An Agent-Based Framework for E-Commerce Information Retrieval Management Using Genetic Algorithms

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The paper addresses the issue of improving retrieval performance management for retrieval from document collections that exist on the Internet. It also comes with a solution that uses the benefits of the agent technology and genetic algorithms in the process of the information retrieving management. The most important paradigms of information retrieval are mentioned having the goal to make more evident the advantages of using the genetic algorithms based one. Within the paper, also a genetic algorithm that can be use for the proposed solution is detailed and a comparative description between the dynamic and static proposed solution is made. In the end, new future directions are shown based on elements presented in this paper. The future results look very encouraging.
***Keywords**: Mobile Agents, Information Retrieval Management, Genetic Algorithm*

1 Introduction

In today's dynamic business world from everywhere, companies need to be innovative and always adapted to the daily reality in order to be able to respond to the constantly changing needs of the market and the customer force and terms, and to withstand competition that become more and more aggressive. This has lead to the emergence of virtual organizations. A virtual organization, often referred to as a virtual enterprise comprises a number of stakeholders that forge a consortium dynamically in order, for instance, to meet customer need and demand, offer new or improved services. The stakeholders may have common, compatible, overlapping or complementary goals, therefore joining forces and operating under one hood enables them to achieve these goals. Streamlining, coordination and integration of operations are central to the concept of a virtual organization.

Business has taken advantage of networking facilities in order to improve communications and the efficiency of their operations. The idea of conducting transactions electronically is not new; many companies have integrated their systems with those of their suppliers and distributors using proprietary networks for electronic data interchange (EDI), called values-added networks (VAN) [1]. However, such networks are static and therefore inflexible: should company decide to change a supplier or distributor, a new and perhaps costly EDI connection needs to be established. In addition, the cost involved in building such proprietary network is prohibitive for smaller business that cannot afford to spend money from the profit for these kinds of networks.

One of the advantages of using the Internet and e-commerce technology is that organizations are in a position to streamline their operations with their business stakeholders, such as suppliers as well as clients. Organizations can interact with other partners seamlessly, and thus increase their effectiveness and efficiency. For instance, the various operations involved in supply chain management, keeping track of supply and demand, procuring raw materials, inventory tracking and order management, can greatly benefit from the use of e-commerce system. This leads to improved relations between business partners.

Another aspect related to Internet and E-commerce technologies, is the cost of storage devices that continues to decrease, their capacity that increases and that is why today there is a tremendous growth in databases of all sorts (relational, graphical, and textual) [2]. Knowledge intensive organizations have vast array of information contained in large document repositories and warehouses. With

the advent of E-commerce and corporate intranets/extranets, these repositories are expected to grow at a fast pace. This explosive growth has led to huge, fragmented, and unstructured document collections that become heavier to deal with.

It has become easier to collect and store, information in document collections, it has become increasingly difficult to retrieve relevant information from these large document collections. Various methods and techniques have been used by specialists to address the issue of improving retrieval performance management. This paper tries to show how genetic algorithms can be used in the field of information retrieval and which the differences between a static are and a dynamic approach, used to match documents descriptions with a set on input data given from an interface by the user and how agent can work to find the most representative results.

2 Agents, Genetic Algorithms and Information Retrieving Paradigms

Agents are computational systems that are capable of autonomous, reactive and proactive behavior, and are also able to interact with each other. The application of agents in E-commerce is one of the fastest-growing and most exciting areas of computer science.

Architectures based on intelligent agents offer several benefits as: reusability, flexibility, less resources use to achieving the application goals, dynamic software component selection, and programming is easier, maintainability and customizability request less time. Also other important benefits of agent technology are that there are necessary less code lines to complete the software application and the user spends less time and effort for having the requested answers. Agent technology has key roles in distributed computing environments such as mobile and pervasive computing, E-commerce, E- services, E-business, infrastructure activities, and the transport and telecommunication services management.

Genetic algorithms may be used in cases where the search space is very complex, and hard to understand, no mathematical analysis is available, classical methods search methods fail to offer an answer.

