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Communication and Services in Open Networks

Kommunikation och Tjänster i Öppna Nätverk

1999 - 2002

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Abstract (aim, method, results):
The project has conducted research grounded in an agent perspective within social information refinement, anthropomorphic interfaces, decentralized recommender systems, e-trading, resource markets and user controlled service collaboration. Research has been conducted both on a theoretical and a practical level. Prototypes and models have been developed within all areas to explore – and verify – theories and designs. In some cases this has resulted in publicly available open source software, e.g., software related to the Trading Agent Competition (TAC) or the personal service environment sView.

Dissemination of project results has been made through university courses and active participation in the national and international research communities. The project has produced 27 publications in the form of conference papers, book chapters and journal publications. The agent perspective has been successfully applied within areas ranging from e-trading to interactive fiction. Experiences gained from this research have confirmed the versatility of agent based technology and has led to deeper theoretical and practical knowledge within the field.

Referat (syfte, metod, resultat):
Projektet har bedrivit forskning utifrån ett agentperspektiv inom områdena social informationsförädling, antropomorfa gränssnitt, decentraliserade rekommendationsystem, automatisk Internethandel, resursmarknader samt användarkontrollerad tjänstesamverkan. Forskningen har bedrivits på ett teoretisk såväl som ett tillämpat plan. Inom samtliga områden har prototyper och modeller tagits fram i syfte att utforska och verifiera teorier och designideér. I vissa fall har detta resulterat i publikt tillgänglig programvara, t.ex. programvara relaterad till Trading Agent Competition (TAC), eller den personliga tjänsteplattformen sView.

Spridning av forskningsresultat har skett genom undervisning på universitet samt aktivt deltagande i de nationella och internationella forskningsgemenskaperna. Projektet har resulterat i 27 konferenspublikaktioner, bok kapitel samt journalpublikationer. Agentperspektivet har under projektperioden framgångsrikt tillämpats på allt från automatisk Internethandel till interaktivt berättande. Erfarenheter gjorda under arbetet har bekräftat agentteknologins mångsidighet, samt har lett till fördjupade teoretiska och praktiska kunskaper inom området.

Communication and Services in Open Networks
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1 Introduction

This project summary builds upon the experiences from the KFB/Vinnova funded project 'kommunikation och tjänster i öppna nät' (below called 'IntAge' for short) in the period 1999 – 2002. During this period we have successfully applied the *agent perspective* to problems in various fields ranging from automated trading to interactive narrative.

Initially the project focused on six areas: *social information refinement*, *anthropomorphic interfaces and avatars*, *automated trading*, *resource markets*, *user controlled service collaboration* and *decentralized recommender systems*. Due to limited funds research on resource markets and user controlled service collaboration was transferred to other projects at an early stage. Further research within these areas has therefore not been conducted within the project. Despite this the project has played an important role in the startup phase of these research activities. We have chosen to attach most of the reports and publications that we have produced in an appendix, since we cannot detail all the results and insights in this summary. All in all this should give a good picture of the project.

The rest of this report is divided into the following sections:

- Social Information refinement
- Anthropomorphic Interfaces and Avatars
- Automated Trading.
- Resource Markets
- User controlled service collaboration
- Decentralized Recommender Systems
- Publications 1999 - 2002.
- Software.

2 Social Information Refinement

When people need information, they will often turn to other people rather than seek information through formalised information artefacts. When navigating cities people tend to ask other people for advice rather than study maps. When trying to find information about pharmaceuticals medical doctors tend to ask other doctors for advice. If your child has red spots you might phone your mother or talk to a friend for an opinion. Even when we are not directly looking for information we use a wide range of cues, both from features of the environment and from the behaviour of other people, to manage our activities. Alan Munro observed how people followed crowds or simply sat around at a venue when deciding which shows to attend at the Edinburgh Arts Festival. We might be influenced to pick up a book because it appears well thumbed, we walk into a sunny courtyard because it looks attractive or we might decide to see a film because our friends enjoyed it. Not only do we find our ways through spaces from talking to or following the trails of crowds of people, we also evaluate the things we find in these spaces through understanding them in a social context. We put them in a framework of relevance.

The research we have conducted within this area has focused on six aspects:

1. **Turning the Space into a Place.**
   When entering a new application, a new space, a new service, users will have to learn how to behave. It the actions of other users are visible in the interface, these can inform and tell us what is appropriate behavior, what can/cannot be done - it provides social affordance. At the same time, this awareness of others and their actions makes us feel that the space is alive, that it is social, and might make it more inviting. In the Social Computing program we investigate how to design to make a place happen.
2. **Usage reshapes functionality.**
   Over a time period, the usage of a space/application/service should make the functionality 'drift', similar to how natural language is under constant change. In current systems, it is only the designer of the system that can influence its functionality. In the Social Computing program the aim is to make the usage, both aggregated behaviors from many users, but also individual users, be part in shaping and reshaping the system. We want to put the human-in-the- loop.
3. **Understanding users' experience.**
   Introducing social trails and other aspects of sociality in the interface will alter users' experience of the system. Systems of this kind will begin to invoke cognitive, emotional, social, aesthetic and ethical reactions not seen with 'traditional' user interfaces. This sets demands for new kinds of user studies to aid design and further our understanding of how these experiences come about. A socio-psychological-affective-cultural approach is needed.
4. **Privacy - Integrity – Trust.**
   Making user actions visible may violate their privacy. Turning some or all users into experts that are part in reshaping the functionality of a system entails creating a trustful relationship. In the Social Computing program, we shall investigate philosophical, empirical, and technical aspects of ensuring privacy and enabling trust.
5. **Beyond the tool metaphor.**
   As we move beyond the tool metaphor of interfaces towards social or intentional interfaces, numerous new metaphors and functionalities become relevant: communication between people, entertainment/affective interfaces, services and work delegation to intentional interfaces, arts and personal expressions, etc. The Social

Computing program aims to investigate some of these through building a set of prototype systems that will provoke our tools- based views on computers.

6. **Changing the world.**
   When new technology is put into the world, it will not only change the way we do things, but also the way we think about the world. We need to understand and follow these changes - a Sociological Computing strand. We move from "innocent" devices to "powerful" technology that changes people's worldviews.

We can divide the idea of social navigation into three different concepts: direct social navigation where users communicate directly in order to help one another, indirect social navigation where we put the trails of user behaviour on-top of the space, and read wear where we show how a particular object has been used by previous users. We believe that Social navigation is largely a design issue: we want to enable (make an information space afford) social interactions and accumulate social trails. In the background, indirect social navigation also requires advanced algorithms and tools for maintaining aggregations of user behaviour.

During the project we have explored the use of all modes of social navigation in different settings, sometimes by themselves but most often in combination. A special focus has been on designing recommender systems. Recommender systems are aiming to help users find relevant information within a domain by giving recommendations as to what the user should look at. Recommendations are based on what users with similar interests previously have found to be relevant information. Until now research in collaborative filtering has been focused on developing algorithms for collaborative filtering and tuning the performance of collaborative filtering systems in various ways. The underlying research question has been: How do we make collaborative filtering work? Relatively little effort has yet gone into considering how users actually interact with recommender systems, how users understand recommendations or in fact how users actually want to use recommender systems. We believe that these are important aspects of recommender system design that deserve further investigation, since in the end it is the way in which a user perceives and uses a system that decides if it is successful or not.

We have implemented two large-scale applications in order to test our designs and gain an understanding of how and under what circumstances social navigation works.

2.1 EFOL/KALAS – an on-line food store

In a typical online grocery store, there will be 10.000 different products to choose from. Navigating such a space is not only time-consuming but can also be boring and tedious. Some users will have more difficulties than others to efficiently make use of the existing online stores. In a study on an existing hypertext based online store, it was show that elderly users spent in average twice as much time finding items on a shopping list than did younger users. In both age categories, users sometimes completely gave up when searching for certain items.

