Operating Room Planning

Agent based system analysis and design

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**Summary**

Für Interessierte, die sich innerhalb kurzer Zeit einen Überblick über den Inhalt eines Berichts verschaffen wollen, ist das Summary (eine halbe bis anderthalb A4-Seiten das geeignete Mittel. Die Zusammenfassung soll die folgenden fünf Aspekte beleuchten: Problemstellung, Problemlösungen, allenfalls mit Varianten, Hauptergebnisse, Schlussfolgerungen und Vorschläge für das weitere Vorgehen. Die Zusammenfassung entscheidet – zusammen mit dem Inhaltsverzeichnis – ob die Leserin, der Leser den Text eingehend studiert oder gleich beiseitelegt.

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# Introduction

The aim of this report is to present an analysis and design of an agent based system which is capable of handling the “Operating room planning” problem.

# Purpose of Agent System

The Operating Room Planning (ORP) problem describes a dynamic environment in which clients in general share a common goal: getting well as soon as possible. Survival is one of the strongest instincts of a human which means that a client, who finds himself trapped in an environment such as the ORP describes, his desires are pretty straightforward and normally don’t change. In contrast, his believes and intentions may change. Unfortunately, once a client falls into the “emergency” category within the ORP environment, his believes and intentions become irrelevant.

The problem of the ORP which has to be solved is therefore not managing the individual wishes or handle the clients differently because of their distinction in believe. It is about live and death and how latest can be minimalized, which becomes more and more difficult due to increasing demand. Health care is a huge building which requires several administrative instances and since there are numerous clients and just limited resources a clever client management system is inevitable.

Each client has its own health status and his own path of welfare it has to go through. In order to achieve the ORP goal, maximize the success rate of surgeries and minimalize the cost, a very simple but effective method has to be applied: Prioritization.

A surgery has to be considered failed, if clients

The facts that the client status may change at any time and the health of a human, as well as the applied medical measurements are everything else than predictable, makes the environment dynamic.

Therefore, the systems prioritization of its clients, the planned procedure as a result of analysis and grading may change anytime. The requirements Additionally to need of

# Agent Architecture

# GAIA Methodology

## Introduction

Regarding the GAIA Methodology we consider the following steps as most relevant:

* Subdivision of System
* Environmental Model
* Organizational Rules
* Role Model
* Interaction Model

We wanted to make sure that we have selected steps of both analysis and design. Since the artifacts “Agent Model” as well as “Services Model” are very time consuming because of their high degree of detail and due to the fact that the Agent Model pretty much matches our Role Model, we left these two steps out.

However, in the following paragraphs we will discuss the Operation Room Planning problem within the above defined topics of the GAIA Methodology. In addition, we will first describe the requirements of the system. Although the requirement elaboration and elicitation process is not included in GAIA it is essential to have solid knowledge about them.

## Vision

The vision of approaching the Operating Room Planning problem with an agent based system is to optimize surgery scheduling in order to improve surgery efficiency, minimize peak demands and save costs.

## Requirements

* The system needs to be able to do long term planning
* The system needs to be able to do short term planning
* The system has to adjust the planning in case of sudden changes of patients state

## Subdivision of System into Sub-Organizations

* Patient
  + Non-emergency case
  + Emergency case
* Patient Departments
  + Surgery Waiting List System
* Operation Room Planner
* Surgeon Manager
  + Surgeon Teams
* Operating Room Manager
  + Operating rooms
* Postoperative Manager

### Patient Agents

We consider each patient as an individual agent with its own desires, believes and intentions. The desires of a patient are pretty straightforward; getting well as soon as possible. Each client has its own health status and its own path of welfare it has to go through. The path itself is the product of a patient’s status and several rules within the ORP (see Organizational rules). The patient’s may intent to skip steps of his path in order to shorten his healing process. However, the system does not allow such behavior. A patient’s path can only be shortened by the system due to negative changes of a patient’s health status.

### Patient Departments

We consider each department as an individual agent with its own desires, believes and intentions. The desire of a department is to heal its patients. Each patient has its own health status and its own path of welfare it has to go through. The path itself is the product of a patient’s health status and several rules within the ORP (see Organizational rules). The patient’s may intent to skip steps of his path in order to shorten his healing process. However, the system does not allow such behavior. A patient’s path can only be shortened by the system due to negative changes of a patient’s health status.

