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Unplanned effects of intelligent agents on Internet use: a social informatics approach

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Abstract This paper instigates a discourse on the unplanned effects of intelligent agents in the context of their use on the Internet. By utilizing a social informatics framework as a lens of analysis, the study identifies several unanticipated consequences of using intelligent agents for information- and commerce-based tasks on the Internet. The effects include those that transpire over time at the organizational level, such as e-commerce transformation, operational encumbrance and security overload, as well as those that emerge on a cultural level, such as trust affliction, skills erosion, privacy attrition and social detachment. Furthermore, three types of impacts are identified: economic, policy, and social. The discussion contends that economic impacts occur on the organizational level, social effects transpire on a cultural level, and policy impacts take place on both levels. These effects of the use of intelligent agents have seldom been predicted and discussed by visionaries, researchers, and practitioners in the field. The knowledge of these unplanned outcomes can improve our understanding of the overall impacts that innovative agent technologies may potentially have on organizations and individuals. Subsequently, this may help us develop better agent applications, facilitate the formulation of appropriate contingencies, and provide impetus for future research.

Keywords Internet · Intelligent agents · Impacts · Social informatics

1 Introduction

"Every technology is both a burden and a blessing."Postman (1992, p. 5)

This paper adopts a socio-technical perspective of intelligent agents. The research exposition is that intelligent agents should be considered as more than

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just tools or applications since the use of this innovative technology is ingrained within a complex matrix of social relations. These relations embrace various entities and institutions, such as organizations, markets, households, and individuals. Furthermore, these relations are associated with formal processes and procedures as well as informal cultural values and norms. It is suggested that intelligent agents may have a number of unpredicted impacts on societies that rely heavily on computer and Internet technologies.

Usually, new technologies introduce minor innovations and improvements to the existing ways that people perform various everyday tasks. Sometimes, a new technology can introduce more than just an incremental change. It impacts the functional execution of tasks at various levels, affects several aspects of human lives, and breaks down many existing social rules. For instance, the advent of the Internet has shaped the way many people work, communicate, learn, and entertain. More importantly, in some cases, the World Wide Web has structured a virtually new social environment with its own rules, values, and lifestyles. Online communities may be a supporting example; according to some opinions in the extant literature, participating in online communities may even foster new ways of building social capital (Lin 2001).

For the past 40 years, academics have often addressed the possible impacts of artificial intelligence (AI) on society (Collins 1987; Minsky 1979; Woolgan 1987; Yazdani 1984). Some researchers and futurists have concentrated on positive impacts of this technology whereas others discussed its negative consequences. At the same time, truly intelligent machines were predicted to deliver novel solutions to existing problems (Gregory 1971). It was envisioned that professionals, commonly referred to as 'knowledge workers' in the new economy, would use smart assistants to augment, rather than replace human judgment by spotting people's mistakes and suggesting solutions in a non-intrusive and intelligent fashion (Boden 1978). Speech-recognition programs, currently labeled voice-recognition software, were foreseen to replace computer keyboards. Home appliances, machinery, and tools were expected to exhibit some degree of useful intelligence. Artificial intelligence was supposed to bring positive changes in many expertise-dependent areas such as medicine, law, commerce, military, and education (Boden 1990; Maybury 1990; Firschein et al. 1973). By taking over monotonous, uninteresting, mundane and repetitive tasks, AI-enabled devices were forecasted to free human workers from boring activities, thereby improving their quality of life.

On the other hand, individuals might exclude artificial machines from the human club, express concerns over their ethics, morale and responsibilities, distrust them, and worry over psychological issues, such as relationships between people and computers, or computers' abilities to express feelings, moods, and emotions (Epstein 1996; Epstein and Kumar 2000). For instance, despite the potential usefulness of AI-enabled computers, individuals have raised the issue of depersonalization of humans who might see an unbridgeable metaphysical gulf between themselves and machines. It has been hypothesized that many AI users would experience a dehumanizing effect by becoming decreasingly dependent upon human contact for advice, communication, and information because they would have a perfect substitute for the fulfillment of their needs (Boden 1978). Consequently, those individuals might acquire profound

psychological distress as they begin to wonder whether there are human capabilities which are truly unique (Firschein et al. 1973; Weizenbaum 1976). AI has been feared to accelerate the growing gap between information rich and information poor jobs by addressing the needs of mostly knowledge-intensive tasks (Sackman 1987).

Even the most advanced systems might be imperfect and error-prone that would lead to dramatic negative consequences (Regev 1987). As the systems become more complex and responsible, they increase their vulnerability and instability (Brunnstein 1987). Science fiction and movie script writers have often capitalized on the unpredictable nature of AI by depicting the use of smart machines by evil forces leading to the destruction of the entire civilization. The classic 'Terminator' series is an example of such an exaggeration. Overall, the discussion above reveals that people value the obvious advantages and benefits of a new technology, but also feel concerned and apprehensive about the less apparent future impacts of an invention on society.

The AI discipline has traditionally focused on the development of machines performing functions that require a certain degree of intelligence (Kurzweil 1999; Kurzweil 1990). Given the complexity of this research field, several branches of AI have emerged, for example, intelligent decision support systems and humanlike machines (Turing 1950; Sakagami et al. 2002; Brackenbury and Ravin 2002; Pendharkara and Rodgerb 2003; Saygin et al. 2000). Recently, a novel form of innovative computer technology, called *intelligent agents*, has appeared that offers people new opportunities to explore cyberspace, automate simple Internet tasks, and enjoy Web surfing. The major difference between intelligent agents and other systems is that the purpose of the former is to improve computer-specific tasks by taking care of simple or repetitive activities, collecting and aggregating information from dispersed sources, improving interface, hiding complexities, and making user experience more enjoyable. As indicated by the growing body of prior intelligent agent research, this promising technology has already brought substantial improvements in various areas.