It has been shown that on-line food shoppers do not gain any time from shopping food online, instead they appreciate flexibility in time and space. Shoppers feel that they can avoid the tedious, boring, food stores, but they loose the sensuous pleasures of seeing, touching and smelling the products. This is somewhat compensated by getting status among friends from being able to tell stories about how they shop food online. In a study by Richmond on shopping in a virtual reality environment, it was found that users also want to be able to access the social aspects of a physical store; they want to socialize with other people.

Given the problems with navigation and the lack of social interaction and sensuous pleasures in the existing online grocery stores, the domain seemed to be excellent for trying social navigation techniques.

We implemented an on-line food store, EFOL (see Figure 1), where users shop for food using recipes, and where they are able to see who else is in the shop, get recipe recommendations, chat with other shoppers and see other social trails. We performed an initial small-scale study of the system, which provided us with valuable insights about designing socially enhanced systems. For instance we found that social trails seem to appeal to some users while they alienate others, which has important implications for design of social navigation (Svensson et al. 2000).

Research questions addressed by this research include but are not limited to:

- **Quality**: Sometimes it is not enough that the information obtained is relevant, it must also possess qualities that can only be determined from how other users reacts to it. E.g., only when an expert verifies that a piece of information is valid, or when a piece of art is often referred to in the literature, will it be of high quality in the eyes of a navigator.
- **Social affordance**: Visible actions of other users can inform us what is appropriate behavior, what can or cannot be done. At the same time, this awareness of others and their actions makes us feel that the space is alive and might make it more inviting. Here the focus is not on whether users navigate more efficiently, or find exactly what they need more quickly; instead, the intent is to make them stay longer in the space, feel more relaxed, and perhaps be inspired to try out new functionality, to pick up new products and new information items, or to try out new services that they would not have considered otherwise. Users can quickly pick up on the "norms" for how to behave when they see others behaviors.
- **Bootstrapping**: Since social navigation systems often rely on the accumulated users behavior, such as, trails of where people have gone and recommender systems, they will work poorly when little information has been collected. Is it possible to find techniques that somewhat overcome this problem by, for instance, using other strategies to recommend in an early stage of the systems lifecycle?
- **Concept drift**: Over time people and information change. What was interesting to me yesterday may be totally irrelevant today. Recommender systems tend to get "conservative" in the sense that once they have a user profile it is very difficult to change it. In order for social navigation to be really successful it has to take into consideration that peoples' interests change and that different types of information have different expiration dates.

Outside the scope of IntAge a second version of the system, Kalas, has been implemented and deployed in a real world setting. Using this system a large-scale user study has been performed with several hundred users. The results of this study are currently being analyzed.

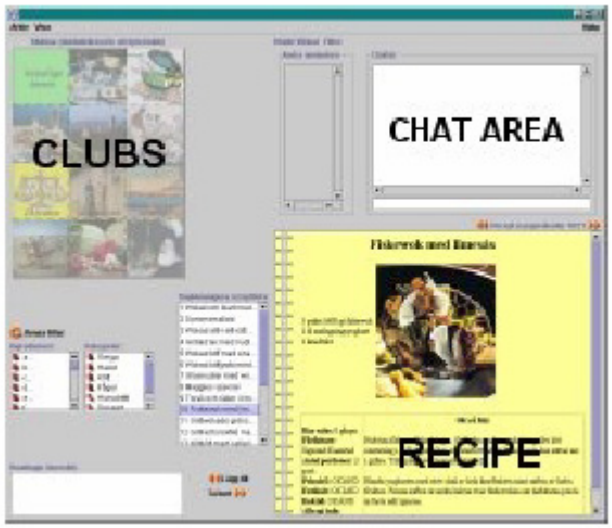

Figure 1. The EFOL Interface

More information about the Kalas system can be found at http://www.sics.se/humle/socialcomputing/kalas/ .

2.2 GeoNotes – a social location based information system

GeoNotes, is a system that allows users to annotate physical locations with virtual 'notes', which are then pushed to or accessed by other users when in the vicinity. Since all users are allowed to put up notes an information overload problem is created. To enable users to find or be recommended interesting annotations GeoNotes employs a number of social filtering techniques, including recommender systems, which all rely on logging of usage rather than content. Figure 2 shows the initial GeoNotes interface.

Designing GeoNotes we faced many design problems including:

- Given that we have a positioning technology in place, how do we allow users on a mass-scale to annotate geographical places with virtual notes via their mobile devices (such as mobile phones and PDAs)?
- Given that mass-scale virtual annotations exist, how will information seekers access these annotations via their mobile devices? How can we support users to navigate this new information space?
- How do we provide social awareness and yet maintain privacy when needed?

