Metadata-based Provider Selection in an Open Market Environment

Michael Christoffel
Institute for Program Structures and Data Organization,
Universität Karlsruhe
Karlsruhe, Germany
christof@ira.uka.de

Abstract

The success of the Internet and the development of worldwide electronic commerce opens the way to completely new market structures. However, finding the most appropriate provider for a given demand continues to be a major problem. This is especially true if the regarded product is information. The paper describes an approach for reliable provider selection based on metadata. Main concern is the design of a trader for an open market. The paper also shows a realization of this approach in an agent-based infrastructure for a market of scientific literature.

1. Introduction

The success of the Internet has opened the way to completely new business transactions. Nowadays, the Internet enables the connection of business partners all over the world and the exchange of huge amounts of information in fractions of minutes. An important part of electronic business is electronic commerce, buying and selling goods and services via the Internet worldwide. It is likely that the ratio of commerce transactions carried out electronically will grow during the next years [2].

Electronic commerce has pervaded nearly all trades, encouraging both traditional and new providers offering goods and services electronically. A consequence was the development of new markets and marketplaces with own rules and mechanisms.

One important upcoming market is the information market. Together with the development of an information society, information has become a valuable good. Many professions depend on the steady supply with newest information. Since information can be created, edited, copied, and distributed electronically, it is in a high degree suitable for electronic commerce.

These new markets need an infrastructure that allows the efficient use for both customers and providers. The idea is not only to imitate market structures that can be found in traditional markets, but also support the new and extended features that come along with the electronic markets. A special role within the infrastructures play (electronic) intermediaries which facilitate and mediate commerce transactions [1]. A theoretic discussion about intermediaries and their value in electronic markets can be found in [25].

The need for intermediaries is especially given in open market, where the market participants may enter and leave without further notice and market conditions (stocks, prices, quality of service) are highly dynamic. A major problem that arises in an open market is information overload. Although there is a large number of providers offering goods and services, the customer is unable to select the most suitable provider for his/her demand. Even if he/she knows some providers by chance, there is no easy way to compare them. The dynamism of the market makes this task even more complicated.

In this paper we deal with a fundamental type of intermediaries that remedy the lack of transparency within the market and assist the customer selecting the most appropriate provider. This type of intermediary is usually called a trader [5].

In the following section we will discuss in more detail the challenges of an open market, with a special concern on information markets. Section 3 introduces a concrete scenario of an open information market, namely the

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market of scientific literature. In section 4 we take a deeper look into our own approach for the design and the functionality of a trader. We especially discuss an approach of provider selection based on metadata, which will bring consequences for the construction of a trader. In section 5 we discuss the situation of having more than one trader in an market (which is probable in each sufficient large market). Section 6 shows a realization of an infrastructure for the selected scenario. Section 7 contains related approaches about the design of traders. We finish this paper with some conclusions and some ideas about future work in section 8.

2. Introduction

In this section we want to discuss the challenges that arise within an open market. The assumption of an open market is mandatory for an investigation of commerce mechanisms within the Internet community. Nevertheless, many electronic commerce applications enforce a restricted set of market participants, because in this case many problems can be neglected.

Assuming an open market, the market must be able to cope with the following conditions:

- The number of customers and providers is not limited.
- Market participants may migrate and immigrate without further notice.
- Providers may change their supply at any time: offered goods or services, prices, conditions.
- Market participants may be very heterogeneous.
- The location of market participants may not be restricted.

These conditions impede the work of traders: Even if a trader can survey the market at one moment, the situation may be completely different in the next moment. So it is very important for a trader to be able to react on the market dynamism.

Internet-based market form completely new market structures [27]. In this paper we will lay our focus on information markets.