The predictable effects of agent technologies have been well addressed in previous agent research in the form of conceptual discussions, empirical studies, and pilot implementations of intelligent agents. Maes (1994) provides reasons to why intelligent agents may need to be embedded in software applications. In the mid-nineties, the first generation agent literature often searched for the possible areas of applications of agent technologies. The contemporary literature focuses not only on the economic benefits of utilizing agent-based technologies but also on the social impacts of intelligent agents. For example, Raisinghani (2001) and Raisinghani et al. (2002) address the philosophical nature of this technology itself by highlighting potential trade-offs of agents. Pickering (2001) suggests that the human-agent interaction process may create new values, especially for young users. Lanier (1995) believes that intelligent agents will have long-term consequences on society. For instance, once people start looking at the world through an agent's eyes, advertisers would aim to establish control over agents as a means of manipulating people's perceptions and behaviors. Agents may potentially become a new information bottleneck if individuals totally rely on information presented by digital assistants. Indeed, even the best personalization

technologies are not capable of detecting sudden changes in user preferences. Some people tend to treat computers and agents as having personality (Dryer 1999; Moon and Nass 1998; Nass et al. 1994); however, those who understand that human emotions may be effectively programmed and reproduced by software may feel that they are bewildered, mocked, or manipulated by a machine (Picard 1997).

The social impacts of most contemporary technologies in various fields have previously been investigated. Recently, several researchers have studied the social implications of the Internet because of the Web's ability to dramatically alter an individuals' behavior, habits, and preferences (Havick 2000; Anderson and Tracey 2001; Howard et al. 2001; Nie 2001; Cummings et al. 2002; Kraut et al. 1998b; Kraut et al. 1998a). However, neither academia nor practice has addressed the social consequences of intelligent agents in a context of their use on the Internet. It is very important to discuss both positive and negative effects of agents because agent technologies are a new paradigm of 'smart' software entities which are mostly realized in Web-enabled computer applications (Serenko and Cocosila 2003). As a first step towards bridging this gap in current literature, this study proposes a framework of the implications of intelligent agents on Internet use. The purpose of this framework is to lay the foundation for future research by capturing key aspects of agent-based computing which may potentially influence the way organizations and individuals utilize the Internet.

The rest of the paper is structured as follows. The next section offers a brief overview of intelligent agents and presents the rationale for their use on the Web. This is followed by a description of the suggested framework and a discussion of its various components. The last part presents conclusions and offers insights for future research.

2 What are intelligent agents?

"Automation is here to liberate us."Hoffer (1972, p. 64)

Despite the extensive efforts to create a uniform and widely accepted definition of intelligent agents, the agent research community has failed to depict clearly what intelligent agents are. A brief review of agent-related literature reveals a variety of fluctuating definitions of intelligent agents. That being said, two distinct but related approaches to the definition of intelligent agents can be identified: (1) agent as a *description*, and (2) agent as an *ascription* (Bradshaw 1997).

As a description, intelligent agents are characterized by describing the features which agents do or do not possess. As an ascription, intelligent agents are characterized in terms of what users ascribe, attribute, or assign agents to be. With respect to this paper, a description approach is followed. An intelligent agent is defined as a software entity which is continuous (long-lived), autonomous (independent), reactive (adapts its behavior under the changes in the external environment), and collaborative (collaborates with users, other agents,

or electronic processes)[1] (Detlor 2004; Serenko and Detlor 2004). Any software system that meets these criteria is considered an intelligent agent. This view is consistent with the opinion of many agent researchers (Shoham 1997; Gilbert et al. 1995; Hayes-Roth 1995). In addition, depending on their areas of applications, intelligent agents may possess extra characteristics, such as personalization, mobility, and inferential capabilities.

Intelligent agents present tremendous opportunities to address the challenges that many Internet users experience today and alleviate the problems associated with the emergence of new software applications. As such, intelligent agents facilitate the evolution of human computer interaction from the direct manipulation metaphor (Schneiderman 1983) to the more efficient practice of indirect management (Kay 1990; Maes 1997). Rather than initiating all tasks explicitly and monitoring associated system events, users can now benefit from a cooperative process with their agents to initiate communication, perform tasks, and monitor events (Bradshaw 1997; Jennings 2001; Maes 1994; Jennings and Wooldridge 1998). Businesses that employ intelligent agents may reduce their product support costs by automating customer services (Raisinghani 2000). For instance, agents may process simple correspondence and provide answers to simple inquiries. Intelligent agents may collect, analyze, and utilize user information to offer personalized online services (Maes 1999). Intelligent agents foster innovation in various fields such as user training (Norman and Jennings 2002), business intelligence (Descouza 2001), and healthcare (Mea 2001, Smith et al. 2003).

The benefits of deploying agent technologies, such as those highlighted above, represent some of the planned gains in efficiency and productivity for individuals and organizations. These gains have been envisaged and discussed by many researchers. However, in addition to these benefits, agent-based technologies also present new challenges, problems, and dilemmas that many people might encounter when intelligent agents permeate computers and telecommunications networks. Such issues have not received much attention by agent designers. Among these potential quandaries, perhaps the most salient are organizational impacts, such as e-commerce transformation, operational encumbrance and security overload, as well as cultural effects, such as trust affliction, skills erosion, privacy attrition and social detachment. The following section describes and investigates these phenomena in more detail.

[1]In terms of this paper, a description approach is believed to be followed since an agent is described in terms of the characteristics that it does or does not possess, such as long-lived (i.e., it works in the background without constant user intervention), independent (i.e., may act on a user's behalf without asking his or her permission every time), adaptive, and collaborative. At the same time, the authors agree that there is some degree of subjectivity in assigning these attributes to a software entity, and one may argue that each characteristic may be simply ascribed to an agent. Indeed, since the agent research community has not agreed on a uniform definition of an agent, there is plenty of room for the interpretation of the methods employed to define an agent. For example, some people may notice that this paper's definition is a hybrid between description and ascription since each individual characteristic of an agent may be ascribed rather than described.

3 Impacts of intelligent agents

The purpose of this section is to present the development of the study's framework, to discuss its components, and to support the viewpoints with relevant examples from the sociological rather than technical perspective.

3.1 Framework development

This paper employs a social informatics framework to describe the impacts of intelligent agent technologies within an organizational and a cultural context. The field of social informatics is appropriate for this discussion since, by its very definition, the field entails an interdisciplinary study of the design, uses, and consequences of information technologies that takes into account their interaction with organizational and cultural contexts (Kling et al. 1998; Kling 1999). During the past two decades, the body of research in social informatics has focused on socio-technical premises around the use of various technologies including the Internet, intranets, electronic forums, digital libraries, and electronic journals (Kling 1996). As such, social informatics applies to a variety of information and communication technologies (ICTs). It is hence natural to utilize relevant concepts from this reference discipline to theorize the consequences of the use of intelligent agents within the context of the Internet.

