Impacts and Limitations of Intelligent Agents in Electronic Commerce

Dong Su Jin[1] and Kyoung Jun Lee[2]

[1] School of Business, Korea University
Anam-Dong, Sungbuk-Ku, Seoul 136-701, Korea
jinds@kuba.korea.ac.kr
[2] School of Business, Korea University
Anam-Dong, Sungbuk-Ku, Seoul 136-701, Korea
leekj@kuba.korea.ac.kr

Abstract. Agent-based economy or agent-based electronic commerce is the term for describing one of possible next steps of electronic commerce. The systematic understanding of the agent-based economy is important for researchers to develop practical intelligent agent systems, and for current electronic commerce industries to cope with the challenges of the intelligent agents. With these purposes, we conduct a comprehensive review of ongoing and future impacts of intelligent agents to electronic commerce from business model perspective. We classify intelligent agents by their functions and roles in electronic commerce and analyze the business model change by intelligent agents, based on Timmers's definition of business model. Changes in architecture of flows, responses of players, influences to revenue model and participant's benefits, and funding source are discussed with real world business examples and related researches. We also discuss the limitations of intelligent agents in electronic commerce.[1]

1 Introduction

One of terms representing changes of economy owing to the diffusion of Internet is *Reverse Market Economy* [16]. The term emphasizes the transformation of the existing economic structure into customer-driven economic structure as customers gain more bargaining power and information by connecting themselves with the Internet. However, although the number of participants that can be reached and the scope of product and raw materials they can deal with increase in the reverse market economy, its transaction process is still complicated. The actors using Internet now suffer from information overload rather than lack of information. They must analyze a lot of information, negotiate over multiple contracts, and execute a lot of complex transactions on Internet. Therefore, it has been asserted that it is necessary to develop marketplaces that control the increase of information overload [24].

[1] This work was supported by Korea Research Foundation Grant (KRF-99-041-C00328).

W. Kim et al. (Eds.): Human.Society@Internet 2001, LNCS 2105, pp. 33-48, 2001.

One of methods for solving the information overload problem is thought to be an intelligent agent. Many companies have been developing intelligent agents that can help Internet users reduce their information overload. Comparison-shopping agents and negotiation supporting agents are the representative examples. Kephart & Greenwald claim that within the next decade, the Internet could be populated with billions of agents exchanging information goods and services with one another and with people [21].

As such, advances in electronic commerce and agent technology are pushing the world rapidly toward ever-increasing e-business automation, where software agents act as autonomous (or semi-autonomous) businesses in their own right, buying and selling information goods and services online [17]. The situation may be called as ‘agent-based economy’ where the principal users of Internet are intelligent agents rather than human beings.

The difference of the 'agent-based economy' from the 'reverse market economy' depends on who are the principal users of Internet resources. When the human beings are the principal users, we may call this economy 'reverse market economy'. If the main users of Internet resources become agents, then we can say that we live in an agent based economy in Fig. 1.

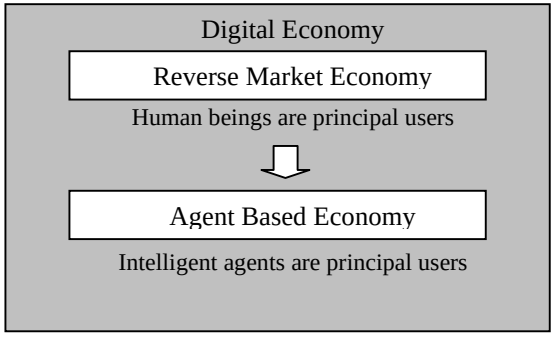

Fig. 1. Digital economy evolution from agent perspective

The systematic understanding of the agent-based economy is important for researchers to develop practical intelligent agent systems, and for current electronic commerce industries to cope with the challenges of the intelligent agents. With these purposes, we conduct a comprehensive review of ongoing and future impacts of intelligent agents to electronic commerce from business model perspective. The remainder of this paper is structured as follows. Section 2 we classify intelligent agents in electronic commerce by their roles and functions. Section 3 explains the changes of business model components and responses of electronic commerce entities confronting intelligent agents. Section 4 discusses the limitation of intelligent agents from business, social and technical perspective. Section 5 concludes with research and business implications.

2 Classification of Intelligent Agents in Electronic Commerce

An intelligent agent is a program that operates autonomously to retrieve and process information on a user's behalf. T•rissen defines an intelligent agent as a piece of software with an element of artificial intelligence, which can be used to support people in the use of computer applications [36]. Nwana defines agent as a component of software and/or hardware, which is capable of acting exactingly in order to accomplish tasks on behalf of its user [29].

