# Improving Knowledge Provision for Shared Decision Making in Patient-Physician Relationships – A Multiagent Organizational Approach

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**Abstract**

*The paradigm of shared decision making in patient-physician relationships is well documented. Moreover, it is an integral aspect of sound patient centric healthcare delivery. Implementing such an approach within established healthcare processes has yet to be successfully realized. This void is causing problems in healthcare delivery in particular in EU countries such as Germany because knowledge sources are distributed and underlie strict privacy policies; while the lack of adequate shared decision making compromises the quality of healthcare delivery and can lead to errors and inefficient workflow. This paper serves to analyze the provision of personal guidance services for shared decision making in eHealth service networks. By doing so, we address the problem of distributed and privacy-aware knowledge sharing by the formation of agent-based organizations to represent the relationships of patients and physicians and study this problem from the perspective of multiagent systems; i.e. we develop technology enabled collaboration solutions. The efficacy of the proffered decision support system will be demonstrated by a scenario-based evaluation. We contend that such an approach will address the current void.*

## 1. Introduction

The provision of individual personal eHealth services has particular requirements with regards to knowledge sharing, especially in terms of security and privacy protection. However, knowledge sharing is essential in the provision of superior, patient centric healthcare delivery. The collaborative paradigm of shared decision making is one applicable approach to try to address this. Shared decision making improves patient empowerment and outpatient care in patient-physician relationships. Though such approaches are well documented [1], implementation details in established healthcare processes still remain unclear. This is particularly problematic in Germany and in other EU countries since personalized health-related knowledge sources are highly distributed and subject to strict privacy policies; while the lack of appropriate shared decision making between patient and physician leads to inferior quality healthcare delivery, medical errors and inefficient workflow and even unnecessary duplication of tests.

Due to the distribution of existing data sources, central knowledge management cannot be applied, i.e., the personal data of users have to be stored and managed in a distributed fashion to foster privacy protection and security. These requirements are especially challenging in view of the heterogeneity of existing data sources: (1) the personal health data and patient data stored in electronic health record (EHR) and patient health record (PHR) systems, (2) available environmental information (e.g., temperature, air pollution), (3) wearable or portable systems for health status monitoring, and (4) common ubiquitous internet services by mobile devices as well as home computers (including user generated information). In order to decide on preventive or therapeutic actions, stakeholders are required to obtain all relevant user-individual knowledge.

To support this distributed knowledge sharing situation we propose personal guidance services for shared decision making in eHealth service networks. We consider the mapping of the health-related shared decision making principles to the technical collaborative decision support approach. Collaborative technologies represent the relationship of patients, physicians and other eHealth service providers in terms of roles, obligations, and permissions. Security and privacy protection requirements for the provision of the individual personal eHealth services, i.e., (1) the set of personal health data required has to be analyzed and transferred for a specific purpose, (2) transparency of the utilization of personal health data has to be assured,

and (3) the control of personal health data utilization by the user have to be guaranteed.

Insofar, distributed, heterogeneous knowledge sources with sensitive health-related data complicate the provisioning of customized eHealth services in patient-physician relationships. To provide decision support for both physicians and patients, we propose a software system in which each individual actor is represented by an intelligent software agent that acts on behalf of its user. In particular, the emerging multiagent system exhibits organizational structures that account for representing the relationships, roles, and permissions of the actors.

We address the problem by designing a decision support system that implements the process of multiagent organization formation. The resulting software system then captures all relevant patient-physician relationships, roles, and permissions, and allows for individualized decision support in distributed knowledge sharing environments.

The formation of multiagent organizations is based on an organizational meta-model that is transferred to an ontology for the purpose of organizational reasoning. Intelligent software agents represent the participating actors (e.g., patients/physicians). To consider the privacy requirements we develop the full lifecycle of agents/organizations presented by patterns for the communication and interactions.

The remainder of this paper is structured as follows: In section 2, we discuss the theoretical background based on a literature review. The formation of multiagent organizations for distributed knowledge sharing is shown in section 3. Section 4 outlines the scenario-based evaluation by demonstrating a use-case around a patient suffering from dementia. Section 5 summarizes the results and concludes.