Pacey (1983) introduced a triad of technology practice that has three key dimensions, such as technical, organizational and cultural. A technical aspect represents the knowledge and activities that make things work, for example, techniques, tools, machines, and chemicals. An organizational dimension reflects the various facets of administration and public policy, for instance, economic, industrial and professional activities, users, consumers, and trade unions. A cultural aspect refers to the beliefs and habits of thinking including goals, values, ethical codes, awareness and creativity. In terms of the present paper, this general view was adapted. Figure 1 summarizes the overall ideas of the social informatics framework by hinging intelligent agents as a technical facet within organizational and cultural viewpoints. It is hypothesized that the employment of agent-based computing may potentially cause professional, market, and industrial changes. It may also alter individual and communal behaviors; these changes will take place in the context of agent usage for information and commerce-related activities. In the past, such an orientation has been used by other socio-technical researchers (Kling et al. 2000).

This social informatics approach will set the course of discussion for the rest of the paper. From a technical viewpoint, Internet-based intelligent agents can perform information-oriented or commerce-related tasks for their users. However, it should be realized that the deployment of intelligent agents for such tasks can cause organization wide changes, influence contiguous market environments, change individual user behavior, and affect social practices.

To examine the diverse effects of agent-based computing from a social informatics perspective, a framework of impacts of intelligent agents is constructed based on the extant literature. Figure 2 presents this framework. The development of a social informatics model facilitates the discussion of agent technologies along the technical, organizational, and cultural dimensions. This

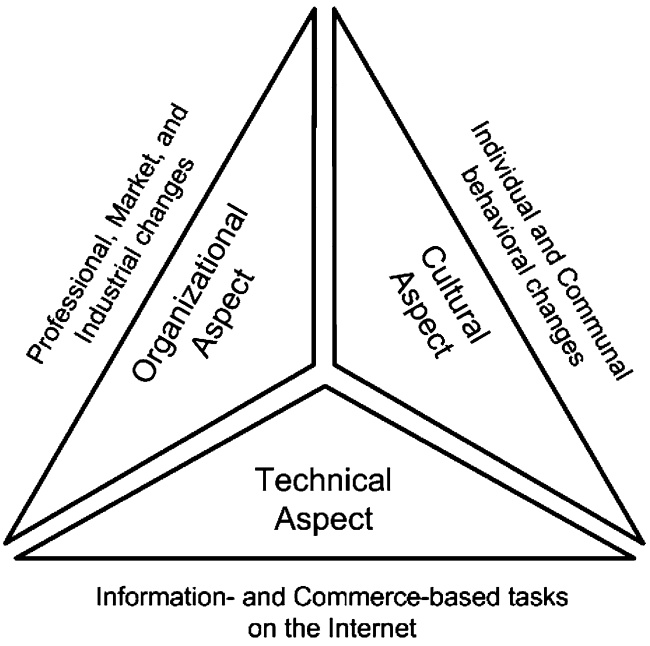

Fig. 1 Pictorial summary of a social informatics framework (Adapted from Pacey 1983)

framework is important because the key to dealing with unpredicted consequences of new technologies is to proactively anticipate them; this allows identifying problems even before they emerge (Brennan 2004).

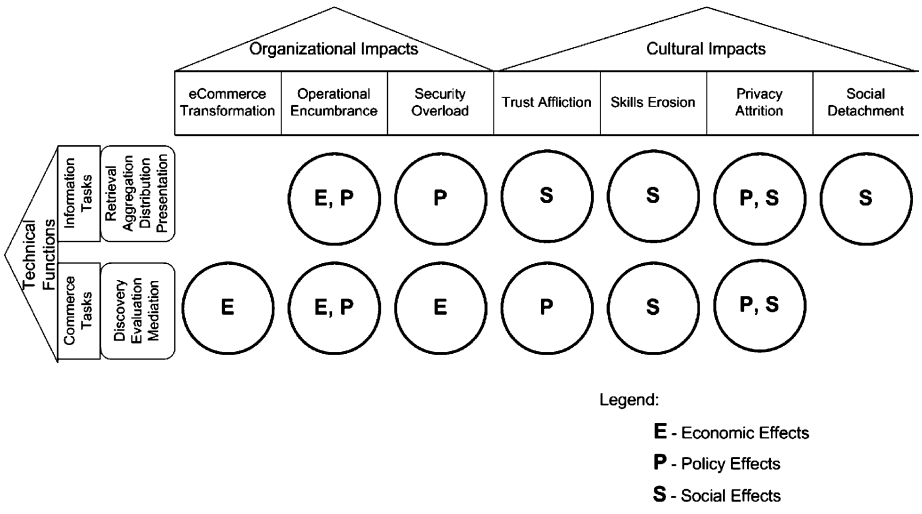

Fig. 2 Unplanned effects of intelligent agents within a social informatics framework

Along the vertical axis of this framework, the technical functionality of intelligent agents is briefly categorized under the headings of information- and commerce-oriented tasks. These captions are in line with the various applications of intelligent agents on the Internet.

The major function of *agents for information-oriented activities* is to search, collect, and process specific information on the web as well as to present it to a user in the most efficient and effective way. For example, these intelligent agents may be used in the electronic job market; their goal is to identify appropriate job candidates or vacancies by continuously analyzing resumes and job descriptions (Turban et al. 2005). Information-oriented agents may also be used as Web browsing assistants (Keeble and Macredie 2000). Their goal is to work in parallel with a user by analyzing his or her behavior and making suggestions. Intelligent agents for email monitor users' interactions with an email system and attempt to mimic people's behavior by processing incoming communications flows. Such agents have already been implemented in the form of pilot projects as well as commercialized end-user applications (Serenko 2006; Gruen et al. 1999; Griss et al. 2002; Bergman et al. 2002; Lashkari et al. 1994).

