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Research Paper ■

Testing the Suitability and the Limitations of Agent Technology to Support Integrated Assessment of Health and Social Care Needs of Older People

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Abstract. This paper explores the potential and the limitations of agent technology to support delivery of integrated information systems for the health and social care sector. In doing so, it points out the similarities and the mutual characteristics (such as distribution of expertise) of integrated health and social care information systems and agent technology. On the other hand, it identifies an important limitation of agent technology in the development of health and social care systems, which is the lack of a complete and mature analysis and design methodology that will provide guidance in the analysis and design of complex computer-based systems for health and social care. The Single Assessment Process (SAP) [http://www.doh.gov.uk/scg/sap/], an integrated assessment of health and social care needs of older people is used as an example of an integrated health and social care information system throughout the paper.

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Introduction

In a distributed health care setting different health care professionals, such as general practitioners and nurses, must cooperate together in order to provide patients with appropriate care and must also work closely with social care professionals, such as social workers, because health and social care needs quite often overlap. National policy in England is to promote the Single Assessment Process (SAP), an integrated health assessment of health and social care needs of older people. The Single Assessment Process aims to create closer working for providing primary health and social care for older people and other groups.

Computerising this process will help to automate some of the administration tasks (such as the management of the health and social care teams, appointments procedures and secure and anonymised sharing of medical records) of the health and social care professionals and thus leave the professionals with more time for the actual care of the older person.

Nevertheless, computerising this process is not an easy task. Only about 1% (in UK) of some health and social care professionals are using computer systems. Apart from the complexity of such a system because of the integration, the security concerns and the mobility, there are other concerns related to the domain of providing health care to older people, which must be taken into account. Thus, the fact that most of the time professionals have to use the system whilst dealing with older people is a concern that must be taken into consideration. Thus, one of the most important decisions in computerising such a process is the choice of the technology that must be used.

The number of information systems based on Agent Technology has increased in the last few years; however, this is not the case in the development of health and social care information systems. More traditional technologies, such as web and database technologies, are still mainly used in the development of such systems. Although, each of those technologies provide advantages, they fail to adequately provide the main reason of using computer systems in the health and social care information systems, which is to reduce the workload and make procedures easier and quicker for health and social care professionals and to improve quality of care for the older people.

We believe that Agent Technology looks very promising to fulfil the requirements of an integrated health and social care computerised system. The scenario of distributed health and social care suits well to an agent-based system since there is distribution of data (each professional owns their data about the patient), cooperation between the different professionals (exchange of information about the older person), and different expertise areas between the professionals.

We are developing the electronic Single Assessment Process (eSAP), an electronic system to deliver an integrated assessment of health and social care needs of older people. The project is run jointly between the Computer Science Department of the University of Sheffield and the Sheffield Institute for Studies on Ageing (SISA), and it is funded by the RANK Foundation. Analysing and designing such a system is not an easy task. Apart from the complexity of the system itself, another important factor is the lack of an existing system, either electronic or "human". Thus, apart from trying to understand the functionality of the system, an understanding of the environment of the system is essential.

This paper, tests the suitability and (some of) the limitations of agent technology in the development of health and social care information systems. It focuses on the lack of a complete and mature agent oriented software engineering methodology, by comparing and evaluate four state of the art agent oriented software engineering methodologies. By performing this evaluation, this paper, originally identifies features and concepts, such as security and mobility, necessary to the development of health and social

care information systems that current agent oriented methodologies fail to capture.

The next section of the paper introduces the Single Assessment Process, an integrated health assessment of health and social care needs of older people. The Single Assessment Process is used as a case study throughout this paper, to identify suitability and limitations of the agent technology for the development of integrated health and social care information systems. The paper then describes the mutual characteristics between agent technology and integrated information systems for the health and social care sector, and also outlines the main limitations of the agent technology in the development of integrated health and social care computerised systems. Especially it describes the limitations of current analysis and design methodologies for health and social care agent-based information systems. Finally, some concluding remarks and directions for further research work are presented.

The Single Assessment Process case

Older people often have a complex mixture of health and social care needs. Several different health and social care professionals such as General Practitioners (GPs), nurses, and social workers are mostly involved in the care of older people with assessments often undertaken in the older person's home. Currently these professionals might belong to different organisations such as GP offices, community services, and social services. The current situation very often results in duplication of assessments, lack of awareness of key concepts of need and fragmentation of care.

