1 Agent.Hospital – Health Care Applications of Intelligent Agents[1]

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Abstract. In SPP 1083 the *Hospital Logistics* group studies the applicability of agent-based information systems in health care business scenarios by identifying problems, analyzing requirements, elaborating the state of the art of conventional and agent-based systems, specifying and designing multiagent applications, and evaluating their application. This chapter includes a survey of both the projects forming the group and their collaboration in order to integrate the systems designed by them into the agent testbed named *Agent.Hospital*. Therefore, two exemplary (hospital) processes are presented involving each project's multiagent application. Also, the ontology *OntHoS* and agent infrastructure services used in *Agent.Hospital* are shown.

1.1 Introduction

Driven by the requirements coming from patients, the domain of health care is characterized by complexity, dynamics, variety, and fragmentation of distributed medical prevention, diagnosis, treatment, and rehabilitation processes. Among other aspects, shared decision-making, combined with different skills and roles of health care professionals, and incompleteness and asymmetry of information results in an environment requesting high

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[1] This chapter is based on the paper "Paulussen, T. O.; Herrler, R.; Hoffmann, A.; Heine, C.; Becker, M.; Franck, M.; Reinke, T.; Strasser, M.: Intelligente Softwareagenten und betriebswirtschaftliche Anwendungsszenarien im Gesundheitswesen. In: Dittrich, K.; König, W.; Oberweis, A.; Rannenberg, K.; Wahlster, W. (Eds.): INFORMATIK 2003 Innovative Informatikanwendungen. GI-Edition Lecture Notes in Informatics, P-34. Köllen Verlag, Bonn, 2003, Vol. 1, pp. 64-82."

demands on information systems applied to reach advanced levels of automation.

Multiagent technology is assumed to be one possible solution to meet requirements coming from complex and dynamic environments. Due to their adaptability and flexibility, agent-based information systems have the potential to significantly improve the competitiveness of enterprises. Their application should allow more effective and efficient (logistic) processes and may also generate new customer welfare by making product improvements available.

Against this background, health care, and especially hospital logistics, was chosen as one exemplary application domain used in the German Priority Research Program "Intelligent Agents and Their Application in Business Scenarios." A special interest group named *Hospital Logistics* has been founded, including all (sub-) projects referring to the application of agent-based inter- or intra-hospital information systems.

Each project has its own specific research question and considers, examines, and analyses specific organizational parts of different hospitals. A nearly complete model of a virtual hospital was generated by the combination of the projects' partial models. Both the partial models and the developed multiagent systems of each project form the agent technology testbed *Agent.Hospital* (cf. [KHHK2003a] [KHHK2003b]), which is addressed and introduced in this chapter.

The chapter is organized as follows: First, the sub-domain hospital is presented by exemplarily identifying domain specific problems in Section 1.2. Based on this, Section 1.3 presents the goals of the single subprojects. Section 1.4 deals with the development of the ontology *OntHoS*, whereas the agent testbed *Agent.Hospital* is described in detail in Section 1.5. Giving two selected examples, the interaction of the subprojects is shown in Section 1.6. A summary and an overview regarding Part III of this book conclude this chapter.

1.2 Hospital Logistics as an Object of Investigation

Due to rising costs, economic ways of acting gain more and more importance in the domain of health care. Among other aspects, this is reflected in the abolishment of the principle of coverage of all hospital costs, i.e. all costs of a hospital were met by the health insurance scheme in 1993. It is also reflected by the introduction of the diagnosis related groups (DRGs) in 2002[2], which succeeded other case-based models of remuneration. DRGs particularly force health care institutions to act economically, as they are now liable for their actions (cf. [Rych1999] [Jast1997]). They also encourage competition between hospitals. Further, the rapid development of new methods of treatment and diagnosis, the application of new medications, and the progress in medical engineering induce an increasing differentiation and specialization of health care service providers. As a result, the demands on networking between all actors participating in fragmented and distributed treatment processes rise. Increasing mobility of patients, change of the age structure, and patients' incremental claims to quality of treatments intensify this situation.

Hospitals can be defined as social organizations with the purpose of improvement of the patient's state of health [Dlug1984]. The main differences between logistics in production and hospitals are based on the fact that not lifeless material is managed, but diseased people. A hospital is thus a service enterprise where production and consumption of services coincide [Greu1997] [Herd1994]. The patient is directly involved in his treatment and its success [DuWi1997].

A hospital is partitioned into semi-autonomous functional areas, where patients pass through according to their particular diseases [Schl1990]. These areas are either organizationally assigned directly to certain (single) departments or can be deployed to several departments as centralized service units [Schm1999], as radiology or operating theatres normally are. Although functional centralization enables more efficient exploitation of rooms and resources and thus more flexibility, the autonomy of functional areas induces the necessity of a comprehensive coordination among the medical departments.

Especially when deploying centralized operating theatres, coordination may become complex. In such cases, scheduling is usually carried out by requests coming from different departments, finally verified and, if required, corrected by a physician in the role of a coordinator. After this verification, the schedule is forwarded to the central operating theatre department assigning the staff, e.g., nurses, to the surgical operations. This multilevel scheduling process is carried out in many hospitals manually, i.e. without IT support. Causes for this are different and contradicting interests and priorities of the involved actors resulting in requirements not capable by conventional systems. Even without considering emergency cases, this manual planning approach results in complex coordination processes.