The most important benefits of using Genetic Algorithms are that they can handle many constraints types and objectives and they are able to discover good solutions rapidly for difficult high-dimensional problems.

The rule that must be apply for software applications that use intelligent agents and genetic algorithms is that: the requested solution to be a sufficient and near the optimum one and not be the best one.

The agent technology and genetic algorithms are enabling individuals and business to take advantage of the new and powerful medium of the World Wide Web.

Information Retrieval System is a system used to store items of information that need to be processed, searched and retrieved corresponding to a user's query. Most Information Retrieval Systems use keywords to retrieve documents. The systems first extract keywords from documents and then assign weights to the keywords by using different approaches. Such a system has two major problems. One is how to extract keywords precisely and the other is how to decide the weight of each keyword. This research presents a solution that uses mobile agents with genetic algorithm incorporated to find the most relevant document according to input date given by the user. An Information Retrieval System is basically constituted by three main components, whose composition is introduced as follows [3].

Vector space model. In this model, a document is viewed as a vector in n-dimensional document space (where n is the number of distinguishing terms used to describe contents of the documents in a collection) and each term represents one dimension in the document space. An input data set of the user is also treated in the same way and constructed from the terms and weights provided in the user request. Document retrieval is based on the measurement of the similarity between the query and the documents. This means that documents with a higher similarity to the query are judged to be more relevant to it and should be retrieved by the Informa-

tion Retrieval System in a higher position in the list of retrieved documents. An algorithm like Fuzzy *c*-means clustering may be used in this method, and after that the documents can be presented to the user according to their relevance to the search.

Probabilistic model. The probability theory may be used by this model to build the search function and its operation mode. For making the information search function is used the distribution of the index terms throughout the collection of documents or a subset of it. This information is used to set the values of some parameters of the search function, which is composed of a set of weights associated to the index terms.

Learning systems based information retrieval. This approach is based on algorithmic extraction of knowledge or identifying patterns in the data. There are three broad areas within this approach: Symbolic learning, neural networks, and evolution based algorithms [4]. In the symbolic learning approach knowledge discovery is done typically by inductive learning by creating a hierarchical arrangement of concepts and producing IF-THEN type production rules. ID3 decision-making algorithm is one such popular algorithm.

Neural networks are connectionist learning algorithms that typically simulate the way human brain learns and remembers knowledge. In these algorithms knowledge is captured and remembered in terms of the weights on synapses, the interconnections of the neurons, and the thresholds on logic units. A. Belew used a neural network of authors, index terms, and documents to produce new connections between documents and index terms.

Evolutionary algorithms are based on the Darwinian principles of natural selection. These algorithms can be further divided into: genetic algorithms, evolutionary strategies, and evolutionary programming. While evolutionary programming utilizes changes at the level of species, the evolutionary strategies exploit changes at individual behavioral level. Genetic algorithms are based on genetic operators of selection, crossover, and mutation. There are a few studies in information retrieval literature that use genetic algorithms. This paper fits well in this paradigm. It will be used genetic algorithms to adapt matching functions that are used to match document descriptions with input data set by user through a specific interface.

3 An Agent Proposed Framework for E-Commerce Information Retrieval Management

3.1 Intelligent agents and information retrieval systems

A framework for clever information retrieving may be seen like a multi-agent system that has specific components, each one with its goal. In the most cases, the information must to be retrieved from the internet, a space where an amount of information must be searched for newer results. Referring to the clever retrieving framework of information in Internet (fig.1), it is possible to observe the presence of mobile agents making the research activity starting from a set of input information, seeking for links of such information and evaluating them through some clever evaluation algorithms as the fuzzy logic, mainly used for the searching for web pages similar to the entry ones, given by the user.

During its life the agent works in many hosts and gets over the limits borne by the presence of different processors and operating systems: in order to be executed it is not necessary for the agent's code to be preventively installed on every host it has to visit, but it is enough that the host supports the mobile agents.

The mobile agents using genetic algorithms have, as their main purpose, the reduction of the useless information transfer, which yields the decrease of the net traffic.

The "Processor" is the application responsible to produce and to classify the URLs database and to manage the interfacing and the execution programs.