Each department has its own patients based on its field of medical expertise. Each department contains a surgery waiting list system consisting of 2 separate waiting lists; one list for surgeon appointments and another for surgery appointments. Each department is responsible for its own waiting list and therefore defines the prioritization of the patients based on department-related indicators.

### Surgeon Manager

In order to allow an adequate level of abstractness we do not consider individual surgeons but rather whole surgeon teams. Each surgeon team consists of a set of employees which is defined by the system rules (see Organizational rules). Every team is identified by two main attributes:

* Field of expertise

Defining in which field of surgery the team is specialized

* Shift

Outlining the teams past shifts

### Operating Room Manager

The Operating Room Manager holds all information about the individual operating rooms. It knows which operating room is able to handle which kind of surgeries based on the room equipment.

### Postoperative Manager

There are postoperative resources within the hospital care such as wards and the ICU (Intensive Care Unit). Each ward as well as the ICU contains a certain available space to offer. The Postoperative Manager is responsible for all these units and is therefore able to provide information about the availability of them.

### Operating Room Planner

The Operating Room Planner has several input sources. On the one hand it receives requests from the different departments, which provides the planner with information about what kind of operations are next. With the gathered information the planner knows what kind of resources it needs in order to fulfill the surgery demand. On the other hand the planner has different input sources, i.e. the surgeon teams and the operating rooms. Based on the requests and the resources the planner is able to generate an always up to date output, which would be a plan of all the surgeries defining which operation should be carried out when, where and with which team.

## Environmental Model

The environmental model of the ORP consists of an information system containing different types of entities and agents. Patients as entities build the input of the system. The output is an always up-to-date plan of surgery procedures. The core attribute of a patient is its health status which is the base for the patient’s periodization within the system. Furthermore, patients get assigned to departments based on their medical issues. The fact that a patient’s health status may change at every time makes the environment dynamic.

In order to achieve the system objectives the departments can communicate with each other and are able to bid for resources, i.e. operating rooms, surgery teams and post-operative measurements. We will present more information about the interaction in the section “Agent Interaction”.

## Organizational Rules

* A patient has to follow its assigned path of welfare which means he has to fulfill the following preconditions in order to proceed:

|  |  |
| --- | --- |
| Step | Precondition |
| Appointment waiting list | Referred from primary care |
| Outpatient appointment | Passed appointment waiting list |
| Surgery waiting list | Passed outpatient appointment |
| Surgery | Passed surgery waiting list |
| Use postoperative resources | Passed surgery |
| Discharged | Passed postoperative ward or ICU |

This rules only has effect as long as a patient’s status is not declared as an emergency case

* Each surgeon team consist of a specified allocation of employees
* An emergency case has always a higher priority as a non-emergency case
* The following artifacts must be available in order to proceed a surgery:
  + 1 operating room, which matches the required equipment
  + 1 operating team, which matches the required field of expertise
  + Post-operative measurements (available resources in ward or ICU)

## Role Model

neDepartment

Permissions

Read healthStatus //health status of incoming patient

Read ApWaitingListStatus //read status of waiting list

Change ApWaitingList //put patient on waiting list

Responsibilities

Liveness: neDepartment = (HandlePatient, InformPatient, InformSurgeon)

Safety: ApWaitingListStatus != empty as long patients are requesting

## Interaction Model

These are the most important protocols we would need in order to make our roles able to interact with each other:

Name SurgeryRequest

Purpose Tell the Planner which surgeries need to take place

Initiator neDepartment

Respornder operatingRoomPlanner

Inputs Surgery waiting list

Outputs RequestConfirmation

Processing

Name

Purpose

Initiator

Respornder

Inputs

Outputs

Processing

# Agent Interaction

## Introduction

We made ourselves several thoughts about how to approach the interaction handing. We consider both, the CNP and the Auctions approach, as very interesting and both of them have characteristics that fit our architecture as well as some that don’t. An auction approach fits due to the fact that we have several individual agent with own desires and resources to fulfill them. The CNP approach fits because we have several instances which need to solve a task which they can’t on their own. Once we analyzed these characteristic and realized the above mentioned facts, we concluded it makes sense to make use of both approaches to build our interaction model.