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Additionally, in contrast to the production domain, there is the problem that the patient's disease is not or only partially known at the time of his admission. Therefore, procedures such as examinations and treatments cannot be predetermined completely [Wend1987]. The lack of accompanying information can be reduced progressively only by multiple and sequential diagnoses, resulting in changes and adaptations of the processes. Further, complications and emergency cases induce partially heavy disruption in regular hospital processes [Schl1990].

In order to react flexibly to those uncertainties, treatments are assigned to patients by a ward's physician and forwarded to the particular functional area by requests. The functional areas then call the patients from the wards depending on their workload. Coordination among different functional areas, which may help avoiding idle time for both patients and the functional areas, is unusual or does not exist [PJDH2003]. Thus, an optimized exchange of information between these units, or even better, between all actors participating in specific treatment process is one of the main challenges of hospital logistics.

Similar problems also exist in hospital emergency centers, whose processes are characterized by cooperation of different clinical departments and handling of various medical data [KnRS2000]. Here emergency physicians coordinate the interaction of different departments in order to perform examinations and emergency or ambulant treatments. Unlike in previously described functional areas, the availability of resources primarily forms the requirements to be met. When locating and calling/using these resources, e.g., medical staff or equipment, both disruptions of running medical processes and effects on already scheduled appointments have to be considered.

An additional challenge becomes obvious if clinical trials are taken into account. In order to prove the effectiveness of therapeutic methods, particularly the application of medication, it is not only necessary to carry out experiments with animals, but also tests on humans. As information systems vastly support scheduling, their usage becomes more and more crucial for the allocation of clinical trials (which are, of course, profitable). Their application may reduce scheduling times, increase planning reliability, optimize structures and processes, and significantly improve the quality of documentation. Furthermore, they may help in integrating clinical trials into the regular operation of hospitals. This is characterized by considerable complexity, as the design of trials allows only marginal flexibility regarding the selection of patients, medication, and documentation.

Currently existing hospital information systems are not capable of mitigating the exemplarily described problems and meeting the outlined challenges. In particular cooperation, coordination, and communication between all actors participating in treatment processes are not supported sufficiently.

Also, the localization of patients, professionals, and resources still takes place by beeper, pagers, and announcements. Thus, localization, identification, and information about availability are still not manageable in an automated way. Direct personal communication is needed, which is time-consuming and characterized by an unacceptable error rate.

Furthermore, access to electronic patient records, which is restricted to preserve the privacy of personal data, does not have the necessary flexibility in terms of context sensitive composition and analysis of medical data. Although clinical data systems and paperless records are very common nowadays [BWWD2002], they are in general still passive and quite inflexible. Retrieving data, even from patient records, is time-consuming [Ginn2002] and also implies the risk of overlooking important information.

At least from an inter-hospital perspective, proprietary data exchange formats complicate and avoid the integration of, e.g., fragmented treatment processes. Even standards like CEN, ISO, or HL7 do not lead to adequate interoperability, as they are not existent, not used, or not usable due to their incompatible software realization.

1.3 Aims and Approaches of Participating Projects

The *Policy Agents* project (cf. III.2) aims at the solution to the described scheduling problem for operating theatres. Using an agent-based planning system, scheduling for operating theatres can be largely automated [CzBe2002]. Special project focus is on the explicit consideration of the departments' and persons' interests. For this purpose a software agent with a person specific preference profile represents each actor. These software agents negotiate autonomously in finding schedules and try to reach an efficient resource allocation well below the usual transaction costs (see also [BeKS2001] [CzBe2002] [CzBe2003]).

The *MedPAge* project (cf. III.4) deals with planning, controlling, and coordination of clinical processes across boundaries of functional areas. A patient-centered approach is chosen, which models both the hospital's resources and the patients as autonomous software agents. On the basis of preference functions, agents representing patients negotiate autonomously with each other for scarce hospital resources. As a coordination mechanism a market mechanism is implemented, in which the resource allocation is improved until Pareto optimality is reached [PJDH2003] [AwPa2001].

The focus of the *EMIKA* project (cf. III.7) is the real-time coordination of patient logistics in radiology in order to integrate acute emergency cases preferably without delay into the current schedule and to analyze these in terms of time accuracy. In a decentralized implementation with localizable devices (e.g., RFID[3] chips), software agents act as shadow objects of the devices. They identify their physical environment and the context of use in order to generate a state model of the reality. Thereon, they decide autonomously whether the current schedule can be met or new planning is necessary. Permanent dynamic feedback between reality and the information system is established via the interaction with mobile devices without central control of the system [SaEM2002].

The *ADAPT* project (cf. III.5) focuses solutions to the described problems regarding clinical trials. The main goal is the construction of an agent-based simulation system that simulates processes relevant to the implementation of clinical trials [HHPA2003]. For that purpose adequate simulation models were implemented, which map necessary and participating actors. These models were based on an actor-centered view and were implemented by an agent-oriented approach. The developed prototype supports medical personnel and other staff of participating departments dealing with analysis, evaluation, and scheduling of the clinical trials [HeHK2002].

