Increase of Travel Safety for Public Transport by Mobile Applications

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Abstract: Mitigating vandalism in local traffic and at stations, violent disorder, and theft by employing security guards, installing video cameras are expensive and only partially solve existing the problems. Related costs directly affect the fares and thus the attractiveness of local public transport. We discuss a concept to implement a *Report*-service to forward emergency and complaint messages in local public transport. The service is based on a mobile application and a message routing system. The aim is to increase travel safety and the attractiveness of the local public transport. On the base of theoretical approaches and the usage of paper prototypes we show the possibilities how such a *Report*-service could be implemented.

1 INTRODUCTION

The local public transport offers a lot of benefits compared to the individual transport. On the one hand, considering the continuous increasing of petrol prices and the problematic parking situation in many German cities, the local public transport will gain importance. On the other hand, German transportation companies are struggling with a variety of problems, e.g., delays, vandalism, late removal of defects, and the coordination of complaints and problem reports incoming decentralized. Hence, a lot of traffic participants are discouraged to switch to local public transport.

The countermeasures to mitigate vandalism in local traffic and at stations, violent disorder, and theft by employing security guards, cooperating with the police, installing video cameras, and school projects are expensive and solve the problems only partially (Bahn.de, 2011), (Schumacher, 2009). The related costs directly affect the fares and thus the attractiveness of local public transport.

Until now the participants were left on their own transmitting information to the transportation companies, e.g., they have to search for phone numbers or email addresses of the responsible department. This possibly entails that information can't be forwarded locally instead only when the participant is able to access the internet. By then, important information details can be lost. Absence of feedback and the uncertainty that the information reaches the right division, possibly influences the participant's motivation and willingness of forwarding information. With regard to the transportation companies similar problems occur. If information reach the wrong division or is forwarded incorrectly, they can't be processed adequately. In the worst case the information becomes worthless.

An approach for an interface to exchange information between transportation companies and their participants would be desirable to improve the travel safety preventively and the client satisfaction as well as saving expenses.

In this position paper we present an intermodal approach to realize such a measure in form of a mobile application we call *Report* combined with a central reporting unit. With this application the participant is able to forward emergency and complaint messages to a central reporting unit which in turn controls the forwarding to the involved institutions. The integration of smartphones entails the advantage that no longer, participants are on their own by searching for the correct contact and information reach the wrong place. Furthermore involving the smartphones components and the application's user interface, the participants can be led through the input procedure and supported with articulation.

This paper is structured as follows: By means of use case scenarios, provided in Section 2, we outline how the *Report*-application could be integrated in the local public transport and simplify the information forwarding. With Section 3 we give a survey of related work, followed by our theoretical approach in Section 4, depicting the essentials for the central reporting unit as well as the analysis of the requirements

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and the input data of the application. With Section 5 we present our paper prototype and its evaluation. Finally with Section 6, we summarize our approach, depict the next steps, and provide an outlook for enhancements and additional areas of deployment.

2 USE CASE SCENARIOS

Based on the following use case scenarios, we exemplify the advantages the Report application entails and sketch possible operational scenarios.

2.1 Forwarding a Hazard Warning

Late at night, Richard waits at the underground station for his line to get home. He discovers a heavy metallic object lying on the rails. To prevent a collision with the underground he uses his smartphone to report the hazardous situation. He sends an emergency message selecting the option that the rails are blocked by an object from a list of predefined option. Further information concerning Richard's location are determined automatically and appended to the emergency message by the *Report*-application in the background. The central reporting unit processes the received message and forwards it to the involved entities, e.g, the affected underground lines and the transportation company.

2.2 Reporting an Act of Violence

In the early morning, Jessica drives to her position by train. In the same compartment she watches two groups of youths between which it comes to a contention followed by acts of violence. Thereby, the installations of the train get damaged. To prevent grabbing the youths attention, Jessica inconspicuously accesses her smartphone to send an emergency message. She indicate the presence of a threatening situation involving a scuffle. Additionally, Jessica roughly indicates her position in the train and adds a photo of the happening. Automatically the *Report*-application adds personal details and the train number. The central reporting unit forwards the message to the transportation company and the closest police station.

