Abstract
Agent-based business in e-commerce can be defined as a business enabled and operated by software-agent technologies. The discrepancies between expectations on and reality of the business have raised research interests in its critical success factors. We suggest a framework for analysing the evolution of the agent-based business and analyse 16 representative agent-based business cases to derive explanatory variables seeming to have effect on the longevity of the agent-based business. The results of the case studies are used as an input to an inductive learning method to generate five theoretical hypotheses on its evolution. Finally, we provide strategic implications of the generated hypotheses about the evolution of the agent-based business.

Keywords: agent-based business, intelligent agent, e-commerce, inductive learning

INTRODUCTION
The wide diffusion of the Internet and e-commerce enables new business models and opens a huge amount of new business opportunities. In particular, agent-based businesses have been expected to give many opportunities to e-commerce business. Brown and Duguid (2000) claim that the Internet having grown so dramatically in the past few years would by now become unmanageable without agents, and that the search-and-catalogue capability of agents transformed the search engine sites into lucrative portals.

Although agent-based business had high expectations and there has been much research on intelligent agents, as yet there are few successful businesses. In particular, agent-based businesses have been expected to give many opportunities to e-commerce businesses. Brown and Duguid (2000) claim that the Internet having grown so dramatically in the past few years would by now become unmanageable without agents, and that the search-and-catalogue capability of agents transformed the search engine sites into lucrative portals.

Although agent-based business had high expectations and there has been much research on intelligent agents, as yet there are few successful business instances. Intelligent agent technology itself has brought innovations in technology, but it has not yet become mature enough to be successful in the commercial market. Now is the time to study the evolution of agent-based businesses and to consider what will make them commercially successful.

We first suggest a framework for analysing the evolution of agent-based business and review expectations and realities of the current agent-based business. Then we select and analyse representative agent-based businesses to derive explanatory variables that seem to have effect on the evolution of agent-based business. The results of the case studies are used as an input to an inductive learning method to generate five hypotheses on the evolution of agent-based business. Finally, we provide strategic implications of the generated hypotheses about its longevity.

LITERATURE REVIEW
Framework for Agent-based Business Analysis
Agent-based business in e-commerce can be defined as a business enabled and operated by software-agent technology. In the agent-involved e-commerce environment, principal actors include users, agent-based businesses, existing e-commerce businesses and other agents. We may add the external environment variables to this framework. We depict the framework for agent-based business analysis in Figure 1. Agent-based businesses in Figure 1 could be comparison-shopping agents, recommendation agents, negotiation support agents, networking agents, interface agents...
‘Existing business’ can both affect and be affected by a specific agent-based business. ‘Other agents’ mean the agents that can cooperate or compete with the agent-based business at hand. ‘External entities’ means legal or technical variables that may affect the evolution of agent-based business.

Arrows (1) and (2) in Figure 1 represent the evolutionary direction of an agent-based business and existing business, respectively. Arrow (3) represents the effect of an agent-based business on existing businesses. Arrow (4) represents the effect of an existing business on agent-based businesses. Arrow (5) represents the interaction between an agent-based business and its user. Arrow (6) represents the interaction with other agents. Finally, arrow (7) represents the influence of external variables on the evolution of an agent-based business.

**Related Research on Agent-based Business**

We classify previous researches in Table 1, according to the framework in Figure 1.

**Table 1. Classification of researches by the framework for agent-based business analysis**

<table>
<thead>
<tr>
<th>Arrow</th>
<th>Research Issue</th>
<th>Related papers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Evolution of agent-based business</td>
<td>This paper</td>
</tr>
<tr>
<td>2</td>
<td>Evolution of agent-affected business (existing business)</td>
<td>Not available</td>
</tr>
<tr>
<td>4</td>
<td>Effect of existing businesses on agent-based business.</td>
<td>This paper</td>
</tr>
<tr>
<td>5</td>
<td>Interaction with agent-based business and user</td>
<td>Pederson (2000), Brynjolfsson and Smith (2000)</td>
</tr>
<tr>
<td>6</td>
<td>Interaction between agents</td>
<td>Kephart and Greenwald (2000)</td>
</tr>
<tr>
<td>7</td>
<td>Influence of external entity (technical, legal etc environments)</td>
<td>Crowston and MacInnes (2000), Jin and Lee (2001), This Paper</td>
</tr>
</tbody>
</table>

