An Electronic Commerce Paradigm for Agent-Based Information Discovery

B.C.M. Wondergem, P. van Bommel, T.W.C. Huibers, and Th.P. van der Weide
Computing Science Institute
University of Nijmegen
Toernooiveld 1
NL-6525 ED, Nijmegen
The Netherlands
bernd@cs.kun.nl
http://www.cs.kun.nl/~bernd/

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Abstract

This article proposes an electronic commerce paradigm for agent-based Information Discovery (ID). ID is the synthesis of Information Retrieval and Information Filtering, thus coping with dynamics from both fields. Agent technology, having a number of valuable properties to attack problems with dynamics, is used in ID, resulting in a paradigm with three types of agents: user, broker, and source agents. Cooperation, which is the keyword for the agents to fullfil ID tasks, is seen as negotiation, thus obtaining a very general and flexible way to describe agents' interaction. The possibilities for ID agents to negotiate are investigated. In addition, remarks stemming from the ID background are made about other issues concerning negotiation such as protocols, strategies, and coordination.

1 Introduction to Agent-Based Information Discovery

Information Discovery (ID) (see [WBHW97b]) is the synthesis of Information Retrieval (IR) and Information Filtering (IF). For a comparison of IR and IF see [BC92]. In ID, we consider a population of users having dynamic information needs. These information needs are to be satisfied with information out of dynamic information sources. To facilitate this process, information brokers act as intermediaries between users and sources. Brokers compare the wishes of users with the available information in the sources.

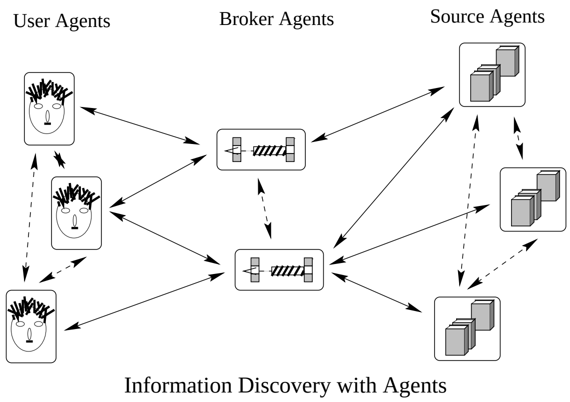

Figure 1: Conceptual ID Paradigm

Figure 1 sketches the ID paradigm at a conceptual level (as proposed in [WBHW97a]). Note that it is not possible for users to communicate directly with the information sources. Since agent technology (see e.g. [WJ95]) fits well in the ID paradigm (especially communication, intelligence, and proactiveness), the entities of the paradigm are seen as agents: user agents, broker agents, and source agents, respectively. The 3 collections of agents are called *spaces*.

Figure 2 sketches a more implementation oriented form of the ID paradigm. The agents reside in a networked world, made up of sites reachable by links, where on each site communication can take place with the ID constraint. This is one of many possible ways to translate the conceptual paradigm to a more concrete paradigm.

The arcs in Figure 1 visualize possible communication in ID: user–broker, broker–source, and

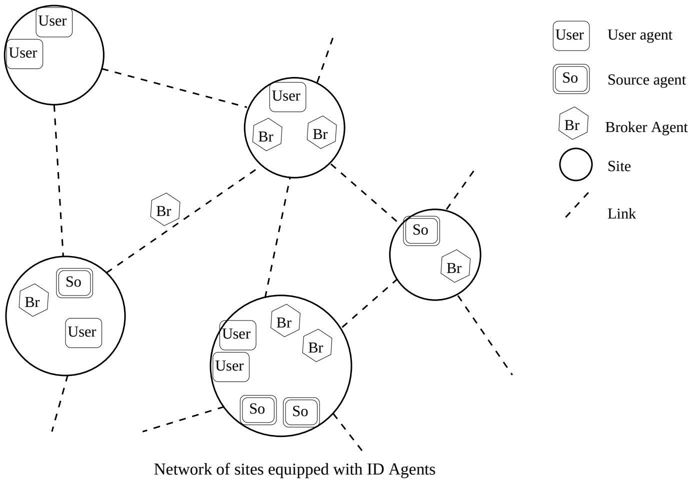

Figure 2: Implementation Oriented ID Paradigm

same type (intra-space) communication. Through communication, the agents effectuate their dynamic cooperation. A general and flexible manner to implement cooperation in a dynamic environment is *negotiation*.