In information markets, information itself is the good that is traded, opening a wide range of possible applications reaching from structured data such as share prices and readings of environmental data to semi-structured and non-structured data such as specifications in engineering and news. There is a series of qualities that differ information market from traditional markets:

- The cost for the production of the first copy of a piece of information may be very high, but the production of further copies is very low (just think of the production of a movie film). Due to this unequal distribution of costs, traditional pricing model do no longer work.
- Since information products can be modified very easy, it is possible for a provider to differ his/her goods from competitive providers. This makes it difficult for the customer to determine the differences between two products and to detect substitutes.
- Transport costs and times are relatively low, because an information product can be delivered either electronically or uncomplicated (e.g., a CD or a book). As a consequence, physical distances are not important.
- Quality of service is very important. E.g., the best and cheapest information delivered tomorrow is worthless if needed today. As a consequence, price is often not the dominant factor for the decision whether to buy or not.
- It is difficult for a provider to inform the customer about the offered information product. The customer can estimate the real value only if he/she knows this information, but then he/she has no more need to purchase it.
- Because of the large number of information products, finding the right product can be a more complicated process then the trade itself.
- Services around an information product (e.g., classification, evaluation, comparison) play an important role and are rewarded by customers.

For a detailed discussion on market structures and challenges within information markets, see [Sha99].

3. Introduction

In this section we want to illustrate an information market with a concrete scenario.

The success of the Internet also brought a change in scientific literature supply. University libraries and bookstores lost their monopoly in supplying scientists and students with literature. Now scientists and the students can access traditional libraries and bookstores all over the world, new digital libraries and Internet bookstores, and also completely new kinds of information providers such as delivery services and electronic journals. There is also a wide range of assisting services offering bibliographic information, author information, or citations. Search, order, and (partly) delivery can be done without leaving the work desk.

In this special market the problem of information overload can be observed clearly. Although it is possible that a customers knows which documents he/she wants to purchase and where he/she can get it, in most cases a customer only has a vague imagination of the document needed. And often the task is not only simply to find a suitable document, but also to meet conditions such as price, delivery ways and times, available languages, etc.. Especially the search for a document may be a limiting factor: Either the customer takes the first suitable document, e.g., at the local library, ignoring the advantages of the Internet age, or the customers tries to access all known sources sequentially in the hope to find the best (or cheapest) document, spending a lot of time and money for the search only.

In this paper we present a solution for the problem of information overload in this important market of scientific literature. However, we also give some clues for an application in other markets.

4. A Trader for an Open Market

A disadvantage of existing approaches regarding provider selection is the outstanding position of the trader. Commerce transactions are not possible without the trader, and the trader often has direct access to the provider's databases. However, this constellation is not desirable in an open market.

In this section we give a conception of a trader which has no need of a dominant position and may be treated as one service among others. An overview on different approaches for the conception of a trader can be found in [14].

4.1. Design of a Trader

The quality of a trader depends in a high degree on its knowledge about the providers in the regarded market. The idea in our approach is that the trader holds profiles of the available providers. These profiles are organized in the form of semi-structured metadata descriptions. Each trader may have its own set of attributes that may be used in the metadata descriptions. The metadata structure is not fix but may be modified during runtime. Usually, the profiles are created and delivered by the providers themselves.

It is obvious that the trader's capacity (and, as a consequence, its potential to survive in the market) depends directly on the quality and the relevance of the collected profiles.

The metadata-based approaches leads to a principle structure of a trader. Using a modular architecture, a trader can be designed having the following basic modules (for an illustration see figure 1):

- a coordinator which evaluates incoming queries and prepares them for query handling;
- a query handling module in which provider selection takes place;
- a profile handling module which enables the access on the metadata repository and the supply with the profiles used in query handling;
- a central metadata repository;
- a metadata management module which validates and updates the repository.

The trader bases on a communication infrastructures that is responsible for the delivery of messages within the market.

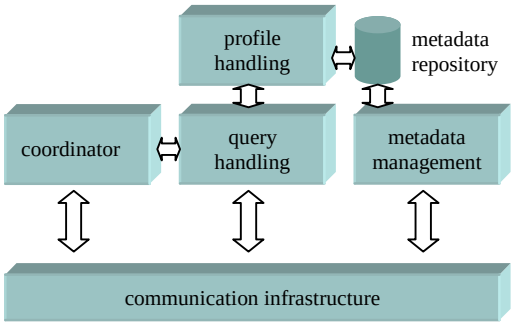

Figure 1: Main modules of a trader

4.2. Metadata Management

A trader must collect metadata covering different aspects:

- general information about a provider;
- locality of the provider;
- general information about the offered goods and services;
- information needed for a query to the provider;
- returned data;
- information about delivery and shipping;
- cost structure.