**Expectations and Reality of Agent-based Business**

Since agent-based businesses emerged, there have been many rosy expectations, which have turned out to be quite different from reality. First, users expected an economic benefit of lower search cost and an increase of convenience due to the use of agent. However, in reality, the expectations did not come true. For example, although comparison-shopping agents have had some effect on the decrease of price, this happened only to some specific commodity products (Crowston and MacInnes 2000, but not to the products that have brand effect and loyalty programmes (Kephart and Greenwald 2000; OECD 1998). We can even see an example of price increases due to a price-monitoring agent in Books.com (Varian 1999). Many users also still enjoy Internet shopping without the aid of intelligent agents because they are inclined not to trust the information and the advice of intelligent agents (OECD 1998). Although Jango.com’s client-based agent, which is not server-based, had been expected to invalidate blocking strategy of sellers, it was not successful owing to the inconvenience of using the agent program.
Second, agent-based businesses expected much revenue from, for example, listing payment, placement payment and advertising payment (Clark 2000). However in reality, those expectations have not been realized. Many agent-based businesses have been merged by portal businesses. According to Jin and Lee (2001), three kinds of limitations exist in current intelligent agents: technical limitations (e.g., the difficulty of processing implicit knowledge and semantics); limitation in business model; and social limitations. There are still many questions on whether agent-based businesses can survive or not.

Third, it has been expected that agent-based business would provide many new opportunities to existing e-commerce businesses. However in reality, it was not the case. Many agent-based businesses did not provide any new opportunities but were rather threats to existing e-commerce businesses. For example, the emergence of comparison-shopping agents raises the price competition between some e-commerce businesses and thus becomes a threat to them. The emergence of advertisement-banner removal agents became a threat to one of the biggest revenue sources of e-Commerce businesses.

Fourth, several agents have been developed with the purpose of establishing coordination or cooperation among agents. But coordination or cooperation among agents has been proved (and is still expected) to be difficult owing to the lack of ontology and trust problem, etc.

These discrepancies between expectations and reality of agent-based business suggest the necessity of studying the evolution of agent-based business.

ANALYSIS OF AGENT-BASED BUSINESS CASES

In this section, we analyse representative agent-based businesses to generate hypotheses on the evolution of agent-based business. The overall steps of this research are represented in Figure 2.

Through the case study, we try to identify the characteristic variables that seem to have impact on the evolution of agent-based business. To do that, we conducted case analysis on 16 agent-based businesses among many agent-based businesses, selected and searched through agents@umbc.edu, botsports.com, search engine’s agent search list and several related papers. Most of the selected agent-based businesses are historically important ones and mentioned many times in related papers. We omitted some agents when they had the same business models as already selected agents. In the following case analyses, we try to extract some meaningful variables, which affect the evolution of agent-based business.

Case 1: BargainFinder. Anderson Consulting’s server-based BargainFinder is the first e-commerce agent (Krulwich 1996). But its service was blocked because seller’s sites denied access to the agent. Though BargainFinder might give some benefit to its users, it became a threat to existing e-commerce businesses. From this case, we could find some variables: user convenience, business relationship, and technical vulnerability. We can interpret this case that its User Convenience (UC) is high, Business Relationship (BR) is threat, and Technical Vulnerability (TV) is high.
Case 2: Client-based Jango. To cope with the seller’s blocking action, a client-based architecture of comparison-shopping agent Jango was developed. Since the agent has a client-based platform, its users had to download the software agent and install it to their PCs. At that time, average e-commerce customers felt difficult and did not have much incentive to download and install the agent, which should cooperate with Web browser. We can say on this case that its User Convenience (UC) is low, Business Relationship (BR) is threat and Technical Vulnerability (TV) is low.

Cases 3 and 4: Server-based Jango and BizRate.com. Later, Jango’s platform changed from a client-based to a server-based one. Most of the current comparison-shopping agents developed since then are not client-based. Unlike the client-based Jango and Bargain Finder, the server-based Jango tried to establish a good business relationship with existing e-commerce businesses. This agent-based business played the roles of recommendation or promotion rather than just comparing prices between vendors.