## 2. Background

Traditionally, decision support systems (DSS) in medicine are clinical decision support systems (CDSS) designed to assist medical doctors and other healthcare professionals with decision making tasks. This kind of decision support is mainly based on patient's medical data and usually built around an alerting system based on medical rules of logic [2]. It was Robert Hayward who proposed a functional definition in this way that: clinical decision support systems link health observations with health knowledge in order to influence health choices by clinicians for improved care. Most DSS consist out of three modules, the knowledge repository, an inference engine, and techniques to communicate with the provider and/or end user. Decision support functionality in healthcare

is in many cases part of a hospital information system or patient data management system used for physician-centered inpatient care.

A systematic review in 2005 by Kawamoto et al. [3] found that decision support systems are able to improve clinical practice significantly. It identified four features strongly associated with CDSS's ability to improve clinical practice – (1) decision support smoothly integrated into clinical workflows, (2) decision support provided at the time and location of decision making, (3) provision of actionable recommendations not only assessments, and (4) using electronic media rather than paper-based.

In an ambulatory setting shared decision making (SDM), known as process in which a healthcare choice is made jointly by health care professional and the patient, could be part of patient's consultation with the family doctor [4][5]. These face-to-face visits are typically not able to deliver care on continuous healing relationships, because responsiveness at all times is missing [1]. The following section points out, how existing approaches to medical decision support address this problem by involving multiagent systems in the process.

### 2.1. Agent-based approaches in medical decision support

Multiagent system technology is a software paradigm where the notion of an agent refers to "*an encapsulated computer system that is situated in some environment and that is capable of flexible, autonomous action in that environment in order to meet its design objectives*" [6]. Such agent-based software paradigms suit well to (1) represent the distributed nature of the problem, (2) enable multiple loci of control, and (3) support competing interests of entities [6]. Agent-based approaches for electronic health services have been subject of much research in the field of medical informatics. Isern et al. [7] give an overview over these agent-based approaches and divide them into five sections: Medical data management, decision support systems, planning and resource allocation, remote care as well as composite systems. Here, we focus on decision support systems that mainly aim at assisting professionals in their daily routine. An early agent-based system to foster patient-physician collaboration is presented by Silverman et al. [8]. The work focuses on reminders, alerts and actions that proactively support the user with additional information needs, anticipated by the system. The knowledge base of each agent is manually updated via a decision table interface. However, the proposed system does not support dynamic learning of the

manually entered rules and does not support the decision in a shared decision scenario.

Huang et al. [9] propose an agent-based approach that coordinates the various actors in health care management. The authors map the main characteristics of agents (autonomy, social ability, reactivity, and proactiveness) to the health care domain. Each agent represents an actor that is involved in the clinical process. This approach focuses on the perspective of hospital staff, and does not involve the patient itself respectively an agent representing the patient in the coordination process.

Mago and Devi [10] present a multiagent system for providing clinical decision support to healthcare practitioners in rural areas, where no specialists for infants and young children are available. The focus is on the development of user agents along with their graphical user interfaces. However, the authors do not consider a shared decision making process between patients and physicians. Zhang et al. [11] develop a multi-agent platform to support the decision making between stakeholders in a diabetic healthcare scenario for children. Software agents provide intelligent decision support to the patients in order to decrease the communication and coordination burden of the healthcare management, and thus, improve the healthcare quality. This includes monitoring of the patient, decision support to diagnosis, as well as meeting arrangements. However, shared decision making is also not provided. These approaches neglect the fact that the autonomy of each agent leads to loosely coupled structures that vanish as soon as the addressed goal is reached. Regarding these structures as organizations enables the integration of persistency and, thus, the sharing of critical data in terms of privacy. The concept of multiagent organizations transfers methods and constructs from organizational theory to the conceptualization of multiagent systems.

## 2.2. Multiagent organizations

Based on our previous work [12], this section provides a literature overview on the concept of multiagent organizations. The oxford dictionary defines an organization as "*an organized group of people with a particular purpose*" [13]. Specific criteria how "*people or things that are located, gathered, or classed together*" [13] form a *group* are not provided. This specification of *organizational membership* is also not done homogeneously in organization theoretic literature. While Luhmann [14] place the employees outside of the organization, Cyert and March [15] even include the customers in the organization. Especially with diminishing boundaries between different types of contracts, e.g. employees and freelancer, we require an

agent for its membership to have a contract with the organization that obliges him to provide its resources.