It is quite clear that it is not possible to use one and the same trader for all thinkable market, just because the requirements are too different (the adaptability of a trader should allow the trader to learn about the market, but it would fairly survive in a market without preparation). A discussion of the metadata needed in our sample market (scientific literature) can be found in [9]. However, the design of a trader should be independent from the market it is employed.

So one precondition is a metadata model that can be used to describe the profiles needed for the special market. In order to provide a maximal flexibility, each profile can be a combination of different attributes which have one or more value. It is possible that the values depend on other attributes. Attributes have a type which may be one of the (system wide) predefined primitive types (numeric types, dates and times, character strings, and term hierarchies) or a composition of other attributes.

The metadata repository has to be validated permanently to make sure that the market view of the trader reflects the real market situation at any time. This validation process encompasses four subtasks:

- The detection of new providers that have entered the market.
- The detection of providers that have left the market.
- The detection of changes in the offers of a provider (e.g., prices, delivery conditions, or extensions/restrictions of supply).
- The detection of wrong attribute values.

It is clear that those tasks are easy to perform if there is a notice from the provider about a change in its status or if the metadata delivered from the provider are always complete and correct. But the open market assumption does not allow to depend on the friendly behavior of other market participants.

Of course, the detection of new providers is only possible if these either contact the trader directly or leave their address in the market system. The trader may try to advertise its services publicly with the idea of getting the attraction of those providers that stay hidden. The detection of providers that have left is easier, since it is sufficient to hold contact to all known providers (using a kind of 'ping' mechanism).

The real challenge is the detection of errors within the profile of a provider. These can occur when the offers have changed or when the profiles delivered by the providers are - intentionally or unintentionally - incorrect. Of course, a trader may ask the provider in regular intervals for an update of the profile. But this does not guarantee that the delivered profiles are correct.

The trader has two principle ways to test the correctness of the metadata: Either it can send test queries to the provider, or it can ask the customers (or their representatives in the system). Important attributes that should be always correct are price information. In order to validate these attributes, the trader could send a test query to a provider, analyze the price being told by the provider and compare this its own estimation. Or it can ask the customers about the real costs they had to pay. Since the importance of the customer feedback, these notes should be sent to the trader regularly (improving the capacity of the trader is in the interest of the customers).

A third idea, tapping the communication between customer and provider, does not work, because a customer and a provider can communicate without knowledge of the trader (and customer and provider would not like the idea of being tapped).

Both methods described above can be used to generate new entries of metadata. This is important for attributes that are not delivered by the provider or which values are recognized to be incorrect. An extreme scenario is when the provider does not give any information about itself on its own. Even in this case the trader should be able to work.

It is quite obvious that the profiles available to the trader may contain gaps and uncertain values. It is also obvious that the different profiles may have a different structure. E.g., for one provider the complete pricing model is given, but for a second provider only the average price of past queries.

4.3. Query Handling

Query handling is based on the collected metadata. A customer query consists of assignments of "desired" values to selected attributes, and the query handling algorithm calculates the degree of conformity between the customer query and all available profiles. This conformity is composed out of conformity for each single attribute. Because if this, the traders hold for each attribute a separate conformity function. These conformity functions are also used to express the neighborship of values. A simple example: The conformity function should recognize that a provider offering a good for 1 Euro is more valuable for the customer than a provider offering the same good for 5 Euros even if customer is willing to pay 5 Euros. The selection algorithm is shown in [8].

The trader sends an ordered list with the names and addresses of the most relevant provider. It may add additional information or the complete profile.

On the first view, it may be surprising that the trader gives the addresses of the providers to the customer (and also additional information), instead of hiding these information and just offering a message forward to the provider. The reason is the competition among trader. The provider addresses and profiles are valuable for the customers. So when there is a trader that delivers theses information, they all would only use this trader and ignore the other traders that hide the information.

Customers can influence the trader recommendations by weighting attribute values and defining own (weighted) conformity functions.