It is possible to move to the user interface, inside the mobile agent, the software parameters of the genetic and of the evaluation algorithm, as well as the precision rate and the

mutation parameters.
In the "processor" moreover, a keywords extend can be implemented through its decomposition in several semantically homogeneous entities. The group of keyword just obtained feeds a suitable database called "relative keywords database".

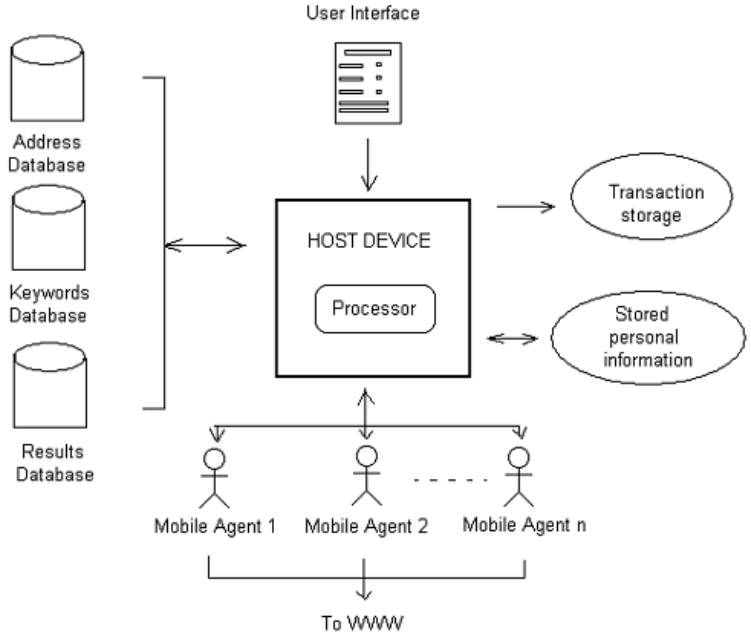

Fig. 1. Agent based Framework for information retrieval

In figure 1, a logical database division is shown: address database containing the address of the pages to be searched, searching result database concerning the results, relative keyword database containing the addresses of the pages to be searched, searching result database concerning the results, relative keyword database containing the keywords as above mentioned.
The task of the "user interface" is to initialize the requests for extraction made by the user and to show the achieved results.
Transaction storage is meant to register all the transaction made by the users. Base on these records a user profile may be done. As a consequence, if the user in the future will have his own personal agent, the agent will know better what and where to search and how big the user satisfaction level is for each solution agent returns.

3.2 Algorithm details for the proposed approach

Within the propose solution, there is an agent that will use a genetic algorithm to accomplished his tasks. The advantage of using it in the diagram is that is contribute to decrease the time response for obtaining the final results In other words, an intelligent mobile agent is used for genetic research task works in steps as follows [5]:

- current set initializing: the set of input documents, representing the pool of the current solutions, are first submitted to indexation and then to a process of keywords extraction.
- the documents found through the links of the elements of the current set are compared with the input objects for similitude through the "fuzzy" analysis algorithms, and the best ones among them are inserted in the current set.
- a new set of solutions is produced by genetic operators: a set of URLs is selected by its database in a random way, it is inserted in the current set and the best document among those ones is chosen in order to add it in the output set. All the documents linked by this last one, which is by the element promoted at the new generation, are added in the current set.
- the second and third steps are repeated,

till the output set reaches the prearranged dimension or the current set turns out to be empty.