Many studies have been made [13, 18] on what the characteristics of an intelligent agent should be to meet its goals. The most common qualities of them are independence, learning, autonomy, cooperation, responsiveness, pro-activity, sociality, and adoption. These qualities make intelligent agents differ from traditional software and well suited to the electronic commerce, which is inherently information intensive domain. Main functions of agents include search, compare, learn, negotiate, and collaboration [19]. Agents may also be classified as collaborative agents, interface agents, mobile agents, information agents, reactive agents, hybrid agents and smart agents [28].

The above researches have focused on classifying intelligent agents on the basis of intelligent agent's attributes. In this section, we classify intelligent agents in electronic commerce context. Table 1 summarizes the typical functions of intelligent agents in electronic commerce and the corresponding business examples or research projects.

Table 1. Main functions and examples of intelligent agent in electronic commerce

	Main functions or roles
1	**Search** information on products and merchants Mysimon.com, Auctionwatch.com, Shopbinder.co.kr
2	**Filter** unimportant commercial messages Adsubtract.com
3	**Gather and Analyze** information on customers and merchants Ffly.com
4	**Match** qualified commerce party Kasbah, Fastparts.com
5	**Notify & Push** event Digitalimpact.com
6	**Monitor & Report** creation, change, and deletion of information Netmind.com, Books.com
7	**Support communication** between business and customers Artificiallife.com, Vperson.com
8	**Personalize & recommend** interface, contents, product, & services. Personalogic.com, Technoagent.co.kr, My.yahoo.com
9	**Make or Support a decision** on bidding, pricing, and negotiation AuctionBot, eMediator
10	**Network** among consumers, merchants, and manufacturers Napster.com, OPEN4U.co.kr

The major market players of electronic commerce are buyers, sellers, and intermediaries. Each market player can employ intelligent agent for its functional

steps. Maes et al [25] presented agent applications based on CBB (Consumer Buying Behavior) model. Bailey& Bakos [3] suggested four roles of intermediary, which are aggregation, trust, matching, and facilitation. Nissen [27] proposed the relationship between buyers with sellers through so called Commerce Model. Fig.2 integrates the three models and the examples of intelligent agents mapped into the functional steps of the buyers, sellers and intermediaries.

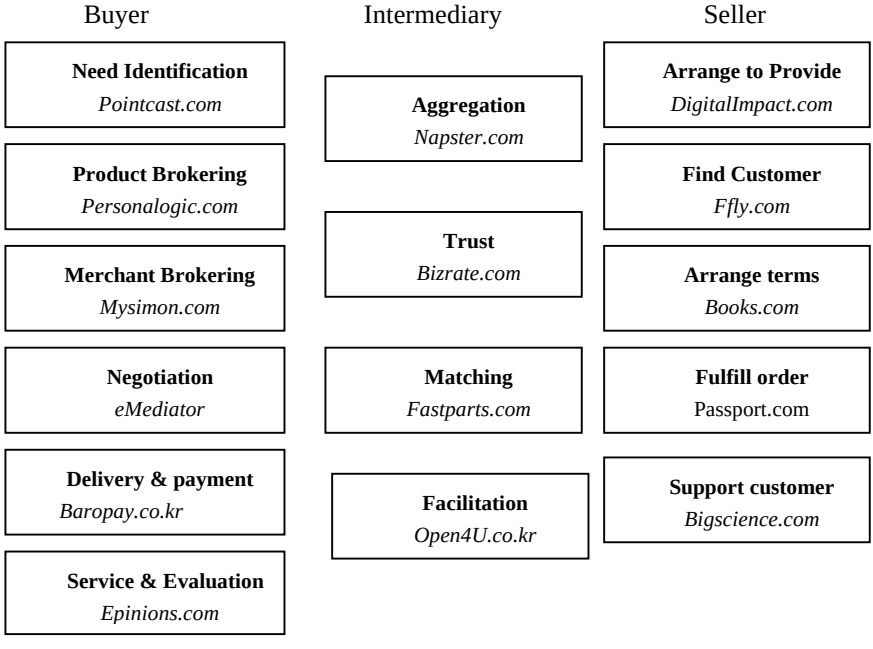

Fig. 2. Functional steps and their agent examples of market players.

3 Business Model Approach to Impacts of Intelligent Agent

Although technical researches on intelligent agents are abundant, yet there have not been many commercially successful cases of intelligent agents. One of reasons why the level of commercialization is low may be explained by the lack of understanding business aspects of intelligent agents. Related to this, there have been some researches on intelligent agents in the business point of view.

Maes et al [25] surveyed how agents are helping buyers and sellers combat information overload and reviewed the technologies involved in buying and selling agents and discussed several agent-mediated electronic commerce systems in the context of a general model of the consumer buying behavior model.

Jonkheer & Jansen [19] explore the boundaries of what might happen in markets when intelligent agents are introduced and used by market participants. They discuss

existing commercial agent-like applications and models on how different functions of agents could affect different stages. Two types of markets - travel and bookselling - were examined, focusing on consumers' interests and the functionality of destination sites.