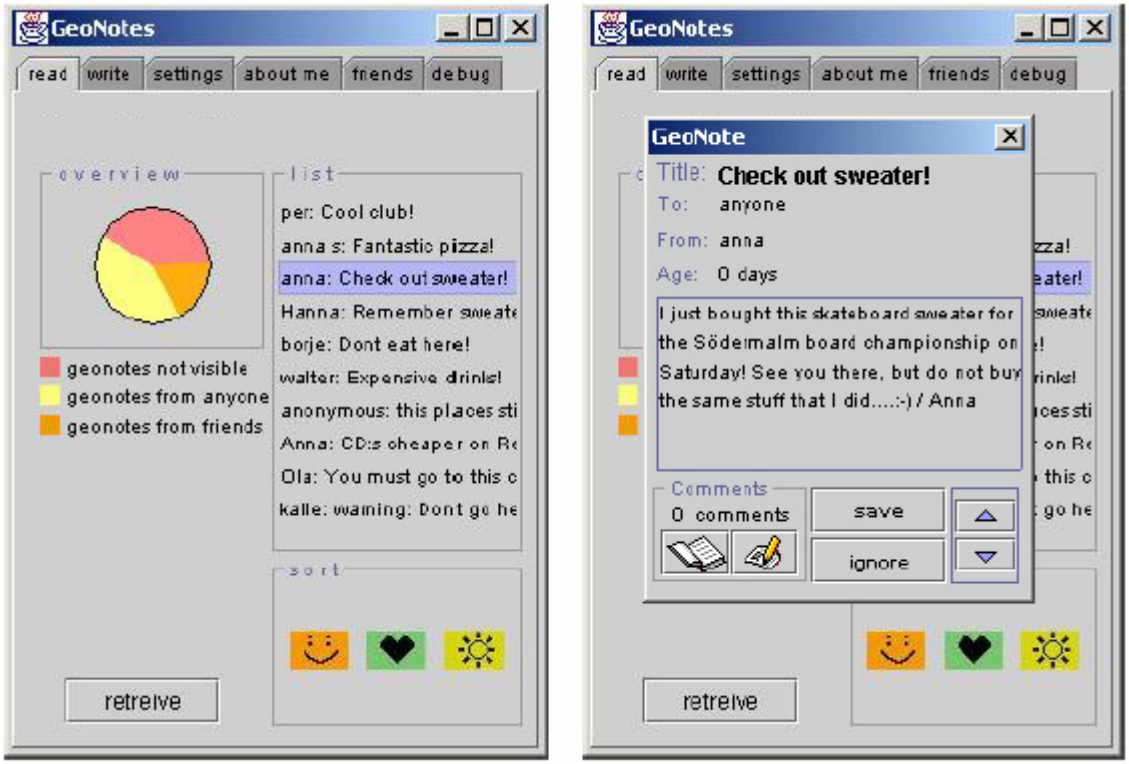

Figure 2. GeoNotes Interface

Placing Notes

Placing virtual annotations in geographical space via a mobile device involves a number of steps and choices. A user creates a GeoNote by typing in text (via a digital keyboard), sound (microphone) imagery (a camera on the device) or a drawing (digital whiteboard). Placing the GeoNote 'here' involves specifying the radius in which it will be active for other users (e.g. 2-40meters). GeoNotes can also be placed on other geographical positions than at the one the user is presently located (through a zoomable and clickable map interface). Moreover, GeoNotes can also be placed at *types of places*, as they are defined in the Yellow Pages (or other) directory. Since this database contains the geographical position of types of businesses, the sender may put a given note on, for instance, all 'Thai restaurants' in downtown Stockholm without knowing their addresses. The choice of 'place' will probably influence the users' construction of the message. In order to regulate privacy, we allow the GeoNote creator to add signatures of his or her own (e.g. 'Anonymous', 'Kilroy', 'Sophie 070-633 15 07' or 'www.sics.se/~soph'). We also let the creator specify the access rights to the note (e.g. 'myself only', 'friend(s) on buddy list' or 'all users'). In order to support navigation of GeoNotes for other users, the creator is also encouraged to place the message in one of three 'sender' categories: 'private', 'commercial', or 'information'.

Accessing GeoNotes: Push & Pull

Users will want to access other people's GeoNotes in different ways, depending on situation and information need. In a strictly *push* mode, users will keep the mobile device in their pocket and when there is a high-ranking GeoNote in the vicinity, the device will signal and the GeoNote will pop up on the device (for filtering mechanisms, see below). If the device beeps too often, the user can change the push activity level (while still maintaining the filter preferences).

In a mixed *push*/*pull* scenario, the user is browsing the social information space of GeoNotes but has no focused information need. Through a circle, whose segments represent the categories of 'private', 'commercial' and 'information', the user can get an overview of the GeoNotes of a given place. The size of the circle represents the number of GeoNotes at this place. While moving through space (walking or riding a bus), the circle will continuously re-segment and change size, representing the 'landscape' of GeoNotes. At any time, the user can click on the circle and access the database of GeoNotes for the present position.

In a strictly *pull* scenario, the user actively searches for GeoNote information (e.g. all notes placed nearby the Swedish Parliament). Independent of geographical position, the user can browse a map with GeoNote circles overlaid. She can zoom in/out, but also set the granularity of the circles (defining the area that each circle represents). In addition to this geographical navigation, traditional word based search engines will be available for any given geographical area. If standing on the actual place, sharing the spatial context of the GeoNote creator may enable the information seeker to exploit this context in formulating more exact search queries.

Navigating the World of GeoNotes

Eventually, geographical space will be cluttered with GeoNotes. Word-based search engines and the private/commercial information categorization are two methods to support navigation. Since we focused on social aspects, we employed several other filtering mechanisms that are currently employed in CSCW and social navigation. By logging the *usage* of GeoNotes and the GeoNote history of each user, we can create filters like the following: 'most recently put'; 'most read (popular)'; 'most commented or copied'; 'put by friends'; 'read by friends'; 'match GeoNotes history'. These filters, some of which may be regulated by the information seeker, rank any GeoNote in the vicinity or in the area specified by the user. In addition, the information seeker will be able reject a message or all messages from a given sender for the future (e.g. spam GeoNotes from MacDonald's). Moreover, if the user already read a GeoNote it will be ranked lower.

When a given GeoNote is ranked over a certain threshold, it is pushed to the user. The filters are also active when accessing a GeoNote database: the top ranking GeoNotes will be placed highest in the list. In addition to this, each database will contain *sorting* mechanisms – which is something different than *filtering* – defining the order in which GeoNotes categories are placed in the database list (e.g. 'show all my buddies' GeoNotes first in the list').

In a system that logs usage, it will also be possible to see all GeoNotes that were created by a specific friend or person (e.g. 'show me all GeoNotes Peter placed when he was traveling in Thailand last year').

Outside the scope of IntAge a user study was performed using a second version of GeoNotes that was distributed to students at the Royal Institute of Technology in Kista/Stockholm. The results of this study are currently being analyzed. More information about GeoNotes can be found at http://geonotes.sics.se/ .

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3 Anthropomorphic Interfaces and Avatars

As computer systems become more complex and autonomous– taking on responsibilities users previously had – we will see a shift in users' understanding of computer technology. Whereas the direct manipulation paradigm encouraged users to perceive computers as tools, agent technology will promote users to project anthropomorphic expectations on computer systems.

As with any other system displaying complex behavior (e.g., animals, corporations, and machines), users will try to understand and make sense of computer technology through everyday expectations of human life. The interaction 'stance' of users will transform from *action* to *interaction* (Dahlbäck, 1999) from a *mechanistic* stance to an *intentional* stance (Dennett, 1987), from *paradigmatic thought* to *narrative thought* (Bruner, 1986), from *dead tools* to *semi-intelligent* and *sociocommunicatory beings*. As designers, we may choose to encourage or discourage such anthropomorphic processes. Irrespective of which, the computer community needs to understand how and under what conditions they work. Anthropomorphism cannot be reduced to observer independent properties of objects, systems, or creatures. Anthropomorphism is an *experience*, an *understanding* of complex – not necessarily human – patterns of behavior in the world. Anthropomorphism is a way of simplifying and thereby making sense of the environment by projecting a host of expectations about human life onto aspects of that environment. 'Anthropomorphizing' reality is a *stance*, describing and explaining intricate domains of reality in terms of abstract frameworks of folk-psychology and human life. For instance, users know that computers do not have *beliefs* or *intentions*, but they still attribute such mental states to them in order to make sense of their surface 'behavior' and create 'interaction protocols' with them (cf. Reeves and Nass, 1996). Anthropomorphism has a fundamental 'sense-making' function. Thus, an interface is not anthropomorphic *per se*, but only in so far as it gives rise to anthropomorphic processes in a given user and situation. However, so far the tool metaphor has been prevailing in HCI research, leaving little or no room for research on anthropomorphic interfaces.

During the project we have worked on improving this situation by exploring the nature of anthropomorphism as well as implementing a system containing interface agents in various settings. The domain we have chosen to work in is rather playful. Believability [1]in interactive characters is a tricky thing, and a serious domain in which the characters should be 'helpful', 'provide information' or teach the user something substantial, will make believability even harder. Gaming, visual chat and other entertainment forms, on the contrary, are much less critical in terms of accomplishing 'serious tasks'. Still they present formidable problems and research questions in terms of believability. In this way, we were able to focus on the *interaction* between users and agents, and less on the 'success' of the agent technology in terms of efficiency.

Research in this area has been conducted in cooperation with the EU funded project MagiCster [2]and the SITI funded project Kaktus[3].

[1] This term is admittedly vague but usually refers to an interface agent's capability to 'suspend disbelief'. One interpretation of the term might be an agent's capability to act according to some human norms in a given context.
[2] See http://www.ltg.ed.ac.uk/magicster/
[3] See http://www.sics.se/humle/projects/Kaktus/

3.1 Interactive Narrative

Agents do not exist in a void but in a context in which they are given their meaning and can be understood. For instance we sometimes laugh at a character that falls over, or feel sympathy for a character that has bad luck. In general we believe that a 'situation' or some 'narrative context', to some degree steers or points the surface level behaviour of agents in certain directions. In order to engage the user, characters need to be inserted in some socially and emotionally rich situation in which they can act and react and that helps users interpret what they experience.