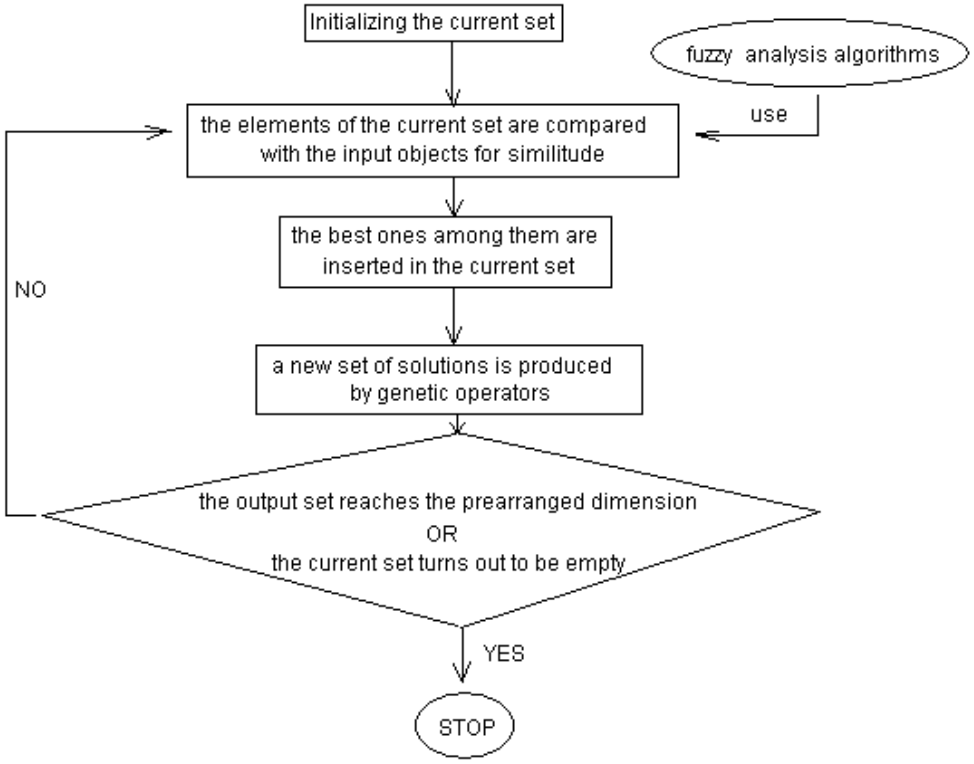

Fig. 2. Steps for a genetic algorithm

For the second step the **Fuzzy *c*-means clustering algorithm** may be used [6]**.** This algorithm is a derivative of k-means algorithm. In fuzzy clustering point has a degree of belonging to clusters, as in fuzzy logic, rather than belonging completely to just one cluster. Thus, points on the edge of a cluster may be *in the cluster* to a lesser degree than points in the center of cluster. For each point x we have a coefficient giving the degree of being in the j-th cluster $u_j(x)$. Usually, the sum of those coefficients for any given x is defined to be 1:

$$\forall x \left(\sum_{j=1}^{ClusterNumber} u_j(x) = 1 \right). \quad (1)$$

With fuzzy *c*-means, the centroid of a cluster is the mean of all points, weighted by their degree of belonging to the cluster:

$$centroid_j = \frac{\sum_x u_j(x)^m x}{\sum_x u_j(x)^m}. \quad (2)$$

The degree of belonging is related to the inverse of the distance to the cluster center:

$$u_j(x) = \frac{1}{d(centroid_j, x)}, \quad (3)$$

then the coefficients are normalized and fuzzyfied with a real parameter $m > 1$ so that their sum is 1. So,

$$u_j(x) = \frac{1}{\sum_k \left(\frac{d(centroid_j, x)}{d(centroid_k, x)} \right)^{2/(m-1)}} \quad (4)$$

For m equal to 2, this is equivalent to normalizing the coefficient linearly to make their sum 1. When m is close to 1, then cluster center closest to the point is given much more weight than the others, and the algorithm is similar to *k*-means.

The fuzzy *c*-means algorithm is very similar to the *k*-means algorithm:

- choose a number of clusters;
- assign randomly to each point coefficients for being in the clusters.
- repeat until the algorithm has converged

(that is, the coefficients' change between two iterations is no more than ε, the given sensitivity threshold) : compute the centroid for each cluster, using the formula above; after that, for each point, compute its coefficients of being in the clusters, using the formula above.
The algorithm minimizes intra-cluster variance as well, but has the same problems as *k*-means, the minimum is a local minimum, and the results depend on the initial choice of weights. The expectation – maximization algorithm is a more statistically formalized method which includes some of these ideas: partial membership in classes. It has better convergence properties and is in general preferred to fuzzy-c-means.
Based on this, the document information is quickly found and the agent is looking for results in fewer datasets. The datasets will be divided based on mentioned algorithm in clusters.