The trader has also to be able to cope with attributes for which he has no values in the profiles. This is usually the case for those attributes concerning not the provider but one special product or service. The trader has two possibilities to react: It can ask all known providers, or it can project this attribute to another known attribute. An import example in the literature market is the keyword problem. It is quite usual that the customer starts his/her query with "Give me everything you know about …". However, this is a question a trader often cannot answer (unless it can perform a full text search in all the providers' databases). So one possibility is to ask the providers and analyze the results. The other possibility is to use a dictionary and try to find out what the customer is looking for. E.g., if the customer asks for documents about "data mining", the trader could recommend a library of computer science.

4.4. Contracts

Providers that are mediated by a trader have to register at this trader. This registration can be seen as a contract between provider and trader. The trader is authorized to give away information about the provider. However, the trader may also mediate other providers, and the provider may register to other traders. Registrations are only valid for a period of time, and the provider can decide whether to extend the registration or not.

A registration of customer is usually not enforced and not necessary, and the trader does not collect information about individual customers (it could try to collect customer data and sell them to a provider, but it would loose these customers). In some special cases, a customer registration may be reasonable.

4.5. Trader Financing

There are four different ways for the trader (or the organization that has installed the trading service, respectively) to collect money: charging customer, charging providers, receiving provisions, and advertisement.

Traders can charge customers for the recommendation of providers. E.g., they can ask the customer to pay for each given provider address. There are also other tariffs thinkable, e.g., flat rates for registered customers. The same way providers can be charged for being mediated by the trader.

Mediation fees can have a negative influence on the quality of the trader, e.g., causing it to select as many providers as possible, even if those are less relevant. So there should be a method of measurement the quality of the recommendation. One idea is to offer services for free but ask for a provision (either from customer or provider) when the trade has been made because of the recommendations of the trader. However, since commerce transactions can be done without the knowledge of the trader, it can not control that the provision will be paid.

A completely different idea of trader finance is advertisement. The trader could return, additional to the selected provider addresses and profiles, some advertisement material, e.g., information about other providers. Maybe, the customer can find this additional provider information useful. It is also possible that the provider simple will not read the advertisement material. So the providers who pay the advertisement have no guarantee about the use.

5. Systems with many Traders

It is quite obvious that in a sufficiently large market there will be more than one trader. These traders compete for customers and mediated providers. However, there are two good reasons why the traders should be able to work together:

- Remedy the customer's problem to select the most appropriate trader.
- Increase the quality of the trader's recommendations.

A trader should always endeavor to give the customer the best advice that is possible, even if this means that it has to share the profit. Otherwise it would risk that the customer will change to another trader.

However, it is rather unlikely for a trader to know and to mediate all available providers in the market. Most providers will have their favorite traders, and traders will try to bind the providers by exclusive contracts. So cooperation will be the only way to be sure to find the best available trader for a special query.

So the trader design has be modified to support cooperation. We use the same mechanism we already use in the isolated case. Each trader collects profiles of the other traders known to it. When the trader detects during query handling that another trader may be relevant for a given query, this query is forwarded to the trader. The results received will be merged together with the own results giving a common result list. When a trader receives an assisting query from another trader, this query is handled the same way as a query sent by customer, and the results will be sent back to the trader which has sent the assisting query.

Of course, a trader may ask more than one trader for assistance. Moreover, because an assisting query is treated

like a customer query, it may be forwarded to a third trader, and so on.

The advantage for customers and provider is obvious, since the quality of the recommendation will be improved. And also providers have a clear advantage, because they will be found by those customers that are interested to buy the offered goods and services. However, a precondition for the work of the idea of cooperation is the existence of trust and reliability among the traders.

There is a large range of different models for traders to guarantee a level of reliability, reaching from bilateral arrangements to trader federations with fixed relations between traders [11]. Independent of the fact whether there is a loose cooperation or a fixed federation, it is important in an open market that both the relations between two traders and the entire structure are dynamic and may be modified at runtime. This enables the trader to change its strategy towards cooperation when the market conditions change.