The key objective of *agents for commerce-based tasks* is twofold. The first goal is to facilitate the discovery of products and services in which users may be interested as well as to offer real-time advice on purchasing processes. Such agents may serve as electronic shopping companions that directly assist people. For example, human- or cartoon-like agents act as conversational sales assistants by communicating with individuals in natural voice and helping them make a purchasing decision (McBreen and Jack 2001). Shopping bots are price comparison agents that visit various vendors' websites with the goal to collect, analyze, process, and present information on particular products or services. For instance, Copernic Agents[2] query major search engines and online resources to locate the best deal on the Web. Intelligent agents for travel services may successfully perform watchdog activities by continuously looking for discount airfares, hotel reservations, or holiday packages (Turban et al. 2005; Camacho et al. 2001). The second purpose of agents for commerce-based activities is to facilitate intra- and inter-organizational transactions by executing continuously and autonomously complex processes. Usually, this is achieved through the implementation of multi-agent systems (Jennings 2001; Jennings and Wooldridge 1998). A multi-agent system is an environment that consists of two or more intelligent agents that constantly interact with one another. For example, an agent-based process management system may embed a number of autonomous problem solving agents that constantly negotiate their actions with other agents in order to receive required services (Jennings et al. 2000). SAP utilizes intelligent agent technologies to enhance the mySAP Supply Chain Management modules (DStar 2001). The intelligent SAP Event Management system administers real-time coordination of the supply network, offers optimized solutions, resolves conflicts, and asks for human intervention only when necessary.

Along the horizontal axis, effects of the use of intelligent agents for information- and commerce-based activities are classified under the headings of organizational or cultural impacts. At the organizational level, the employment of intelligent agent technologies necessitates various undertakings by businesses

[2]Available online at the Copernic website at http://www.copernic.com.

to support new system functionality. This requires additional investments in information systems and revisions of current business practices and procedures. Such activities epitomize economic and policy effects for the organization. Specifically, three types of organizational impacts are suggested, such as eCommerce transformation, operational encumbrance, and security overload.

Electronic commerce is the process of selling, buying, or exchanging products and services via computer networks including the Internet. Despite the recent dot com crash, online sales continue growing making electronic commerce an attractive and important business area (Turban et al. 2005). Intelligent agent technologies offer tremendous opportunities for online shoppers in terms of product location, comparison, and assessment. Their usage may have an impact on the behavior of online shoppers, on product commoditization, and even on the entire eCommerce market. Therefore, *eCommerce transformation* is selected as an organization-level impact.

The emergence of new information technologies affects labor distribution and job markets; people have to upgrade their skills to stay competitive (McIver 2004). Organizations have to develop new standards and codify them into policies to accommodate the usage of new technologies (Woodbury 2004). This also applies to agent-based computing since organizations deciding to deploy intelligent agents should invest in their human capital to train information technology personnel. This places an extra burden on the organization in terms of unplanned financial expenditures, and corresponds to an effect labeled as *operational encumbrance*.

Security is an important domain of information system planning, development, and management (Clarke and Drake 2003). There are various technical reports, bulletins, periodicals, books and refereed journals entirely devoted to this topic (Egan and Mather 2005). For example, Computers & Security is a highly respected publication in the domain of IT that for over twenty years has solely focused on offering advice on software security issues to industry, business, and academia. As such, the role of security is frequently cited as one of the most important areas of investigation not only from the technical, but also from the human-computer interaction perspective (Karat et al. 2005). Security has also become a central issue in the development and deployment of agent-based applications, and organizations employing agent technologies have to allocate sufficient financial and human resources to deal with the issue (Guan and Yang 2002; Mouratidis 2005). This identifies the third, important effect of agents that is referred to as *security overload*.

At the cultural level, the use of intelligent agents implicates altering some patterns of individual user behaviors. For example, individuals may change their everyday task execution, communal interactions with other people, and commercial contacts with businesses because they delegate to specialized agents some of the afferent tasks, such as time-planning (i.e., arranging dates with other entities) or news-filtering (i.e., sorting information of interest for the user) (Maes and Kozierok 1993). These changes may potentially affect the way users cooperate with other physical and virtual counterparts, and the respective behavioral transformations correspond to social and policy effects at the cultural level. For instance, email agents, which are able to send and receive email on behalf of their users, may be programmed to favor or obstruct the contacts with other individuals. However, despite instructions, agents are still unpredictable because

of various factors including a continuously increasing number of decisions they must make, interactions with other agents, or emergent phenomena beyond the intended initial behavior of the agents (Wagner 2000). These issues make the decision-making process more complicated and less consistent; users take chances by allowing agents to affect their social contacts in the long-run. To ensure that this technology is employed properly and help individuals, public bodies may attempt to design recommendations and guidelines for agent users. In the past, a number of scholars have already proposed the development of laws and policies devoted specifically to agents (Wettig and Zehender 2004; Bing 2004). Particularly, four impact areas are suggested: trust affliction, skills erosion, privacy attrition, and social detachment.

The assurance of trust is vital in all business relationships including software systems, telecommunication networks, and electronic commerce (Gefen et al. 2003; Grandison and Sloman 2000; Papadopoulou et al. 2001). For intelligent agents to achieve the same level of acceptance as that of non-agent technologies, trust should become an integral part of the human-agent interaction process (Hertzum et al. 2002; Jones 2002). In virtual societies, multi-agent applications and other agent-based systems, the problem of potential deception is of primary concern for both agent users and developers (Jianga et al. 2005; Castelfranchi and Tan 2001). Indeed, an individual should believe that an agent is capable of reliably performing required tasks, and that it will purse his or her real interest rather than the interest of the third party. Thus, *trust affliction* is the first potential cultural-level effect.

For almost a half of the century, there has been a strong debate in the academic community on the effect of automation on worker deskilling (Braverman 1974; Hoos 1960). Particularly, information and computer technologies are often credited as being the reason for a fast pace of skills obsolescence (Hirschheim 1986; Tansey 2003). As new generation programming languages and software systems appear, workers frequently notice that computers may complete tasks that were previously done by people more effectively and efficiently. Since the purpose of agent-based computing is to fully automate simple and repetitive tasks, agent users may realize that they tend to solely rely on technology losing previous skills. Therefore, *skills erosion* is identified as a potential cultural-level impact.

As information technologies evolve, new threats to people's privacy emerge, and individuals develop new protecting and coping mechanisms (Spinello et al. 2004; Cook and Cook 2004; Metzger 2004). For example, privacy concerns affect someone's willingness to release his or her personal information to an online marketer and to make other transactions over the Internet (Luo 2002; Malhotra et al. 2004). This also holds true with respect to intelligent agents because they tend to obtain a great deal of private information about their users (Nabeth and Roda 2002; Brazier et al. 2004); this suggest *privacy attrition* as the third impact.

