologies disappear into the background? The vanishing of electric motors may serve as an instructive example: At the turn of the century, a typical workshop or factory contained a single engine that drove dozens or hundreds of different machines through a system of shafts and pulleys. Cheap, small, efficient electric motors made it possible first to give each machine or tool its own source of motive force, then to put many motors into a single machine.
>
> A glance through the shop manual of a typical automobile, for example, reveals twenty-two motors and twenty-five more solenoids. They start the engine, clean the windshield, lock and unlock the doors, and so on. By paying careful attention it might be possible to know whenever one activated a motor, but there would be no point to it. (Weiser, 1991)

Weiser understood that this would fundamentally change the relationship between humans and computers, as part of this inevitable historical process. Of course, the development of motors (beginning with water and then steam actually) changed the Western world with large-scale factories, urbanization and industrialization, and the resulting significant displacements of artisans and other workers.

Outside of the large-scale vision, changes in computer applications are almost prosaic. Unlike the Semantic Web with its large-scale applications, pervasive computing has very small-scale applications in its usage vision:

> This will ... let people arrange their computer-based projects in the area around their terminals, much as they now arrange paper-based projects in piles on desks and tables. Carrying a project to a different office for discussion is a simple as gathering up its tabs; the associated programs and files can be called up on any terminal.... (Weiser, 1991)

In fact, some of the applications envisioned by Weiser have already become commonplace:

> To manipulate the display, users pick up a piece of wireless electronic "chalk" that can work either in contact with the surface or from a distance. Some researchers, using themselves and their colleagues as guinea pigs, can hold electronically mediated meetings or engage in other forms of collaboration around a liveboard. (Weiser, 1991)

Weiser argued against “intelligent agents”, arguing instead for small applications with little reasoning. He believed, however, that the final outcome would be similar to AI’s general goals:

> In the next revolution, as we learn to make machines that take care of our unconscious details, we might finally have smarter people. (Weiser, 1996)

Weiser argued that such capability would come from many small applications with little reasoning (similar to the later claims of Hutchins 1995). It should be noted that later advocates of pervasive computing argue for “proactive” agents in the environment, inferencing of context, and location awareness (e.g., Satyanarayanan, 2001; Dey et al., 2001; Mynatt et al., 2001; Sawhney & Schmandt, 1999).

Pervasive advocates note the possibility of social issues, although the social issues do not play a significant role. The social issues are often limited to privacy and trust, occasionally including issues in location and context awareness made possible with sensor networks. Still the outlook is generally held to be positive:

> ...A well-implemented version of ubiquitous computing could even afford better privacy protection than exists today.
>
> ... If anything, the transparent connections that they offer between different locations and times may tend to bring communities closer together.
>
> ...Sociologically, ubiquitous computing may mean the decline of the computer addict. (Weiser, 1991)

What is clearly missing is a sense of who gets control over the placement and operation of services, sensors, and data. Clearly in a pervasive environment as envisioned, there will be many computational services getting flows of data from sensors and inferencing services. Even more than today, a “user” may not be aware of those trafficking in his data. Furthermore, in the visions of pervasive computing, many systems with many owners may operate within a single environment, and those systems and their owners will exist within a complex set of relationships (many hidden) with any given user (Ackerman et al., 2002). The user may lack effective control. (Sorensen and Gibson in this volume examine the idealized visions of pervasive and ubiquitous technologies, as argued here, against the mundane practicalities that users might face.)

In Weiser’s vision, there is little centralized infrastructure that ties these hidden and everyday computational devices together. Pervasive computing is also libertarian, in that it assumes that any given device is equivalent and that some user can pick the services, sensors, and data he wishes. In reality, the environments may largely choose which services and sensors are present, and the data will flow automatically. Furthermore, these services and sensors must interoperate to be effective, and if data fusion is profitable (as it may be for tracking purchase decisions), then data flows must also interoperate. A need for interoperationalization leads, without an adequate infrastructure design, to large vendors or institutions controlling significant portions of the infrastructure. In this case, the libertarian bias of pervasive computing will not lead to democratization, but rather to oligarchic arrangements. The democratization that does occur could very well be limited to the mass consumerization.