To effect negotiation, a basic assumption is that the services of agents are not for free and that their costs are negotiable (within limits). This conforms to the modern trend on the Internet that the information available in the sources involves costs. The costs of information can be defined in terms of access-costs, transportation costs, complexity costs, etc. In addition, broker agents will also charge their clients. By negotiating, the agents in the ID paradigm form a *dynamic economic market*. For another multi-agent ID application see [Mar97].

The goal of this article is to show how electronic commerce can serve as the basis of an Information Discovery paradigm when negotiating agents are used.

Section 2 investigates the possibilities for negotiation amongst agents in the ID paradigm. Section 3 touches upon a number of aspects of negotiation, looked upon from an ID perspective. Section 4 offers concluding remarks and directions for further research.

2 Possibilities for Negotiation in Information Discovery

Basically, there are 2 types of negotiation in the ID paradigm: inter-space (among agents of different types) and intra-space (among agents of the same type) negotiation:

1. **Inter-space** negotiation among users and brokers or among brokers and sources involves the price/quality ratio of information (basic IR and IF).

2. **Intra-space** negotiation involves team formation and intra-team negotiations.

Figure 3 provides a scheme to characterise the types of negotiation. The circles represent the types of agents, and the arrows represent messages sent. Several types of negotiation will be described below. Starting at a certain agent type, negotiation follows the direction of the arcs, i.e. only outgoing arcs can be followed. In every type of negotiation between of agents, 1-1, 1-N, M-1, and M-N forms are possible.

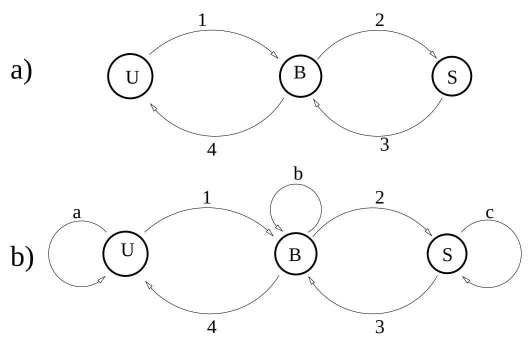

Figure 3: Communication Possibilities

2.1 IR and IF as Inter-space Negotiation

The ID paradigm is a synthesis of IR and IF. Both aspects of ID are covered in inter-space negotiation.

In figure 3a), a 1234-cycle represents the IR related task of query processing. A user fires a query, which contains a price/quality ratio, to a number of brokers (1). These brokers pass the query on to a number of sources to inform about a an offer (2). The offers (3) are sent as bids to the user (4). The user then selects *only* the most favourable bid (if not too expensive).

A 3412-cycle in figure 3a) represents IF. A source offers a number of documents to a number of brokers (3). The brokers pass the offer on to a number of users (4) which inform the broker about their bid (1). *Every* interested user is considered, to maximize payoff. The broker agent informs the source about the process (2).

Without negotiation, the above plans of attack collide with the standard notions of distributed IR and IF (viz. non negotiating brokers such as Lycos[1] and AltaVista[2]).

Negotiation can be effectuated by cycles of communication. For instance, a (14)*-cycle, where $*$ denotes iteration, (user-broker) can represent negotiation about the exact user query or about the broker's fee. The best bid after round n serves as the price to beat for round $n+1$. The negotiation terminates if no agent can beat the best price so far. As another example, consider 1(23)*4-cycles, in which the negotiation between broker and source is an iterative process. A (1234)*-cycle represents an iterative form of the standard IR negotiation.

2.2 Teams of Agents: Intra-space Negotiation

When an agent is not capable of achieving its goals on its own, the agent tries to form a team and achieve the (common) goal as a group. The team acts as a *single party* in the negotiations. The two aspects of teams, *team formation* and *intra-team negotiation*, involve the reflexive links in figure 3b) (links a, b, and c).

Reasons for ID agents to form a team:

1. **User agents** can form a team based on their queries or user profiles to place a common request at a number of brokers and pay only once.