3.3 The dynamic agent based approach for information retrieving management

When the documents in the pool of interest contain several links, this approach can be very slow because in order to choose the best elements of the current generation, all the documents belonging to it and the ones pointed by it have to be evaluated.
In the research algorithm presented above, some elements as the quantization of the search quality, the selection of the elements that have to be promoted to the new generation, the representation of URLs string, the crossover and mutation operators assume particular importance.
As regards the URL representation, that is the address of an Internet document; it represents a first coding of the possible solutions for the genetic seeking algorithm. This representation is divided into fields of different length and meaning: the first one is the Internet protocol, the second one is the server's address (net's denomination, server denomination, Internet protocol organization) and the third one provides information about the routing path from the root server to the document at issue.
The crossover and mutation operator allow the passage from the current generation URLs towards those of the next one: a "gene" is randomly chosen inside a string, to be modified in order to obtain a new "allele", allowing the identifying of the new string and the new URL that is very similar with the initial one.
The task of the "fuzzy" analysis algorithm is to count the occurrences of the keywords, and of the words related to them in the document at issue, and to attribute to the document a "weight" in terms of evaluation proportional to such occurrences. Among the numerous analysis algorithms, this one is characterized by a low time of evaluation.
In the multi-agent platform used for the clever search presented above, the mobile agents are sent in the sites where the useful documents are stored and where they implement the evaluations taking back only the results. The genetic evaluation algorithms apply the "temporal locality" and "spatial locality" principles. This last one means that all the explorations are implemented in the environments close to server where the father-document is located such as the same server or the local network; the "temporal locality" instead refers to the conservation of the elements according to the foreseen results and to the application to a subset of such elements of the mutation operator.
The mobile agents are sent to more than one site at the same time; they execute the documents evaluation in parallel on remote servers and only the results are sent to the home server. The technique just explained brings good results in the terms of times of return, memory utilization and network traffic.
A scheme of a possible implementation is presented in figure 3, where the continuous lines show the data flow, the dashed ones indicate the control flow, the rectangles identify the applications and the ellipses show the input and the output data.