OECD [31] reports that the increasing presence of intelligent agents raises a number of user issues and policy considerations. As for electronic financial transactions, consumers must trust them if they are to grant them some autonomy and decision-making power. Issues of trust, privacy and consumer protection need to be addressed and there must be an appropriate legal and commercial environment for tackling the challenges that these non-human economic actors present on the Web.

Varian [37] point out that sellers discriminate price between the searchers and the non-searchers. He also explains that one of reasons why customers do not use intelligent agent is the loyalty program. If the customer stays with one merchant, he can receive benefits that cannot be offered by the low-price merchant. He also explains that agents are not always beneficial to consumer's benefits because they not only allow consumers easy access to other firms' prices, but they also allow the firms themselves to monitor each others price movements.

Crowston & Macinnes [10] present a simple framework for the decision of a vendor to block or accept a buyer's agent and provide empirical evidence to support the framework. Empirically, they found that agents seem to be accepted for differentiated goods, but resisted for more commoditized goods. An analysis of prices from one agent shows that a small number of sellers tended to have the lowest prices and while divergence in pricing remains, price dispersion declined over the period studied.

Kephart et al. [22] deal with Shopbot for buyer and Pricebot for seller. They present a theoretical analysis of a simple economic model, which is intended to capture some of essence of shopbots, and attempt to shed light on their potential impact on markets. They performed experimental simulations of an economy of agents, designed to model the dynamic interaction of electronic buyers, sellers, and shopbots.

Brynjolfsson & Smith [7] empirically analyzes consumer behavior at Internet shopbots sites that allow consumers to make one-click price comparisons for product offerings from multiple retailers. They found while shopbots substantially weaken the market positions of branded retailers, brand name and retailer loyalty still strongly influence consumer behavior at Internet shopbots.

Hanson [17] suggests some of the foreseeable developments and challenges in the growth of agent-based electronic commerce. He deals with emergence of a new type of agent-human hybrid firms, new business models and services tailored to agents, and a new forms of collective behavior that are agent-agent interactions.

Similar to the above researches, our paper also deals with intelligent agent from business perspective. Especially, we adopt a concept of business model to analyze the relationship between intelligent agents and electronic commerce. Using the Timmers's definition of business model, we will comprehensively discuss the impacts of intelligent agent to the business model components of electronic commerce business.

3.1 Impacts on Business Model Components by Intelligent Agent

In the seminal paper, Business Models for Electronic Market, Timmers [35] defines the business model as follows:

1) An architecture for the product, service and information flows,
2) A description of the various business actors and their roles,
3) A description of the potential benefits for the various business actors, and
4) A description of the sources of revenues

If we add a funding component to his definition, then the impacts on the business model component by intelligent agents can be summarized as in Table 2.

Table 2. Impacts on business model components by Intelligent Agent.

	Impacts of intelligent agent on business model component
Architecture of flow	Architectural change of the product, service and Information flows owing to agent
Actors and their roles	Changed role or response of the various business actors owing to agent
Source of Revenue	Threat to or creation of revenue sources owing to agent.
Potential Benefit	Change in potential benefits for the various business actors owing to agent.
Source of Funding	Funding source among main actors for developing, introducing, and maintaining the agent

3.2 Architectural Change in Flows

3.2.1 Change in Information Flows: Change in Navigation Pattern

A recent research on the so-called 'diameter of the world wide web' shows that an HTML document on the web can be connected by, on average, 19 mouse clicks from any other HTML document [5]. This implies that, with a proper intelligent agent, we can find out a wanted web page by 19 clicks. However, current intelligent agents have only the level of intelligence of string matching capability, as pointed out in [33], so they cannot search or support the navigation of the documents effectively. However, if an intelligent agent is developed, which can exploit the knowledge of Internet structure and user's context beyond the simple string matching capability, then the navigation pattern of users will be changed. The representative examples of intelligent agents resulting in the users' navigation pattern are comparison shopping agents such as MySimon.com and peer-to-peer file sharing agents such as Napster.com.

To find out the best product, without agent, potential buyers had to navigate multiple Internet shopping sites sequentially. However, with the aid of comparison shopping agent, potential buyers do not have to navigate all the sites, but only visit the comparison shopping site. (In Fig. 3.) Such comparison shopping agent impacts the shopping site's business model, which has assumed that users will visit their sites for product search.