Following organization theory, the concepts of roles and structures constitute the two major measures to be applied to multiagent systems [16]. Concepts and implementation guidelines describing these roles, structures, and interactions within a multiagent system are presented by Ferber et al. in (2004). An organization centered multiagent system (OCMAS) is a multiagent system whose foundation lies in particular organizational concepts such as groups, communities, and roles [17]. An OCMAS extends the more familiar notion of an agent centered multiagent system (ACMAS) which solely deals with the individual agents' mental states. As the classical ACMAS approach reveals a number of drawbacks on the organizational level, Ferber et al. [17] focus on the design of multiagent systems using organizational concepts only and so propose a framework where agents with different cognitive abilities interact with each other. Based on their organizational framework they provide a generic organizational model called AGR (Agent/Group/Role) and demonstrate the usefulness of these concepts by means of an illustrating example.

Multiagent organizations have been modeled based on the concept of virtual organizations (VOs) from management science [18]. These concepts have been transferred to the formation of organizations within multiagent systems. Barbuceanu [19] employs a multiagent system to analyze different entities in an inter-organizational supply chain. An agent-based system where different entities of organizations and their operations are explicitly modeled by software components is provided by Fischer et al. [20]. The authors focus on different possibilities with regards to the contribution of software agents to the formation of agent organizations. Besides the mere setup of organizational structures, their approach includes the model of complex operational functions as autonomous agents that allows for direct horizontal coordination of geographically distributed entities. In their approach, the negotiation process for the selection of appropriate organization partners by means of mutual agreements with regards to the structure of the organization is realized through an agent-based software architecture. An application of autonomous agents in a manufacturing supply chain forming an agent organization is proposed by Jain et al. [21]. Since software agents are assumed to act autonomously within an organization, the authors state that the main basis for managing agent autonomy lies in a more flexible formulation of the agents' commitments. Tambe et al. [22] propose a framework for partner selection in an agent-based organization in cyberspace.

An agent resources manager searches the cyberspace for agents of interest and recruits them for the emerging organization. In Petersen and Gruninger [23], human resources are represented by software agents which compete to become partners in the organization. The authors derive basic concepts that apply to an organization and define a generic model of an organization using an agent-based system. Their model incorporates the concepts of goals, activities, roles, skills, and agents and provides a way to describe the relationship among these attributes and how they can be used inside the multiagent system.

Software agents are used to represent potential partners of an organization that negotiate conditions for an organization membership in Petersen [24]. The agents employ bidding in an electronic market on behalf of their users while individual bids are evaluated according to certain criteria. Hence, the main focus of their work lies in the formation process of an organization by means of the analysis of several industrial use cases. Their approach describes the communication among intelligent agents using the technology of an agent interaction protocol (AIP) to provide insight into agent messages that are actually exchanged. If by negotiation the individual goals of the agents correspond to the goals of the organization and the requirements of specific roles match those needed in the organization to some extent, these agents become partners of the organization.

A good overview of existing paradigms that can be applied to multiagent organizations has been presented by Horling and Lesser [25] who identify most existing approaches used in the formation of organizations within multiagent systems.

## 2.3. Distributed knowledge sharing for shared decision making

This section will introduce the principles of shared decision making and show how the concept of multiagent organizations fit in this domain. The challenge of this work is the provision of beneficial computer-based ingredients of shared decision making processes together with a useful aggregation of distributed knowledge sources using state-of-the art information and communication technologies. One goal is to implement a method which supports information personalization and shared decision making in the dementia domain, wherein disease knowledge management plays a critical role.

Hence, we focus on processes of shared decision making in using eHealth service networks to improve patient empowerment and outpatient care. This requires new methods to allocate and distribute

context-specific knowledge and information between the participating stakeholders.

Traditionally, it is the physician who decides about the therapeutic path, care or treatment of a patient. This tradition comes from a paternalistic view of the doctor-patient relationship. Informing and involving patients in these decision making processes is increasingly becoming a standard for good medical care [26]. Shared decision making (SDM) is the process of patient-physician communication where both parties are acknowledged to bring respective expertise to the process and to work in partnership to make a healthcare decision [27]. Many healthcare systems are currently facing SDM in order to improve health interventions and services. In the report, Crossing the Quality Chasm, in 2001 the Institute of Medicine recommended redesigning health care processes according to 10 rules, a lot of them emphasize shared decision making. Rule No. 3 for instance, underlines the importance of the patient as the source of control, envisioning health care systems that encourage shared decision making and accommodates patients' preferences. Another rule requires that knowledge is shared and information flows freely in order that clinicians and patients communicate effectively and share information. Based on the broadly accepted condition that care has to be customized and tailored according to patient needs and values, which in turn will become transparent in communication processes of SDM.