An important new idea which comes up with trader cooperations and federations is specialization. This gives the trader the chance to become an expert in one area. But also here the precondition is trust and reliability among the community of traders. The trader must be sure that it will receive all messages concerning its special area and that it can forward all other queries (without annoying customers). Most likely, specialization will only work within a trader federation.

6. Realization

In this section we will show a realization of our approach in the implementation of an infrastructure for a special information market, namely the market of scientific literature.

This work is done within the UniCats project, which is a common research project of the Institute of Program Structures and Data Organization and the University Library in Karlsruhe [7]. The project is funded by the German Research Foundation (DFG) as a part of the national strategic research offensive “Distributed Processing and Exchange of Digital Documents (V^3D^2)”.

6.1. Agent Infrastructure

Basis of the UniCats system is the UniCats environment, a framework of independent UniCats agents [10]. Figure 2 shows the layered structure of a UniCats agent.

The communication layer implements two different ways off communication: Directed communication works between two agents; group communication works between all agents or a group of agents. Both ways of communication base on TCP/IP. This protocol is available for nearly all computer systems and hardware platforms. All communication transactions are performed by the exchange of XML documents.

The intermediate layer implements message encoding and decoding. Basic transactions such as acknowledgements and status reports can be handle within this layer. All messages are treated as instances of the Message type and its subclasses.

The agent layer may differ from one agent type to the other and contains all the communication transactions that are available to the agent type.

The application layer contains all the algorithms and the logic of an agent, and also the agent’s interface towards a human user. This layer may be individual for each agent.

6.2. Architecture

In addition to the traders described in detail in this paper, we have implemented two other agent types as representatives of customers and providers.

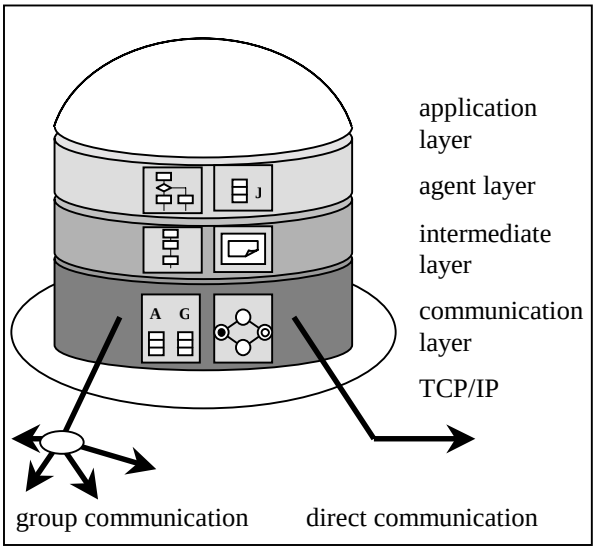

Figure 2: Structure of a UniCats agent

User Agents [25] are the connection of the customers to the system. They provide a uniform user interface for all services that are available within the environment and assist the customer in the formulization of his demand. Incoming results and offers are integrated, evaluated, and presented to the customer, who can use them directly or as a basis for continuing queries. Integration of results is a major task for literature resources, because it can be difficult to decide whether two document offered by two providers are identical or find the differences (e.g., the issue). Figure 3 shows different views of the user interface.

