

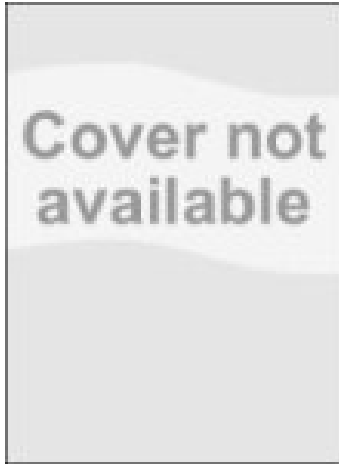
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Publisher Taylor & Francis

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## Encyclopedia of Software Engineering

Publication details, including instructions for authors and subscription information:

<http://www.informaworld.com/smpp/title~content=t929373902>

### Smart Machines

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Online publication date: 10 November 2010

To cite this Chapter Kallinikos, Jannis(2010) 'Smart Machines', Encyclopedia of Software Engineering, 1: 1, 1097 — 1103

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# Smart Machines

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## Abstract

The entry reviews Shoshana Zuboff's acclaimed work *In the Age of the Smart Machine: The Future of Work and Power*, originally published in 1988 against the backdrop of the considerable technological changes that have occurred over the last two decades. The core themes of the book dealing with the impact of information technology on the workplace are highly relevant even today while the analytic paths Zuboff pursued seem to hold considerable promise in approaching key issues raised by the expansion of information technology in social and economic life, and designing better systems.

## INTRODUCTION

It has been 20 years since Shoshana Zuboff published her *In the Age of the Smart Machine: The Future of Work and Power* (hereafter the *Smart Machine*), a profound study of the work implications associated with the extensive involvement of information technology in organizations. The book rapidly gained recognition across a wide spectrum of social science disciplines, including management and organization studies, information systems, social psychology, and sociology, and has been debated and quoted extensively. Twenty years may seem an awfully long time in this age of speed and rapid technological change. But, the *Smart Machine*, as perhaps every great work, holds out remarkably. The central themes of the book are equally if not more relevant today. Key insights the author develops concerning the nature of information and its relation to reality can be brought to bear on the analysis of phenomena such as the emergence and diffusion of the Internet that were not yet manifest at the time she conducted her study. Indeed, later and significant works on the social and organizational implications of information technology draw in one way or another on the legacy the *Smart Machine* has left.<sup>[1,2]</sup>

The significance of computer-based technologies for organizations had certainly been acknowledged prior to the publication of the *Smart Machine* in 1988.<sup>[3]</sup> And yet the book was rapidly recognized as making a unique contribution to a variety of fields that, in one way or another, relate to the expanding involvement of computer-based technologies in social and economic life and its implications. There are several reasons for this. Zuboff was among the first to weave together with elegance, precision, and depth the conceptual threads she derived from the careful exploration of a broad social science literature. The contribution of her study owes definitely very much to the historical awareness she demonstrates of the technological,

sociological, and psychological processes that converged to shape the modern workplace. By psychological processes I mean the formation of predispositions and the development of cognitive and behavioral habits. At the same time, the analytic threads she unfolded have been firmly rooted in the empirical relationships she explored through deep ethnographic involvement in eight different contexts, in which comprehensive computerization of work processes had been undertaken. The distinctive flavor of the book and its enduring significance are inextricably bound up with the masterly ways Zuboff managed to navigate between the potent but tidy worlds of theory and the inspiring yet messy reality of the workplace. Her work represents long-standing evidence of the fact that theory and concepts if skillfully used may sharpen observation, disclosing aspects of reality that might otherwise have escaped attention.

Written in superb prose, the *Smart Machine* deserves to be described as a landmark contribution to the cross-disciplinary field of the history and social psychology of work. While a book about information and its significance in restructuring and redefining the patterns and meaning of work, the *Smart Machine* is much more than a treatise on this subject. Out of the pages of this remarkable book emerge with evocative force the history of work as the bodily struggle to master the resistant materiality of the world through skill but also exertion and toil; the mixed blessings of technology and the forms through which technology liberates, enables, and enslaves at the same time; the stratified character of the workplace and the social struggles that have underlain its formation and its persisting role as an institutional pillar of modern societies; the history of administration and the different social connotations white- and blue-collar work came to embody; the developments of managerial methods and techniques and the relentless discipline they impose in the factory and the office; and, finally, the allure of technology in general

and information technology in particular to construct a more fulfilling workplace and the rather disappointing outcome in which automation, driven by the dominant elites and their will to control, erodes and undoes the promise of a transparent and multivalent workplace in which information could have played an enlightening role.