## Interaction Model

The main interaction in our ORP system happens between the different departments and the resources. Each department is self-interested and tries to achieve its own goal, which would be to get all the resources it needs to put its patients into surgery. Therefore, departments are surgery agents which “protect” their own patients. We consider the resources as goods, i.e. surgeon teams, operating rooms and postoperative measurements such as beds in a postoperative ward or in the ICU. For each type of resources there are one-sided auctions for which departments are allowed to bid. The sellers offer teams, rooms and beds for periods which are not yet reserved. Bidders submit bids for the wanted goods. The price they offer to “pay” is the health status of their next patients represented by a calculated value. Of course the departments do not really pay but the value is needed in order for the seller to determine which department, more precisely which patient will receive the goods. If a bidder wins it will receive confirmation about it. As soon as surgery package is feasible, the surgery appointment for the corresponding patient is fixed. Furthermore, departments are able to interact with other departments in means of solving tasks (CNP). These tasks represent the needed surgeries. For example: If a department was not able to “buy” an operating room for a given time span, it can initiate a task which would be to make this specific surgery package feasible. Different departments which may have a room at the given time but still miss another resource may be willing to help. Why?

The emergency department is the only one which does not bid, since it immediately needs resources rather than planning a surgery. Some resources are always put on hold for emergency cases.

# Agent Communication

# Register of Illustrations

[Abbildung 1: Logo FHNW (Quelle) **Fehler Textmarke nicht definiert.**](#_Toc305602880)

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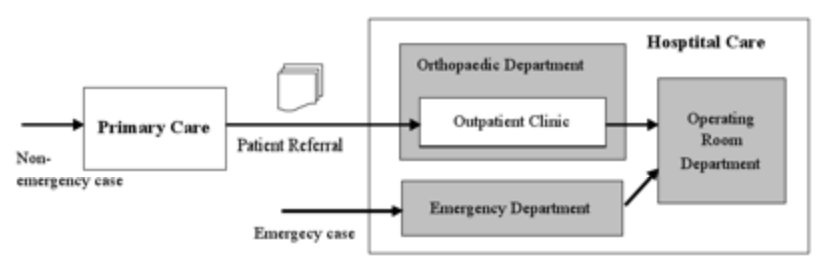
# Appendix 1 – Operating Room Planning

## Introduction

Most countries today, try to adjust to increasing demand and cost for healthcare services. One of the most expensive areas in healthcare is surgery, which necessitates many expensive resources in terms of staff, equipment, and medical resources. Generally, these resources have to be managed and divided between several departments within the hospital, e.g., orthopaedics, gynaecology and general surgery, in order to meet the total surgery demand.

## Operating Room Planning

The operating room planning includes both short term planning and long term planning, i.e., emergency cases and non-emergency cases. Non-emergency cases are described as elective cases and are commonly referred from primary care to a specified department within the hospital care. Before surgery is decided, the patient generally meets the surgeon at the outpatient clinic, i.e., the hospital care. Emergency cases commonly enter the Operating room department passing through the Emergency department as illustrated in Figure 2. However, there are exceptions to this rule; for instance, an elective patient admitted to an inpatient ward can suddenly become an emergency surgery case due to unexpected complications.



In general, the elective surgery process starts at primary care. The patient is then referred to specialist care for an outpatient appointment. If surgery is decided, the patient is then put on hold for surgery. In reality, the *surgery waiting list* system consists of two waiting lists; one, waiting to meet the surgeon specialist at the outpatient appointment, and one, waiting to be scheduled for surgery after the appointment. Moreover, there is one surgery waiting list system representing each of the operating departments and which are separately managed, i.e., one waiting list system at the Department of Orthopaedics (as depicted in Figure 2), another one at the Department of General Surgery and at the Department of Gynaecology, and so on. Consequently, the allocation of operating room resources affects every surgery waiting list system. In addition, the Operating room department also has to consider a variety of postoperative resources when planning. After surgery, the patients are monitored in a postoperative ward for circulation and respiration, but also for assistance with analgesic before being transferred to the ward or directly discharged. In addition, some patients will need postoperative intensive care and consequently have to be transferred to the Intensive care unit, (ICU) after surgery.