Through the discussion of various treatment options, patients develop a deeper understanding and a greater awareness of the necessary therapeutic interventions and activities. A deeper understanding of the healthcare background and its processes as well as possible side effects of the therapy enables patients for better integration of therapy in their everyday life. It was realized that for a successful implementation of treatment plans it is advantageous when patients were actively involved in the treatment decision. Active participation in decision-making allows the patient to take steps and ensure that the mutually agreed therapy takes into account their specific needs and interests. Furthermore, the relationship between patient and doctor can improve and intensify. Many patients confirm a higher satisfaction with their treatment, the treatment decision, the treatment result and their physician. This results in higher satisfaction also results from the fact that patients in SDM processes have a more realistic understanding of the achievable goals of the treatment because of the intensive dialog which is able to prevent disappointments, frustrations or conflicts with the doctor. Because of all these factors SDM processes result in many cases in a faster

treatment response and/or a better treatment outcome [28][29].

Compared to traditional media forms, the web offers an integrated approach, i.e. a combination of video, audio, e-mail and other interactive functions which can be useful in supporting shared decision making by personalized e-health services. One challenge will be to transfer the traditional face-to-face interaction model effectively into a user interaction design, suitable to apply evidence in health care delivery.

The central issues arise from both the heterogeneous, distributed characteristic of the domain knowledge and the ethical and security concerns that make the information even harder to share. Thus, shared decision making shows the main characteristics of multiagent systems presented in section 2.1: (1) knowledge is distributed between patients, physicians and caregivers, (2) each of them acts autonomously, and (3) in case of privacy competing interests may arise.

In summary, existing decision support systems based on autonomous agents lack in persistency and in privacy-aware knowledge sharing required from highly distributed data sources. The concept of multiagent organizations provides suitable means to address these shortcomings and the research question guiding this study is: How can knowledge provision for shared decision making in patient-physician relationships be improved using a multi-agent approach?

## 3. Multiagent organization formation

In this approach we represent the participating actors (e.g. patients/physicians) by intelligent software agents and map their mutual relationships to a multiagent organization. The formation of organizations in a multiagent system implements the privacy requirements regarding sensitive information in a medical knowledge sharing context. Personal medical information that is known to a patient and a physician should not be shared with any other participant that is not explicitly authorized to access this information.

### 3.1. Model

Ferber et al. [17] introduce a generic concept for modeling an organization centric multiagent system, which represents the basis for the organizational model of this work. We adapt this meta-model to suit our purpose. The basic elements of the model can be summarized as:

- Agent: An agent represents/acts on behalf of /supports a real world actor. An agent is able to hold multiple roles and may be member of several organizations.
- Role: A role describes a function in an organization.
- Organization: An organization consists of a set of agents that share one service. Agents' communication is restricted to agents that belong to the same organization with the exception of communication that is part of the formation of an organization. An agent may belong to several organizations at the same time.
- Organizational structure: The organizational structure maps services to organizations and defines which roles form which organizational structure. An agent has to play a role to be part of an organization. Some roles may be played by several agents, e.g. in a patient-centric care giving scenario several care givers attend one patient.

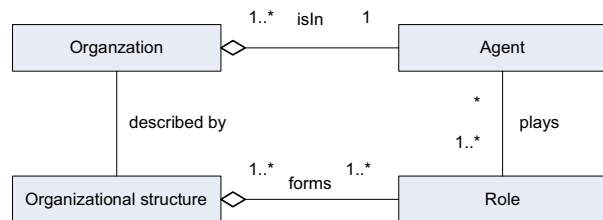Figure 1 illustrates the relationships between these elements.



**Figure 1. Meta-Model of multiagent organizations**

### 3.2. Organizational reasoning

In order to base the formation of an organization on the described model and to guarantee the restricted communication, an organizational reasoning mechanism is developed. This accounts for the following two steps: (1) the presented meta-model is converted to an ontology, that represents the organizational concepts, and (2) the agents are enabled to execute reasoning on an ontology.

The integration of semantic web technologies into multiagent systems, proposed in previous work [30], is based on the concept of deliberative BDI agents [31]. The BDI paradigm specifies explicitly (1) the current facts about the world (beliefs), (2) the motivational attitude that form concrete goals (desires), and (3) the appropriate actions to achieve the given goals (intentions).