## PERSISTING RELEVANCE

Since the publication of the *Smart Machine*, the work involvement of the new technologies of information and communication has expanded substantially. Information, as Professor Zuboff already discerned, has become a key component of organizational life, engulfing organizations and their dealings. At the same time the sophistication and operational smoothness of computer-based technologies have steadily risen. New applications have progressively been emerging at the same time as the functionality of older systems has been improving.

As briefly indicated above, a path-breaking development, hardly discernible at the time she wrote the book, has been the emergence and spectacular diffusion of the Internet. This development coincided and was paralleled by the construction of large interoperable information infrastructures (public or private) in which data and information that were previously limited within specific systems, sources, or life contexts could be accessed and increasingly aggregated, mixed, or combined. The interoperable character of text, sound, and image provides a good illustration of these processes of technological convergence. Prior to computerization, text, sound, and image formed different and incompatible technological islands. Media convergence, as this phenomenon is often called, reflects wider trends in which families of technologies and artifacts are brought to bear upon one another.

Taken together, these developments have significantly expanded the involvement of information technology in social and economic life<sup>[4,5]</sup> and brought about a number of significant changes across a wide range of practices and institutions. Among these changes figure the redrawing and, in some respects, weakening of the boundaries separating work and private life and the transformation of the very conditions under which work is performed and evaluated. The diffusion of networks and flexible forms of work and employment stand as clear indicators of these trends.<sup>[6,7]</sup> Information services delivered over the Internet and the growing significance of decentralized Web-based communities like Linux or Wikipedia represent other important fields that demonstrate the comprehensive socio-technical change occasioned by the steady development of computer-based technologies and the information and communication patterns they promote.

Against this backdrop, it would be reasonable to conjecture that a book written in the pre-Internet age might well be outdated and no longer relevant. This holds

undeniably true for many issues, ideas, or debates that took place during the 1970s and 1980s. However, the case of the *Smart Machine* is rather different. The central theme of the book concerning the hot issue of whether information technology is or will be used as a means to automation and control or as a way to construct new, less hierarchical, and more rewarding forms of collective engagement and an enlightened workplace is equally, if not more, relevant today.<sup>[8,9]</sup> The widely diffused fear of the Orwellian big brother is just an indicator of this, as is the debate of how personal data produced from our online habits and Internet site trajectories will be used.<sup>[10]</sup> Another highly crucial issue evolves around copyright and the efforts of the culture industry to control and shape the growth of the Internet and the patterns of exchanging ideas and culture.<sup>[11,12]</sup> To some degree, time has supported Zuboff's rather gloomy predictions of the appropriation of the promise of information technology by powerful groups and its concomitant use in ways that, by and large, accommodate the interests of these groups. It is thus more than urgent to revisit that issue.

Another central and highly interesting theme of the book evolves around the relationship of information to reality in general and work reality in particular. The production of information is never an innocent description, a literal, point-by-point mapping of a pre-existing world. The comprehensive rendition of work states and processes to information constructs new realities in the workplace, lifts up factors or processes that have gone unnoticed, raises new problems and opportunities, and defines priorities and relevancies that were not there prior to computerization. By the same token, comprehensive computerization samples and assembles reality in a variety of ways and thus shapes the forms of perceiving and acting upon it.<sup>[13]</sup>

The central and timely character of these issues provides evidence of the persistent relevance of the *Smart Machine*. One could indeed go as far as to claim that in some respects the book is even more relevant and timely today than it was at the time of its publication.

## INFORMATION TECHNOLOGY AND POWER

The *Smart Machine* has been widely cited for the distinction it made between the automating and informing potential of computer-based technologies. Automation coincides with the deployment of information technology as predominantly a means to streamline and procedurally simplify organizational operations and speed up the accomplishment of organizational tasks. Thus viewed, automation is predominantly driven by the goals of efficiency or performance gains. But what is considered as efficient or performance gain is the outcome of a particular social order and the interests it accommodates and renders legitimate. Even within the bounds of the legitimate order, what is a gain for some may turn out or be perceived as a

loss by others. It therefore comes as no surprise that automation has been considered as an important means to improve efficiency within the prevailing structural arrangements in organizations. Structural changes of the kind “reengineering” came to represent by and large leave intact the social and moral order supporting the prevailing structural arrangements in organizations. More often by design rather than accident, automation has been pursued with the view of re-enhancing the established hierarchy and reinforcing the position of privileged groups (owners and top managers) in organizations.