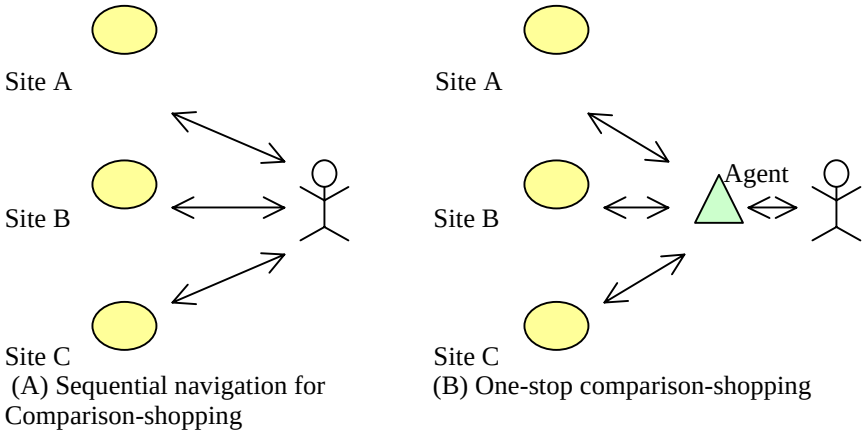

Fig. 3. Change in information flows between sites and users

Napster.com is a networking agent for MP3 file search, which is implemented by so called 'peer-to-peer' architecture rather than existing 'client-server' architecture. With the emergence of such agent, a user who wants to search and download a MP3 file from Internet does not visit any web pages, but uses a sort of agent program such as Napster and gets wanted MP3 files from the Internet. Napster has destroyed the business models of web-based music file service and even threatened the offline music industry. This is a typical example that an agent technology changes the information flows and impacts on the overall business model of existing business, which is online or offline.

3.2.2 Expected Change in Information Organization: From Eyeball to Machine

Increase of software agent usages over human usage implies that there will be changes in current web design currently focused on human being's eyeball searching. As intelligent agents are emerging, web site design and promotion strategy should consider the new group of users and be changed to appeal to machine readability as well as human's eyeball readability. The gradual employment of XML (extensible markup language) as a machine-readable script language for web is interpreted as one of preparation for the emergence of agent.

However, as O'Leary pointed out, firms develop best practices knowledge bases with reuse in mind, yet different firms use different ontologies for these bases, making them difficult to share because of the many differences at the basic level of categories of processes. Therefore he concludes that there is no single optimal ontology for best practices [32] and expects that the standardization of ontologies across the various business entities will not come in the near future. Accordingly the change in information organization from eyeball to machine will take much time to be realized.

3.2.3 Expected Change in Pattern of Consuming Internet Resource

Unlike human beings who have limited time using Internet directly, intelligent agents can search and gather information without a rest. If such personal agents will become ubiquitous, it may be expected that unprotected Internet resources will become overwhelmed because of selfish users and their agent. To prevent such a tragedy of commons, it is claimed that the Internet would shift to a pay-as-you-go system where agents use e-cash as a bargaining chip [9]. Although there is no agreement on the possibility of the tragedy of the commons in the Internet [30], the abundance of software agents and the large consumption of Internet resource by them will affect the pricing of the Internet service and accordingly drive the advancement of micropayment technologies.

3.3 Changed Role or Response of Related Actors

3.3.1 Response of Sellers to Intelligent Agents

Confronting with the comparison shopping agents, some sellers with weak price competitiveness or branded vendor, which do not want a visit of the intelligent agents, have taken various actions to cope with the agents.

First, they use technical methods. In Bargain Finder case, sellers blocked the HTTP request from the IP address of Bargain Finder agent. In the case of Jango agent, sellers frequently changed text arrangement so that their user interface becomes incompatible with the agent's assumption. Some sites deploy a semantic barrier by presenting a common sense question that only average human being can answer. By doing so, they could block agent that cannot answer the easy question.

Second, they may use legal methods. eBay.com sued against the 'trespassing' of Bidder's edge's agent [20].

Third, they may adopt differentiation methods. Brynjolfsson & Smith [7] suggest several differential-pricing strategies for agent markets. They noted that sellers might adopt different pricing strategies for shipping cost between buyers' agent and other buyers who are not using agent. Bakos [4] also noted airlines offer many different prices and rules to make comparison difficult. Crowston & Macinnes [10] also presented similar results in their papers. Most of the current intelligent agents are known to be beneficial to buyers rather than sellers. But this is not so obvious since agents not only allow buyer easy access to other seller's prices, but they also allow sellers themselves to monitor each other's price movements [37]. In reality, buyer-owned shopbots and seller-owned pricebots try to maximize their owner's individual benefit. Rapidly increasing in number and sophistication, shopbots like comparison-shopping agent support to minimizing buyer's expenditure and maximizing benefits. In response to this trend, sellers may rely on their pricebots, which employ price-setting algorithms in an attempt to maximize benefits [22]. Some sites may charge lower prices, so called partitioned pricing, to price sensitive buyers using intelligent agent than buyers who visit their web site directly [7]. Examples of pricebots include Books.com's competitor monitoring agent, consumer information gathering agent, and data mining agent etc.