The standard BDI concept has been integrated with explicit semantics: the agent's beliefs, stored in the

agent's beliefbase, partially base on semantic data. Conceptual definitions of the organizations are given in the predefined OWL DL ontology [32]. Every agent holds his own copy of this predefined ontology. In the case of the formation of a new organization or change of an existing organization the new organizational information is inserted as instances into the knowledge base/ontology, which is automatically enriched using description logic (DL) reasoning. Agents can then retrieve the results of reasoning via the beliefs. An embedded OWL engine provides the core semantic functions inside the agents. The OWL engine is connected to the BDI agent via the beliefbase. The implemented BDI agent plans add or modify facts in the semantic database, which activate any OWL DL reasoning or other rules inside the semantic core.

The organizational reasoning itself gives information about the organizations in which the agent is member. As a result, active and passive communication can be restricted to those agents that belong to the same organizations as the agent itself.

### 3.3. Formation and execution

The full lifecycle of the agent-based distributed knowledge sharing consists in multiple steps.

The initial step is the registration of a participant. The portal represents the main entry of the participant to the provided eHealth services. Once a participant registers at the portal, the agent that represents this participant has to be created. Furthermore, a new instance of the ontology with the organizational concepts has to be created. The directory facilitator (DF) is a standard platform agent that provides the registration and the discovery of services. The newly created agent registers at the DF. Figure 2 illustrates the registration step as an UML-sequence diagram.
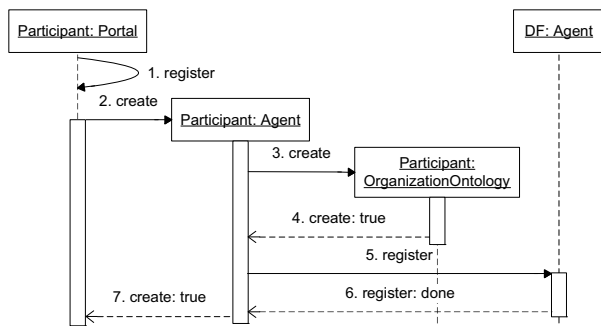


**Figure 2. UML-sequence diagram of portal registration**

The second step is the subscription for one of the offered services via the portal of the participant. This subscription refers to the creation of a role and an organization belonging to this service. In detail, the role belonging to this service is added as an instance to the ontology. Secondly, the instance of the underlying organization structure is added to the agent's ontology and the agent's role is related to the created organization. Figure 3 illustrates the service subscription step as an UML-sequence diagram.
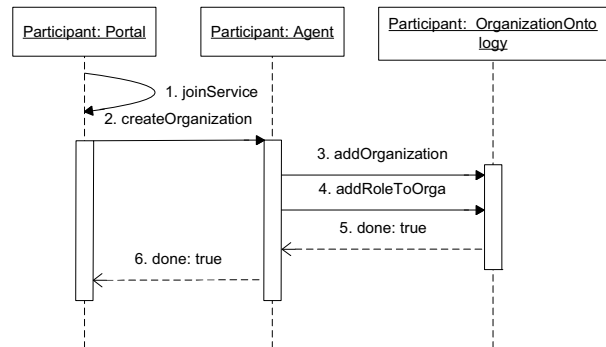


**Figure 3. UML-sequence diagram of service subscription**

A participant that subscribes to a service is able to invite other participants to this service instance, e.g., a patient that subscribed to an eHealth service may invite his/her attending physician to this instance. Subject to the condition that the inviting participant knows the identification details of the other participant. Though the invitation is triggered by one of the participants via the portal, it actually refers to an invitation of another participant's agent to the organization. Hence, the agent queries the details about its organization from the local organization ontology. A request at the DF delivers the endpoint of the invited agent. The actual invitation is represented by a message that is sent from one agent to another containing details about the organization. The invitation is handed through the portal to the real world actor whose decision is necessary regarding the invitation request.

In the case of a positive decision the invitation has to be confirmed by sending a message to the inviting agent. Furthermore, the details about the new role, organization, and relationship have to be added to the local ontology of the invited agent. The inviting agent has to add the new membership of the invited agent to his ontology and to inform all other members of this organization about the new member.

In case of a refusal of the invitation the decision has to be sent to the inviting agent; no further action is required.

Figure 4 illustrates the invitation step as an UML-sequence diagram.