The *ASAinlog* project (cf. III.6) tackles questions in hospital information logistics regarding the use of patient records. There are two main aims: (1) All persons involved in the treatment process are to be provided with relevant and context-sensitive information at the right point in time and at the right place; (2) Processes for cooperation and coordination are to be effectively supported regarding information needed for cooperation, i.e. context-sensitive medical data. Central elements of the solution are active medical documents implemented as composite software agents. They encapsulate both data of patients and elementary agents that interpret and concatenate these medical and administrative data.

In the *AGIL²* project (cf. III.3), e.g., treatment processes are modeled using a Java based tool (AGILShell), which was developed in the first phase of the project and can be deployed for the design and implementation of multiagent systems. The pursued approach comprises three steps: (1) domain experts model existent processes; (2) analysis of processes in order to identify application scenarios for agents; (3) optimization of processes through integration of agents. Based upon existent processes of the previously described projects, an "agentified" process is elaborated by interdisciplinary cooperation. In this process, agents carry out tasks that were

[3] RFID – Radio Frequency Identification.

previously done by humans. The described approach improves the quality of the software, since the user is actively involved [BACR2001] [Sta+ 2001].

In order to take advantage of all described approaches, full integration and coordination of the individual projects through the consortium Hospital Logistics is necessary. The need for support and coordination is implemented on the basis of the cooperation platform RealAgentS (http://www.realagents.org) [AnKi2003].

1.4 Development of the Common Ontology OntHoS

One of the first steps in the direction of an integrated scenario was the establishment of a task force in March 2002. Its aim was the development of an ontology crossing the boundaries of the individual projects. It was recognized that the developed multiagent systems were based upon different knowledge representations and slightly different terms, blocking complex interactions between the systems. In order to abolish this deficit, the ontology *OntHoS* for the domain hospital and nursing was developed.

OntHoS was modeled using a widely used ontology and knowledge engineering tool, Protégé. It allows the domain expert to model the formal definition of concepts and terms of the application domain and provides support for programmers regarding agent implementation. For that purpose, a defined ontology can be transformed into Java code. The advantage of this approach is the absence of an additional error-prone manual transformation process between model and implementation.

One problem of the collaborative development of an ontology is the integration of overlapping concepts. Therefore the domain was divided into a set of concept categories. As a result, a consensus regarding the underlying hierarchy was found (cf. Figure 1). At several places, one tried to use established ontologies or parts of it, e.g., the *temporal concept*, which is mainly based upon the Dharma Guideline Model [Dhar2005]. Nevertheless, most of the categories could not be based upon existing ontologies. For these reasons, each project elaborated suggestions, which were discussed within the group and, if necessary, adapted. As a result, the ontology *OntHoS* is capable of expressing message contents of all project agent systems.

The concept classes used in *OntHoS* are described as follows (cf. [BHHK2003]):

- *Temporal concept*: The defined terms are domain-independent definitions of temporal concepts, e.g., date, fixed or relative points in time,

time intervals, or duration. In addition, more abstract terms such as "today" or "now" are defined, which need reference points of time for interpretation.

- *Medical concept*: Terms within this concept define medical knowledge. These range from symptoms, diagnoses, and therapies to a representation structure for formalizing clinical guidelines. Knowledge bases for a particular scenario can be developed by the insertion of instances of a defined class or term.

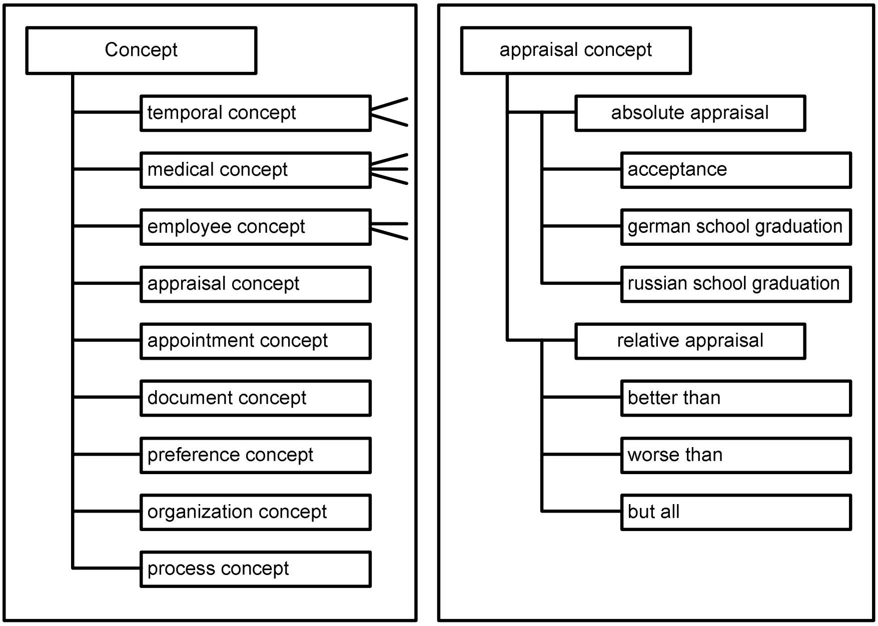

Figure 1. *OntHoS* – main hierarchy level of the ontology and base concepts (left) and concept hierarchy of appraisals (right)

