Effects of Smartphone-Based Alerting on Reducing Arrival Times for Volunteer Fire Departments

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ABSTRACT

This practitioner paper describes the efforts of a volunteer fire department in Germany to reduce the time to arrive at a place of emergency. It presents the former situation, identifies reasons for delays and highlights the volunteers' first years in utilizing an existing smartphone application for alert and response as a mean to optimize their times of arrival. The paper finally evaluates the effects of the application's usage.

Keywords

Volunteer Fire Departments, Time Reduction, Inefficiencies, Smartphone Application.

INTRODUCTION

In Germany most fire-fighting services are organized as volunteer fire departments. In 2016, the number of volunteer fire departments was 22,853 as compared to the 105 professional fire departments (Deutscher Feuerwehrverband, 2020). Volunteer firefighters are primarily working in their daily jobs and are called to operations via sirens or radio pagers when needed. Firefighters of one fire department are normally organized in different sized alarm groups. These groups are summoned depending on the type of the operation and consist of firefighters with various roles and abilities (truck operator, smoke diver etc.).
Small volunteer fire departments face the problem of gathering enough firefighters in a reasonable time to arrive early enough at the emergency site. This issue intensifies in rural areas where recruitment of volunteers becomes difficult due to the aging population. Some municipal administrations support their local fire departments with the hiring of civic employees willing to volunteer as firefighters. The problem in recruitment can generally not be solved by the firefighters directly. Therefore, they focus on improving their time and troop strength with the given resources.

The volunteer fire department of Frankenthal, Germany, is such a small fire department with the stated problem. Currently, 28 voluntary firefighters serve at the fire department. Their average yearly number of incidents varies between 20 and 30. The fire department operates three vehicles, a fire engine, a reconnaissance truck and a personnel transport car. In 2018 the fire department choose an established smartphone application which enables their members to respond to an alert call. Therewith, each volunteer has the ability to accept or decline any incident. The smartphone application was introduced to decrease the time between an alert call and the arrival at the place of action as well as to increase the troop strength.

FOUNDATIONS

As a sound foundation for measuring and optimizing times and troop strength, we introduce a common set of terms. For comparisons, a standardized incident is used. Normally, this is the so called critical domestic fire which is defined as a fire in the upper floor of a multi-storey building with smoke-filled escape routes (AGBF Bund, 1998).
The time between the occurrence of an incident and the arrival of the firefighters is generally separated by defined events into multiple periods (see Figure 1).

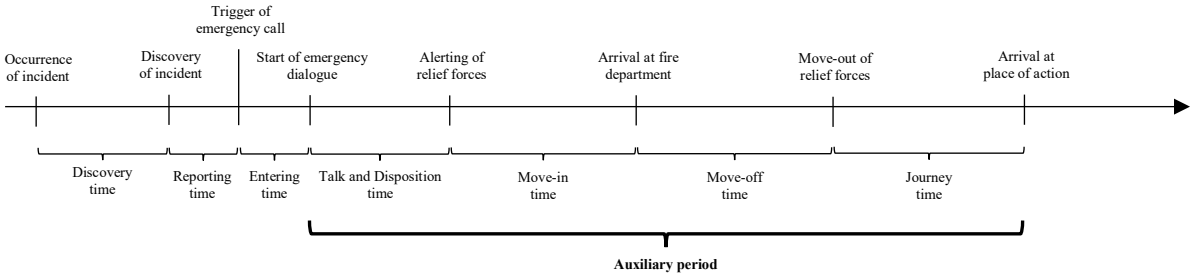

Figure 1: Sequence of events and times during an incident (based on (AGBF Bund, 1998)).

The "Move-in time" occurs only for volunteer fire departments while for professional fire departments the "Move-off time" starts directly after the "Talk and Disposition time". The time between the beginning of the emergency dialogue and the arrival at the place of action is called auxiliary period and is tracked for most operations.

The guidelines of what auxiliary period is acceptable, vary between states, countries and type of fire department (professional or volunteer). For the Frankenthal fire department the goal is to arrive at the place of action within 9 minutes with 9 firefighters, but consensus is to keep this period minimal in general. The firefighters only have the means to reduce the duration of move-in time, move-off time and journey time, therefore we will concentrate on these three.

The departure requires not only enough firefighters at the fire station but also enough volunteers with the proper qualifications. Each truck needs one operator, one commander and at least two smoke divers. Firefighters can have multiple qualifications but can only serve one role during an incident.

INITIAL SITUATION

Up till 2017, the Frankenthal fire department used only sirens and radio pagers as means of alerting. The firefighters reported that available staff number and auxiliary period varied and that they worked with less information than desired. Organizational solutions such as cooperating with neighbouring fire departments or recruiting of civic employees were already exhausted or maxed out.