National policy in England is to promote the Single Assessment Process (SAP), an integrated assessment of health and social care needs of older people. The Single Assessment Process aims to create closer working for providing primary health and social care for older people and other groups. With closer working, professionals will work in teams that will be responsible for the health and social care of the older person. Each team will consists of many different (health and social care) professionals that they will cooperate and share information between them. In addition each of those professionals will posses some expertise. The teams will promote person-centred care by allowing the patient to actively involved in their care.

The single assessment process will also provide the older person and their carer with a personal copy of their care plan to support person-centred care. The single assessment process involves three main stages; the initial contact, the overall assessment and the follow-up action. During the first stage, contact assessment will provide basic information. In the second phase an overall assessment using a validated assessment instrument, such as Easy-Care,[1] will take place. The third stage will provide older people with more care in particular problems (might be different problems for each individual such as housing and loneliness problems) and with more detailed assessment if appropriate. The selection of the problems is determined by the results obtained from the Easy-Care assessment instrument.

Computerising this process will help to automate some of the administration tasks, such as the appointments set up between the health and social care professionals, and the management of the health and social care teams, and thus leave the professionals with more time for the actual care of the older person. Furthermore, it will help older people to be actively involved in their health and social care, since they will have access to the system.

Suitability of Agent Technology

In a Multi-Agent System a software agent is considered as a problem-solving entity. In this type of system a complex task is accomplished by combining different software agents that possess

different skills (expertise). All the different software agents that co-exist in the system possess their own expertise, which can be related to the other agents of the system but it is distinct, and they use this expertise at different stages of the solving process in order to accomplish the system's aim.

A reason that makes this kind of Multi-Agent System very attractive to researchers is because these systems can be viewed as human societies in which the roles of the human beings are played by the software agents, or there is a mix between human beings and software agents that cooperate and communicate in order to solve a complex problem. Thus, a software agent in the system can be viewed either as an entity that acts on behalf of a human, or as an autonomous entity that possesses some expertise and it is able to cooperate and communicate.

Table 1 Mutual characteristics of the single assessment process and an agent-based system

Single Assessment Process	Agent-Based System
Professionals	Software Agents
Cooperate	Cooperate
Expertise	Expertise
Distribution	Distribution

It is concluded from the above that the single assessment process can be modelled into a multi agent system that consists of many different software agents (and humans), which can cooperate with each other, share information (distribute information) and each of them possesses some expertise. A summary of the mutual characteristics of the Single Assessment Process and a multi-agent system is given in Table 1.

In our system, the software agents will act on behalf of professionals. Each professional will have their "own" software agent, which they will customise according to their needs. The agent will have enough information about the professional, such as personal information and professional commitments, and it will be intelligent enough (capable of analysing the information and take decisions) to enable it to act on their behalf, and also negotiate for the interest of the professional.

The system will have the following characteristics:

1. The system will consists of software agents as well as human professionals.
2. Each professional will have his/her software agent.
3. The professionals must able to customize their software agents through an easy-to-use interface.
4. The system must be developed with mobility in mind since many of the professionals will use it whilst in the older person's house
5. The system must be secure.
6. The software agent will be capable of analysing information and taking decisions. Also, it will have information about the professional (personal and professional) that will be able to act on his/her behalf.
7. Software Agents in the system will be able to communicate between themselves as well as with the human professionals.

Agent technology is suitable to fulfil all the characteristics required by such a system. However, in developing such a complex system the first step is to analyse and design the system. In our case we have to model the single assessment process into a multi-agent system in which software agents and humans cooperate together to deliver better health.

Limitations of Current Agent Based Methodologies

Before starting the implementation of such a system, it is necessary to fully analyse and design it. Designing and analysing a system before it is actually implemented helps to better understand the system requirements, the user needs and thus the whole system. Starting to implement a system without a design might work for small systems that only require a few lines of code and one developer. However, trying to implement complex distributed systems (like health care systems), that require hundreds or thousands of lines of code, and large teams of developers, without a design proves to be a nightmare.