During the project we have worked with *Kaktus* a socio-emotionally rich interactive narrative. The aim is to create a truly interactive story in which the user actively participates and influences the plot in non-trivial ways. The narratives created within *Kaktus* strive to move away from the simplistic, and often violent, way of interacting found in many games, and instead focuses on social and emotional interaction. The current scenario focuses on three teenage girls arranging a party. Taking on the role of one of the characters, the user is called upon to make socio-emotionally complex decisions in arranging the party, e.g., who to invite, or where to stage the party. As unfolding of the plot is partly determined by the affective state of the other (computer-controlled) characters, a fundamental aspect of playing the role is to be sensitive to, maintain and/or improve social and emotional relations with those characters. In narrative media emotional experiences such as suspense, comic effects or sympathy often depend on the ability to specify a *sequence* of events in the 'right order' (often called *timing*). *Automatically* generating such sequences is one of the main challenges addressed by *Kaktus*. Figure 3 shows a screen shot of the current prototype.

Figure 3. The Kaktus Game

Creating a socio-emotionally rich interactive drama presents new research challenges. In such a scenario it is not enough that characters 'look' believable, (i.e., a sufficiently large amount of polygons is used to model them) but they must also be able to act and react in a socially and emotionally appropriate way taking the narrative context into account. For instance if the user insults Lovisa, one of the agents, she may refuse to let the user use her parents big villa for the party. Hence an important part of the work has been to investigate models of emotional and social behaviour, which can be used to guide an agent's behaviour.

As part of the work on Kaktus we also performed a small-scale user study of (a previous version of) the game. The main objective of the study was to investigate whether the use of a model of emotions would lead to any perceivable difference in the agents' behaviour. The user study, while being very small, clearly indicated the usefulness of an emotional model and gave valuable insights regarding design of systems containing socio-emotionally rich agents.

In cooperation with MagiCster we have also worked on developing a deeper understanding regarding the concept of *believability*. What makes agents believable? What faculties does a user employ when interpreting what she experiences? This work has led to a multi-layered view of user expectations regarding character behaviour in given situations (Persson et al. 2000; Persson et al. 2001; Persson et al. 2002).

Currently we are working on a narrative guidance mechanism using anticipatory planning that will influence plot unfolding in the scenario, hopefully giving the user a more enjoyable experience.

More information about Kaktus can be found at http://www.sics.se/humle/projects/Kaktus .

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4 Automated Trading

Distributed systems and component technologies have been thoroughly investigated for several decades, but until very recently with the unspoken underlying assumption that systems are owned and controlled by single individuals or organizations. This means that all components of a system are thought to be working cooperatively towards a common goal and that they may safely do what they are told and trust whomever requests them to supply information or perform services. On the Internet, this assumption is no longer true. There, Mary's software may meet and be required to interact with, e.g., Acme Inc's software. Mary's goals may be quite different from Acme Inc's, perhaps even conflicting and her only safe assumption will be that Acme Inc's software is designed to act in Acme Inc's best interests. She should obviously likewise make sure that her software acts in her best interests.

In the following, the term software agent (or just agent) refers to a software component that acts on our behalf, with our authority, and that is intended to do so in our best interests.

What does it mean for an agent to act in our interests? How free are our agents to act in our interests given existing technological constraints and limitations? How free could we make them if we design future information society technologies with this in mind? How do we make these technologies robust against errors and intentional misuse? These questions form the foundation of the research conducted within this area.

Our main focus has been on how to automate participation in electronic markets. Through automated trading by software agents, we expect improvements in the quality of existing markets, such as consumer goods markets, service markets, and the emerging information markets, and to reap the benefits of markets as effective instruments of resource allocation also in non-traditional domains, such as fine-grained markets for electric power and communication bandwidth. Agents have the capacity to consider more information, e.g., evaluate thousands of offers for a new car and hundreds of recommendations from various sources, and may also act in domains where we are disqualified due to speed requirements, e.g., buying the bandwidth we need packet by packet or the additional electricity needed when we turn on a light switch.

The research falls into two main lines of investigation:

- Internet commerce infrastructures, with the subtopics
    - Dynamic component architectures for evolvable electronic markets
    - Matchmaking based on explicit interests
- Service access architectures

As more and more activities are brought onto the Internet, we expect our results from these investigations to be of critical value in the near future. The research on component architectures led to the forming of a spin of company BotBox in 1999 after which it was no longer funded by the project.

An important test bed for research within this area has been the yearly *Trading Agent Competition* described below. In 2002 this competition is arranged by SICS.

Recently SICS has coordinated an expression of interest for EU's 6th frame program (FP6) for a project about automated trading, eTrading, that is supported by leading researchers,

industries and governmental authorities within the area. The aim is to develop – and introduce – the best possible methods for B2B and public purchase all over Europe.

4.1 Trading Agent Competition

In 2002 SICS arranges the "world championship in automated agent trading", the international event Trading Agent Competition (TAC). The competition involves automated trading using XML over the Internet, with 19 registered teams from USA, India, China, South Korea and several European countries. A game involves 8 agents that during 12 minutes compete in buying the best combination of goods from 28 simultaneous markets. Over a thousand games are played during the four weeks of the competition, with the finals taking place at a workshop in Edmonton, Canada on July 28th 2002. For the competition SICS has developed robust server-software for automated marketplaces that is distributed as *open source* for research and educational purposes.

The Trading Agent Competition (TAC) is an international forum designed to promote and encourage high quality research into the trading agent problem. TAC trading agents operate within a travel shopping scenario, buying and selling goods to best serve their given travel clients. TAC scores the results based on the client's preferences for trips assembled, and net expenditures in the travel markets.

By a trading agent we mean software that trades combinations of goods on multiple markets on behalf of one or more clients, based on expressed or elicited client preferences. A software trading agent can potentially handle more complex combinations of goods, larger numbers of goods and markets, a wider range of market types, and faster markets with more fine-grained goods than its human counterparts.

Relative to their clients, trading agents have to solve a combinatorial assignment problem, where goods available to an agent are packaged into bundles, and delivered as such to the clients. This problem is related to that of an auctioneer determining winning bids in a combinatorial auction. A successful trading agent must therefore make use of similar integer programming techniques or, alternatively, techniques of constraint programming.

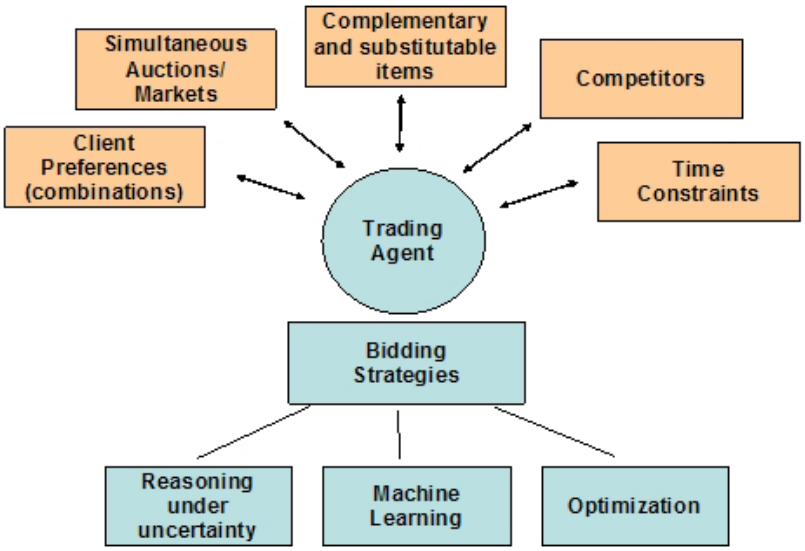

Figure 4. Aspects of the trading agent problem

In the TAC shopping game, each "agent" (an entrant to the competition) is a travel agent, with the goal of assembling travel packages (from TACtown to Tampa, during a notional 5-day period). Each agent is acting on behalf of eight clients, who express their preferences for various aspects of the trip. The objective of the travel agent is to maximize the total satisfaction of its clients (the sum of the client utilities).