Comparison-shopping agents such as Jango had been expected to survive by their own revenues based on banner advertisement payment, listing payment, and placement payment. However, most of the famous server-based comparison-shopping agents have been merged by established portals rather than having survived independently. For example, Mysimon.com has been merged by Cnet.com, Jango.com by Excite.com, and Junglee.com by Amazon.com. But a few comparison-shopping businesses like BizRate.com make money by selling marketing research results on consumer buying patterns obtained from consumer feedback. Also this site receives a referral fee from many online merchants to which it directs businesses. Therefore, we can judge its Business Relationship (BR) is opportunity.

Cases 5 and 6: ClickTheButton and Savingbot. While most of the current comparison shopping agent’s technical platform is server-based, there are a few client-based shopping agents, which are different from the client-based Jango.com mentioned earlier. ClickTheButton has a button on the task bar of its operating system’s menu. Users who are looking at a product on an e-commerce site can click on the button to make fast comparisons to other vendor’s product (Pederson 2000). So, we interpret that User Convenience (UC) is high for this agent.

Case 7: PersonaLogic. Recommendation agents play the role of which goods and services are appropriate for their users. One representative example of commercialized recommendation agents is PersonaLogic, which uses knowledge-based filtering. This agent supports users who do not have detailed knowledge on certain goods. By providing recommendation, the agents can both raise the level of customer satisfaction and reduce the marketing cost of e-commerce businesses. So, we can say that Business Relationship (BR) is high and User Convenience (UC) is high for this agent. To give a good recommendation to its user, such an agent should have some knowledge on the user. The knowledge can be acquired directly from user input or indirectly from a machine learning process. In general, knowledge-based recommendation agent such as PersonaLogic needs some user input, and that can be a burden on the user. This case lets us think of a new variable. We can say that Input Quantity (IQ) of this agent is high.

Case 8: Firefly. Firefly.com is another representative recommendation agent-based business. Unlike PersonaLogic, Firefly, by adopting a collaborative filtering technique, tries to minimize user input by exploiting the similarity between user actions on multiple items. In this case, we can say that Input Quantity (IQ) is low.

Case 9: Kasbah. MIT Media Lab’s Kasbah is a virtual marketplace with buyers and sellers represented by intelligent agents. Kasbah is not commercialized and only remains to provide testing services, but its automated negotiation system is embedded to many online auction systems. One reason why it could not be commercialized by itself is that it does not have a common inter-agent communication mechanism, i.e. the Ontology (ON). In this case, therefore, we can say that Ontology (ON) is lacking.

Case 10: Napster.com (early version). Networking agents comprise special-purpose networks among consumers, merchants and manufacturers. The emergence of networking agents can be interpreted as the commercial realization of multi-agents. Napster.com is a good example of these networking agents. Napster is an application-level network that allows users to share MP3 libraries with others, no matter where they are located. Although users need to download particular software (therefore, we can say that Technical Platform (TP), a new variable, is client-based), they are willing to use this service owing to its evident benefit, free MP3 files. It threatened the recording industry by demonstrating to the public that this site zeroed the costs of distributing music.

According to Youll (Youll 2001), even a versatile agent will be constrained by laws and policies. Napster.com greatly affects existing e-commerce businesses like music distributors and music content providers because of its free MP3 model. Therefore, we say that Business Relationship (BR) is threat. The existing e-commerce businesses do not have a technical method for blocking the service (its Technical Vulnerability is low).
(TV) is low). Some music distributor sued Napster.com (so, its Legal Compliance (LC), a new variable, is low).

Case 11: Napster.com (later version). After the first legal decision on Napster, it tried to ally with existing music distributors to cope with existing business’s challenge. Napster and allied partners began to impose rental fee on their users. Through the change of business model like this, it tried to resolve the problems of legal weakness. It builds a win–win model with existing e-commerce business by providing marketing information obtained from usage data. Therefore, its Legal Compliance (LC) becomes high and Business Relationship (BR) becomes opportunity.

Case 12: Gnutella. Unlike Napster, Gnutella has no central server directory, it is a pure peer-to-peer collaboration model. Existing e-commerce businesses have difficulty in instituting Gnutella-based business. Legal Compliance (LC) may be high in this case. But the early version of Gnutella has difficulty in building a win–win model with existing e-commerce businesses. Its users have the inconvenience of registering particular IP addresses of the peer users to contact for downloading MP3 files. In this case, we can say that its User Convenience (UC) is low and Business Relationship (BR) is threat.