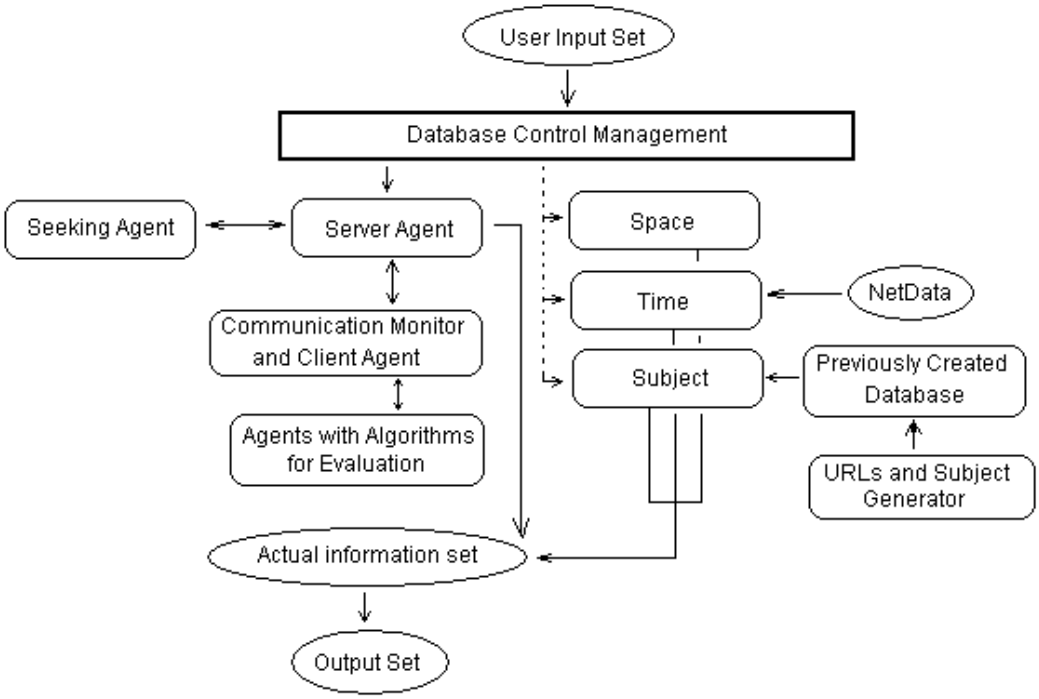

Fig. 3. Block diagram of the dynamic implementation

In particular blocks are distinguished in some characteristics that are specific for each module in its way:

- Database Control Management – coordinates the static and dynamic application of mobile agents systems. It is responsible for the management of database described above: it looks for every element of the output database in the Net Data. If the search has a positive result, the counter is increased by one unit; vice versa the element is inserted in the Net Data after having set its counter value equal to one; in the overflow case, that is when the Net Data touches its defined maximum dimension, the elements having the counters with lower values are cancelled in order to create new free space.
- Server agent – is the application executed in the local server for the coordination o several mobile agents placed in the remote servers, and for signaling the best documents suitable for the output.
- Agents with Algorithms for Evaluation – is the application having the evaluation algorithms sent to the remote server, which will feed back only the results of such evaluation
- Communication Monitor and Client Agent - allow the communication between the Server Agent resident in the local host and the several Agents with Algorithms for Evaluation resident in the remote sites. In particular, if the used platform is the Concordia it is possible to use some of RMI (remote methods invocation) to keep the Server Agent and the Agents with Algorithms for Evaluation informed about the messages delivering.
- Subject – is the application that implements the mutation; its task is to select the URLs by the previously created database and to insert these ones in the current set.
- URLs and Subject Generator – is the application producing the URLs database. This database is used for the mutation and each of its elements is constituted by two fields: URL and subjects. The input parameters of the applications are stored in this field.
- Seeking Agent – is the application used to seek for the documents in the “best ones” set received from the Server Agent. The documents are stored inside the local disc: a new folder is created for each remote server containing hyperlinks to the documents on the local disc.
- Space – is the application responsible for the mutation performances; it uses the spatial locality principles. If a genetic algorithm

looks for an element having a high value of adaptability on a determinate site, it is possible that some similar documents are located there or in the close network. In a circumscribe area of the network it is therefore possible to find the addresses of documents concerning our seeking.

-Time – is an application referring to the temporal locality principle that takes part in the mutation process; it has a database containing URLs coming from the output database and it also has a variable whose value refers on the number of times each URL is present in a given set. The mutation process is implemented through the insertion in the new-generation output database, of URLs with a higher counter.

An important aspect of Communication Monitor and Client Agent, Server agent and other agents is represented by the communication between agents. The communication is assured by the KQLM (Knowledge and Query Manipulation Language (KQLM) ([7], [8], [9], [10]). It is a high-level, message-oriented, communication language and set of protocols for information exchange. In fact, KQLM is a language based on speech act theory. It consists of three layers: the content layer, the message layer and the communication layer (figure 4).

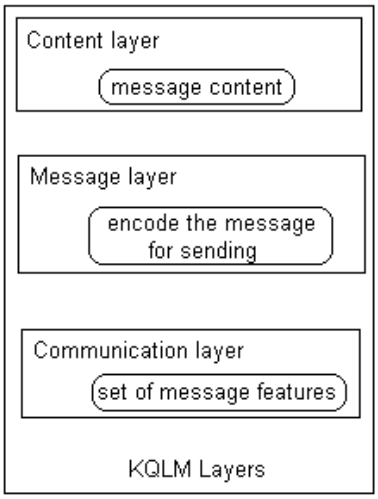

Fig. 4. KQLM Layers

The communication layer encodes a set of message features that describe the lower-level communication parameters, such as the identities of the sender and addressees and a unique identifier associated with the message. The message layer is used to encode the message to be sent. This layer specifies the speech act or function that the sender attaches to the content and sends to the addressee. It also includes optional features such as the content language or he ontology used, among others. The content layer includes the content of the message itself. This can be in any representational language.