In contrast to automation, information technology can be used in ways that generate a more adequate, indeed much richer, picture of organizational reality. Computerized rendition of organizational tasks and operations enables capturing and recording of a much wider range of details than those made possible through writing and paper-based documents. Computerization thus provides ample possibilities for enriching the descriptive details of organizational records, classifying, bringing together, and systematizing information across types and functions. A variety of possible spin-offs results from this. A new insight to reality can emerge out of the systematization, juxtaposition, or comparison of computer-based records. Computer-based information can in this respect be deployed to construct a new visibility of organizational relations. This however makes necessary new and shared forms of acting, generating, and evaluating information, making it widely available across functions, departments, and locales. The capacity to obtain this richer view of reality, which Zuboff calls *informating*, thus demands a much more open and mobile social order and an improvising configuration of task distribution, positions, and roles in organizations. Such a configuration may not always be aligned with the prevailing stratified social order in organizations and the structural arrangements that it embodies and through which it is sustained. Accordingly, the deployment of information technology in ways that would have implied a drift away from the prevailing conditions is usually considered threatening and is resisted by the dominant organizational elites. The information potential of the smart machine is thus foregone and the automation of existing operations under the prevailing structural and behavioral regime dominates.

This may seem as a straightforward argument but it is not. What is foregone is not exactly evident if the new forms by which information can be used to enlighten our understanding of material and social reality are not sufficiently depicted. Zuboff’s analysis of the ways information can be used to slice reality and obtain a deeper understanding of its underlying processes and mechanisms represents an outstanding contribution. Organizational relations are rendered visible by the ability to construct a “binocular” view of reality that brings together (mixing or comparing) records of previously unrelated operations. This is of course as much a technological as a social operation.

The self-recording capacity of computers (e.g., the computer is the first machine to record its operations) and the flexibility and granularity of computer-based information are essential prerequisites to that goal but so is an open and socially fluid workplace. There ought to be no doubt about the relevance and timely character of these claims whether they concern the still bounded character of the workplace or the more open arrangements enabled by the Internet and its growing involvement in shaping the social and economic relations of our age.

Zuboff’s historical awareness of the origins of the workplace and the stratified social topology of organizations gives both subtlety and momentum to the argument on the foregone possibilities of information technology. Drawing on key social thinkers such as Hannah Arendt, Michel Foucault, and Max Weber, Zuboff has been able to conceive and explain the hierarchical stratification of the workplace as more than the haphazard or contingent outcome of the ability of some groups to seize and maintain power and control. Hierarchical stratification inheres in organizations; it is part and parcel of the reality of the workplace as this has been constituted in modern times, for power constitutes itself through the division to the rulers and the ruled, and the establishment of the institutional mechanisms that enforce, maintain, and reproduce that division. The workings of power are of course unobtrusive. Power, in the context of modern societies, seldom manifests itself straightforwardly or coercively. It rather emerges as a moral order vested with legitimate authority and the resulting naturalized division of the rulers and the ruled. Placed in this context, technology has never been a neutral road to efficiency. Technology has historically been used as a means of reducing the cost of human skilful labor and, by the same token, as a mechanism both for averting the dependence of organizational elites on skilful labor and for firmly controlling the contributions of workers.<sup>[14,15]</sup>

The conclusion deriving from these analytic endeavors is that the possibilities of deploying information technology for constructing what Zuboff calls an *informed* workplace are squeezed or foregone. The interactive patterns of an *informating* work environment and its open and fluid character threaten the moral order of the workplace established over two centuries. Accordingly, the established elites seek to insert the deployment of technology in the prevailing social and economic order from which they derive their privileges, resisting and undermining alternative uses. This ought to make evident that a new workplace cannot result from those naive recipes cultivated by *Human Resource Management* and managerialist thinking in general. Even though it is perfectly possible that some groups may become empowered by deliberate managerial strategies, the enduring characteristics of the workplace coinciding with its hierarchical constitution cannot be drastically changed this way. To some degree the issue is closely associated with the prevailing cultural

beliefs and a moral order entrenched over a longer historical period in which concentrated systems (i.e., bound and hierarchical organizations) were built. Cultural beliefs seldom change overnight. But power is also tight to privileges and economic gains, and in this respect concentrated systems and the hierarchy and power they exemplify are instantiations of the property rights and the significance they have assumed in the construction of the capitalist economic landscape and the constitution of corporations as institutional pillars of the capitalist economy.<sup>[12]</sup>