Once an organization is formed, the actual execution is enabled. However, a further organization entry is possible at any time.
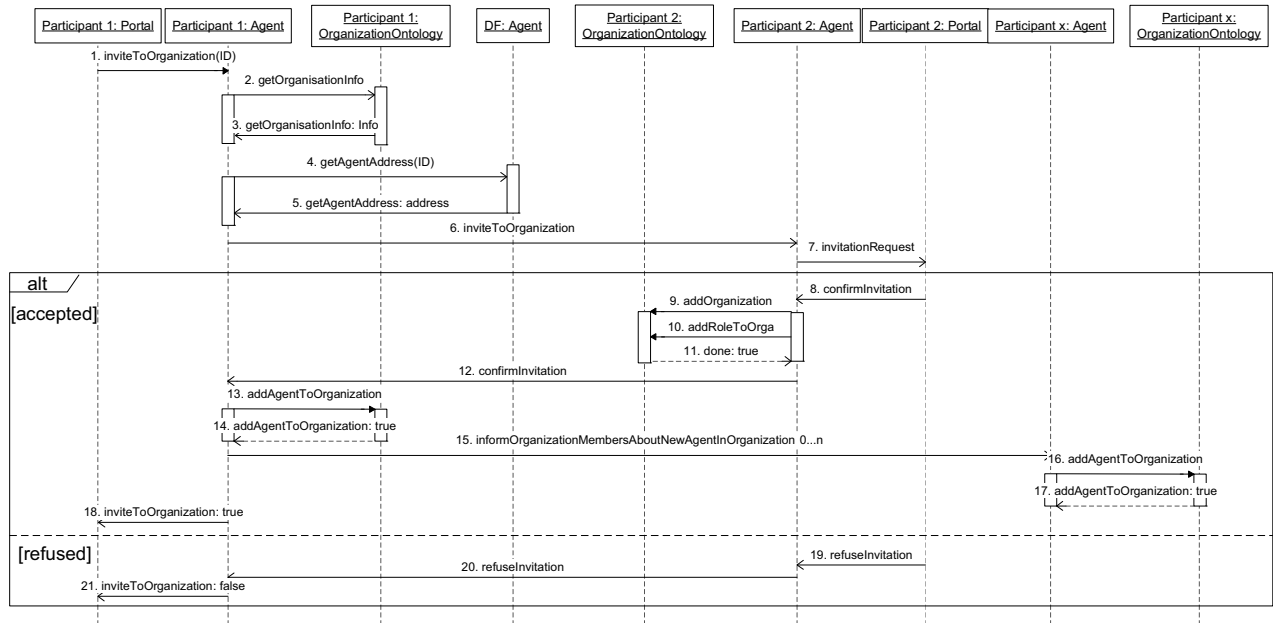
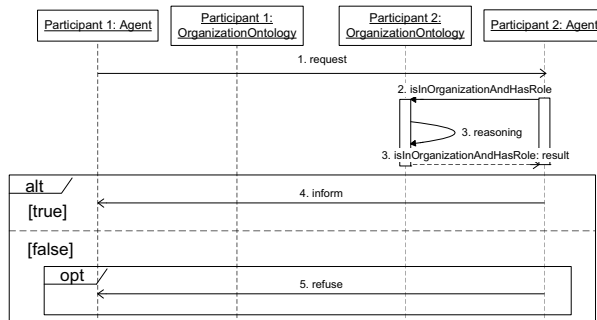**Figure 4. UML-sequence diagram of an invitation**



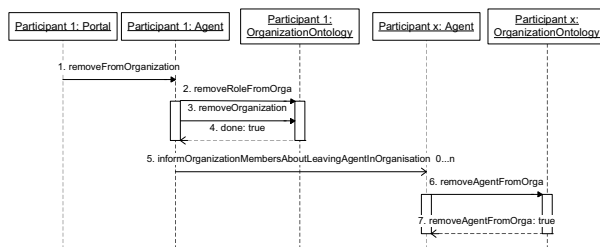**Figure 5. UML-sequence diagram of execution phase example**



**Figure 6. UML-sequence diagram of leaving an organization**

Figure 5 shows an example of an execution phase interaction as UML-sequence diagram. An external trigger or the agent's proactive behavior determines aninteraction demand regarding another agent that is member in one of his organizations. So the agent sends a request message to the other agent. After receiving this message, it has to be verified by the receiving agent. The organizational reasoning checks if the

sending agent is allowed to query that request. This verification mechanism prevents misuse and guarantees privacy of sensitive information.

Optionally, the verification maybe also executed on the sender side before sending a request. In the case of a positive verified request the agent reacts according to the content; otherwise the agent refuses the request.