To help with analysing and designing systems, partial methodologies have been created. But as Kinny et al argue "If multi-agent systems are to become widely accepted as a basis for large scale applications, adequate agent-oriented methodologies and modelling techniques will be essential[2] ". This is not just to ensure that systems are reliable, maintainable, and conformant, but to allow their design, implementation, and maintenance to be carried out by software analysts and engineers rather than researchers. Thus, it is recognised amongst the agent research society[3,4,5,6,7] that there is a need for a complete analysis and design methodology for multi-agent systems.

The main role of such a methodology will be to help in all the phases of the development of an agent-oriented system. There are plenty of issues that must be considered when analysing and designing such systems, such as coordination, cooperation and communication between the agents[7] . In addition, analysing and designing health care information systems, such as the Single Assessment Process, involves integration and sharing of information and introduces some extra requirements. First of all, security is a major concern in such a system. The system will contain personal and medical information and thus must be very secure. Also, the methodology must give developers the flexibility to use any kind of software agents that might be needed. In the Single Assessment Process computerised system, mobile agents are most likely to be used. Mobile agents are software agents that can be moved to other computers in the network to obtain some information that the user requires. Another important point is the interface that will be used to enable the health and social care professionals to interact with their personal agents. Designing and analysing such interfaces will help to make the system easier for the users (professionals). Thus, the methodology must support the analysis and design of the characteristics that a health and social care system introduces.

Testing Current Agent-Oriented Methodologies

Although, there are methodologies for analysing and designing agent-based systems, these are failing when designing agent-based information systems for the health and social care. Four leading methodologies (GAIA, MaSE, MESSAGE and MASB) for agent-based systems were reviewed and evaluated. These methodologies were chosen since they represent the state-of –the-art in agent-oriented software engineering.

- GAIA methodology is specifically tailored to the analysis and design of agent-based systems. The methodology deals with both the societal (macro) level and the agent (micro) level aspects of the design. The developers of the methodology argue that GAIA allows a designer to systematically go from requirements to a detailed design that can be implemented. GAIA methodology separates the analysis and the design phases explicitly and are considered (both analysis and design) as a process of developing models of the system under development.[8]

- The Multi-agent Systems Engineering Methodology (MaSE) is similar to the GAIA methodology but more specialised for its use in the distributed agent

paradigm and goes further by providing support for generating code using the MaSE code generation tool. One of the main differences between this methodology and other agent-based methodologies is that in the MaSE methodology the general components of the system are designed before the system itself is actually defined .[9]

- The Methodology for Engineering Systems of Software Agents (MESSAGE) focuses on the analysis and design steps. It provides a set of analysis and design models suitable for analysing and designing Multi-Agent Systems and gives some recommendations on how these models can be built. The methodology starts by using UML and extends it by adding entity and relationship concepts required for the analysis and design of Multi-Agent Systems. Thus, it provides additional "knowledge level" concepts and uses the methodology's meta-model in order to define these concepts.[7]

- Multi-Agent Scenario-Based (MASB) method is a multi-agent system design approach based on the analysis and design of scenarios involving human and artificial agents. The methodology can be used to design multi-agent systems in the area of cooperative work. The method is divided into two phases, the analysis and the design. In the scenario description step, the designers give a description of a scenario, using natural language, which emphasises the roles played by the humans and the agents. Thus, the typical information exchanges between the agents and the humans are described along with the events and the actions performed by the agents.[10]

Eleven (11) evaluation points were identified for the evaluation of these methodologies. These points are enough to obtain adequate results and conclusions about the methodologies, since they evaluate the two main aspects necessary for every agent-oriented methodology. That is, the modelling of the agents of the system and some software engineering concerns, such as flexibility that every methodology should provide the engineer. The evaluation points are as follows: (1) Identification of the agents of the system - can the methodology identify the correct number of software agents of the system; (2) Communication - can the methodology capture all the available communications that happen in the system; (3) Intelligence - can the methodology capture the intelligence of the agents of the system; (4) Agent Expertise - can the methodology capture the expertise that the agents of the system must posses; (5) Interfaces - can the methodology model the interfaces used from the humans to communicate with their software agents in the system; (6) System Environment - can the methodology capture adequately other aspects of the system environment, such as the borders of the system; (7) Mobility Aspects - can the methodology capture the mobile agents of the system; (8) Security - can the methodology capture the initial requirements for the security of the system; (9) Easy-to-Use - is the methodology easy-to-use and understand when employed by not very experienced software engineers; (10) Consistency - does the methodology provide rules to test the consistency between the analysis and the design phases; (11) Flexibility - does the methodology allow for design flexibility.