The persistence of the hierarchical constitution of the workplace is a clear indicator of the lasting value of the *Smart Machine* and the ways Zuboff approaches and explains the construction of the modern workplace. The relevant and timely character of the issues Zuboff raises in this respect are further exemplified by the experience of alternative forms of collective engagement that do ride on the liberating potential of information technology. As the cases of Linux (and open source in general) and Wikipedia demonstrate, alternative Internet-based collective engagements able to produce highly sophisticated products usually have to bypass the established organizational forms that have been driven by the imperative of profit and the centralized governance mechanisms this has occasioned. Benkler<sup>[12]</sup> used the evocative term *social production* to describe these new forms of collective engagement, juxtaposing them on the closed and unitary systems that the profit imperative (production for a market) and the institutional edifice with which it is associated generated. The collaborative forms Benkler explores are no doubt closely associated with the possibilities the medium of the Internet establishes. However, similar processes of decentralized interactions and collective learning have been identified and discussed extensively in the *Smart Machine*. Indeed, as I have been at pains to show above, a key claim of the book pivots around the necessity of finding alternatives to centralization and hierarchy. The current diffusion of collaborative arrangements indicates, as I claimed above, the timely character of the book and the persisting relevance of the analytic paths Zuboff explored at a relatively early stage in information technology's involvement in social and economic life.

## INFORMATION TECHNOLOGY AND REALITY

The potential of computer-based technology to informate is part and parcel of a new relationship that computer-based information maintains with reality, whether within the workplace or in the more fluid and open context of the wider society. To some degree, technological information represents an assembly of traditional, oral, or textual forms for describing reality and, in this sense, its diffusion recounts the old and vexed issue of how representation relates to what it represents. Is, for instance, a verbal description a copy of the world it describes? But what

sort of a copy is it? After all, a description is an arrangement of words whereas what it seeks to describe often has an extralinguistic and factual mode of existence. The same applies for what it may initially seem as a straightforward mapping of reality such as that produced by photographs. The lies of photographs, Susan Sontag<sup>[16]</sup> wrote sometime ago, are more powerful just because of the implicit, socially constructed claims to truth photographs are believed to maintain. But again, photographic pictures are flat, two-dimensional objects of real-life phenomena generated by the mechanics of optical transcoding. How then should the relationship between the two worlds be gauged? How does one pass from descriptions or depictions to referential reality and vice versa?

To complicate matters further, many descriptions or depictions are not at all about a world out there but about other descriptions or depictions, commenting on the content a statement or picture mediates or spelling out the rules (e.g., grammar and syntax if you like) by which statements or pictures are made possible and produced.<sup>[17,18]</sup> In the world of cognition and the signs or symbol tokens by which it is mediated, it is always possible to produce second- or even third-order discourses and descriptive or prescriptive statements, that is, statements that have as an object other statements. Ratio analysis in accounting, for instance, is information about information generated by first-order accounting records (profit and loss account and balance sheet). These days the same holds true for widely deployed methods such as those linking or summarizing data like, for instance, search engines and data mining and profiling.<sup>[5]</sup>

Original but also recent applications of information technology have widely adopted the representing conventions established by writing and specialized systems of recording (e.g., statistical records, finance, and accounting) indicative of the paper-based culture of office work and administration. In this respect, computer-based information duplicates recording and representing procedures of a long-established paper-based culture and recycles the possibilities, problems, and opportunities they have been associated with. However, computer-based information has also brought changes and promoted new cognitive forms, processes, and conventions. The *Smart Machine* has captured and analyzed some of these with perspicacity. Let's attempt a brief overview of these issues.

First, computer-based information systems embody rules for acting upon and processing information that were previously the outcome of experiential knowledge derived after long years of acquaintance with a particular set of tasks. Paper-based documents are by large mnemonic devices; the knowledge by which they are produced is to a large extent mobilized by sentient human beings, enacting rules of sense making and expertise gained through formal training and experience, that is, skill interiorization. Computer-based systems increasingly explicate these rules, embody them in programs, and automate their execution. This is mostly evident in the case of computer-based

expert and decision support systems but apply by and large to most computer-based information systems. Second, computer-based information is much more comprehensive than the records deriving from the paper-based administrative culture. This is closely associated with the ample information storage and retrieval functionalities that computer-based systems provide. At the same time, the comprehensive and considerably standardized character of computer-based information enables different breeds of information to be related to one another. This expands considerably the amount of information generated through data recycling and recombination and multiplies the contexts in which information is used. In this respect, the range of operations rendered as technological information casts an extensive perceptual and action net through which reality is apprehended, framed, and acted upon. Third, in being automated and comprehensive, computer-based information becomes procedural and performative; for, as tasks become automated in a larger scale they are chained together in fixed sequences or trails that have to be pursued. In this sense, the computerized rendition of organizational tasks embodies scripts of acting-upon information and particular courses of action that are necessary to follow to accomplish a particular task or outcome.