- *Employee concept*: This concept group unites terms for the description of clinical staff, e.g., qualifications and roles.
- *Appraisal concept*: For planning and scheduling in hospitals and for making decisions terms for expressing evaluations are needed. In order to be as flexible as possible it is only distinguished between absolute and relative appraisals. Absolute appraisals are, e.g., school grades, relative appraisals are terms like "better than."
- *Appointment concept*: For the scheduling of treatments and examinations additional terms – not included, e.g., in the temporal concept – are necessary, e.g., *appointment task*, *appointment time, etc*. We dis-

tinguish between previously agreed upon appointments and appointment suggestions to be evaluated.

- *Document concept*: Format and contents of different typical clinical documents such as findings or patient records are described. Standards for hospital information systems are also to be taken into account.
- *Organizational concept*: In order to model a hospital, underlying organizations and their units are to be described. There are usually functional units that provide services such as examinations and treatments. Additionally, there are wards, administration, and special units, e.g., a pharmacy or an external orthopedic service. All units have resources and provide several types of services (see process concept).
- *Process concept*: Processes can be described as sequences and alternatives of atomic actions. A simple basis process representation was chosen, which can be extended in order to support domain modelers with different kinds of model languages, e.g., modeling using EPCs (Event-driven Process Chains) or Petri nets. Atomic actions of these processes are either medical or logistic actions. Medical actions are subdivided into examinations, treatments, or nursing. Many actions need to be carried out by special functional units and others need special resources or persons (see object concept or employee concept).
- *Object concept*: In contrast to the terms described above, which refer to abstract, non-existent concepts, object concepts define all real objects and persons. Real objects are, e.g., rooms, medical or technical devices, or drugs. Objects can be relevant resources for actions or they can be subject to appraisals. Persons like patients and clinical staff are subclasses of this concept, whereas their tasks, qualifications, and roles are partly described by the employee concept.

1.5 Agent Technology Testbed Agent.Hospital

Agent.Hospital is a testbed for agent-based information systems in health care, supporting both the development and the evaluation at the level of modeling and implementation. At the model level a framework for different partial models of health care is provided. At the implementation level, infrastructure services and multiagent-based modular health care services exist. As the integration of additional partial models and multiagent applications has been one requirement right from the beginning, *Agent.Hospital* is designed to be an open framework. Thus, only open standards for, e.g., application integration, are used.

Figure 2 illustrates the architecture of *Agent.Hospital*. Currently, the following integrated supply chains are implemented: Clinical trials, radiotherapy (ADAPT), emergency patients (AGIL), lung cancer treatment (ASA*inlog*), angina pectoris (MedPAge), gall stone treatment (MedPAge and Policy Agents), operating theatre processes (Policy Agents), and radiological processes (EMIKA). Further information, as detailed process models, can be retrieved from http://www.realagents.org.

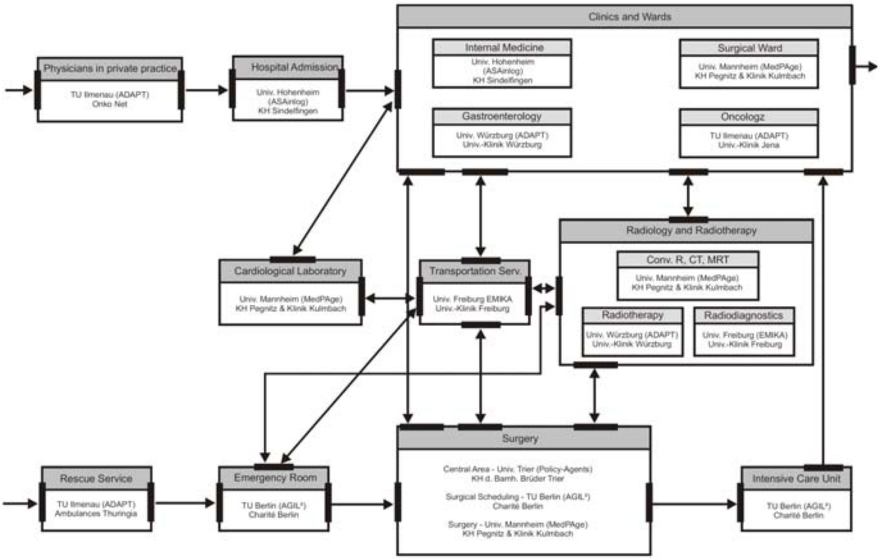

Figure 2. Architecture of and supply chains in *Agent.Hospital* (as of 2003)[4]

Several infrastructural services are provided by *Agent.Hospital* coupling the subsystems of the individual projects. These comprise the following services (for a detailed description see [KHHK2003b]):

- *Agent.Hospital Directory Facilitator (AHDF)*: Directory service for the registration and supervision of *ServiceAgents* and for display of registered agents and their services.
- *Agent.Hospital TimeService (AHTS)*: a time service that allows for the registration of several groups of *ServiceAgents* and for their discrete timing.