3.3.2 Changed Role of Intermediary

With the emergence of the Internet, it has been anticipated that role of intermediaries may be reduced or eliminated, which is called, disintermediation hypothesis [14]. However, now it is agreed that although a certain type of intermediaries may extinct, a new types of electronic intermediaries will perform functions with such as aggregating information, matching buyers and sellers, managing physical channels, and providing trust etc. [3]. However, we may expect that the intelligent agent based marketplaces may replace role of the new intermediaries. The new disintermediation caused by intelligent agent may bring an emergence of agent based new intermediary, which is called facilitator [12].

3.4 Impacts on Source of Revenue

3.4.1 Direct Threat to Source of Revenue: By Impacting Banner Advertisement

One of the major revenue models of Internet content providers has been known to be banner advertisement model. Even an electronic shopping site such as buy.com has the revenue model from banner advertising rather than sales margin. However, if a software agent changes the large amount of current Internet navigation from human's eyeball navigation to agents' machinery navigation, the revenue model based on banner advertising would be threatened. Although navigation by agents may not reduce number of hits of the banner advertising, the effectiveness of the advertising will be damaged because intelligent agents will neither gather nor recognize the banner advertisements while they hit the banner advertisements. The lowered effectiveness of banner advertising will make advertisers invest less money on banner advertising. Moreover, some Internet users want a banner ad filtering functionality in their web browsers because banner advertisements tend to delay total download time of web pages. For instance, AdEater [23] and adsubtract.com automatically remove advertisement images from web pages during browsing. Vulkan also expected that the increasing usage of agent is likely to change the way revenues from advertising on the WWW are distributed and if most hits are from agents then this measurement is clearly no longer suitable [38]. As such, intelligent agents directly threaten the revenue model of existing electronic commerce.

3.4.2 Indirect Threat to Source of Revenue: By Impacting Brand and Reputation

As one of several economic factors reducing the chance of generating or sustaining monopoly profits in the digital marketplace, Choi & Whinston [8] points out the fact that rational consumers equipped with smart agents are less swayed by reputation. Intelligent agents are known to reduce the power of intangible assets, such as brand and reputation, of the existing electronic commerce businesses, which enables them to get much profits.

On the other hand, there are other opinions on the impacts of intelligent agents to brand or reputation effects. Brynjolfsson & Smith [7] demonstrates that while intelligent agents substantially weaken the market positions of branded name, brand name and seller loyalty still strongly influence buyer's behavior using intelligent agent's service. The reason may be derived from service quality

differentiation, asymmetric market information regarding quality, or cognitive lock-in among buyers. OECD's report [31] claims that buyers will not use intelligent agent's advice because they do not trust information given by intelligent agent. Varian [37] points out that buyers may not use Shopbot because of existence of loyalty programs.

This issue depends on the capability of intelligent agents. If an agent has a capability enough to give a rational recommendation for its user, who suffers from bounded rationality, then businesses with brand and reputation may lose its power in market competition.

3.4.3 Creation of Direct Revenue

Although many people does not realize, but as Brown & Duguid [6] pointed out, without agents the Internet which has grown so dramatically in the past few years, would by now be unmanageable. The search-and-catalogue capability of agents transformed the sites such Lycos, Excite, and AltaVista etc from mere search engines into lucrative portals. It naturally means that the agents can become a direct source of revenue.

In addition, agents can create a new source of revenue for existing electronic commerce providers. The revenue model of auction sites is mainly based on commission from sellers. In auction, the more bidders participate, the more the final contract price increases and consequently the auction site acquires the more commission fee. Therefore, it is important for an auction site to develop a mechanism that motivates the participation of more bidders. Agent-based automated bidding will promote participation of bidders and create a direct revenue stream from bidders.

Agents exist for the benefit and convenience of users. If the benefit or the convenience is sufficient for the beneficiary willing to pay money for, it naturally creates direct revenue for the agent service provider.

3.4.4 Expansion of Market Size

According to Forester Research's recent survey, the 35 % of shopping mall visitors abandon shopping while inputting their subscription or payment information. This implies that reducing user’s hassle in the subscription and payment process is very critical.

Form filling capability provided by Baropay.co.kr or Passport.com enables users to easily fill their information in the subscription or payment page. However, without a standard on the user information, it creates another hassle to users. In Korea, there has been an effort to establish industry standard in application of such intelligent agent. KECML (Korea Electronic Commerce Manipulation Language) derived from ECML was proposed as government-supported payment information standard for business-to-consumer electronic commerce and a form filling agent system based on the standard has been developed. Employing such a form filling agent is expected to contribute to increase of electronic commerce industry volumes.

Basically, agents exist for reducing transaction costs of electronic commerce; there fore the proper employment of agents have the impacts of expanding markets.