The problems, issues, and opportunities associated with the growing involvement of computer-based records and operations in organizations emerge forcefully in Chapter 5 of the *Smart Machine*, entitled “Mastering the Electronic Text,” one of the most penetrating and evocative pieces ever written in the century-long history of the administrative sciences. The entry offers the conclusions of the first of the two parts that comprise the book, dealing with the history of work, and the role of technology and knowledge in constructing the modern industrial workplace. With force and almost cunning insight into what is yet to come, Zuboff describes what may well be considered the predicament of this age, that is, the construction of reality out of the cognitive forms the technologies of computing avail.<sup>[1]</sup> The varieties of technological information that computer technology generates construct an expansive electronic text, which is accruing every single moment by the potent recording and storage capacities of computer technology and its inability, as it were, to forget. The perceptual inputs of human agents are increasingly provided by this potent cognitive machinery and the procedural scripts it embodies.

The fuller appreciation of these trends emerges against the background of the traditional forms of work that have been nourished by industrial capitalism. Whatever its exploitative and unattractive characteristics, the industrial workplace was a setting in which humans encountered the world in an array of physical forms made of raw materials, finished products, tools, and imposing technological arrangements. They did so under conditions that were marked by the disciplined or messy presence of fellow workers and peers. These conditions established over the

course of nearly two centuries and recounting, at least to some degree, the whole history of humankind<sup>[19,20]</sup> are being subjected to a remarkable tweak over the last few decades, as information and information technology become increasingly implicated in the description, constitution, planning, and monitoring of work tasks and operations.

All across the first part of the book and in greater detail in Chapter 5 Zuboff demonstrates how the actuality, physical constitution, and social buzz of the workplace are increasingly giving way to a surrogate reality made of codified descriptions of work processes often enacted in isolated work settings. Whether in the factory or the office, tasks and work processes have to a significant degree become mediated and are carried out by means of software code and the technical instructions and procedures necessary to mobilize and control them. A continuously accruing electronic text installs itself at the center stage of work and organizational life. A crucial outcome of these developments is the fact that referential reality (whether physical or social) is increasingly accessed by means of these software-based, decontextualized descriptions that become windows, screens, and blindfolds of this reality at the same time.<sup>[1]</sup>

Work, Zuboff prophetically said, becomes literally a *reading* of digital marks and codes that may lack the coherence and narrative forms characteristic of traditional modes of human cognition and communication. The computer-based assembly of reality is different from these old but essential forms of human cognition. It is made of lists, tables, variables, cause-effects, and technical connections or descriptions of how the system should be operated. Out of this bare cognitive scaffold, workers must find the ways to reestablish their relationship to the world. This normally entails the understanding of the semantic content of this austere electronic text (what it means) and its connection to the reality it stands for. Sense and reference, as these critical operations are called in linguistics and semiotics, are separate but interdependent cognitive operations, reenforcing one another. Making sense involves invoking a referential world (a reality) that further strengthens and embeds understanding and vice versa.

Placed in this growing and engulfing electronic text, work as reading entails a quite distinctive profile of competencies than the traditional skills industrial capitalism nourished. No longer physical exertion or a skillful materially embedded exercise, work as reading encumbers and strains cognition, making necessary the nourishment of skills that Zuboff subsumed under the generic name of *intellective skills* to contrast them with the bodily anchorage of most work skills typical of the industrial age. To make sense of the world of work through reading of the electronic text usually entails three different types of intellective skills. These are *abstract thinking* entailing the ability to understand states and relationships that lack immediate reference to the world; *inference drawing*

coinciding with the ability to combine, delete, or supplement information items and discern patterns in the data; and *procedural reasoning* entailing the execution of stepwise procedures to resolve a task.