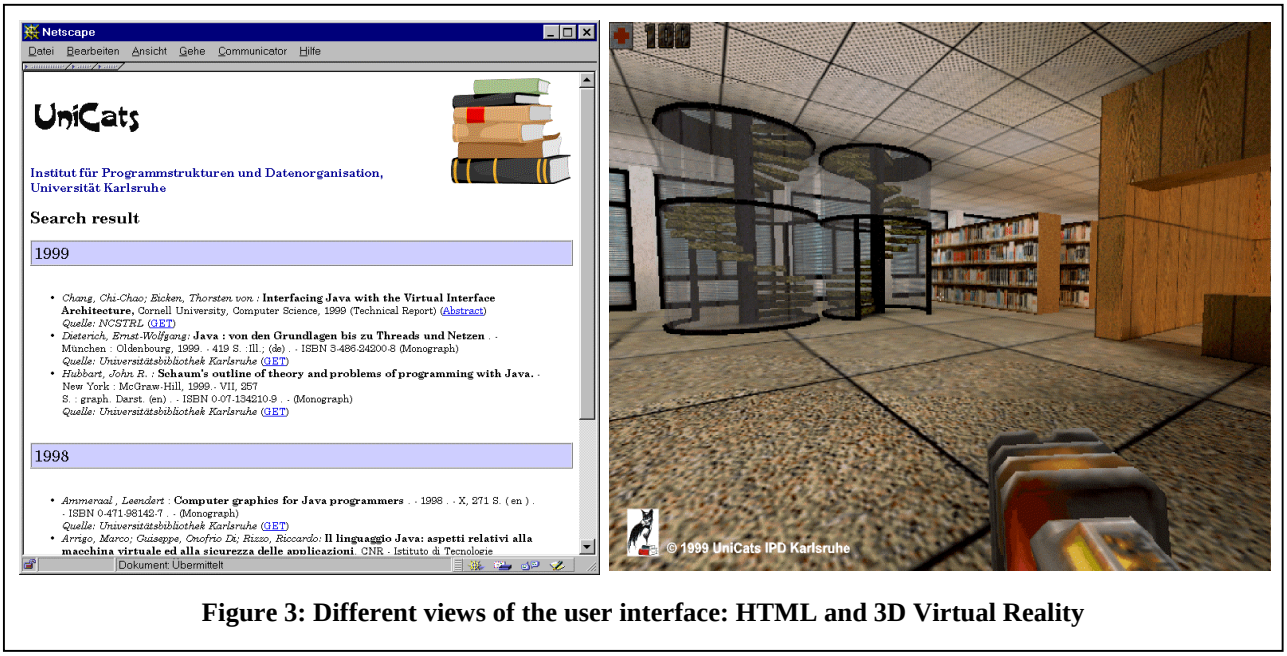

Figure 3: Different views of the user interface: HTML and 3D Virtual Reality

Wrappers are the connection of the providers to the system [23]. They transfer queries into the native protocol of the provider and re-transfer answers back into the uniform protocol. Our main concern in the design of the provider connection was the reductions of requirements for the provider. Because of this, our wrappers need no other provider side access than an HTML interface, which practically every provider already has. In order to optimize the functionality of query execution, wrappers are tailored for an individual provider semi-automatically with the help of a wrapper generator [22].

Figure 4 shows the teamwork of the three agent types. However, although there are good reasons for an agent to cooperate, all the agents joined in the UniCats environment are independent and principally competitive. This gives the system a high level of robustness. The complete system will not be blocked by a failure of a single agents (e.g., the user agent will find another trader, or the trader will find another wrapper for a provider).

7. Related Work

An early and important approach for the design of a trading service in a distributed and open system has been done in Canberra and Queensland in connection with the idea of open distributed processing (ODP) [4]. Although the application field has been restricted to object trading in distributed system, most of the ideas can be transferred to electronic commerce applications [6]. A trader is described as an object receiving service offers from a exporter and service request from an importer. Service selection has been done by a matchmaking process using a trading function. The trader is bound to importers and exporters by special contracts. The approach also foresees cooperations of traders joined in decentralized federations.

The DRYAD project in Helsinki continues the idea of traders linked with service importers and exporters by contracts [15]. A major extension is the control of the trader's behavior by the choice of different trading policies. Cooperation between traders can be established by trading communities sharing trading domains. The approach contains first ideas of electronic commerce applications [16].

The idea of AI-based trading, which has been developed in Frankfurt am Main, refines the previously mentioned idea by basing service matching not on simple service specification but on a high-level language, improving the capacity of the trader [20, 21]. The disadvantage of this method lies in the complexity of the used conceptual graphs, which makes the definition of services difficult and the application error-prone.

The work in Hamburg (TRADE project and others) aims on an extension of the ODP trading model for a service mediation in open systems [18]. Ideas for an application of the trader for electronic commerce applications are given within the Common Open Service Market (COSM). The approach also considers different kinds of trader cooperations [19].