3.5 Change in Benefit to Participants

Although it is difficult to say that intelligent agents create much revenue, it is evident that they may increase or decrease benefit to related actors. Once an intelligent agent has been developed, its relative operation cost is very low and it can continue operating automatically in electronic commerce environment. Such an intelligent agent may benefit or damage related business actors without much cost. Napster.com in music industry is such a typical example.

If the increase of the entire market size can be achieved by intelligent agent like the form filling agents using KECML in the previous section, related actors will gain benefit in common. However, collusion among intelligent agents may do harm other market players. Jonkheer and Jansen [19] suggest a possibility of the emergence of so-called digital cartel. They call for an extensive ruling mechanism because agent mediated communication is hard to control and relatively easy to manipulate.

3.6 Source of Funding

To successfully introduce an intelligent agent to an industry, we should solve a problem who will pay the development and introduction costs. It means that an introduction of intelligent agent needs decision making on funding in the industry. Crowston [11] suggests three possible sources of funds to develop and employ intelligent agent: vendors, buyers, and third party. Table 3 summarizes the possible funding source among the actors.

Table 3. Funding source of intelligent agent in electronic commerce

Funding Source	Comments
Funding From sellers	Commission for referral, Bundled into the cost of goods.
Funding From buyer	Charge the buyer fee, Sell agent software.
Funding From third party	Sell ads, Sell market information about clients.
No funding	Research Project.

Based on the Table 3, we may explain the case of intelligent agents in electronic auction. In auction, the more bidders participate, the higher bid price increases. Therefore, sellers may be willing to fund agents for inducing bidders using automated bidding agents. On the other hand, when an agent gives bidders some convenience in supporting functions of bidding process, monitoring and gathering prices of heterogeneous sources, then bidders may pay for such agents. If agent increases bidders' benefit larger than its costs, then bidders are willing to pay and get the agent software. Auctioneer may pay and use data mining agents for analyzing participant's bidding history.

4 Limitations of Intelligent Agents in Electronic Commerce

Though agent researches have been going on for more than a fifteen years and became a buzzword in the popular computing press [28], agents have not yet shown remarkable impacts. This may imply that agents have some limitations to be deployed in the real world business. In this section, we discuss the limitations of the intelligent agents in electronic commerce domains from the three points of view: technical, business, and social perspectives.

4.1 Technological Limitations

According to Maes [25] the impacts of intelligent agent may be occurring as agent technologies mature to better manage ambiguous content, personalized preferences, complex goals, changing environments, and disconnected parties. Since Internet environment is fundamentally open, a behavior of an agent is easy to be observed or imitated by its competitors. For example, if an agent's bidding patterns are too simple, then they may be easily disclosed by other parties, as the result users may not use the agents. Talukdar [34] mentioned that existing software agents tend to be rich in problem solving skills but poor in social and learning skills. For an instance, there exists considerable amount of researches in comparison shopping agent, these agents are not yet designed to learn about the customers and the changing marketplace or interrelations.

4.1.1 Limitation in Processing of Implicit Knowledge and Semantics

According to Afuah & Tucci [1] current Internet technologies have mainly two kinds of limitations: First, Internet cannot transfer tacit knowledge. Second, users of Internet, human beings, have a bounded rationality to process the vast amounts of information available on the Internet. While an intelligent agent supports augmenting the bounded rationality of human, it still has problems in understanding and transferring tacit knowledge [6]. Hanson [17] also pointed out that agents are faster at carrying out well-specified tasks and capable of employing sophisticated mathematical reasoning far beyond the typical human's ability, while human beings are vastly more able to learn from past behavior, to invent new approaches to problems, and employ what is usually called common sense. Recognizing the relative strength of human and agent, he proposed an agent-human hybrid firm in the marketplace.

In addition, current intelligent agents cannot process semantics involved in the exchanging of information. Therefore, actors, who do not want visit of agents, have employed a semantic barrier strategy.

4.1.2 Ontology Issues

Ontology in intelligent agent is a language for the communication between agents. For independently developed agents to communicate seamlessly and even contract each other automatically, a standardized common ontology should be shared among the agents involved. For the electronic commerce area, there have been some efforts to develop agent ontology. One of them is the IBM's BRML(Business Rules Markup

Languages)[15], which is an XML encoding of CLP (Courteous Logic Programs), a new knowledge representation formalism. Generalmagic.com also developed ontology named Telescript, but it is not widely used owing to incompatibility with other agents.

As such, commonly shared agent ontology in business domain has not been employed in real world applications. According to O'Leary [32], firms develop best practices knowledge bases with reuse in mind, but different firms use different ontologies for these bases, making them difficult to share. Applying Arrow's 'impossibility theorem [2]' to the problem of choosing optimal common language, he concludes that there is no single optimal ontology for best practices. His finding of the difficulty in developing common ontology for human reuse could be extended to the agent ontology area, which implies the more difficulty of developing a ontology standard for agent. In fact, the difficulty is one of important reasons why multiagent systems researches have not yet produced real world successful applications. Many researches have assumed a common ontology among the agents, but in reality it is not feasible. Therefore, deciding whether an agent system will depend on a common ontology or not, is very critical point for developing practically successful agent applications.