Travel packages consist of the following:

- A round-trip flight,
- A hotel reservation, and
- Tickets to some of the following entertainment events
    - Alligator wrestling
    - Amusement park
    - Museum

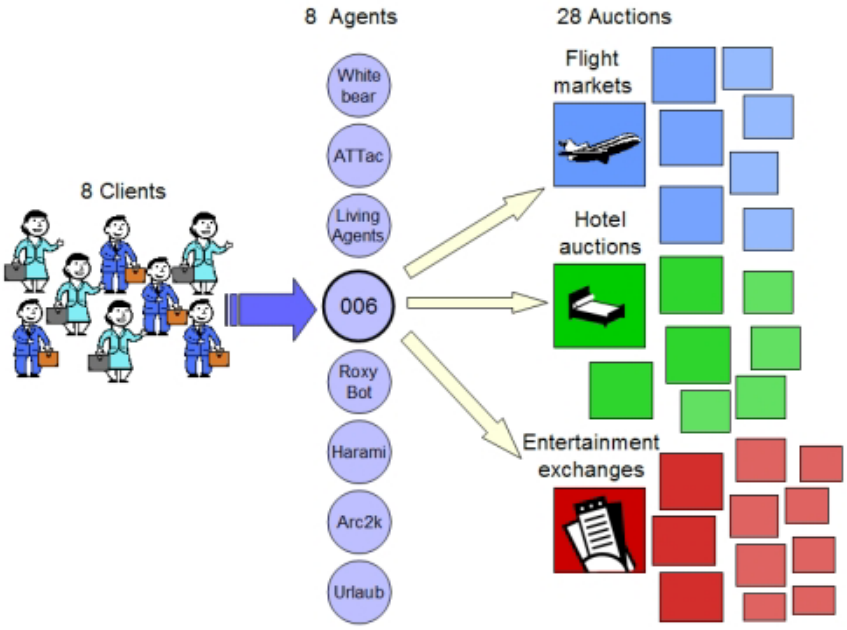

Figure 5. Illustration of the environment a TAC agent operates within. To the left are its eight clients and their preferences, in the middle all its competitors lined up (7 competitors/game), and to its right are all the auctions (28 simultaneous auctions of three different types).

There are obvious interdependencies, as the traveler needs a hotel for every night between arrival and departure of the flight, and can attend entertainment events only during that interval. In addition, the clients have individual preferences over which days they are in Tampa, the type of hotel, and which entertainment they want. All three types of goods (flights, hotels, entertainment) are traded in separate markets with different rules.

A run of the game is called an instance. Several instances of the game are played during each round of the competition in order to evaluate each agent's average performance and to smooth the variations in client preferences.

In TAC 2000 and TAC 2001 SICS competed with trading agents, based on *genetic programming* and *constraint programming* respectively. The latter is presented in the report "A constraint programming agent for automated trading". This year SICS is competing with an improved version of the same agent.

4.2 BotBox AB

In December 1999 the new SICS spin-off company BotBox AB was formed by three SICS researchers from the SICS Intelligent Systems Laboratory with venture funding from Telia Business Innovation. SICS holds a minority position in return for licensed technology, as made possible by the new SICS spin-off policy.

The company will bring to the market the *BotBox bot environment and user interface*, a result from SICS research into agent-based systems, partially funded by the KFB funded project IntAge.

Bots are software helpers that aid users in easily understood and predictable but repetitive or otherwise time-consuming Internet-related tasks such as comparison shopping (shop bots), bidding at auctions, watching stock markets, and the like. Teams of bots may cooperate in providing a service. For example, a bot-based stock trading environment may consist of an open team of bots from different providers for obtaining stock quotes, interacting with on-line stock brokers, presenting aggregated information, providing analyses, etc.

BotBox is designed to allow any user, novice or expert, home or business, to manage a personalized environment of bots on their personal computers with great simplicity and safety.

Publications within the area of 'Automated Trading'

1. Sverker Janson, Smartare e-handel med intelligenta agenter, Forskning och Framsteg 7/00, pp. 44-48. http://www.fof.se/artikel_tips.lasso?&-token.redirect=00744&-nothing
2. Lars Rasmusson and Sverker Janson, Agents, self-interest and electronic markets, Knowledge Engineering Review, Vol. 13:2, 1999, 1-8. http://www.sics.se/~sverker/public/papers/selfinterest.pdf
3. Sverker Janson,Vad är agenter? Varför behöver vi agenter? Vilka är deras roller? Rättsliga och andra aspekter på agentteknik, PM 7:2000, Det IT-Rättsliga Observatoriet, 2000. http://www.sics.se/~sverker/public/papers/pm-07-2000-agentteknik.pdf
4. Erik Aurell, Magnus Boman, Mats Carlsson, Joakim Eriksson, Niclas Finne, Sverker Janson, Per Kreuger, and Lars Rassmusson, *A constraint programming agent for automated trading,* 8th International Conference of The Society for Computational Economics, Computing in Economics and Finance, Aix-en-Provence, France, June 27-29, 2002, http://www.sics.se/~sverker/public/papers/sics_tac_01.pdf

5 Resource markets

Although present in the original project proposal, research within the area of resource markets was only initially financed by IntAge due to limited project funds. During this period preliminary experiments on using evolutionary programming to create market negotiation strategies were performed. Since then research within this area has been conducted within the COORD and AMRAM projects, financed by VINNOVA, and the EMARKETS project financed by SITI. However since it is tightly interwoven with automated trading, we give a short summary of research conducted within the EMARKETS and COORD projects.

5.1 EMARKETS

The project develops theory and methods for modeling and controlling computer networks, consisting of entities that trade network capacity between one another. Our approach allows both network providers and end-users to efficiently tailor network services to their needs. The theory can be used to compute fair prices for very complex communication needs, such as virtual channels, batch transfers with deadlines, quality-of-service, and more.

End users and network providers can express their needs in bids. Resources will be more efficiently used, and needs more closely satisfied, if markets allow for bids closely corresponding to true needs. In resource markets, e.g. in bandwidth markets, needs may be very complex, i.e. of alternative virtual paths. Automatic trading allows for liquid trading in more markets, and on much faster time-scales, and therefore entails a better global need satisfaction.

There is in general a trade-off between how complex bids a market can handle, and how quickly the market can handle them. We have created a very fast network resource market model, in which simple resources are traded in individual markets, operated by market makers. For achieving speed it is essential to only accept bids at market on this lowest level. Complex resource bundles are treated as derivative contracts on the underlying bandwidth, and are priced as such using standard mathematical finance methods. This structure allows us to price almost arbitrary complex network resources in a decentralized, efficient and scalable fashion.We have developed a simulation platform for analyzing aggregate behavior of networks used by bandwidth-trading agents.

For more information see http://www.sics.se/isl/emarkets/ .

5.2 Coord

This project aims to develop methods to coordinate the actions of agents by using market-based models of interaction. We are interested in how to construct complex plans and resource allocations, and applying the results in a "band-width market". The new idea is to use derivatives to express more complex resource demands while maintaining the volatility of the resources in the market.

Coordination is broadly the process of deciding when a task should be performed and which resources that should be used. Coordination is necessary in domains where resources are shared between agents, when the resources are limited and when using a resource can inhibit another agent from fulfilling its goals. Factories, communication networks and company work flow are all examples of domains where coordination is necessary.

Coordination can be performed centrally by a global planner or in a decentralized fashion. Global planning is the process of collecting information from all agents involved and using that to design a (unique) time plan for each agent. The agent may not deviate from this plan during execution. Decentralized planning means that the decisions of which actions to take are delegated to the agents. It almost always also implies that each agent makes its decision based on only a subset of the information used by the global planner. This has the advantage of allowing the agents to make faster decision and to make partial changes in their plans if their goals or environment changes.