Cases 13: Bidxs.com. Bidxs.com is an auction site using agents that gather information from existing auction sites. This company aggregates product information, but executes comparison against other auction sites rather than retailers. eBay, one of the biggest auction sites, sued Bidxs.com because Bidxs searches eBay’s database without agreement. A federal official issued a preliminary injunction barring Bidxs.com from using an automated system to search eBay’s site for auction information. Therefore, its Legal Compliance (LC) is low.

Case 14: Adeater. Adeater is a representative advertisement-banner removal program (Kushmerick 1999). Users need to install a proxy program to get this service, and then they are able to browse a website without the banner advertisements that slow access speed. Existing e-commerce businesses consider this program as a threat because one of their revenue sources depends on banner advertisement fees (so, its Business Relationship (BR) is threat). Inspired by Adeater, many advertisement-banner removal business sites have been developed such as Netsday.com.

Cases 15: Neuromedia.com. Neuromedia.com is one of the representative interface agents. Its service supports automated online customer service with agents called virtual representatives. Its agents are automated agents that answer customer questions via two-way conversational dialog and rules-based display of relevant content from key corporate information sources, including website search, CRM knowledge bases, and customer-facing databases. Users both question and answer queries directly in real time in natural language (so, its User Convenience (UC) is high). Using such agents, e-commerce business can have a low cost call center on the Web.

Case 16: Bullseye.com. Bullseye is an intelligent agent-driven software solution for those who must find useful information on the Web. In addition to using intelligent agents, it combines the sophisticated search capabilities with a built-in browser, so that users can quickly locate and review pertinent data. Bullseye scans some 700 search engines, databases and Web shopping sites. It offers 14 subject areas. Within each subject area, users choose categories, which the program associates with Web sources. So, User Convenience (UC) is high.

Independent Variable Selection

Through the above case study, we have found seven variables: TP (Technical Platform), IQ (Input Quantity), UC (User Convenience), BR (Business Relationship), TV (Technical Vulnerability), LC (Legal Compliance) and ON (Ontology). Figure 3 shows, which variables correspond to which arrows in Figure 1. For the completeness of the model, we have added another variable, state, to the figure, which will be explained in next section. The six independent variables are selected from the case analysis and each of which is explained in Table 2. The variable Ontology is omitted because it is not applicable to every case.

Value Assignment on the Dependent Variable

The values of the current state (the dependent variable) of agent-based business cases are assigned as shown in Table 3. The criterion that we have used to tell Accepted from Rejected is whether the corresponding
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agent-based business site is still live or not. That is, we think that if an agent-based business site is old enough to live for a while and still be living, they can survive eventually (so, we Accept it).

In case of Kasbah and Adeater, although they do not remain with their original name, we judged them as Accepted because they are utilized in their adopting sites. The bidding system of Kasbah is being used by many online auction sites and the banner removal function of Adeater was also adopted by many similar sites. Although PersonaLogic.com and Firefly have stopped recently, we considered the state of these business sites as Accepted for the same reason.

HYPOTHESIS GENERATION USING INDUCTIVE LEARNING

For each of the 16 cases of agent-based business, we investigated the values of 6 independent variables and 1 dependent variable and summarized them into Table 4. (Every value in cases was chosen based on the related literature review, case analysis, and site surfing.)

In that table, ‘S’ and ‘C’ mean server-based platform and client-based platform in TP (Technical Platform), respectively. ‘O’ and ‘T’ mean Opportunistic and Threat, in BR (Business Relationship), respectively. ‘H’ and ‘L’ mean High and Low in other independent variables, respectively. ‘R’ and ‘A’ values of variable State mean Rejected and Accepted, respectively.

There are various analytical methods for analysing the dataset: linear regression, neural networks, and inductive learning etc. For the purpose of generating hypotheses based on the current dataset, we employed the ID3 algorithm (Quinlan 1986), an inductive learning method, which can generate intuitive decision tree-like hypotheses.

The decision tree generated suggests five hypotheses on the evolution of agent-based business as follows.

- **Hypothesis 1**: If the business relationship with existing business is an opportunity, the agent-based business is accepted (Rule 1 in Figure 4).
Hypothesis 2: If the business relationship is a threat, the technical platform is client-based and user convenience is low, the agent-based business is rejected (Rule 2 in Figure 4).