5. CONCLUSIONS: THE POLITICS OF DESIGN

As CMs, the Semantic Web and pervasive computing rely on the computerization movements that have preceded them. This can be seen even in their names. Earlier CMs like "artificial intelligence", "machine learning", "information highway", or "organizational memory" took their names by concatenating existing, everyday entities ("highway" or "memory") and added to them an abstract, computer-based term on the left (Ackerman, 1994). The names derived some of their symbolic power by arguing that the new CM would be like some natural entity but indeed would be better. "Semantic Web" and "pervasive computing" rely, instead, on their right-hand terms being existing infrastructure ("Web" and "computing"). They add to this a left-hand term that adds even more abstract meaning. In other words, they rely on readers understanding existing computational infrastructure and being able to infer from them; these CMs have been created as second-generation CMs.

Because the Semantic Web and pervasive computing rely on pre-existing notions of computerization, they display two common biases. First, they both nominally eschew previous, under-performing CMs, especially AI. In fact, both CMs include and supplement previous AI visions of the future. These AI visions have a deep resonance, I would argue, for Americans and will not lightly vanish. And, these CMs build upon previous CMs' successes.

Second, and more importantly, both CMs are founded on the libertarian-infused infrastructures of the Internet, networking technologies, and distributed computing. As such, these new CMs carry forward a sense that a libertarian sense of control is appropriate; other possibilities for political relationships have largely vanished. I have argued above that this libertarian sense of control, however, brings with it a sharp tension – how will all the disparate parts work together? Over time, who will allow the competing portions of the environment to work together, how will conflicts be reconciled, and the necessary updates and maintenance occur? Neither CM deals extensively with this tension (as I believe it is a problematic aspect of this libertarian bias, but is an easier sell for the CM). But, the Semantic Web, perhaps because of its roots in the Web infrastructure, shows an understanding in its design that that interoperationalization is necessary and conflict must be reconciled and managed. This understanding offers some hope for democratization of effort and control, although the current history of the Web argues more heavily for corporate influence. (Indeed, the W3C is largely a corporate consortium.) I have argued, on the other hand, that pervasive computing, as it has grown since Weiser, by ignoring issues of conflict and control, is likely to head towards vendors or other institutions providing islands of interoperationalization and thus maintaining oligarchic control over the infrastructure.

How these new CMs play out is, of course, an empirical question. The above argues that Iacono and Kling's viewpoint is likely to be correct:

> In its most likely form, the rise of computer technologies and networks, while promising technological utopias for all, will lead to conservative social arrangements, reinforcing the patterns of an elite-dominated, stratified society. (Iacono & Kling, 1996, p. 102

Yet, they also argued that:

> The best answers come from a kind of close empirical observation that opens up the real possibilities, limitations, paradoxes, and ironies of computerization situated in very real social settings. (Kling, 1991a, p. 72

This is vital to design of these next-generation environments. The future of people's control over their environments – computational, domestic and organizational, or political – is critical. Influencing the environments' design, and countering the accompanying CMs, requires a constant attention to empirically-grounded observation and critical discussion.

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7. REFERENCES

Abowd, Gregory D., & Elizabeth D. Mynatt. (2000). Charting past, present, and future research in ubiquitous computing. ACM Transactions on Computer-Human Interaction, 7(1), 29-58.

Abowd, Gregory D., Elizabeth D. Mynatt, & Tom Rodden. (2002). The Human Experience. 1(1), 48-57.

Ackerman, Mark S. (1994). Metaphors along the Information Highway. Proceedings of the Symposium on Directions and Impacts of Advanced Computing Systems (DIAC 94).

Ackerman, Mark S., Trevor Darrell, & Daniel J. Weitzner. (2002). Privacy in Context. Human-Computer Interaction, 16(2-4), 167-176.

Berners-Lee, Tim. (1998a). Semantic Web Roadmap, http://www.w3.org/DesignIssues/Semantic.html.