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[4] Please note that some allocations of projects have changed, e.g., ADAPT is now located at the Universität Hohenheim, ASA*inlog* at TU München.

- *Agent.Hospital Ontology Repository (AHOR)*: A repository for domain and task ontology of the health care domain. This service supports the exchange of task ontology and the access to the common domain ontology *OntHoS* [BHHK2002].
- *Agent.Hospital Knowledge Base (AHKB)*: A knowledge base for the health care domain. It is comprised of an A-box and a T-box. The T-box contains all terms of the domain ontology and structures for formulating concepts. The A-box aggregates instances of terms and concepts of the T-box, which helped in modeling representative scenarios of the health care domain.
- *Agent.Hospital Actor Agent (AHAA)*: An additional common element of *Agent.Hospital* relevant for coordinating the services. Instances of actor agents represent patients with their basic personal data and individual time schedule.
- *Agent.Hospital CVS (ACCVS)*: A repository for the administration of source code of *ServiceAgents*. It supports the exchange of commonly usable modules and interface classes between the developers.

Most of these services are based on and extend existing infrastructural services of the FIPA-compatible Java Agent Development Framework JADE.[5] Afterwards they were reintegrated in JADE.

Besides the infrastructural services, *Agent.Hospital* contains *ServiceAgents* of the individual projects. These implement gateways among the organizational units of the domain model and provide their functionalities in the form of an agent service to the remaining organizational units and their representing agents. By the deployment of FIPA-compatible gateway agents for the functional integration of the technically different multiagent systems, a standard at the level of communication was established. This enables the cross-project usage of common interaction protocols, agent communication languages, and knowledge representation languages (for a detailed description see [KHHK2003b]).

The central integration element of *Agent.Hospital* is *AHDF*, as it implements the mediation of the services. The main task of the *AHDF*, and also the differentiating criterion regarding the global DF (Directory Facilitator) of the *Agentcities*[6] network, is the bundling of services of the same context to an application-specific services forum. The implemented functionality of the *AHDF* is domain independent and allows for the deployment in the production domain within the SPP 1083 (cf. II.1).

[5] Cf. http://jade.tilab.com/
[6] Cf. http://www.agentcities.net/

Finally, *Agent.Hospital* is implemented as part of the *Agentcities* community. As a result, five new *Agentcities* platforms have emerged: Aachen, Ilmenau, Würzburg, Freiburg, Hamburg, all integrated by the common directory service *Agent.HospitalDF*.

1.6 Selected Agent.Hospital Application Scenarios

Two cross-project application scenarios demonstrate the interaction of the projects' multiagent systems within the *Agent.Hospital* framework: (1) clinical trials and (2) diagnosis and treatment of colon cancer. Except for the ADAPT project, in these scenarios the acronyms of the projects are similarly to the names of the developed multiagent systems. The ADAPT projects consists of two applications named DAISIY (Deliberative Agents for Intelligent Simulation Systems) and SeSAm (Shell for Simulated Agent Systems). Although both systems are part of *Agent.Hospital*, SeSAm is used additionally for simulating the *Agent.Hospital* real world environment, in which the other multiagent systems are situated.

1.6.1 Clinical Trials

The goal of (controlled) clinical trials is the deduction of a general statement regarding the benefit-risk ratio of treatments on the basis of study results, which have to be reproducible within a given probability. Besides strong medical and statistical requirements to be fulfilled by hospitals when performing clinical trials, additional challenges for the participating hospitals exist. So, besides the determination of the required patients needed during a certain time period, a hospital has, e.g., to calculate whether sufficient resources are available. If shortages jeopardizing trial execution are identified, the hospital is obligated to, e.g., employ additional trial nurses or documentalists. Usually, such decisions are made intuitively, which may lead to inefficiencies and errors – due to the complexity of trials.

Figure 3 illustrates an exemplary section of the integrated scenario process "clinical trials." The description is based upon the extended EPC. The tight bipartite alternation of events and functions is abolished in order to simplify the representation.

In general, at the beginning of clinical trials a lot of diagnostic and therapeutic measures need to be coordinated and scheduled. Also resources like equipment and staff need to be assigned and possibly informed. The process given in Figure 3 focuses on this first phase. It illustrates both US (ultra sound) and MRI (magnetic resonance imaging) examinations and related surgery.