Finally, if a participant unsubscribes from a service via the portal, the agent has to leave the organization, i.e. remove this instance of the role und organization from his local organization ontology. If there are still other members in this organization, the agent has to inform them about its leaving. If the agent is the last member in this organization, the organization is destroyed immediately. Figure 6 illustrates the leaving step as an UML-sequence diagram.

### 3.4. Organizational knowledge space

Multiple memberships of an agent are explicitly allowed in our model. In other words, this implies for example that one physician treats several patients. In the context of a multiagent system, this means that the physician agent is member of separate organizations for each patient agent. Considering the privacy issues in a health-related environment (1) the knowledge that is shared by the agents in one organization and (2) the knowledge that is recreated due to the participation in the organization form the abstract concept of the organizational knowledge space. Agents that are not part of an organization are not allowed to participate in the knowledge sharing activities.
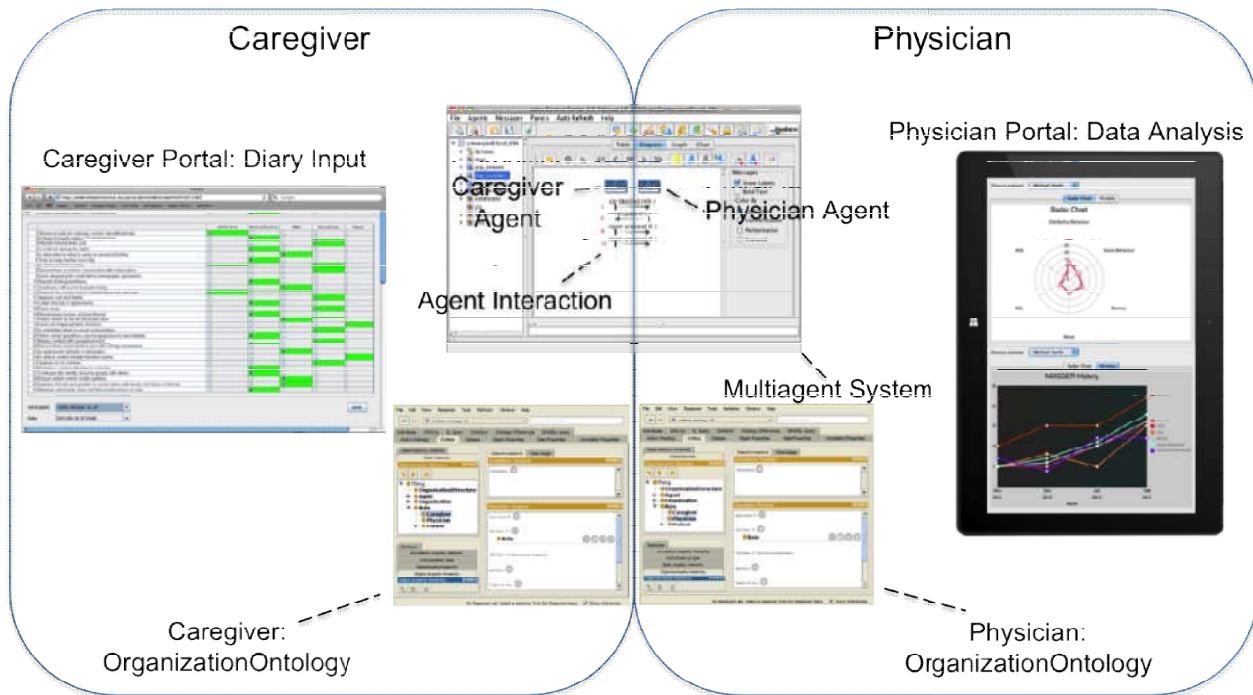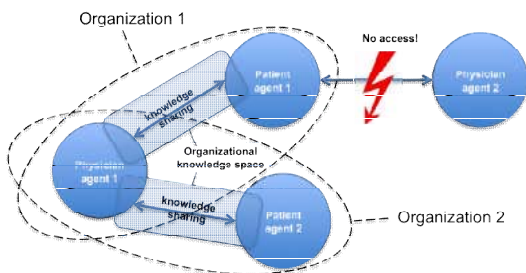
**Figure 7. Diary service**



**Figure 8. Illustration of organization**

Figure 8 illustrates these organizational concepts in an example of a physician agent that is member in two organizations. Another physician agent that is not part of the organization has no access.

The multiple memberships of agents raise a couple of issues that are not explicitly in the scope of this contribution, however, mentioned in the following.