Berners-Lee, Tim. (1998b). What the Semantic Web Is Not, http://www.w3.org/DesignIssues/Semantic.html.

Berners-Lee, Tim, James Hendler, & Ora Lassila. (2001). The Semantic Web. Scientific American, 35-43.

Berners-Lee, Tim, & Eric Miller. (2002). The Semantic Web Lifts Off, ERCIM News No. 51, http://www.ercim.org/publication/Ercim_News/enw51/berners-lee.html).

Bowker, Geoffrey C., & Susan L. Star. (2000). Sorting Things Out: Classification and Its Consequences. Cambridge, MA: MIT Press.

CMU Project Aura. (2000). CMU Project Aura concept video, http://www.cs.cmu.edu/~aura/auravideo.mpg.

Cowan, Ruth Schwartz. (1983). More work for mother: the ironies of household technology from the open hearth to the microwave. New York: Basic Books.

Dertouzos, Michael L. (2001). The Unfinished Revolution: : How to Make Technology Work for Us--Instead of the Other Way Around. New York: Collins.

Dey, A.K., D. Salber, & G.D. Abowd. (2001). A Conceptual Framework and a Toolkit for Supporting the Rapid Prototyping of Context-Aware Applications. Human-Computer Interaction (HCI) Journal, 16(2-4), 97-166.

Hutchins, Edwin. (1995). Cognition in the Wild. Cambridge, MA: MIT Press.

Iacono, Suzanne, & Rob Kling. (1996). Computerization Movements and Tales of Technological Utopianism. In R. Kling (Ed.), Computerization and Controversy: Value Conflicts and Social Choices (Second edition ed., pp. 85-105). New York: Academic Press.

Iacono, Suzanne, & Rob Kling. (2001). Computerization Movements: The Rise of the Internet and Distant Forms of Work. In J. Yates & J. van Maanen (Eds.), Information technology and organizational transformation: history, rhetoric, and practice (pp. 93-136). Thousand Oaks, CA: Sage Publications.

Kindberg, Tom, & Armando Fox. (2002). System Software for Ubiquitous Computing. IEEE Pervasive Computing, 1(1), 70-81.

Kling, Rob. (1991a). Computerization and Social Transformations. Science, Technology and Human Values, 16(3), 342-367.

Kling, Rob. (1991b). Value Conflicts in the Design and Organization of EFT Systems. In C. Dunlop & R. Kling (Eds.), Computerization and Controversy, first ed., pp. 421-435. Boston: Academic Press.

Kling, Rob, & Suzanne Iacono. (1994). Computerization Movements and the Mobilization of Support for Computerization. In S. L. Starr (Ed.), Ecologies of Knowledge. New York: SUNY Press.

Langheinrich, Marc. (2002). A Privacy Awareness System for Ubiquitous Computing Environments. Proceedings of the Ubicomp 2002, www.inf.ethz.ch/~langhein.

Mynatt, Elizabeth D., Jim Rowan, Sarah Craighill, & Annie Jacobs. (2001). Digital Family Portraits: Supporting Peace of Mind for Extended Family Members, Proceedings of ACM CHI 2001 Conference on Human Factors in Computing Systems, 333-340.

Orlikowski, Wanda. (2000). Using Technology and Constituting Structures: A Practice Lens for Studying Technology in Organizations. Organization Science, 11(4), 404-428.

Satyanarayanan, M. (2001). Pervasive Computing: Vision and Challenges. IEEE Personal Communications, 8(4), 10-17.

Sawhney, Nitin, & Chris Schmandt. (1999). Nomadic Radio: Scaleable and Contextual Notification for Wearable Audio Messaging, Proceedings of ACM CHI 99 Conference on Human Factors in Computing System, 96-103.

Weiser, Marc. (1996). Open House, Interactive Telecommunications Program Review 2.0, http://www.itp.tsoa.nyu.edu/~review.

Weiser, Mark. (1991). The Computer for the 21st Century, Pre-press for Scientific American article, available at http://www.ubiq.com/hypertext/weiser/SciAmDraft3.html.