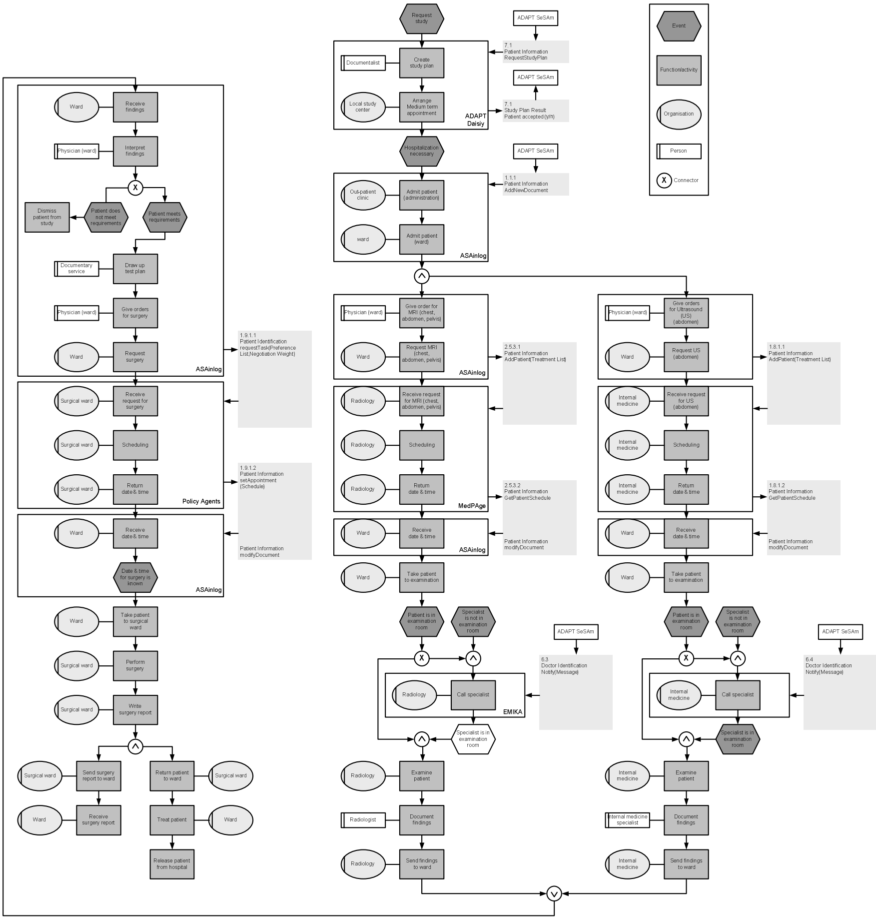

Figure 3. Exemplary section of a process of the integrated scenario "clinical trials"

As a first step, the eligibility of the patient for the trial is checked. The DAISIY-system evaluates the data provided by the SeSAm-system with specific inclusion and exclusion criteria of the clinical trial. If the patients meet the study requirements, an individual study plan is generated for the measures to be taken by the service *RequestStudyPlan*. The trial's documentalist can insert individual appointments. After the medium-term study plan is planned for the patient (usually a study cycle of four weeks), the electronic patient record is extended applying the ASA*inlog* service *AddNewDocument*. The multiagent systems of MedPAge and Policy Agents start their operative planning and scheduling of binding appointments based on this information, i.e. they are triggered by the active patient records of the ASA*inlog* system. While MedPAge schedules the examinations, the surgery is scheduled by Policy Agents.

If the actual appointment for an examination approaches, tracking services provided by EMIKA are deployed. They support the localization of a particular bed or a mobile examination device or inform the physician about the current appointment.

In case of, e.g., an emergency examination involving the resource MRI, the responsible systems for the management of the trial and for the scheduling of the resource reschedule appointments if necessary. This is performed on the basis of standardized agent languages (here FIPA-ACL – Agent Communication Language [FIPA2005a]) and interaction protocols (e.g., FIPA Agent Interaction Protocol [FIPA2005b]). The described section of the process ends with the temporary discharge of the patient from the hospital.

1.6.2 Colon Cancer Treatment

Colon cancer is, with an incidence of 40:100,000, the third most frequent carcinoma in Germany [Psch1998]. Besides medical relevance (the probability of surviving for five years is 95%-100% at best and below 6% at worst [Psch1998]), the involvement of all individual projects was a criterion for choosing colon cancer diagnosis and treatment as a reference scenario. In order to make sure that the exemplary scenario process illustrated in Figure 4 and described on the following pages maps a realistic medical process, it was evaluated in cooperation with anesthetists, internists, and surgeons of the Charité Hospital, Berlin.