An algorithm that only uses a subset of the total information may be unable to find the optimal solution of a coordination problem, something which may or may not be acceptable depending on the domain. Therefore, many decentralized algorithms are search heuristics approaching good solutions rather than a computation delivering the optimal global behavior. Decentralized coordination is therefore useful for problems where no global planner can deliver a solution within reasonable time.

Another (and perhaps more interesting) area where decentralized coordination may prove useful is in domains where the first priority of a participating agent is to maximize its own performance rather than the global performance. Competing organizations/companies as well as individuals can be represented by such agents. For companies, a decentralized coordination framework will allow sharing and trading of resources as long as it is beneficent for the individual companies. Individuals will program their personal assistants to prioritize the interest of its client user over that of other agents (such as advertisers or sales agents). We call the domain open when it intends to support the existence of self-interested agents. Domains that do not assume that agents are self-interested will have to control and limit which agents that may interact with the system, i.e. the system will in generally be closed.

5.2.1 Market-oriented coordination

The project has in particular investigated market-oriented approaches to coordination. A key idea for this approach is to represent the systems and resources that need to be coordinated by agents that broker their resources on an exchange. Other agents are responsible for obtaining the resources needed to fulfill the goals of the users. Coordination of the resources amounts to exchanging resources and finding market prices such that all agents are satisfied. Note that satisfied means that the agent has no intention to trade, which can be the case if the resources are too expensive.

Compared to other research in this area where agents can negotiate and commit, a market based approach has "simpler" interactions (only bidding), and can therefore be faster. But if we only allow bidding on the resources, agents have no way to construct more complex plans without large risks or inefficiency. Therefore, we introduced derivatives into the market, and design agents that generate plans by bidding on options and/or futures. This allows agents to produce complex plans, indirectly taking into use the capabilities of several other agents.

In a market (without external events), resources are iteratively interchanged towards a more stable state of allocation. When events occur, such as adding new resources to the system or failure of participating components, the prices of the resources change as a result of the event. This will cause the agents to take on trading again, but considering the new state of affairs. In this sense, a market based system can be considered to be self-coordinating and adaptive.

5.2.2 Research topics

Research topics we have investigated include

- planning by using derivatives
- higher level behavior as coalition formation
- market behavior as communication channels
- bids that express negotiation
- applications:
    - network bandwidth market for allocation of resources
    - consumer power distribution market for coordinating deals for users with different preferences
    - factory scheduling for the creation of complex plans

The most interesting question to investigate is to what extent it is possible to express more complex behavior as commitments and delegations in terms of actions using financial instruments. For instance, can an agent delegate its intention to achieve a task to another agent by buying a certain portfolio of futures or options? This would have two large advantages, namely the speed of interaction and to translate utility to economic terms. Speed would increase since the agent would simply announce intentions to buy or sell financial instruments. In previous work we were concerned with the possibility to manipulate agents into performing actions that were potentially harmful for their clients. By translating the utility of actions into economic terms, an agent will have a better opportunity to compute the real benefit and risk that is associated with its decision.

With complex financial instruments such as options or futures, it may be possible to create behavior similar to coalition formation or shared plans. Compared to other research in this area where agents can negotiate and commit, a market based approach has "simpler" interactions (only bidding), and can therefore be expected to be faster. But if we only allow bidding on the resources, agents have no way to construct more complex plans without large risks or inefficiency. Without the ability to ask others for help, agents have to buy resources speculatively, not knowing if they will eventually obtain all the required resources.

A market with derivatives may allow agents to produce complex plans, indirectly taking into use the capabilities of several other agents. An agent that needs a particular resource in the future may need to plan that it has the resource. Agents may reduce the risk they take when they plan, by buying an option to obtain the resource at a later time. The interesting thing about this is that it reduces coordination through negotiation to a risk decision problem, which may be faster to compute.

For more information see http://www.sics.se/isl/coord/ .

Publications within the area 'Resource markets'

1. Rasmusson, Lars. *Agent Negotiation over Compound Network Resources*. In Proceedings of the IAT99 Workshop on Agents in Electronic Commerce, Hong Kong, 14-17 December, 1999. Hong Kong Baptist University, 1999.
2. Lars Olsson. *Strategy Evolution for Electronic Markets Using Genetic Programming*. In Proceedings of the 1999 Genetic and Evolutionary Computation Conference Workshop Program. Orlando, Florida, July 1999.

3. Lars Olsson. *Evolution of Bargaining Strategies for Double Auction Markets Using Genetic Programming*. Master's thesis, Department of Computer and Systems Sciences Stockholm University / Royal Institute of Technology (KTH), October 1999.

6 User Controlled Service Collaboration

Research on user controlled service collaboration was initially partly funded by the project. However due to limited funds, research within this area has instead been conducted within the sView project financed by SITI. Below we give a short summary of this project. The main result of this project is the sView system – an embodiment of a Personal Service Environment (PSE) – available for free from http://sview.sics.se . Figure 5 shows an overview of the sView architecture.

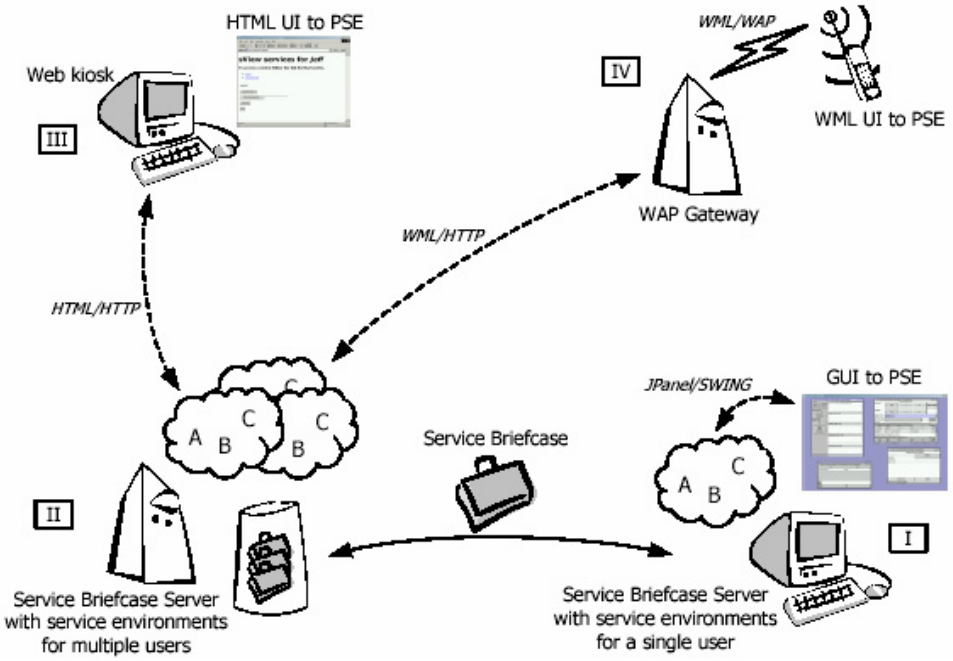

Figure 6. Overview of the components in sView

6.1 The sView project

We believe computer usage is moving towards a mobile, distributed, and service centric model. As we have followed the development of the World Wide Web, we have seen that it has moved from publication of information to providing interactive services. We have also followed the development of mobile computing and communication in terms of mobile phones and PDAs, as well as the start of a wider deployment of interactive services over broadband, cable-TV, and digital-TV networks. Interactive electronic services, such as those that are appearing on the web, over mobile phones, and in the broadband networks, call for service platforms. In a somewhat more distant future we believe the advancement will move even further, towards a ubiquitous computing model, wherein computer devices may disappear completely to be replaced by intelligent artifacts powered by highly specialized computer devices. Electronic services are central to both scenarios and the deployment, delivery, and user access to electronic services constitute the main motivation for the sView project.