KQLM has its own keywords with reserved meaning, the most important of which are given. An example of a KQLM message that may exist in the propose framework and that use the "tell" function is the following:

(tell
:sender Agent001Server
: receiver Agent005Mobile
: in-reply-to message-no-M0023
: language KIF
: ontology onto1
: content (URL-Id 823 www.itshop.com))

The interpretation of tell function is: the message is sent by "Agent001Server" to "Agent005Mobile". The message is a reply to a previous message "message-no-M0023". The language used to write the content of the message is "KIF" using the "onto1" ontology. The message itself is (URL-Id 823 www.itshop.com) which represents the information that the name of the URL with id 823 is www.itshop.com.

The function "tell" asserts what follows

":content". The values in ":in-reply-to", ":sender" and ":receiver" are the communication layer, the values in ":language" and ":ontology" comprise the message layer, and the value in ":content" is the content layer. The use of the ":in-reply-to" keyword indicates that this message is sent by "Agent001Server" to "Agent005Mobile" in response to a previous message which must have been a query.

3.4 The static approach of the project

To evaluate the mobile agents' positive contribution in a generic research algorithm it is needed to consider the static implementation of the same project presented in the initial figure, where the "Database Control Management" has been replaced by the "Database Control Tasks" that keeps only the tasks linked to the static components of the first one. The "Seeking Agent" activities also become different; in fact it does not look for the "best documents" for the output (as we said in the previous case) any more, but it also implements a wide ray searching in Internet.

As it can be seen in Figure 5, The Server Agent is in the same block with Seeking Agent. Still, the Seeking Agent has the role to seek for documents in the "best ones" set, but for this time, it is also in the same module as the Server Agent and the communication it is made in a local mode. The documents are also stored in the local disc and a new folder is created for each remote server containing hyperlinks to the documents on the local disc.

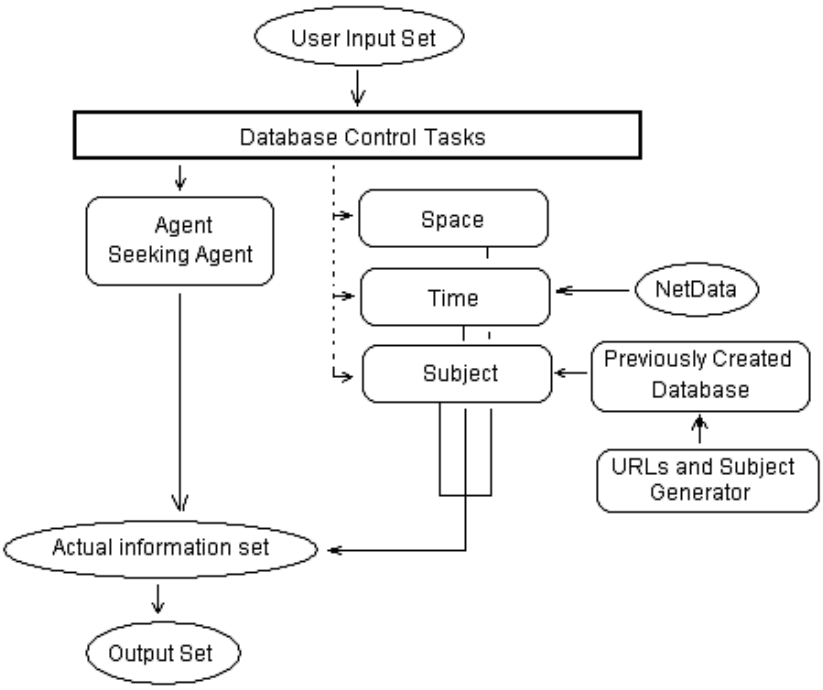

Fig. 5. Block diagram of the static implementation

Comparing to the initial structure, the static one, Agents with Algorithms for Evaluation module is no longer present. This will make to increase the time response and the used resources for finding the final results.

In this way the overhead rate is high because all the documents are taken to the home server, off-line examined and evaluated, so that enormous memory space is taken up.