The Stanford Digital Library Project presents a framework of different services for the access and the work with digital libraries. Provider selection enforces a direct access to the providers databases and is restricted on content-based criteria [13, 14]. However, first approaches

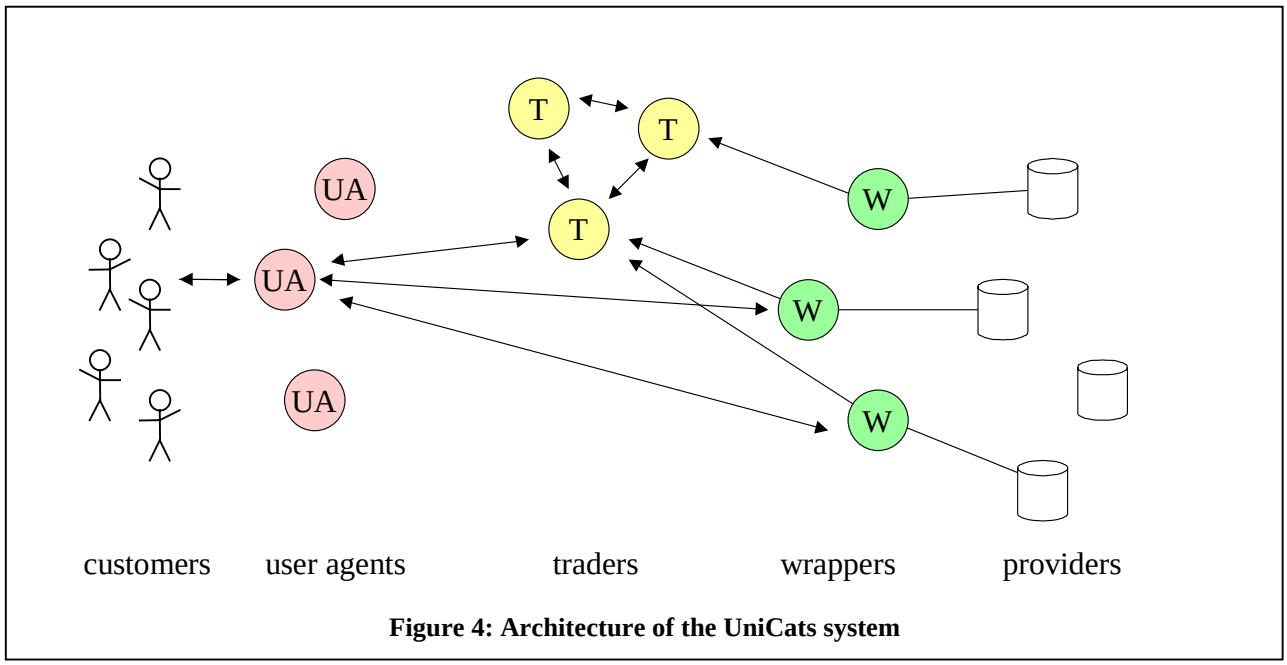

Figure 4: Architecture of the UniCats system

for a metadata architecture are given [3]. The Stanford Digital Library Project does not consider a market environment.

The Medoc project has created an architecture for the integration of digital libraries under the assumption of a (restricted) market. Provider selection uses a ranking process based on the estimated costs for the access on the information source [12].

8. Conclusion and Future Work

In this paper we have presented an approach for effective provider selections within an open market. The trader described in this paper allows to mediate between a large number of different customers and providers without restricting their independence.

The most important features of the approach are the implementation of providers selection in an autonomous and neutral market instance, the metadata-based query handling, the set of methods for metadata generation and validation, and the ability of cooperation between competitive traders. We have shown a realization of our approach in an infrastructure for a selected important market, namely the market of scientific literature.

We will continue the work on the investigation and the support of open market structures. Our main concern will be information markets, because of their growing importance. We already have started first simulation studies about the rules and mechanism that can be found within information markets. More simulations series are planned and also surveys and tests with human customers.

We want to extend the UniCats architecture. One main task is the extension of the infrastructure, adding encryption and secure data transfer. New agent types are planned for decision support, certification, and payment.

A continuing idea is the application of our approaches to other markets and scenarios.

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