6.1.1 SView Purpose and Goals

The sView project has had two main purposes: the first was to build a working prototype platform for a Personal Service Environment (PSE), which would tackle the service delivery and interaction problems of the World Wide Web. The second was to provide this PSE as a

platform for other re-search in the fields of service cooperation, personal adaptation, user integrity and privacy, etc.

Throughout the project lifetime it has become obvious that electronic services are becoming important in users' interaction with computer systems. The World Wide Web is a good example. The Web has become a great success much due to the fact that it is easy to create and distribute content and it is easy to access the content. But the Web has evolved from a publishing channel to more of a service deployment and access channel. Users are now accessing their electronic services such as banking, ticket booking, information searching, and communication over the Web. Unfortunately the Web is not an optimal platform for electronic services. Some of the reasons are:

1. The Web is based on a client/service model where a server supplies many clients with the same web based service. As the number of users grows, the scalability of this model becomes a problem.
2. Access to services is limited to web interfaces such as web and WAP browsers. Not only do these interfaces provide limited interaction capabilities (which are ample for publishing and accessing plain information, but insufficient for highly interactive electronic services) but they also depend on an ever-existent network connection. If the connection breaks a web interface is unable to provide access to the service.
3. User control of web-based services is low. Many times a service provider will strive to personalize a service to make it more useful or pleasing to a user. To do this, the service provider needs access to information about the user. In a web scenario this information is transferred to the provider at which point the user's control over the information is lost. Additionally, as the number of services the user subscribes to increases, the risk of unauthorized use of the personal information increases. Finally, as the information changes (for example if the user changes his or her address) the user must update this change with all subscribed service providers.

Our solution to these problems (and more) is the sView service platform. We have built a working prototype of a PSE system. It consists of a server which you may run on several machines, a service briefcase in which the user places his or her services, and system type services (services which add to the capabilities of the system).

The user chooses services and places them in his briefcase. An sView-service may be completely self-contained, or it may have a network connection to a back-end service on the network. This choice is up to the service provider. The fact that a service can be self contained means that it is possible to run it locally without a network connection. A self-contained service is typically one that is relatively small and that has within itself all the functionality and data that it needs (for ex-ample a calculator). A service that uses a back-end often has a network connection to a database that is too large to move to each client (for example a search service for Encyclopedia Britannica).

The briefcase is an environment in which services are constantly running and in which the user may interact with the services. Services are downloaded as code modules and are executed in the briefcase. As the user changes his or her location (point of access), i.e. when going home from work, the briefcase is halted and moved to another server, where it is reactivated. The user may then access the services remotely using for example a mobile phone or a web browser at a public terminal. When the user gets home, the briefcase is once again moved, this time to the user's home server. The purpose of moving the briefcase is to keep the

services close to the user. Thereby the user is always able to interact with the services using the best possible mechanisms (a graphical user inter-face for a local service is more powerful that a Web or WAP based interface to a remote service).

Storing and running services in the user's briefcase has other advantages as well. The user's control over services increases because he or she is able to supervise the distribution of personal information to the services. Moreover, services are constantly active. This means that they may perform tasks for the user even while the user is not on-line. It also means that the user experiences a continuing session. Each time the user accesses his or her briefcase, services are in the same state as the last time of access: windows have the same sizes and locations, ongoing tasks are still active, and the preferences and settings of the user are persistent.

More information on the sView architecture is available on the sView community website (http://sview.sics.se).

Publications within the area 'User Controlled Service Collaboration'

1. Espinoza, F., *sicsDAIS: A Multi-Agent Interaction System for the Internet*, In Proceedings of WebNet 99 - World Conference on the WWW and Internet, Honolulu, Hawaii; October 24-30, 1999, 1257-1258.
2. Tierney, Mark., *Concall: An Exercise in Designing Open Service Architectures*, Licentiate Thesis, Department of Computer and Systems Sciences, Stockholm University/ Royal Institute of Technology. Report Series 00-002. March 2000

7 Decentraliserade rekommendationssystem

Ett rekommendationssystem är en tjänst som utifrån handkodad eller automatisk inlärd kunskap hjälper användarna att välja ett alternativ från en mängd olika valmöjligheter. Forskningen om rekommendationssystem har i huvudsak resulterat i centraliserade tjänster t.ex. MovieLens (Good et al. 1999) och många andra system (Breese et al. 1998; Schafer et al. 2001). Alla domäner passar dock inte för centraliserade lösningar t.ex. sådana domäner som i grunden är decentraliserade eller när användarnas integritet är av stor vikt.

Genom att samla all data om användarna på en plats hotas användarnas integritet. Det sker dels genom att någon icke-auktoriserad person kan ”hacka” databasen men kanske framför allt för att tjänsteleverantören kan använda datat till något som inte användarna tänkt t.ex. sälja den till något marknadsföringsföretag (Foner 1999). Ett annat problem som en centraliserad lösning för med sig är att användarna är helt beroende av tjänsteleverantören medan en decentraliserad lösning, om den är rätt implementerad, kan fortsätta att fungera även om den ursprungliga tjänsteleverantören försvinner.

I IntAge har vi tidigare arbetat med ett decentraliserat rekommendationssystem i ett “Virtual Community Library” (Olsson et al. 2000) men under perioden 1999-2002 har vi främst arbetat med ett decentraliserat rekommendationssystem för informationsövervakning.

BotBox PA är ett program för informationsövervakning utvecklat av BotBox AB[4] som är helt klientbaserat utan någon central server. BotBox PA håller användaren uppdaterad om förändringar på webbtidningar och webbsidor. Informationen visas för användaren som rubriker i ett litet inställbart fönster. All bearbetning av information och alla anrop till webbplatser görs lokalt utan någon central nod vilket gör att domänen passar bra för en decentraliserad lösning. Vårt arbete har utgått från det hypotetiska sammanhanget av att inför BotBox PA på alla nivåer i en organisation t.ex. ett medelstort företag.

Arbetet har bestått av två delar dels har vi implementerat en prototyp av det decentraliserade rekommendationssystemet i ett samarbetsprojekt mellan SICS och BotBox AB (HT2000-VT2001), och dels så har vi byggt en simulationsmodell av införandet av systemet i ett företag (HT2001-VT2002). Den senare är nödvändig då vi saknar lämpligt antal användare som kunde testa systemet under en längre tid och för att kunna avgöra den exakta utformningen av systemet. Utvärderingen av denna modell pågår fortfarande och slutförs med pengar från det SITI-finansierade PERSONAS-projektet och kommer att resultera i en vetenskaplig publikation och som en del av en licentiatavhandling.

Det decentraliserade rekommendationssystemet består av rekommendationsagenter sammankopplade i ett nätverk där varje agent är kopplad till en eller flera användares BotBox PA. Agenten övervakar användarens beteende och lär sig vilka nyheter som använder tycker är intressanta. Den inlärda kunskapen används sedan till att hitta andra intressanta nyheter i samarbete med de andra rekommendationsagenterna.

7.1 Det simulerade systemet

Det fanns en rad problem att lösa vilka kan delas upp i två delar. Första delen är hur själva rekommendationssystemet ska fungera och andra delen är hur simuleringen av införandet i en organisation går till.

[4] BotBox AB ett spin-off företag från SICS. Se avsnittet om Automatisk Internethandel.

Systemet i sin helhet består av användare, en samling dokument, rekommendationsagenter och informationskällor. Det är bara rekommendationsagenterna som ingår i det decentraliserade rekommendationssystemet vilka implementeras som det skulle i verkligheten medan användare, dokument och informationskällor simuleras. I prototypen så hanteras dokument och informationskällor av BotBox PA och vi har naturligtvis också riktiga användare.

