



**FACULTY
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Tomáš Arnold Tillmann

Emergency services shift plan optimization

Department of Software Engineering

Supervisor of the bachelor thesis: Adam Šmelko

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Author's signature

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Author: Tomáš Arnold Tillmann

Department: Department of Software Engineering

Supervisor: Adam Šmelko, Department of Distributed and Dependable Systems

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Introduction

1. Introduction

1.1 Problem definition

One of the main problems emergency medical service providers (EMS) are facing is at what times should their ambulances on particular depots be available. The main goal is to maximize number of successfully handled incidents and at the same time minimize the costs of ambulances operations. Meaning, the dream situation is being able to handle all, or almost all incidents for the least possible cost. To describe this assignment of ambulances and when each one is available, it is often used a term shift plan.

Shift plan is an assignment of shifts and ambulances for a particular time interval. The time interval is usually simply one day. Thus, denoting when the ambulances are available during a day.

Shift is a time interval, describing from when and to the ambulance is available. It represents when an ambulance crew is operating the ambulance and consequently making the ambulance available.

The ambulance crew or the ambulance itself can be more specialized in some way than the rest. For example, the crew can also have a doctor on board or generally more experienced personal. The same goes for an ambulance. The ambulance can be of a bigger size, so more patients can fit in or it can have more sophisticated tools. To capture this notion, each ambulance has a type.

This ambulance type is an abstraction of all these possible scenarios and specify, which incidents the ambulance is able to handle. Imagine a situation, where the incident is of type, which specifies, that some specific tool is needed or bigger ambulance etc ... For this reason, only some of the ambulances might be able to handle such an incident.

Ultimately, we care only whether particular ambulance can handle particular incident based on ambulance to incident type mapping. During a day, only one shift can be assigned to each ambulance. Ambulance can also have no shift assigned, hence the ambulance is not available at all through the day and cannot participate in incident handling.

Shift plan has a cost. This is the cost, we will try to minimize. We will define the cost of a shift plan as a function of duration and cost of an ambulance type.

Having the cost defined, we can move to how to define shift plan's performance. We will measure performance of a shift plan against many incidents set. One incident set represent when and where incidents happen during a day. A set of these incidents sets than represents a spatial and time distribution of when incidents happen. There are two main ways how we can obtain such incidents sets.

First way, we can obtain these sets from historical data. Where and when in area of our interest incidents happened over many months or years. We can than uniformly randomly sample some representative subset and test generated shift plan against it. By this approach, we assume, that how the incidents happened in the past will also remain in the future. These historical data are definitely the most reliable way to imitate the behaviour of incident occurrences.

Second way, we can define a distribution which will generate incidents based on some prior knowledge. For example, we might observe, that incidents usually happen earlier in the morning until lunch at transport communication locations, because people travel to work / school etc ... Or we can observe, that during a night much less incidents are occurring than during a day.

The first approach more accurately describes when and where incidents might happen in the area of our interest, but on the other hand, it is hard to obtain this data. If EMS didn't record this data throughout it's functioning, obtaining such data might take a long time. Furthermore, these data are confidential, which also makes it harder to obtain them, for example from other EMSs.

For above reasons, we will use the second approach for generating representative incidents sets. It is also more flexible, since we can play around with the distribution and generate whatever data to our liking. This might be useful, to see how shift plan behaves under some unexpected situations.

2. Title of the second chapter

2.1 Title of the first subchapter of the second chapter

2.2 Title of the second subchapter of the second chapter

Conclusion

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List of Abbreviations

A. Attachments

A.1 First Attachment