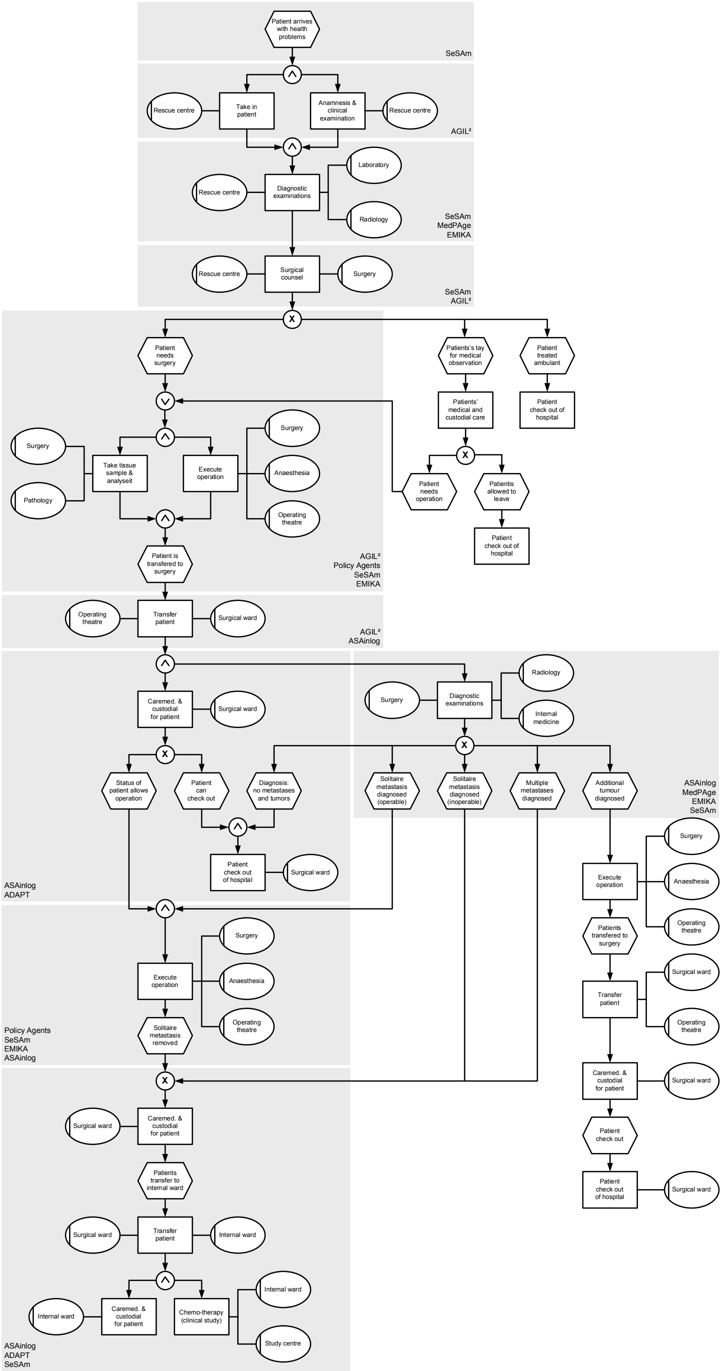

Figure 4. Integrated scenario "colon cancer treatment"

The scenario process starts with the arrival of a patient at the hospital and his admission to the emergency room. After an anamnesis, an emergency physician arranges a blood and x-ray examination using the coordination services provided by agents of the AGIL² project. As the emergency room lacks radiology equipment, the coordination task is transferred to the MedPAge multiagent system in order to rearrange appointments of, e.g., (central) radiology. Also, the EMIKA system ensures that the necessary staff and examination devices, despite other appointment schedules, are available.

Based upon the findings of the blood and x-ray examination a surgical council is initiated by the emergency physician. It decides whether the patient is operated on immediately, first stays in the hospital for further observation, or can be discharged. Within the exemplary process an intestinal obstruction is diagnosed. The patient is also suspected of having cancer. So, surgery is needed immediately.

In this case, the Policy Agents system is involved by AGIL.[2] It schedules the allocation of operating theatres using the localization services provided by EMIKA.

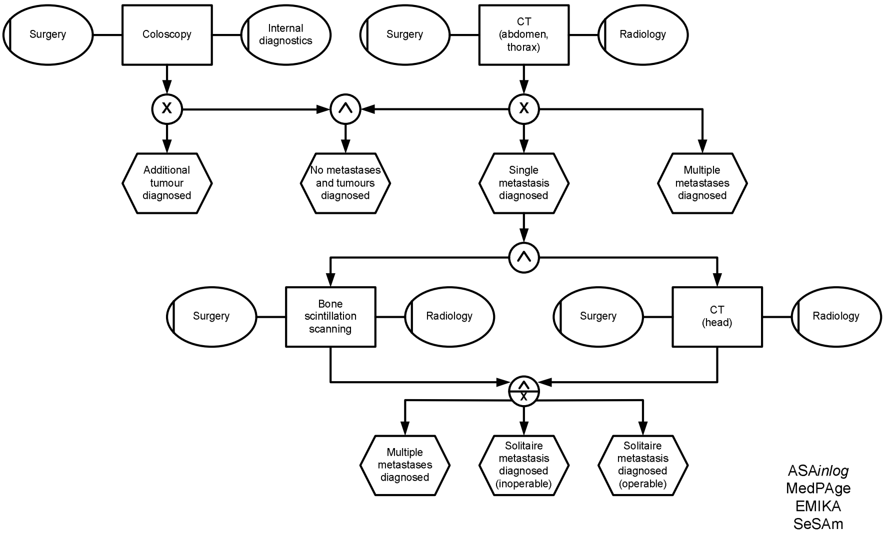

Figure 5. Diagnostic examinations

During the surgery a tissue sample is removed and transferred to pathology for further analysis. After the surgery, the patient is relocated to the surgical ward. Meanwhile, additional supplementary examinations for the exclusion of metastases and other tumors are performed. These diagnostic measures (see Figure 5) are coordinated by the MedPAge project, while the patient is scheduled in regular intervals by the EMIKA agents for check-ups in radiology.

