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Using a Business Rule Management System to Improve Disposition of Traumatized Patients

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Abstract

We propose a business rule management system that is used to optimize the dispatchment on a mass casualty incident. Using geospatial information from available ambulances and rescue helicopters, a business rule engine calculates an optimized transportation plan for injured persons. It automatically considers special needs like ambulances equipped for baby transportation or special decontamination equipment, e.g. to deal with an accident in a chemical factory. The rules used in the system are not hardcoded; thus, it is possible to redefine them on the fly without changing the program's source code. It is possible to load and save a rule set in case of a catastrophe. Furthermore, it is possible to automatically recalculate an already planned operation if it becomes clear that the rescue vehicles assigned are needed by a person with life-threatening injuries.

Keywords:

Mass casualty incidents, Online systems, Decision support systems

Introduction

Even though mass casualty incidents occur only rarely, they present a major challenge for medical personnel. While the number of injured complicates a fast decision on how to treat individual persons, dispatchment has to be done quickly in order to save lives. Thus, efficient means to support humans in managing mass casualty incidents are sought for.

In Germany, the EMS (Emergency Medical Service) is organized municipally [1]. Every municipality has its own infrastructure. Often they are using central PSAPs (Public Safety Answering Point) to dispatch rescue operations. These headquarters answer the emergency calls and assign vehicles and personnel provided by different local organizations such as hospitals or private emergency medical services. To improve communication among these headquarters and different organizations, special networks like the "Trauma Network North-West" have been founded [2]. These networks make it easier to organize transports of injured people to hospitals in neighboring areas. However, the methods used by this network only suit a limited number of patients.

In the case of mass casualty incidents, the patients are brought to a special place to conduct triage. After being prioritized, seriously injured persons are transported first [3]. This simplified system is not good enough because it does not consider special needs of the patient. A baby for example needs a specially equipped ambulance and a hospital that is able to treat it appropriately [4]. Besides, the available transportation should be used in the best way possible.

The requirements to a dispatchment system are similar to decisions done in business environments. We hence suggested using rule based systems to support the assignment of injured people to available vehicles or helicopters and their transfer to hospitals.

This paper is structured as follows. In the next section we show the project background. Then we outline the technical implementation and present results from the evaluation. Finally, we give a conclusion and sketch future work.

Project Background

The Trauma Network North-West is a union of 43 hospitals in north-western Germany and the Netherlands. Its main goal is to improve trauma care. In the TEAM project, emergency physicians are equipped with mobile devices to get a quick overview of the time needed by an ambulance to the nearest trauma centers. Furthermore, they are able to request a rescue helicopter, and see, if it is on the way and when it will arrive. Thus, they are able to decide which transport would be best for the injured. After selecting a hospital, his decision will be shown to an agent at the next PSAP who is able to accept or decline this suggestion [5].

The described procedure works well for one or two injured people, but in a case of a mass casualty incident, the emergency physician does not know all the circumstances to properly decide which transport would be best considering the whole situation. In such a case, only the agents at the PSAP are able to decide properly about transfers and destination hospitals. However, they do not have much time to decide on dispatching plans. Since a fast transport to hospitals can significantly increase survival rates [6], agents need the means to work out plans without much delay or effort.

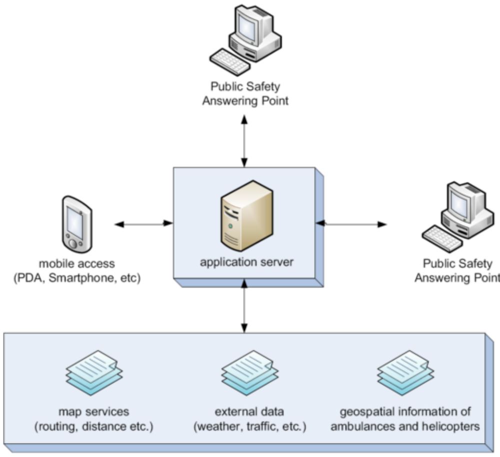

Figure 1- The technical architecture of the system.

Implementation Details

Technical Details

The software used on the server is written in Java and deployed to a central Tomcat application server. It is platform-independent and flexible [7]. Furthermore, the business rule system Drools [8] is included to provide the rule-based decision functionality. The rules can be edited with Guvnor, a web based rule editing tool [9]. The whole system is accessible online using a standard web browser. No proprietary software is needed on the client device.

External services are included in different ways. For example the "Rescue Track", a system to get geospatial information from rescue helicopters, is included as a XML-web-service (see Figure 2). In addition to its current location, its status is transferred via two-way radio [10]. The dispatchment system is able to recognize if the helicopter is available for another mission or if it currently carries a patient. Additionally, the estimated time for the helicopter to be available again can be provided by the system.