In the mobile agent system, the evaluations are executed in the server where the documents are stored, and only the "Agents with Algorithms for Evaluation clones" can go through the net; this yields a decrease of the amount of the memory used and of the net traffic. The net result is a decrease in runtime and an increase in an information transfer quality.

It is furthermore observable that the "time of return" is in inverse relation both to the search paralleling process and to evaluation degree.

4 Future directions

This work has introduced a new perspective to the area of matching agents' adaptation in information retrieval. Prior research in information retrieval has focused on document information and agent technology for obtaining the final results. It has been shown that genetic adaptation of matching agents can lead to improved retrieval performance. The aspect of large data store spaces that lead to amount of data bigger and bigger that will be very hard to control and to use for decision making. More work, however, needs to be done in this area.

The presented algorithm seems to work well within the presented framework. It is also necessary to test this algorithm on different document collections to see how it performs with scaling both in sizes of the database and in the features available.

The presented model requires only the retrieval values specified in the input dataset associated with a document. That is way the propose model may be used for a multitude of retrieval methods based on agent technology.

The described agents may be set-up according to the administrator indications and to the user preferences. Al variable may be defined for having a quantification of the user satisfaction level for the results that hi gets.

Current research in information retrieval focuses on adaptation of an individual subsystem. In future it should be possible to combine the new genetic algorithms with agent technology best features. It is to be noted that mobile agents and genetic algorithm are complementary to each other. We do not necessarily have to choose any one of these approaches over the other. Both of them can coexist in an information retrieval system. From a practical perspective, mobile agents and genetic algorithms can be executed during the user's query session. Document adaptation involves changing document descriptions for thousands of documents, which is a time consuming process.

Our research combines various types of agents available by combining them. Another promising area could be to see, if rather than using an input set every time, an agent may be set to make these datasets, according to the user profile. This evolution of novel intelligent agents could be done using genetic programming type of techniques by appropriately combining various features (e.g. access number, document rate, appearance frequency, document frequency, paragraph lengths, availability of tokens in the titles etc.) utilized in retrieval.

5 Conclusions

Partially or fully automating some of the processes involved in e-commerce will bring about significant cost saving. Although the choices and opportunities for individuals and organizations have increased dramatically, unless they can actually locate these opportunities – clients, markets, potential partners, openings in the market - they will be unable to take advantage of them. Using agents, an organization can truly do business 24 hours a day and take advantage of opportunities as they arise, even if they present themselves in different time zones or continents. As a software agent can search tirelessly for the best matches globally, the costs of searching for partners or products can be minimized and efficiency can thereby increase. The searches that these agents can perform on behalf of the user can be intelligent searches, involving visiting a number of sites in order to extract the required information, match the user's preferences and find the best possible deal. Such agents can undertake one of the most time-consuming tasks, which is that of negotiating the terms of the transactions and contracts. Agents can make good decisions fast, again minimizing costs and improving overall economic efficiency without necessarily involving humans. Agents can also be used to offer personalized services to users.

Agent technology and genetic algorithms represent powerful tools in the management of virtual organizations. Agents representing different entities such as manufacturers, suppliers, service providers, brokers, and other partners, can take advantage of new opportunities and changing circumstances in markets and organize themselves into virtual or-

ganizations or enterprises to achieve temporary objectives. Although consisting of a number of autonomous and independent partners, the individual organization acts and appears as a single conceptual entity to any other third party that will be dealing with it, therefore integration and coordination are fundamental issues. Agility and the ability to respond to constant change in an unpredictable environment is what characterize virtual organizations. Genetic algorithms offer fast solutions that may be included in the agent software, making them become very efficient to return the best results in a very short time.

As the technology matures, more and more complex tasks will be delegated to software agents, who will become an indispensable part of an increasingly open, free-market information economy. Agent technology can reduce the costs of trading and thus, increase market efficiency and profitability, trading volumes, as well as the speed of trading. Agents can enable the move from traditional brick and mortar companies to intelligent and ubiquitous business. The vision is that agents will evolve from being simple facilitators to complex and autonomous decision makers handling incomplete, inconsistent information in real-time and making complex but good decisions.

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