If there are no metastases or tumors, the patient is cured and needs no further therapy. If there are metastases, their number and localization give clues about further actions. If there is a single metastasis, it will be removed in follow-up surgery if possible (coordination via Policy Agents). If there are several metastases in a single organ, or in several organs, or if the single metastasis cannot be removed due to its localization, additional surgery makes no sense. The patient will be treated with chemotherapy.

For clinical trials only those patients are suited that fulfill special study requirements. During the process it will continuously be checked whether the patient meets these requirements and can participate in a study. The ADAPT project chooses patients for a clinical trial and optimizes the accomplishment of the trial (cf. Figure 4). If the patient meets the requirements and if the patient agrees to participate, he becomes a trial patient for chemotherapy.

The previously described projects interact with the agents of the ASA*inlog* project during the entire process. These agents manage and provide relevant data in terms of active documents, forming the active patient record. The interactions between the multiagent systems ASA*inlog*, MedPAge, and EMIKA are illustrated in Figure 6.

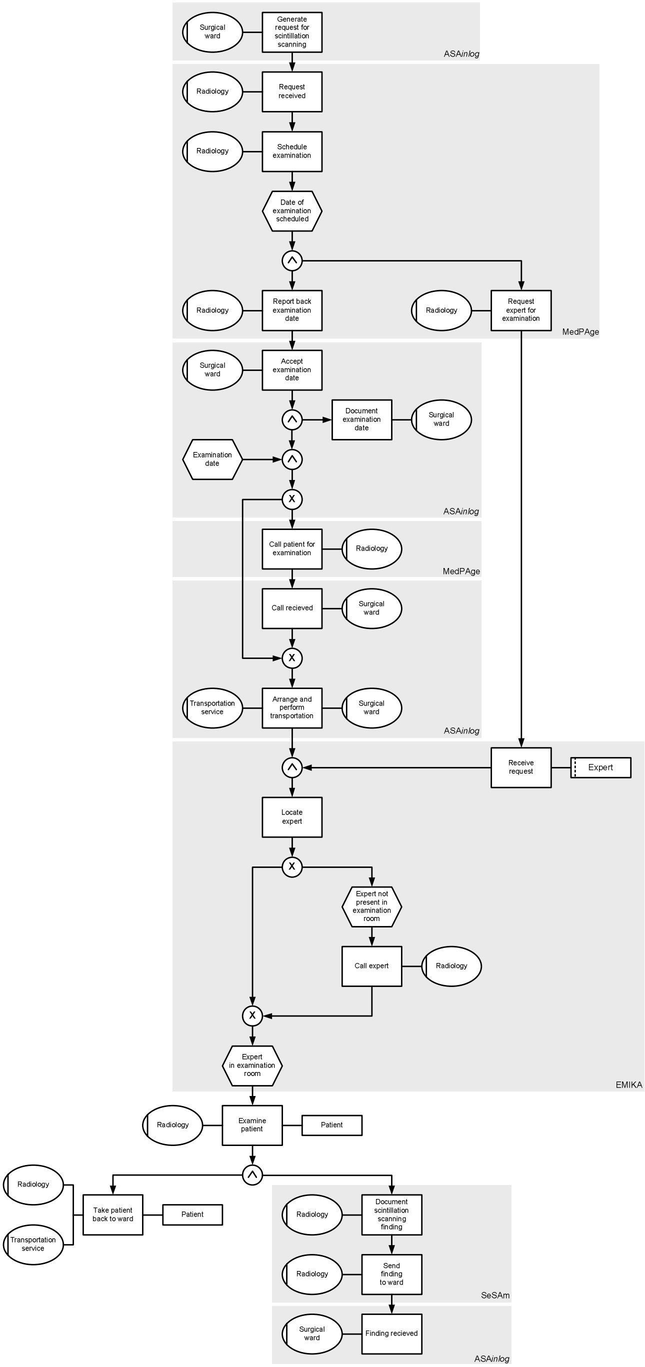

Figure 6. Detailed diagnostic examination in the example scintigraphy

1.7 Summary and Outlook

The goal of the *Hospital Logistics* consortium is the deployment of intelligent software agents in realistic business application scenarios in the health care domain, especially in hospitals. In this chapter, the cooperation between the projects forming this group is shown. A selection of the problems identified is given, trying to illustrate the challenges regarding information systems used in this domain. Also, the aims of the projects have been described in brief.

As both problems and goals of all projects showed high interdependencies, the group decided to integrate both their partial models and developed multiagent systems into the agent testbed *Agent.Hospital*. This testbed, developed in cooperation with the *Technology* consortium of SPP 1083 [Kre+2003], is described by (1) the ontology *OntHoS* used for agents communication, (2) the organizational structure of *Agent.Hospital*, (3) the main infrastructural services, and (4) two application scenarios.

In Part III of this book, all projects participating in *Agent.Hospital* and thus outlined in this chapter were described in detail. With the information given in this chapter the overall domain specific situation can be considered when looking at specific research questions addressed by the projects.

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