Also the mapping service which provides the geospatial information is included externally. It is possible to reconfigure the system to use a local installation easily [11].

In general, one of the advantages of external web services is their exchangeability. If a service is broken or discontinued, it is possible to get the needed data from another provider. This change can be done automatically in case of a failure or manually if it becomes clear that another service is able to provide more actual or detailed data. For that purpose multiple sources of external services can be provided in the system.

In addition to using the clients at the PSAP, it is possible to get access to the system with mobile devices such as PDAs or notebooks. This is useful to get a fast overview in a mass casualty incident at the accident site.

Rule Management

As outlined before, rules are edited by a special editing tool. (see Figure 3). The rules are written in a DSL (domain-specific language [12]) which is leaned against usual language and may include technical terms of the considered domain. A benefit value is allocated to every transportation possibility. This value is made up of the hospital's care level, the characteristics of the ambulance or rescue helicopter and the duration of the transportation. The rules are used to manipulate this value.

The screenshot in Figure 3 shows a rule that recommends an ambulance with special baby equipment for a patient with an age below two years. This rule causes ambulances with this equipment to be rated higher. Therefore, such an ambulance is rated higher if it is available. It however would less likely be assigned to an injured that is older than two years. The system tries to keep special equipment available if the medical conditions of patients that currently need help allow it. This means that it prefers available ambulances without special equipment that can transport an injured as fast as the one with the (not required) equipment could.

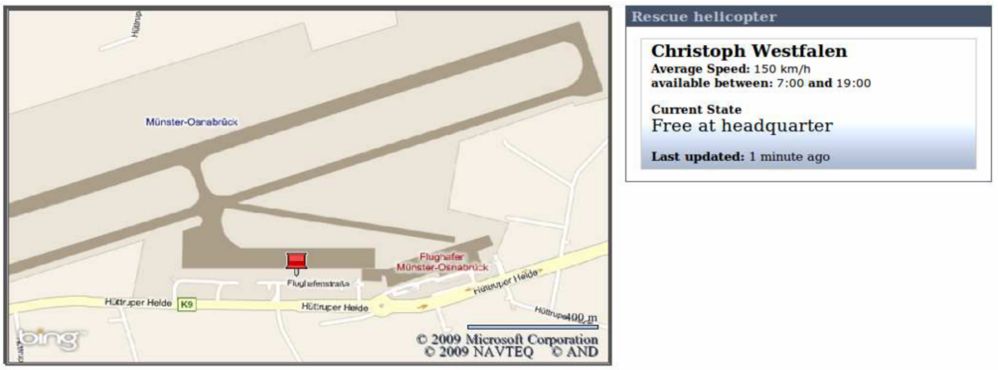

Figure 2- The rescue helicopter at its base.

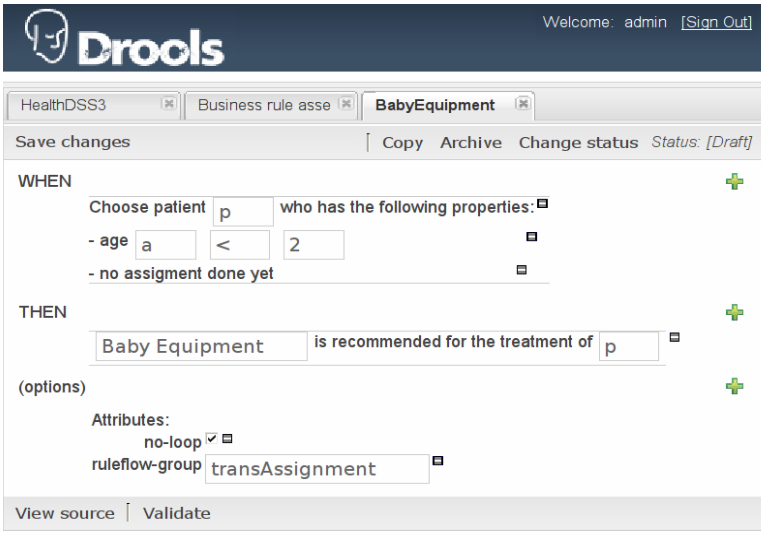

Figure 3- An example rule to assign an ambulance with special baby equipment.

In case of conflicting rules, the first rule that fits to the given situation is fired. Thus, there is no possibility of a deadlock situation. If no specialized rule fires, general rules will apply to ensure transportation for all patients.