Electronic channels such as email, blogs, chats, and instant messaging have become one of the major communications media of the twenty-first century. Such channels are often used by individuals because of their convenience rather than their suitability for a particular situation. For example, many researchers (Webster and Trevino 1995; Trevino et al. 1990; Schmitz and Fulk 1991; Lucas 1998) regard email as a moderately low richness media which is unsuitable for

conveying highly equivocal information. As indicated by the actual email usage studies, individuals still utilize email to transmit both equivocal and unequivocal information (Rice and Shook 1990) since email is always available. By exchanging personal or equivocal information through a lean channel, some people may feel themselves isolated from their counterparts. By allowing intelligent agents to handle the flows of electronic communication and, therefore, to facilitate the process of social interaction (Roda et al. 2001), users create another barrier between themselves and other participants of the virtual network. Thus, some users may tend to develop *social detachment* from other people.

As mentioned previously, these impacts are not generally captured as part of anticipated efficiency and productivity gains associated with the use of agent technologies. Instead, they change the patterns of business processes, social relations, interactions, values, and cultural norms (Sproull and Kiesler 1991). The following subsections discuss these issues in more detail.

3.2 Organizational impacts

3.2.1 E-commerce transformation

The first organizational impact of intelligent agent technologies is their potential to alter user behavior, commoditize many products and services available on the Internet, and transform the dynamics of e-commerce. As witnessed by a current trend of agent-based Web applications development, electronic commerce may gradually go through a major alteration phase because people will start discovering, evaluating, and purchasing online products differently. More importantly, e-shoppers may alter their online purchasing behaviors and change perceptions of electronic markets.

Shopping bots (or shopbots)[3] are an important agent innovation for electronic commerce (Rowley 2000). Bots visit a variety of online vendors, investigate and analyze products details, and present this information to users in the most efficient and effective way. Shopbots are often labeled as 'price comparison shopping agents' (Kephart et al. 2000) because of their ability to compare item price and delivery options of hundreds of online vendors in less than a minute. For example, consider someone who wishes to purchase online the book "Mail and Internet Surveys" by Don Dillman (1999). One option would be to manually visit several Internet book stores, such as amazon.com or barnesandnoble.com (Barnes and Noble), locate the book, and compare prices. This process requires a great deal of time and effort. More importantly, a person will never be sure that the best option in terms of price has been located. Another alternative, however, would be to visit a website that offers a shopping bot, for example, AddALL[4]. Within a few seconds, the shopbot presents a list of forty-four online stores that have this item available and offers relevant information about the product[5]. Thus, the shopbot located one of the lowest item prices on the Web and saved the individual's time and search efforts.

[3]For a list of shopping bots, visit the BotSpot website at http://www.botspot.com.
[4]Available at http://www.addall.com.
[5]In this experiment performed by the authors, the item price provided by the shopping bot ranged from US $104 (max) to $62 (min), with the average price of $79, and standard deviation of $12.6.

The usage of price comparison agents has three major implications for electronic commerce. First, price comparison applications will alter the behavior of online shoppers. People will expect to effortlessly locate online products and to obtain all pertinent decision-making information. Moreover, recent developments in the field of agent-mediated e-commerce demonstrate that agents may also perform the actual purchasing transactions of online products or services (Ripper et al. 2000). As such, an agent will not only discover a product and negotiate all details, but also conduct a purchasing transaction.

Second, the degree of commoditization of online offerings will be affected. The adversaries of e-commerce agents often argue that the workings of most shopping bots are based on the comparison of only a few product criteria, such as price, delivery cost, and shipping time. This limited subset of decision factors will make people perceive many products and services as commodities. A commodity is any concrete thing which is perceived to be identical to other things in the same category of products and whose price is determined by bids and offers on a competitive market. In order to make offerings compliant with the way shopping agents present information to potential customers, online businesses will have to standardize their products and services to an extent where pricing and delivery options will be the only differentiators among the competitors. This may in turn lead to an overall decline in prices and hence lower profit margins for the industry.

Third, the entire electronic commerce industry will be transformed (Nwana et al. 1998). On the one hand, intelligent agents will create new electronic markets and increase online sales by matching consumer needs with merchant offerings. On the other, wide employment of this technology may transform the total online shopping industry into a perfect competition market. The Internet is one of the rare examples of existing competitive markets characterized by low entrance barriers (Porter 1979), large numbers of buyers and sellers, unfettered resource mobility, and relatively perfect (compared to that of bricks-and-mortar) shopping information. The Internet increases price transparency and creates large, often international, markets for goods and services (Welfens 2002). As the Internet grows and the potential benefits obtained from the Web magnify, the economic value of online information also increases (Lee et al. 2003) making it one of the most valuable intangible assets. This is where intelligent agents may realize their potential by offering product information location services (Kephart et al. 2000) that may not only save customer information search costs but also transform the entire online shopping industry into a single, large perfect competition market in which no individual buyer or seller influences the price by his or her purchases or sales (Miller 1982). Overall, organizations will have to deal with new challenges to accommodate changing customer behavior, product commoditization, and increased competition.

At the same time, it is acknowledged that the future impacts of shopping bots on the development of eCommerce have not been fully understood. In addition to the economic issues discussed above, several technical and consumer perception problems need to be addressed. First, some individuals may not employ shopping bots because they assume that this technology represents a very biased view of online offerings. The business models employed by shopping bots assume that subscription fees are paid by vendors who sell their products rather than by buyers (Menczer et al. 2002). Therefore, a shopping agent usually visits

and considers limited number of vendor sites (i.e., the subscribing online stores, although some agents also present information for additional non-subscribing stores); this narrows the general validity of the offers being presented as 'the best.' Second, some shopping bots try to differentiate from competition and answer customers' demands by offering additional information, such as delivery terms, warranty and product description (Vijayasarathy and Jones 2001). In this case, customers have to carefully review each offering and compare it with others based on certain criteria that is very inefficient and defeats the initial purpose of this technology. Third, despite the shopbots' speed of information retrieval, one cannot be assured that the best option was found, and the number of deals presented by bots may be overwhelming for some people. This may have an effect on a user's decision whether to employ this technology. Overall, more research is needed to understand the influence of shopping agents on online businesses.