The fire department had three issues with efficiency:
(I) The cars were filled mostly in the order of the firefighters' arrival and departed when fully staffed. This led to situations where all available drivers were on the first car already leaving the fire station, not knowing that further smoke divers would arrive a few minutes later without driving qualifications.

(II) The information, that the number of participating firefighters was too low to depart, was only available after some minutes. The procedure was to wait until more firefighters would arrive or call the rescue coordination center to repeat the alerting after a defined period of time.

(III) If the number of participating firefighters was low but big enough to depart, they sometimes waited for further staff.

The results of all these inefficiencies came down to cases where less than possible firefighters departed and cases where the depart time was increased from a lack of information that others were approaching. Further time was wasted for clarifying the incident and wayfinding.

Another optimization potential was identified in the missing redundancy of alerting. If volunteers forgot their pager, they normally would not notice the alerts.

OPTIMIZATION APPROACHES

The Frankenthal fire department was aware of all these inefficiencies and focused primarily on optimizing move-in and move-off time with a smartphone application and secondarily the journey time.
The fire department attempted to utilize various messaging services that allowed group chats. In the end, the department was dissatisfied with these solutions due to poor representation of the responses as single messages. Also, specific qualifications of each firefighter could not be directly depicted. Based on that, the fire department

looked for a smartphone application that enabled their firefighters to respond if they could participate or not in an operation and showed the firefighters' qualifications. The application the fire department ultimately chose to use, was already in use by similar nearby departments who gave positive feedback of their experiences using it and was therefore selected from a variety of similar ones available in Germany.

The application is triggered by a webserver, which receives the alert information via different channels: a central radio pager in the firehall, via e-mail, via phone-call or via web-push from the rescue coordination center. If one of the channels towards the server is blocked due to a power outage or network problem during a crisis the other channels take over (see Figure 2).

The server forwards the text alert to the smartphones. The smartphones receive a push notification containing the alert information, ringing loudly and showing buttons to send the response. The app shows the responses of the other firefighters organized by participation and their abilities. In crisis situations with interrupted internet connections the firefighters receive a phone call alert or SMS (see Figure 2).

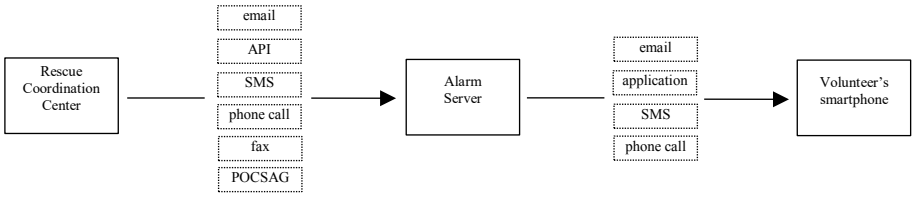

Figure 2: Channels for sending an alert to the alarm server and from there to the firefighter.

The alert server sends the alert information also to screens in the fire department's locker rooms showing the alert's category, direction maps, responses, requested cars and fire hydrants. The firefighters gather around the screens and pre-plan the operation while readying themselves. By having all the necessary information at the arrival of the first firefighters, the intention is to reduce staffing time of vehicles and to properly organize each transport with the qualified specialists thus improving the move-off time.

The journey time was planned to be reduced by navigating to the place of action via the smartphone app. The journey time should further be reduced by the fire hydrant information in the app, telling the driver what fire hydrant is nearest and most suitable.

RESULTS

After the introduction of the smartphone application, we observed the fire department for the first two years. During that time 50 incidents occurred. For the two preceding years data for 45 incidents is available and was complemented by the statements of the firefighters. The number of active firefighters in the fire department stayed the same over the last years.

Rescue coordination centers record the points in time when an alert is dispatched and when the staff sets the status "Departure" on the car. The resulting time span contains the move-in and move-off time. Since each firefighter arrives at a different time at the fire department and is not tracked individually, move-in time cannot be determined separately. Therefore, we considered the combined move-in and move-off time as a comparative value.

As a further comparison, we used the percentage of incidents where the fire department arrived at the place of action within the recommended auxiliary time of 9 minutes. We focused on the incidents where the fire engine was the first car used, since it offers seats for 9 firefighters and supports the standardized incident presented in the foundations. Additionally, we analyzed the percentage of incidents where the car was fully staffed.

In the years before 2018, the available data shows that the recommended auxiliary time was achieved in 40% of the incidents. With the introduction of the application, the achievement rate rose to 48% (see Figure 3).

Combined move-in and move-off time improved from 4 minutes and 36 seconds in the years without the smartphone application to 3 minutes and 50 seconds, showing a time reduction of 17% (see Figure 4). Additional time for volunteers to respond to an incident had no negative impact on the combined move-in and move-off.