Using this technique simplifies the creation and maintaining of rule sets to a level at which no knowledge in programming is needed. Furthermore, every user is able to validate them and to see how they work. The understanding of the rules is very important to create trust in the system. The rules can of course not be changed arbitrarily; we however suggest that a system that can be changed by authorized personnel in order to cope with new situation is suited for the complexity and criticality of disaster management operations.

New rules or entire rule sets are activated and deactivated with one mouse click in case of a mass casualty incident or disaster situation. This ensures that the dispatchment in these cases follows special rules, e.g. that vehicles for non emergency patient transfers are used as ambulances to deal with many injured.

Evaluation

To evaluate the execution time of the dispatchment program, two different rule sets have been run on a 1,6GHz Intel Core2Duo processor with 1GB of DDR2 RAM. Even with sophisticated rule sets the dispatcher gets an optimized result within about one second.

As shown in figure 4 using hard-coded rule preparation may increase performance significantly. But even without them calculation time grows only linear with the number of transportation possibilities. By using high performance hardware it is possible to decrease the calculation time to an acceptable minimum. Also the parallel execution of several calculations could be realized in a future version of the program.

Other factors for the execution time are external web services. If they are, for instance, used to calculate the time required by every transport possibility, they are called hundreds of times for one calculation and may slow down the dispatchment to an unacceptable rate. Therefore, the most important web services such as distance and routing calculation should be provided locally.

At all stages of the development, test runs were made by medically skilled personnel to verify the system. The results are promising and show that the dispatching system presented is able to enhance the dispatching system currently used.

Nevertheless, the presented system is in prototype stage. Further evaluation is needed before installation in time- or life-critical environments.

Conclusion

We presented a system for the dispatchment of casualties. By using a business rule management system it is possible to dispatch nearly every mission from an accident with only one injured to a mass casualty incident. The PSAP operators are able to get an optimized dispatching plan within seconds after a new emergency call is answered.

While the evaluation of the system is very promising, the system can be extended. For future purposes it is planned to include live GPS data from every vehicle involved in emergency services. This would allow even more precise routing and a better assignment of vehicles and injured.

To increase the performance of distance calculation between two positions it is possible to set up and run a local routing server. It is also conceivable to use the linear distance for the first optimization and then the real routing and traffic information for the few realistic transport possibilities only.

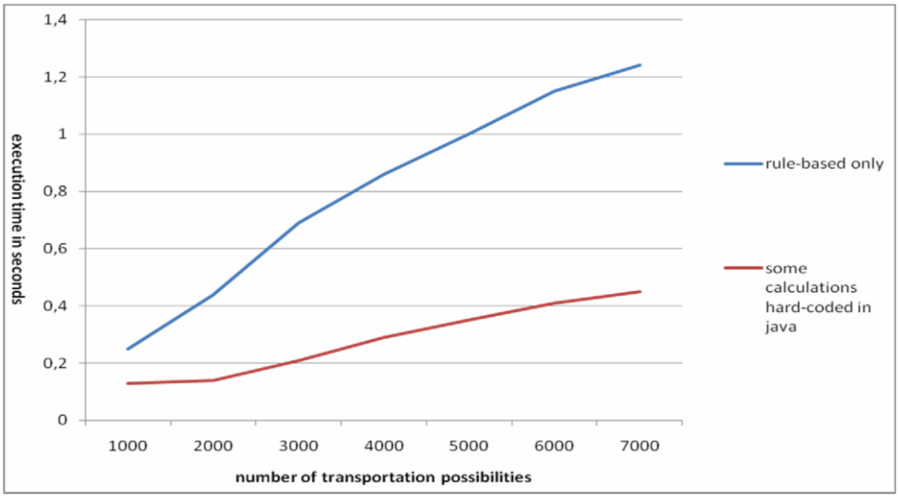

Figure 4- A partial hard-coded rule set may decrease execution time.

This would speed up calculation without losing precision. Furthermore, the local mapping web service can be extended to provide an intelligent visualization and a more sophisticated routing mechanism which includes the current traffic situation [13, 14].

In the next development step, the system will be included into the dispatching system of the Trauma Network North-West. In that project an emergency physician is able to suggest a destination hospital on a mobile device. Afterwards the PSAP agent receiving his request has to accept or decline it. The new dispatching system will assist the PSAP agent to rate these suggestions according to several characteristics like the current load of rescue vehicles and emergency physicians.

If the emergency physicians are equipped with mobile terminals in case of a mass casualty incident, they may be used for other purposes like an electronically health card [15]. Eventually, medical personnel could be equipped with multi-purpose mobile devices that allow for an even better treatment of injured.

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