Hypothesis 3: If the business relationship is a threat, the technical platform is client-based, user convenience is high and legal compliance is low, the agent-based business is rejected (Rule 3 in Figure 4).

Hypothesis 4: If the business relationship is a threat, the technical platform is client-based, user convenience is high and legal compliance is high, the agent-based business is accepted (Rule 4 in Figure 4).

Hypothesis 5: If the business relationship is a threat, and the technical platform is server-based, the agent-based business is rejected (Rule 5 in Figure 4).

**IMPLICATIONS AND CONCLUSION**

**Strategic Implications for Agent-based Business**

Considering the decision tree generated in Figure 4, we notice that the establishment of mutually beneficial business relationships with principal participants is important. Based on the generated hypotheses, we derive some strategic implications about the longevity of agent-based business.

Implication 1. The most important variable that determines the longevity of an agent-based business is business relationship. That is, if the business can establish mutually beneficial relationships with existing businesses, it can survive. In our case set, five out of the seven that became a threat to existing e-commerce businesses have been rejected. Most agent-based business threats for existing businesses concern their price comparison function or advertisement-banner removal function. Existing e-businesses try to block agent-based businesses using some technical method, as was done in BargainFinder.

Therefore, an agent-based business which is a threat to existing businesses, need to be changed so that it provides some benefits to existing businesses.

Napster was once a threat to existing music distributors, and at the same time it was not legally compliant. Later, it was merged with a music distributor, which tried to resolve the legal problem by imposing rental fees on its users. If it could be beneficial to existing businesses, it might be able to survive without being merged. For example, what if it provides music distributors with some useful information obtained from the analysis of visitors’ information? Jango was once developed as client-based, in order to avoid the technical blocking of existing businesses. But later, it changed from client-based into server-based. Further, it came to establish good relationships with existing businesses by providing them with useful information for recommendation or promotion.

Implication 2. Even though an agent-based business becomes a threat to existing businesses, it would survive if it is designed to provide convenience to its users and is legally compliant. According to our analysis, if user convenience is low in an agent-based business, not many users adopt the agent. So, it is important to develop an agent-based business so that it provides its users with convenience. Savingbot has a clear benefit of providing information with low price. For that reason, its users are willing to download and use the client-based agent. Adeteer was a threat to some existing businesses because it removes their advertisement banner. However, users accept this site, because it makes the downloading speed of web pages faster than otherwise. Although Bullseye may be a threat to existing business, it brings a clear user convenience like reduction of search cost, so users accept it.

One way of increasing user convenience is to integrate various services such as function or technology integration. For example, Metaprice.co.kr has integrated various functions in a consumer buying behaviour model, such as price comparison, recommendation and purchase proxy. Nureomedia.com has integrated various technologies like natural language processing and voice recognition. Vperson.com’s Sylvie interface agent has also integrated various technologies including facial animation, lip synchronization, script, and natural language processing. We need to recognize that intelligent agents are 99% computer science and 1% AI (Etzioni 1996).

**Contributions and Limitations**

To our knowledge, this paper is the first systematic case study of the agent-based business using inductive learning. The primary contribution of this research can be described as follows. First, we proposed agent-based
business analysis framework and matched prior related researches into the framework. Second, we identified the variables that affect the evolution of agent-based business. Third, we generated the hypotheses on the evolution of agent-based business using inductive learning. Fourth, we derived strategic implications about the longevity (and thus success) of the agent-business.

However, this research shows some limitations. First of all, the number of cases that we analysed is so small that some part of the generated hypotheses might be less reliable than others. In fact, it was very difficult to get information on more agent-based businesses that ceased service. In addition, we have examined agent-based businesses all together, without classifying them. If we collect a sufficient number of cases in each of the categories and analyse them separately, the generated hypotheses obtained in each category will give more convincing implications.

In the current research of this paper, we did not mention the evolution of existing businesses that could be affected through interaction with agent-based businesses and/or with other agents. As a future research, we need to do research on Arrows 2, 5 and 6 in Figure 1. We have a plan to refine the decision tree by refining the values of variables as well as variable addition and deletion. For example, we may have to diversify the current status of agent-based business into more than two values, instead of Accepted/Rejected.

References