3.2.2 Operational encumbrance

One of the major benefits that has long been proposed by the intelligent agents research community is the ability of agent-based systems to reduce workload associated with performing routine and repetitive tasks (Maes 1994). Agents that facilitate information-based activities may help enhance core internal processes through adroit information retrieval across a variety of data sources. Similarly, agents that facilitate commerce-based tasks may help realize market efficiencies through seamless information exchanges and financial transactions between interconnected buyers and sellers. However, before organizations start reaping the planned productivity- and efficiency-related benefits of intelligent agent systems, various operational challenges need to be addressed.

First, organizations need to realize that intelligent agent systems will essentially extend the 24/7/365 epitome by offering online services for users in the background. An organization may have conceded to a similar phenomenon in the past by offering information, products, or services on the Internet. Due to the use of intelligent agents, the operational outfit can be expanded further by implementing advanced back-end functionality interconnecting an organization's intelligent agent systems with other collaborating agents or multi-agent systems. As pointed out by several researchers, agent implementation can be a challenging task involving complex issues, such as agent communication, cooperation, representation, and manipulation of knowledge (Ram 2001; Nwana and Ndumu 1999; Davis et al. 1995).

Secondly, whereas intelligent agents may potentially alleviate an organization's workload by automating certain types of activities, the maintenance and efficient operation of innovative agent systems will necessitate new organizational task roles to be established and filled. Basic and simple tasks, previously delegated to frontline employees, may be performed by agents (Detlor and Arsenault 2002). In the back-office, support staff that is familiar with the incumbent technologies will need to continuously control the operation of agent applications by ensuring corporate compliance with new information standards while maintaining conformity of their systems with new industry standards that allow the organization to participate in the external environment through multi-agent systems.

Issues related to agent implementation need to be addressed early on in the process since they are critical to business continuity. The implementation of new technologies is intrinsically disruptive to an organization's regular operations, but vigilant planning can reduce the disruption to a minimum. In the case of intelligent agent systems, the investment in new technology and information standards evokes an economic effect for organizations. Also, new agent systems will bring new job roles for frontline and back-office workers. The establishment of these roles implicates a policy level impact.

3.2.3 Security overload

The implementation of security mechanisms presents both economic and policy implications for organizations using intelligent agent systems. In a business-to-business scenario, it is common for numerous organizations to be linked through various types of intelligent agents. This results in the formation of multi-agent systems entailing various types of interface agents, information agents, task agents, and middle agents. Whereas interface agents directly interact with their owners by receiving service requests and presenting results, it is the information, task, and middle agents that function in the background to fulfill service requests. To perform different transactions, these agents need to exchange information among one another. Often, the information that needs to be shared includes confidential financial and customer records. As such, information should only be exchanged among these agents if there is pre-established trust between the sender and the recipient.

Numerous studies address the importance of trust in business-to-business multi-agent systems (Robels 2001; Nwana et al. 1998; Jaiswal et al. 2003). Researchers maintain that trust is a central issue in agent-mediated e-business environments (Wong and Sycara 1999). Since intelligent agents are able to perform important tasks with a significant level of autonomy and without explicit user intervention, new models to handle distributed trust are required (Abdul-Rahman and Hailes 1998). This increases the level of the decentralization of traditional Internet services.

Previous agent security projects demonstrate the various technical possibilities for the implementation of security mechanisms to ensure smooth functioning of multi-agent systems in a business-to-business environment. However, due to the autonomous nature of intelligent agents and the exceptionally decentralized structure of multi-agent systems, the conventional security models for online services fall short. Multi-agent systems that connect organizations across industries and along supply chains necessitate the use of technologies enabling enhanced authentication mechanisms, improved authorization, access control procedures, and non-repudiation processes (Jaiswal et al. 2003; Abdul-Rahman and Hailes 1998). This shows the need for new security measures. The implementation of new agent applications results in a considerable undertaking for information systems professionals and requires additional financial resources from participating organizations. This exemplifies an organizational level economic impact of agents.

In addition to the economic implications associated with security overloads, the adoption of intelligent agents requires that organizations alter their existing policies. Businesses need to go through the extensive process of establishing trust

with one another before they can allow the automation of secure transactions through intelligent agents. Furthermore, to establish an adequate level of trust, organizations may need to conduct automated agents-based transactions through a third party (Nwana et al. 1998). Consequentially, such an endeavor will require revamping old business rules and setting up new guidelines for online information exchanges and commercial transactions transpiring through the deployment of various types of intelligent agents. Substantial efforts required in formulating new strategies and tactics for business-to-business collaboration signify a policy impact of agent-based computing. In some cases, existing policies and procedures that have proved to be successful in the past may be extended to agent-based technologies.

3.3 Cultural impacts

3.3.1 Trust affliction

Trust is a subject of interest in diverse fields such as social psychology, relationship theory, and human-machine interaction (Kini and Choobineh 1998; Rempel and Holmes 1986; Rempel et al. 1985; Muir 1987; Barber 1983). Trust that users instill in their everyday computing applications determines not only their attitude towards the technology but also their decisions related to other similar technologies. In general, trust in technology is a significant factor in determining the adoption of a system (Muir 1996). Researchers and practitioners of intelligent agents agree that trust is one of the key issues involved in the success of intelligent agents (Maes 1994). Several studies have shown that trust and competence are often conflicting factors in intelligent agent design (Schneiderman 1983; Murray et al. 1997).

As a result of popular interest in the concept of trust and its applicability in sociological and psychological contexts, there exists a plethora of different definitions. This paper adopts a definition of trust related to the use of computing applications proposed by Kini and Choobineh (1998) in their discourse on e-commerce applications. They argue that a user's trust in a system involves a belief influenced by the individual's opinion about certain critical system features. Regarding intelligent agents, one of the critical system features may be an agent's ability to autonomously perform required tasks.

Trust guarantees that users feel comfortable delegating tasks to an agent (Maes 1994). The more prevalent models of intelligent agent systems, such as semi-autonomous agents or knowledge-based agents, further highlight this problem. Whereas semi-autonomous agents help enhance an individual's trust in technology by involving users in elaborating task specifications, they can also be seen by the user as lacking sufficient competence to perform tasks on their own. In contrast, knowledge-based agents boast competence by virtue of the system's extensive built-in information base allowing agents to perform tasks without user intervention, but the user may not entirely trust the system because individuals feel a loss of control and understanding of an agent that was programmed by someone else. The employment of learning agents may potentially address this issue (Tang et al. 2002). Learning agents perform new activities based on previous patterns of user behavior and by soliciting feedback on their performance. In either case, the success of intelligent agents in accomplishing

tasks on users' behalf will enhance people's confidence in technology and ensure trust in agents to perform similar tasks in the future.