The diffusion of the kind of skills Zuboff summarizes with the concept of intellectual skills is not simply the description of work prerequisites that define the postindustrial workplace. In many respects, intellectual skills mediate the profile of the new age in which digital representations, data mining, and data search become part and parcel not simply of working but of living.<sup>[21]</sup>

## DESIGN IMPLICATIONS FOR SOFTWARE ENGINEERING

The themes of power and social action, cognition, and reality presented in the last two sections suggest that computer-based systems and the information operations they enable are deeply immersed in social reality and the pursuits of social agents. This is perhaps true for all technologies and artifacts. Vehicles, television sets, electric appliances, to name but a few examples, have all been centrally integrated in the everyday life of people. However, traditional hardwired technologies and artifacts have been possible to considerably insulate from the social contexts into which they have been used. This has been accomplished by a fundamental design principle of engineering commonly referred to as blackboxing. Through the application of such a design principle, technological imagination and ingenuity have been able to construct relatively encased technological objects with a very constricted human interface (e.g., a steering wheel and a gear, a remote control, a button or a switch).

Software engineering too has made use of blackboxing, at least to some degree. Software-based systems and applications are often encased procedural machines that exchange information with other systems along very constricted and standardized interfaces. However, information processing and communication are not equally detachable from the stream of life and the events to which they are embedded. Zuboff's insightful analysis of the ways through which electronic text is accruing suggests a complex and non-linear pattern by which information grows. The use of computer-based information itself generates new information by virtue of its recording and storage functionalities. Every piece of information that is recorded is added to an existing information source, amplifying it and changing its relevance. In this respect, computer-based systems and artifacts can never be entirely insulated from the stream of events that they form part of. This self-accrual and self-amplification of computer-based systems and applications suggests that software engineering faces a highly complex task environment in which the principle of shooting moving targets must be made integral to the design and development of such systems.<sup>[5]</sup>

These observations gain greater relevance when analyzed in the context of the Internet and the design and development of Web-based services immersed in the ongoing operations of people and a networked information environment under steady change and growth. Standardization, interoperability, and openness are currently important design principles of software engineering that will most probably acquire even greater importance in the years to come. The issues Shoshana Zuboff once explored with respect to the complex relationship information bears to reality and the patterns by which information accrues and grows amidst the pursuits and projects of social agents represent a wealth of ideas that software engineering has yet to accommodate in ways other than trivial.

Zuboff's analysis also provides interesting observations as regards the social context in which the design and development of software is embedded. The development of open and extendible artifacts is never a sheer technical task. The distributed interaction and information exchange patterns that electronic communication promotes often contrast with the concentrated nature of organizations and the powerful interest of mass media that seek to constrict and shape the information and communication flows within and across settings. Zuboff's work is a masterpiece in this respect, whose potential for the design and development of information computer-based systems and technologies has been far from exhausted.

## CONCLUSIONS

In this entry I have sought to revisit and reconsider the key claims Shoshana Zuboff put forth in her much celebrated book *In the Age of the Smart Machine: The Future of Work and Power* published originally in 1988. I have grouped these claims in two broad clusters, one pivoting on power, information technology, and the workplace and the other dealing with the shifting relationship to reality occasioned by the diffusion of information and the technologies by which it is supported. Rather than losing relevance, the issue of power, information, and democracy within and beyond the workplace has become even more salient than it was when the *Smart Machine* was originally published. Both the libertarian ideas coupled to the diffusion of the Internet and the continuing debate over alternative forms of economic and social organization which information technologies and the Internet enable provide evidence for the centrality and persistent nature of the issue.<sup>[12]</sup>

The second cluster of ideas concern the relationship of technology to reality and its implications may be more unobtrusive and surreptitious. This is partly the outcome of the fundamental fact that perception and cognition are always immersed in the realities they seek to fathom and cannot easily be detached or separated from these. Since

the publication of the *Smart Machine* information has grown to engulf an impressive array of everyday work tasks and habits, reshaping in this process a variety of practices and institutions. In its descriptive affluence, prescriptive potency, and automated nature, information and the technologies by which it is supported have given rise to a second reality indicated by a growing vocabulary of terms like “virtual,” “semantic web,” “information services,” to name but a few. Once *about* or *for* reality, as acclaimed professor of philosophy Albert Borgmann<sup>[1]</sup> has put it, information has become reality on its own.

These analytic insights hold promise for software engineering and the design and development of computer-based systems and technologies. While some of the processes Zuboff analyzes extend far beyond the variables and parameters technological design is able to control and manipulate, they represent nonetheless important points of reference for designing better systems.

These considerations ought to make clear that despite the many shifts and changes that have occurred over the last two decades, the *Smart Machine* still enlightens. It seems to me that it always will.

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