In order to evaluate the methodologies an appointment system was partially analysed and designed using each of the above methodologies. In this system, each professional has a personal software agent and the software agents have enough information about the professionals so that they (agents) can book appointments on their behalf. The decision of employing an appointment system took place since such a system provides all the functionality necessary to evaluate a methodology according to the above-mentioned evaluation points. The results obtained from the evaluation are shown in table 2. The "√" symbol means the methodology provides means to model

adequately the characteristic. "~" means that improvements are needed in order to fully capture the characteristic, while "X" means the methodology cannot capture the characteristic.

The approach of analysing and designing the appointment system with each of the above-mentioned methodologies proved to be quite useful for many reasons. First of all, valuable knowledge was obtained for each of the methodologies. By obtaining this knowledge and having a common ground for comparison (the appointment system) the final evaluation came natural. Also the approach of using different methodologies in the analysis and design of the system provided us with very useful feedback for the system itself since we obtained different "views" of the system from different perspectives.

Table 2 identifies important limitations of the methodologies under evaluation. The most important of these limitations, especially in the design of health and social care computer systems, is the lack of modelling the security aspects of the system under development. The need for security is a major concern, especially in health information systems, since revealing a medical history could have serious consequences for particular individuals. Although security aspects are taken into consideration after the design of the system has been finished and during the implementation stage, this is not the best approach. Security must be concerned from the start, since there is not much hope to design a secure system by making changes and additions to an insecure system.

In addition, the capturing of mobile agents is another important limitation of the current methodologies. Mobile agents are a crucial part in most agent-based systems and the lack of a model to capture them restricts the usefulness of the existing methodologies. Especially in the health and social care information systems, mobile agents can play a major role. For example a mobile agent can migrate off a mobile device (from a health care professional visiting an older person in their house), and roam the Internet to gather information. Since it is not in continuous contact with the device (it can transfer itself in the requested network location), even if the professional disconnects (to visit another patient) the mobile agent is not affected. Thus, when the professional re-connects the mobile agent will deliver the requested information to the mobile device.

Table 2 Comparison of the methodologies

Characteristic / Methodology	GAIA	MaSE	MESSAGE	MASB
1	√	√	√	√
2	~	√	√	√
3	√	√	~	~
4	~	~	~	~
5	X	X	X	X
6	~	~	~	~
7	X	X	X	X
8	X	X	X	X
9	√	√	~	~
10	√	√	√	~
11	√	√	√	√

Finally, the modelling of the interfaces between the humans and the software agents involved in the system is an important characteristic that is not captured by any of the existing methodologies. Although there is rich research on the Human-Computer Interfaces (HCI) area, it is important to identify how the design of agent-based systems is depended on the interfaces between the humans and the software agents of a system.

Conclusions and future work

This paper argues that agent technology has the potential to support the development of health and social care information systems. Nevertheless, although there are some attempts of employing agent technology in health and social care information systems, [11,12] these are the exemption rather than the rule. Mostly, developers of health and social care information systems are reluctant to use agent technology. One of the reasons is the lack of a mature and complete analysis and design

methodology for agent-based health and social care information systems, which will help developers throughout the development of such a system. Thus, in order for the agent technology to be widely accepted in the development of computer based medical systems, it is necessary to develop a complete and mature analysis and design methodology to support all the stages of the development of agent-based medical systems.

The results presented in this paper are the initial exploration of the suitability of agent technology in the development of health and social care information systems. Much remains to be done for further research. Future work is directed towards extensions to support the integration of security and the modelling of mobile agents during the development of our system. Thus, we are extending Tropos [13,14] agent-oriented methodology to support integration of security aspects during the analysis and design stages. In doing so, we aim to provide a set of concepts and notations customised to security modelling, and a clear process that will guide the developer during the development stages. Future work on mobile agents modelling involves the identification of a process that will help developers to correctly identify the kind of agents that are suitable for their system, and then provide concepts and notations to capture them.

By doing so, we hope that agent technology will advance and will be easier to use in the development of health and social care information systems providing all the advantages that are described in this paper, such as problem-solving capabilities, information sharing, encapsulation of expertise, and even more.[11,12]

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