4.2 Limitation in Business Model and Market Based Approach

Comparison shopping agent business started with the revenue model which makes money from banner advertising, referral fee, and listing payments. However, there has been fierce competition among so many similar comparison shopping businesses, therefore the revenue realized has been much smaller than expected. Even famous comparison shopping agents have not proved as an independent business model, so there were, as summarized in Table 4, finally acquired by the larger portals.

Table 4. Acquisition of comparison shopping agent by portals

Comparison shopping agent sites	Recent their position
Mysimon.com	Acquired by Cnet.com
Jango.com	Acquired by Excite.com
Junglee.com	Acquired by Amazon.com
Personalogic.com	Acquired by AOL.com

From the above cases, we learn that to develop and sustain successful agent based business, we should develop strong business model before its technical implementation. If we judge that an agent-based business will not sustain as an independent business entity, that we should consider product model, i.e., selling the agent product to electronic commerce providers, rather than service business itself.

For the practical use of agent in electronic commerce such as auction, bidding, and negotiation etc, the more investigation on the economic behavior of intelligent agents should be followed. So far most of technical studies on agent have focused only on

improving the functionality of agents, but for the agents to be successfully applied to real-world electronic marketplace, then we should make effort to enhance the functionality of the agent based electronic marketplace. The key aspects of improving agent based electronic marketplace we suggest include interface between users and software agents, language for the communication between agents, trust between users and agents or among agents, security of agent behaviors and its internal codes, and market transaction mechanism synergistically operated with intelligent agent.

4.3 Social Limitations

Some researchers such as Odlykzo [30] do not have an optimistic view on the applicability of agents. He predicts that software agents will be used, but only to a limited extent. He pointed out that agents supposed to simplify life are not easy to master, and so are not as widespread as many people had hoped. He claims that even when software agents are used, they serve to encourage the growth of complexity that eats up any gain that had been achieved.

Brown & Duguid [6] pointed out that the human and the digital are significantly distinct and the distinction is rather useful. Human planning, coordinating, decision making, and negotiation are quite different from the capabilities or task characteristics of automated intelligent agent. Delegation to agent by human should be limited because rules and contracts rely on unspecifiable discretion and judgment on the part of the subject following those orders. Another problem is who will take responsibility for the agent decisions. Therefore, they claimed agent would be better to pursue not substitution but complimentarity.

Human beings are not only economically oriented, but also pursue enjoyment and affections. This fact is also applied to the Internet. Modahl classified the objectives of using Internet into three factors: career (money), enjoyment, and affections [26]. One of its implications to those who proclaim the occurrence of agent-based economy, where most of Internet users are agents rather than human beings, is that human users may mostly enjoy using the Internet rather than delegate their activities to agents.

As we see in the above, understanding the social limitation of agents, which has been neglected, gives a new insight to agent research and development. According to Wagner [39], a comprehensive underlying social theory for multi-agent environments is still missing, therefore the agent research should take into account not only particular problems (say the construction of a shopping agent) but also the consequences for society of these developments (such as the effects of agent-mediated commerce).

5 Conclusion

In the previous sections, we reviewed ongoing and future impacts of intelligent agents to electronic commerce as well as their limitations. We classified intelligent agents by their functions and typical roles in electronic commerce. Impacts on each component of business model are analyzed: changes in architecture of flows, responses of players, influences to revenue model and participant's benefits, and funding source.

The primary contribution of this research can be summarized as follows. First, we propose a digital economy development phase model from reverse market economy to agent-based economy with intelligent agent point of view. Second, we employ a business model framework to give a comprehensive review and preview of the impacts of intelligent agents. Third, we also deal with the technical, business, and social limitations of current phase of intelligent agent researches and real world implementations as well as their impacts to electronic commerce.

The systematic understanding of the agent-based economy will guide researchers to develop practical intelligent agent systems and help current electronic commerce industries cope with the challenges of the intelligent agents.