In addition to user trust in agent competence, the integrity of agents is another issue. An agent may pursue the interests of a third party, for example, a manufacturer, rather than the interests of a task delegator. There is evidence to suggest that the reliability and accuracy of results presented by agents may be seriously compromised in various electronic commerce activities. For example, it is often unclear whether intelligent agents, such as shopping bots, truly present a comprehensive list of best options or only deals from vendors paying subscription fees to be included in the service (Detlor 2003).

Whether users choose to trust agents with everyday Internet tasks, such as information seeking and online shopping, depends on people's knowledge and familiarity with those activities. At the same time, adequate control mechanisms should be in place to protect novice users and develop their trust in this technology. On a social level, the issue of trust in agent-based systems alludes to greater or lesser use of technology based on positive and negative experiences of users. Individuals are more likely to adopt new intelligent agent systems if they trust other similar agent-based technologies. In terms of policies, the agent community needs to work towards the standardization and regulation of online information sources and virtual storefronts to protect consumers from false information and fraudulent commercial activities.

3.3.2 Skills erosion

One of the main reasons for the implementation of intelligent agents in Web applications is to make the human-computer interaction process easier, more efficient, and enjoyable. For instance, intelligent agents implemented in a Web portal assist people in information seeking and retrieval by presenting high-quality information rapidly and effortlessly. If agent services are beneficial to people, it is expected that users will increasingly start delegating various activities to agents as agents become more 'intelligent' in future.

However, this idyllic picture may be a façade for a reality that people may not like. As computer applications possess more intelligence, it is often feared that humans may become more ignorant as they stop relying on their own intellectual abilities (Yazdani and Narayanan 1984). The delegation of Web-related tasks to intelligent agents may make people passive spectators rather than active participants in activities that are now managed by their agents. For example, individuals may become mere receivers of information presented by intelligent agents based on the inferences agents make about user needs. As a consequence, people risk missing potentially valuable pieces of information that might otherwise have been acquired by exercising a do-it-yourself approach to investigating adjacent and alternate paths in their search for information (Lieberman 1995). A human mind is always more inventive than a machine no matter how 'intelligent' the latter may be. When people have an active role while searching information on the Internet, innovative ideas usually emerge during the process. For instance, new branches of information are explored which may lead to interesting findings, even superior to those expected initially, before starting the search task. Given the recent development trends in agent technologies, it is predicted that agents may potentially do an

accurate and fast job but a previously wandering human mind will no longer be involved in the process. Consequently, in the long term, some people may lose the opportunity to efficiently acquire new information if agents become too excessively exploited on the Web.

A less apparent consequence of the wide usage of agents is the erosion of people's skills. When users start delegating as many Web activities to agents as possible, their own Internet competence will deteriorate over time. It is still unknown whether skill and knowledge erosion would happen to individuals already possessing certain expertise since, according to the cognitive and biological views (Winograd and Flores 1986), once acquired knowledge cannot erode. More likely, individuals who eventually become consumers of 'ready to be digested' information offered by intelligent agents will look at the Internet from their agent's point of view thus missing the opportunity to build new skills. The situation may be more obvious for younger generations for which computers and the Internet already hindered the building of 'classical' knowledge. For instance, the use of the Internet tends to replace Swedish by English as the second language spoken by young Finnish people (Kivinen 2000), and in China, computer use made some younger people forget the traditional handwriting (Lee 2001).

Overall, the employment of intelligent agents on the Internet is expected to have unplanned effects on people's skills. Although these software entities were created to help users perform various repetitive tasks, delegating too many activities to agents may result in negative consequences affecting the user's Web performance and skills.

3.3.3 Privacy attrition

Privacy is the claim of individuals to determine for themselves when, how, and to what extent information about them may be communicated to other people (Westin 1967). Privacy issues are extremely important for the proper functioning of electronic commerce because individuals are becoming increasingly concerned over the use of their personal information obtained by online businesses. The use of intelligent agents for both information- and commerce-related activities may dramatically increase privacy anxieties of Internet users, seriously impede the usage of existing Web technologies, and even hamper the growth of the Internet in the future (Borking et al. 1999).

The workings of intelligent agents are often based on obtaining detailed personal users' information (Schiaffinoa and Amandi 2004). There are two basic ways intelligent agents obtain personal information about their users (Maes 1999; Maes et al. 1999). First, individuals may voluntarily express their private information when they first start using agents. For example, a personal e-shopping agent may ask users to fill out a questionnaire where they explicitly indicate their habits, interests, needs, requirements, idiosyncrasies, and preferences. Second, certain intelligent agents may work in the background by constantly monitoring all users' activities such as surfing pattern, purchasing behavior, and search engine results. Once the agent has accumulated a great deal of a user's personal information, it tries to interpret it to identify high-level user goals and starts making suggestions or acting on behalf of the person.

For example, Aria[6] is an agent which assists users to annotate and retrieve digital images (Lieberman et al. 2001). The agent runs continuously and autonomously in the background and observes certain kinds of user behavior. When an individual starts working with a system, Aria builds a database of image annotations by looking at the user's image manipulation behavior. After that, it monitors all text a person types while interacting with an email application. The agent analyzes this text, creates keywords, and attempts to present images relevant to the message content. On the one hand, user testing demonstrates the value of Aria as a means of automating complex and repetitive information retrieving, aggregating, and sharing tasks. On the other, individuals may be concerned about their privacy if they realize that a software entity is monitoring their activities and is creating their user profiles.

Another serious issue is the genuineness, authenticity, or credibility of personal user profiles created by an agent. These profiles are automatically generated by agents based on user interaction with a system, online resources, or other people. They contain private information about a particular individual and form part of his or her digital identity (Roda et al. 2003). However, these profiles will not necessarily reflect the true identity of a person. Some individuals intentionally tend to develop an online identify that is fundamentally different from their real one (Barnes 2003). For example, a 55-years-old male named John living in Timbuktu may pretend to be a 13-years-old girl named Wanda from Miami Florida in discussion forums or chats. In this case, the private John's profile developed by his agent will be that of Wanda. This will magnify the problem since now the agent will help John pretend to be Wanda in future by offering advice, filtering information, or communicating with other agents and people in a way it is done by a 13-year-old-girl. It is also possible to deliberately mislead an agent by providing inaccurate instructions or manually building a fake initial profile.