In order to not swap information between the organizations an agent is participating, the knowledge has to be stored separately (at least logically, optimally physically).

Furthermore agents need to act asynchronously with agents of different organizations without mixing knowledge. This avoids a long queue time and enables parallel actions.

Learning on the base of analyzing the history of different patients could be one asset of a physician agent, however, current privacy regulation in the medical domain would not permit this advancement.

## 4. Evaluation

We present a scenario-based evaluation [33] that applies the organizational approach. BDI agents that are able to communicate with each other to achieve their design objectives represent individual actors. The common goal of the multiagent system consists of the production of services complying with the privacy policies. The following description is based on the user story for a dementia patient.

### 4.1. Description

The scenario includes a physician and a caregiver of a patient suffering from dementia. The nurses' observation scale for geriatric patients (NOSGER) [34] form the basis of a course-of-diseases diary. The analysis of these data on physician side enables tightly focused the provision of customized information to support a shared decision making process regarding the current situation. The first steps represent (as described in the previous section) the registration of the caregiver and physician to the platform, if they are not yet participants. Followed by the subscription of one of the participants to the diary service, the invitation of the other to that service, and her or his confirmation. A caregiver agent and physician agent and the individual organization ontologies with an assignment to this diary service organization have been created. During the execution phase in the diary scenario the caregiver

is consigned with the task to fill out the NOSGER scale instrument in predefined iterations. The instrument assesses and observes the current patients behavior in 30 statements that record aspects of six dimensions: memory, instrumental activities of daily living, self-care, mood, social behavior and disturbing behavior. The caregiver informs the physician via the multiagent system with the ontological privacy check on communication about the new dataset. In this scenario the diary represents the core of the organizational knowledge space.

The physician agent provides an analysis that can be visualized on the physician portal. The results are consolidated per dimension. Predefined individual thresholds trigger action plans. Possible actions are: (1) do nothing, (2) give an alert according to the threshold, (3) provide information regarding the current situation for a shared decision making context, and (4) give recommendations. Some actions, e.g., give medical recommendations require the involvement of the real-world actor, where the physician has to decide which recommendations are given to the patient.

Figure 7 shows the look-and-feel of the diary service. It illustrates the diary input form of the caregiver, the multiagent system, the organization ontology of the caregiver agent and physician agent, and the data analysis visualization for the physician.

## 4.2. Discussion

With the proposed approach we provide a platform that enables distributed interactions in a shared patient-physician context considering privacy issues in a medical scenario. The NOSGER scale is a valid and reliable instrument that can be filled out easily by caregivers in short time and serves as the basis for the course-of-diseases diary. The usability of the system is a very important issue in order to not fail because of low technology acceptance of the users.

We aim to achieve the following benefits for the different participants. Caregivers of patients suffering from dementia are often family members of the patient. The approach gives individual support for handling the patient and should finally reduce their burden and improve the quality of life of caregivers and patient. Physicians enhance the quality of treatment and save time. Treatment decisions can be made together with the caregiver/patient due to higher level of information in the shared decision making context.

## 4.3. Mapping to ontological framework

The model proposed in this work can be mapped to the ontological framework presented in the mini-track

description as follows. The multiagent system with its organization formation process can be viewed as a decision support collaboration technology. Clinicians, nurses, and patients use the system to provide and consume eHealth services in order to exchange medical data and diagnosis results. In particular, since individual partners are represented by software agents in our approach, collaboration and content exchange exist among software agents as well. Hence, this is an example of how multiple collaboration combinations may coexist in the system. In addition, each actor uses an individualized portal as a media platform to provide and consume relevant content for the purpose of improved patient care.

## 5. Conclusion

The preceding has served to present a research in progress study focused on trying to address the current challenges with shared decision making in healthcare delivery by the design and development of a multiagent solution. Specifically, we attempted to address the problem of distributed knowledge sharing by the formation of agent-based organizations to represent the relationships of patients and physicians and study this problem from the perspective of multiagent systems; i.e. we develop a technology enabled collaboration solution considering privacy issues. The efficacy of the proffered decision support system was demonstrated by a scenario-based evaluation. Key next steps include testing this in a real world context and then developing a complete solution for application in specific healthcare contexts in various settings. Without a doubt this is an important area for healthcare delivery that will only become more critical as healthcare delivery continues to grapple with current challenges. To date our study is one of the first of its kind. We close by calling for further research in this area.

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