2. **Broker agents** can make aboutness decisions cooperatively to obtain better efficiency

[1] Available from: http://www-nl.lycos.com/

[2] Available from: http://www.altavista.digital.com/

(filter teams) or to obtain better quality (using a structural hierarchy of composed brokers). In a non-negotiating way, MetaSearch[3] and MetaCrawler[4] are examples of the latter.

3. **Source agents** can cooperate if the information they carry is complementary or related, for instance. This can result in a structure not unlike a hyperindex (see e.g. [Bru93]).

Team formation is initiated by an agent incapable of achieving its goal or not making enough profit on its own. The agent has to search for agents with similar goals, so as to form a common goal which is supported by all the members of the team. In principle, a very large number of teams can be formated. The negotiations, from which agents can step down at any moment, has to establish a suitable team efficiently. When a team is formated, a team coordinator can be assigned to facilitate coordination within the team.

When a team of agents negotiates as a single party, the decisions of the team have to be supported by all the team members. For example, each agent in the team must be satisfied with its share of the total fee. Intra-team negotiations have to take place to establish this. The agents should take into account that the team can break up if one of the agents receives a better offer during the negotiations.

2.3 Other Negotiations in ID

Next to the basic IR and IF functions, possibly with teams, other forms of negotiation are possible in the ID paradigm. In all cases, all the parties involved should be better of in the end.

For instance, user agents can cooperatively expand their queries and user profiles. In addition, source agents can send out sample documents as advertisement material. Also, relevance feedback can be seen as a negotiation process. Merging of documents can also be viewed as a negotiation process. Next, agents can communicate about their domain knowledge. It is also possible for agents to form long-term contracts by forming coalitions. For example, a broker agent with specific domain knowledge can form a coalition with a source containing information about that specific topic.

[3] Available from: http://metasearch.com/

[4] Available from: http://www.metacrawler.com/

3 Other Aspects of Negotiation

This section touches upon a number of aspects of negotiation, seen from an ID perspective: coordination strategies, protocols, negotiation strategies, negotiation mechanisms, and properties of ID agents.

Conditions stemming from the ID context are: dynamics of agents influence population during negotiations (open environment), bounded rationality (due to e.g. limited computation time or reasoning capabilities about the enviroment), and privacy (obvious for users, also concerning competition). The negotiation strategies should be able to cope with these problems.

An important aspect of negotiation is the coordination among the agents. Basically, there are 3 forms of *coordination strategies*: centralized, decentralized, and multi-level coordination. Centralized coordination assumes a global manager taking care of the coordination. In decentralized coordination, the agents themselves carry this burden. Multi-level coordination, lying in between, can, for instance, assume a manager at every site. Because of the decentralized nature of the Internet, decentralized coordination seems most natural. However, tuning the retrieval performance fancies centralized coordination.

The type of messages sent during communication should carry all the information needed in the protocol used. The Contract Net Protocol, for instance, is not viable since it cannot cope properly with open environments (dynamics of multiple negotiations in ID) and bounded rationality (see [SL95]). An extension by Sandholm and Lesser supplies abstract payment and commitment functions. These will properly have to be filled in for the ID context. Payment can be defined in terms of complexity, efficiency, accuracy, etc. Commitment functions are applied to ensure a certain fairness (for example, to protect users from negotiation violating brokers).

Agents will apply *negotiation strategies* to implement their goal-directed behaviour. The strategies can be based on mathematics, or on heuristics, for instance.

The negotiations can be held according to several *negotiation mechanisms*. Examples are voting (majority, veto, etc.), auctions (English, Dutch, Vickrey, etc.), and contract negotiation. It has to be investigated which mechanisms suit ID: efficiency and privacy are required.

There are *properties of agents* which influence the negotiation. It must be investigated which properties are possible or needed for ID. Examples are benevolence (agents always do what is asked for by absence of conflicting goals), veracity (to communicate false information deliberately), rationality (act to achieve goals), and mobility (agents do not have a stable address).

4 Conclusions

We proposed an economic market paradigm for agent-based ID. It was shown about what issues ID agents can negotiate. The simple IR and IF tasks were set in this framework. Additional aspects of negotiation were touched upon from an ID perspective.

Additional research is needed for further investigation, but also for implementing and testing the ideas. On a theoretical basis, a *classification* of ID system can be made according to the types of negotiation they support. In this way, an ID system can said to be embedded (see [Hui96]) in another if the second system supports at least all the negotiation forms of the first.

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