Despite the various advantages of personalized intelligent agents, the improper use of people's personal information may seriously undermine trust in intelligent agents, the Web, and online shopping activities resulting in major economic impacts of agent-based computing (Serenko 2003). Currently, many agent researchers are becoming aware that privacy issues may impede the expansion of agent-based Web technologies (Wagner and Lesser 2001; Sycara et al. 1997; Borking et al. 1999). Therefore, it is suggested that privacy aspects of intelligent agents should be addressed at the early stages of agent development. Businesses employing agents should re-evaluate and adjust their privacy policies accordingly. Otherwise, the careless use of agent personalization abilities may have negative consequences in the future.

3.3.4 Social detachment

The contemporary work environment in large organizations is becoming increasingly associated with the idea of knowledge portals deployed over corporate intranets. At the outset, portals are shared information workspaces situated at the intersection of three domains: content, communication, and coordination (Detlor 2000). They not only guide users through information

[6]Aria stands for Annotation and Retrieval Integration Agent.

paths but also provide tools for exchanging information and work routines. This exquisite collaboration technique helps build virtual networking organizations allowing individuals to work remotely and to communicate with one another electronically. Not only does this generate supplementary cost savings, but also makes work more convenient and enjoyable.

With the rapid advancement of technologies, the growing need for current and up-to-date information, and the scarcity of time at the individual level to handle multiple tasks, it would be difficult to imagine this new type of work collaboration through knowledge portals without the active involvement of adaptive smart helpers such as intelligent agents (Detlor et al. 2003). This new breed of software is already being used in the creation of schedule management agents that can intelligently read all incoming messages, identify meeting requests, verify owner's availability, book a time slot in a person's calendar, and send a meeting confirmation notice. Consequently, these intelligent agents may increase work efficiency and save people's valuable time, efforts, and money. However, in the long-term, unanticipated social implications may develop. The work pattern that mankind has been accustomed to for millennia involved a common space that facilitated direct social interactions with their peers.

The emulation of work in a group of people guided by a team leader and outlined by strong social relationships has proved to be one of the factors of progress. These interactions proved to help people better fulfill their job tasks by asking and offering advice, opinions, and feedback. The new work context populated by agent-facilitated knowledge portals would make people substitute their direct social relationships by links mediated through machines and software. People may become more isolated and individualistic, and this may alter their current social behavior. The effect could be even more dramatic in cultures with a predominant collectivist work culture and social behavior. Consequently, massive and indiscriminate use of software agents to assist work collaboration through the Internet and portals may have serious implications. The work process may seem more enjoyable, and the general outcome for an organization may appear positive, while a more insightful long-term analysis may reveal significant drawbacks. People may exhibit progressive social isolation and detachment with respect to their immediate work organization; everybody, including individuals, organizations, and the society may be affected by this issue.

Overall, it is believed that the use of knowledge portals empowered by intelligent agent technologies may help increase work efficiency and job satisfaction due to workplace location and schedule flexibilities. However, altering the social-type work pattern, which existed from times immemorial, may lead to unpredictable social behaviors.

4 Conclusions and directions for future research

The outcomes of the introduction of new information and communication technologies on both organizations and individuals are especially difficult to predict in early stages of new technology developments. Agent-based computing is a recent innovation which already has presence on the software market. Currently, one cannot say whether intelligent agents will ever be capable of

delivering services that were predicted by agent visionaries a decade ago. Nevertheless, the authors believe that it is imperative to be aware of the unplanned impacts of this technology in order to avoid negative consequences and to deliver constructive and valuable agent products in the future.

As a subject area, unplanned effects of intelligent agents have received little attention from the research community in the past. There are various approaches to study unplanned effects of ICTs. This study has adopted a social informatics framework to facilitate a discussion of unplanned effects of intelligent agents along the organizational and cultural dimensions. To apply the existing body of social informatics literature to this new technology, this paper has followed a critical orientation approach. The critical orientation was chosen because it allows an expeditious depiction of specific ideas representing a multifaceted viewpoint of the use of intelligent agents for various Internet activities. The approach is well-suited for the investigation of untapped, novel fields, and it encourages information professionals and academics to examine ICTs from multiple perspectives (Agre and Schuler 1997). It is believed that the application of this orientation has met the objective of the paper.

In addition to the critical approach, there are also normative and analytical orientations in social informatics (Kling et al. 2000). These approaches represent next steps to investigate unplanned effects of new technologies, including intelligent agents. The normative methodology will require empirical evidence to illustrate the outcomes of the use of intelligent agents in a range of organizational and social contexts. Results of such research can help create guidelines and solutions targeted towards professionals who design, develop, implement, and use intelligent agents. After these recommendations have been developed, the analytical approach in social informatics may be utilized to develop conceptual models and theories to help generalize an understanding of the application of intelligent agents in particular usage contexts. The suggested framework may also be improved by including other potential impacts of intelligent agents, for example, their effects on the user perceptions of other information technologies, communicational patterns among organizations, the flow and formation of organizational knowledge, and individual learning habits. Future researchers may test the framework by using various inquiry methods, for example, case studies. Another potential examination area may pertain to the role of the individual differences of agent users. For example, depending on personality types, some individuals may experience the cultural-level effects of agents to a greater or lesser extent. The authors also caution on the generalizability of the discussion above. Similar to vigorous debates among scholars on the universality of the social implications of the Internet (Ferrigno-Stack et al. 2003; Nie and Erbring 2002), it is argued that the extent of the unplanned effects of intelligent agents may depend on various cultural and social norms or levels of economic development of a country. For example, in some developing states, the World Wide Web is meaningless, and so are agent-based technologies. However, as the Internet and other computer technologies penetrate these parts of the world, researchers, practitioners and government policymakers need to be aware of the unpredicted impacts of new systems.

Overall, this paper attempts to identify and describe organizational and cultural impacts of intelligent agents in the context of their use on the Internet. It is hoped that future agent researchers and practitioners will be exhorted to explore

and utilize the ideas expressed in this discussion to improve our understanding of this previously untapped phenomenon.

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