7.1.1 Det decentraliserade rekommendationssystemet

En rekommendationsagent använder en maskininlärningsalgoritm för att bygga profiler av en eller flera övervakade användare och några grannar. Agenterna kan använda olika inlärningsalgoritmer. Användarprofilerna används sedan för att göra prediktera relevanta dokument åt de övervakade användarna men också för att välja vilka som ska behållas som grannar.

Agenterna fungerar också som mellanhänder för varandra (”brokers”) genom att vidarebefordra rekommendationer av dokument till sina grannar som kan i sin tur kan skicka dessa vidare till sina grannar. Vidarebefordringen av rekommendationer gör det också möjligt för agenterna att hitta nya grannar förutom att det sprider dokumenten i systemet. Antalet vidarebefordringar av rekommendationer är begränsade (max två steg i nuvarande implementeringen) så att inte oändliga kedjor av rekommendationer uppstår.

Ett grundläggande antagande är att användarnas intressen överlappar och att agenterna kan hitta nya bättre grannar genom ”hill climbing”. I vår nuvarande arkitektur så använder sig agenterna av en slags ”random search” för att hitta bättre grannar.

Observera att systemet är ”push”- och inte ”pull”-baserat. Agenterna skickar rekommendationer till varandra inte på begäran utan var gång en användare bedömer ett dokument som relevant. Detta betyder att endast vad användarna gillar är vidarebefordrat till deras agenter så att var gång en användare får en rekommendation så vet denne att någon annan gillat dokumentet.

Agenterna får sina initiala grannar via en peer-to-peer liknande ICQ mekanism med en kontaktlista med ”buddies” och en ”instant message”-funktion[5]. Idén är att användare normalt har ett socialt nätverk av vänner och medarbetare som användarna kan lägga till sina kontaktlistor. Användarna på kontaktlistorna kan sedan användas som agenternas initiala grannar. Ytterligare grannar får agenterna sedan från vidarebefordrade rekommendationer från andra agenter eller när nya användare läggs till kontaktlistan. Initialt har agenterna endast användarna i kontaktlistorna som grannar. I prototypen är denna mekanism implementerad men i det simulerade systemet är detta dock endast simulerat utan möjligheten att nya grannar kan läggas till via kontaktlistan.

7.1.2 De simulerade delarna

En simulerad användare modelleras med några intressen, prenumerationer på en eller flera informationskällor, några medarbetare, och en rekommendationsagent. Informationskällorna är mängder av dokument och intressena är booleska funktioner som visar om ett dokument tillhör ett intresse eller inte. En användare kan få dokument dels från sina informationskällor och dels rekommenderare av sin rekommendationsagent. Alla mottagna dokument placeras i

[5] www.icq.com

en kö med olästa dokument tills användaren läser dem. Medarbetarna används som initiala grannar för rekommendationsagenterna som beskrivet i sista stycket under föregående rubrik.

Vi simulerar införandet av systemet i ett företag genom att simulera ett företags organisation på följande sätt. Först låter vi en användare vara högste chef och som dennes medarbetare har vi k andra underordnade användare. Dessa underordnade har sin chef och ytterligare k andra underordnade användare (eller så många som finns kvar) som medarbetare, osv. till det inte finns några fler användare kvar utanför trädet av medarbetare (där löven naturligtvis inte har underordnade medarbetare utan bara sina chefer som medarbetare). I våra simuleringar har vi valt k = 5. Detta resulterar i en hierarkisk, företagsliknande struktur som i verkligheten skulle hämtas från ett företags verkliga organisation.

För att simuleringen ska bli någorlunda verklig har vi valt att använda CLEF-samlingen från TREC-9 till våra dokument, intressen och informationskällor[6]. CLEF-samlingen består av alla artiklar från 1994 års upplaga av Los Angeles Times och 40 sökfrågor med några av artiklarna klassificerade som relevanta respektive irrelevanta för varje fråga. En sökfråga med klassificerade artiklar motsvarar ett intresse och artiklarna utgör systemets dokumentsamling. Ett problem är dock att systemet kräver mer än en informationskälla för att vara meningsfullt och istället för att använda 10 källor vi inte har så duplicerar vi CLEF-samlingens artiklar så att vi får 10 informationskällor i stället för endast en (vi duplicerar inte sökfrågorna utan varje sökfråga täcker i stället 10 gånger så många artiklar). Detta är realistiskt då tidningar ofta publicerar artiklar i samma ämne samtidigt och vid informationsövervakning vill man få reda på allt som sägs i ett ämne t.ex. allt som skrivs om ett visst företag.

7.2 Sammanfattning

Vi har under denna period implementerat

- En prototyp av ett decentraliserat rekommendationssystem som använder en ICQ-liknande mekanism för att koppla ihop användare i ett nätverk med rekommendationsagenter för informationsövervakning.
- En simuleringsmodell av hur ett sådant rekommendationssystem skulle fungera i ett medelstort företag på 100-400 medarbetare.

Det som återstår är utvärderingen av simuleringsmodellen och rapporteringen av denna dels genom en vetenskaplig publicering och som en del av licentiatavhandling.

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[6] http://trec.nist.gov/data.html

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Marketplace server used in TAC. Implemented in SICStus Prolog. Available as open source software for research and educational purposes.	http://www.sics.se/tac/download_server.php
Development kit for building TAC agents in Java. Available as open source software for research and educational purposes.	http://www.sics.se/tac/docs/agentware/java/
SView, server software and development kit for personal service environments.	http://sview.sics.se/index.php

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1 Explorative System-Integrated Technologies – EXSITE

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5 Organisationsövergångar och unika kulturer. Förändringsdynamik och utvecklingsstöd via Växtkraft Mål 4. *För kortversion se VR 2002:21*

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8 Knowledge exchange, communication and context in electronic networks (KnowHow). *Endast PDF*

9 Systemiskt lärande som ansats i logistikutvecklingen – en studie av internethandeln. *Endast PDF*

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12 Den nya ekonomin – ett internetperspektiv. *Kortversion av VR 2002:11*

13 Projekt Camelot. Rundabordssamtal och seminarier kring framtidens boende

14 Tyskland och användningen av Internet - en jämförelse med Sverige

15 *Under produktion*

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20 Transport and Environment R&D in Sweden 2002

21 En sammanfattning av boken: Organisationsövergångar och unika kulturer. Förändringsdynamik och utvecklingsstöd via Växtkraft Mål 4. *Kortversion av VR 2002:5*

22 Nya material och produkter från förnyelsebara råvaror. *Kortversion av VR 2002:16*

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24 Trä-, Bygg- och Möbelprogrammet - en analys av insatser och resultat

25 Face synthesis as a communication aid for hard-of-hearing people. Teleface l and ll. Final project report. *Endast PDF*

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2 PIRATE – EU-projekt om attraktivare bytespunkter med fokus på de svenska studieobjekten Lund C och Vellinge Ängar. Svenska delen. *Endast PDF*

3 Innovative Transit Systems. *Endast PDF*

4 Arbetssituation och stresshantering hos kabinpersonal. *Endast PDF*

5 Japan inför nya fordonsbränslen och drivsystem. En översikt hösten 2000. *Endast PDF*

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5 IT i verkstadsindustrin. Program för mångvetenskaplig forskning i samverkan industri, högskola och institut

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7 Effekter 1975–2000. Stöd till behovsmotiverad forskning. *Populärversion av VF 2002:1*

8 Impact of R&D during the period 1975-2000. The impact of VINNOVAs predecessors support for needs. *Engelsk version av VI 2002:7*

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VI 2001:

1 *Se VI 2001:12*

2 *Se VI 2002:1*

3 Verksamhet som VINNOVA övetagit från NUTEK år 2000

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