References

1. Afuah, A., Tucci, C., Internet Business Models and Strategies, McGraw-Hill (2000)
2. Arrow, K., Social Choice and Individual Values, Yale Univ. Press, New Haven, Connecticut (1970)
3. Bailey, J., Bakos, Y.: An exploratory study of the emerging role of electronic intermediaries, International Journal of Electronic Commerce, 1(3): 7-20 (1997)
4. Bakos, Y., A Strategic Analysis of Electronic Marketplaces, MIS Quarterly, 15(3): 295-310 (1991)
5. Barabasi, A., Albert, R., Jeong, H. Scale-free characteristics of random networks: the topology of the worldwide web, Physica A 281: 69-77 (2000)
6. Brown, J., Duguid, P., Agents and Angels, Chapter 2 of The Social Life of Information, Harvard Business School Press (2000)
7. Brynjolfsson, E., Smith, D., The great equalizer? Consumer choice behavior at Internet shopbots, Working Paper, http://ebusiness.mit.edu/papers/tge/ (2001)
8. Choi, S., Winston, A., Is It Spring Time for Internet Tulips?, CREC Working Paper, University of Texas (1998).
9. Croft, D., The Agent Crisis and Resolution of 1999, http://alumnus.caltech.edu/ ~croft/research/ agent/crisis/ (1999)
10. Crowston, K., MacInnes, I., The effects of market-enabling Internet agents on competition and prices, Journal of Electronic Commerce Research 1(4) (2000)
11. Crowston, K., Market-making agents on the Internet", Proceedings of International Conferences on Information Systems (ICIS-96) (1996)
12. Finin, T., Labrou, Y., Mayfield, J., KQML as an Agent Communication Language, Software Agents (Eds. Jeff Bradshaw), MIT Press (1995)
13. Franklin, S., Graesser, A., Is it an agent, or just a Program: A Taxonomy for Autonomous Agents, Proceedings of the Third International Workshop on Agent Theories, Architectures, and Languages, Springer-Verlag (1996)
14. Gellman, R., Disintermediation and the Internet, Government Information Quarterly 13(1) (1998)
15. Grosof. B., Labrou. Y., Chan. H., Declarative Approach to Business Rules in Contracts: Courteous Logic Programs in XML, Proceedings of 1st ACM Conference on Electronic Commerce (EC-99) (1999)
16. Hagel, J., Armstrong, A., Net Gain: Expanding Markets Through Virtual Communities, McKinsey Quarterly, 1: 141-153 (1997)
17. Hanson, J., Cultivating the Agent Economy, Proceedings of the Fifth International Symposium on Autonomous Decentralized Systems (ISDAS-01), (2001)
18. Jennings, R., Wooldridge, M., Agent Technology, Foundations, Applications and Markets, Springer-Verlag (1998)

19. Jonkheer, K., Jansen, T., Intelligent agents, markets and competition, EIM. (1998)
20. Kaplan, C., Arguing Against Net Trespass, Cyber Law Journal, July 28, New York Times (2000)
21. Kephart, J., Greenwald, A., When Bots Collide, Harvard Business Review, July-August, (2000)
22. Kephart, J., Hanson, J., Greenwald, A., Dynamic Pricing by Software Agents, Computer Networks, 32(6):731-752 (2000)
23. Kushmerick, N., Learning to remove Internet advertisements, Proceedings of the Third Annual Conference on Autonomous Agents (1995)
24. Liang, T., Hung, J., A framework for applying intelligent agents to support electronic trading, Decision Support Systems 28: 305- 317 (2000)
25. Maes, P., Guttman, R., Moukas, A., Agents that buy and sell: Transforming Commerce as we know it, Communications of the ACM 42(3): 81-91 (1999)
26. Modahl, M., Now or Never: How Companies must change today to win the battle for Internet consumers, Harperbusiness (1999)
27. Nissen, M, The commerce model for electronic redesign, The Journal of Internet Purchasing (1997)
28. Nwana, H., Ndumu, D., A brief introduction to software agent technology, foundations, applications and markets, Springer-Verlag (1998)
29. Nwana, H., Software agents: an overview, Knowledge Engineering Review, 11(3): 205-204 (1996)
30. Odlyzko, A., The history of communications and its implications for the Internet, Working Paper, http://www.research.att.com/~amo (2000)
31. OECD, Electronic Commerce: Prices and consumer issues for three products: Books, Compact Discs, and Software (1998)
32. O'Leary, D., Different Firms, Different Ontologies, and No one best ontology, IEEE Intelligent Systems, September/October (2000)
33. Petrie, C., What an Agent And What So Intelligent About It, IEEE Internet Computing, July-August, (1997)
34. Talukdar, S., Collaboration rules for autonomous software agents, Decision Support Systems 24: 269-278 (1999)
35. Timmers, P., Business Models for Electronic Markets, Electronic Markets 8(2) (1998)
36. T•rissen, B., Intelligent Agents and Conceptual Modeling, http://www.pvv.org/~bct/sprithesis/iathesis.html (1996)
37. Varian, H., Market Structure in the Network Age, Prepared for Understanding the Digital Economy conference, Department of Commerce, Washington, D.C. (1999)
38. Vulkan, N., Economic Implications of Agent Technology and E-Commerce, The Economic Journal 453:67-90 (1999)
39. Wagner, D., Software Agents take the Internet as a Shortcut to Enter Society: A Survey of New Actors to Study for Social Theory, First Monday 5(7) (2000)