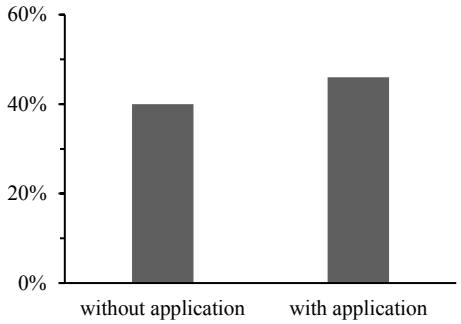

Figure 3: Percentage of arrivals at place of action within recommended auxiliary time.

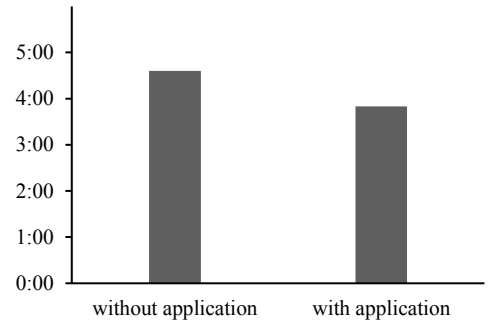

Figure 4: Combined move-in and move-off time (i.e. time between alerting and departure) in minutes.

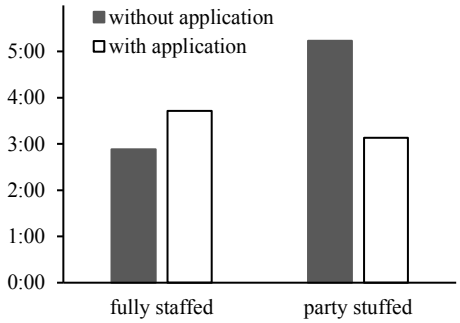

Figure 5: Combined move-in and move-off time in minutes differentiated by staffing of the fire engine.

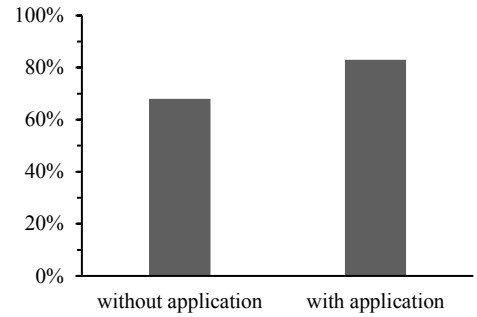

Figure 6: Percentage of fully staffed departures of the fire engine.

Interesting are combined move-in and move-off times when also taking into account if or not the fire engine was fully staffed. Before utilization of the application and when the fire engine was fully staffed with 9 firefighters, it took 2 minutes and 53 seconds to leave the fire hall. On the other hand, when the application was already implemented, it took 3 minutes and 43 seconds. During incidents when less firefighters participated, the time decreased from 5 minutes and 34 seconds to 3 minutes and 8 seconds (see Figure 5). In preceding years without the use of the application, staffing rates hovered at 68%. In the years after introduction, this number increased to 83% (see Figure 6). Firefighters confirmed that they waited longer periods when they knew other volunteers were on their way to the fire hall as compared to when they immediately departed if nobody else was expected, even when not fully staffed. Retrospectively, firefighters preferred more staffing resources over having faster departures and evaluated this approach effective in event reviews.

The acceptance of the smartphone app was high. 89% of all firefighters installed the app in the first month and on average 80.6% of them responded to incidents. Reasons for why some firefighters did not use the application were simply that some did not have their smartphones with them. Another reason was that when the alert came in, the firefighter was already near the fire station and responding to the alert would have taken more time than to just coming directly to the firehall.

The firefighters emphasized the usability of the information screens in the fire department and the routing information but could not quantify the effect on the preparation and especially the journey time. Overall, journey time even increased by 26% during the two-year research period. This was due to an increase of 38% for incidents outside of the Frankenthal municipality, therefore creating longer routes for the fire department. Since the incidents' distances influence the journey time more than the time savings by precise routing, the application's effects on journey time were overlaid by external factors.

CONCLUSION AND OUTLOOK

In the two years since Frankenthal fire department has been utilizing the smartphone application, combined move-in and move-off times have improved, and the recommended auxiliary time has been reached more frequently. Most time savings came from departing with not fully staffed vehicles, by having correct response information about which volunteers would participate or not in an incident.

The application usage was high from the beginning and the information on the screens in the fire station was appreciated. Overall feedback from the firefighters was very positive.

The reviewed fire department was a well enclosed use case to easily monitor efficiency and staffing levels. The smartphone application is currently utilized by bigger organizations with over 1000 users and in cross-agency environments (e.g. Wolfsburg, Germany). Thereby multiple local fire departments, rescue services and medical professionals have access to shared alerts, responses and resources. The responses can be examined by the rescue coordination center to realize shortages during the early stages of an incident. Existing systems like operational support software and administration software can be connected to allow the triggering of alerts, exchange of information and to generate statistics.

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