2.3 Notification of a Defective Elevator

Charlie visits his relatives traveling by train. He arrives at a provincial station and because he carries a lot of luggage, he wants to take the elevator on his way to the exit. He realizes that the elevator is not workable. Since there is no staff he can turn to, he uses his *Report*-application to inform the transportation company within seconds. Fortunately, the application determines his position and appends it to the message because Charlie is not familiar with the environment. On the same day, Charlie gets an pleasant answer that the defect will be fixed as soon as possible.

3 RELATED WORK

A large part of reporting systems research is discussing the analyzing and filtering of social media (e.g., Twitter[1], Facebook[2]) for detecting patterns of civil relevance (Kavanaugh et al., 2011), (Linders, 2011). Additionally, there are approaches involving citizens taking part in creating government decissions (Greenwood et al., 2012) on the base of social networks.

The focus in this chapter lies on target based and explicit digital data collections for emergencies and complaints transmitted by citizens in the domain of public transport. We have to increase the radius of the topic, because there is no related work for the special domain of public transport. Digital citizens engagement in civil matters include a few research projects and a lot of running applications. The related work is strictly split into reporting complaints and emergencies.

Typical examples for mobile complaint services are FixMyStreet[3], SeeClickFix[4], NeatStreets[5], and CitySourced[6] where citizens report complaints online via website or mobile application. Users can create reports (in most cases inputs are images, locations, a type, and a description) and get an overview of reports in different areas. Town administrations can subscribe to their region to get the newest complaints in their area. 1,748 reports were posted in week no. 22 at FixMyStreet.

In (Foth et al., 2011) an iOS App is presented which works as an overlay for an online formula for complaints with similar inputs like the mentioned services. Their evaluation illustrates the positive aspects of reporting complaints via mobile devices. For their future work they plan an enlarged feedback system to include the citizens into the act of improvement.

A further approach is (Whittle et al., 2010) which is a complaining system based on a kiosk system, located in a city. Citizens can give comments on current

[1]http://www.twitter.com
[2]http://www.facebook.com
[3]http://www.fixmystreet.com/
[4]http://seeclickfix.com/
[5]http://neatstreets.com.au/
[6]http://www.citysourced.com/

problems and suggestions how to improve it.

In contrast to complaining services, emergency services, especially mobile emergency applications on the basis of *distress radiobeacon* are major tools in this area. Mobile applications like Emergency Distress Beacon[7], CerberTouch[8], CrimePush[9] and Emergency Beacon[10] send messages with a predefined emergency text and user's location. While the most functional approaches are available in the App Store, research is mostly done on the technical site to integrate GPS coordinates into emergency messages (Stastny and Merka, 2006).

Another approach is the community platform SpotCrime[11], where users can report crimes and emergencies to an online platform to make crime public and comprehensible.

Overall, the applications and approaches show that there is currently no system which combines emergency and complaining reports in one tool. Furthermore, the degree of complexity for input data ist very low. There is no positioning operation for moving vehicles like trains or more complex places like rail stations. The classification of complaints is mostly based on one stage, while for complex infrastructures with many departments a finer classification is essential for a fast and robust work flow. This is where we focus on.

4 APPROACH

The *Report*-service basically consists of two components: the mobile *Report*-application and the central reporting unit (see Figure 1). The transportation company supplies the *Report*-application which its customers can download on their smartphones. To send an emergency or a complaint message the customers interact with the mobile application's user interface which requests all relevant information from him. The message is send to a system of servers, the central reporting unit, which makes the decision based on routing information where to forward the message to. The notified institution is able to directly process the transmitted information and is able to get in touch with the customer intermediately.

[7]https://itunes.apple.com/us/app/emergency-distress-beacon/id288770664

[8]http://cerberus.briartek.com/cerbertouch

[9]http://crimepush.com/

[10]http://emergencybeaconapp.com/

[11]http://spotcrime.com/

4.1 Requirement Analysis

We divide the requirement analysis into the analysis of sending emergency messages and sending complaint messages.

4.1.1 Emergency Messages

Especially time-critical situations (danger of life, property damage, and infringing the law generally) belong to the category of emergency. It is important that those messages contain all relevant information to enable processing them, that is to comply with the five questions for the controlled process of emergency calls:

Who? - identify yourself

What? - the reason for sending the message

Where? - the location of the event

How Many? - number of involved/injured people

When? - the point in time of the event

The *Report*-application has to require and request those five items. Due to the time factor, the user interface has to assist the user doing the input. Information which the mobile device is able to determine by itself shouldn't be requested. Supporting user's articulation as well as providing precast options helps the user to concentrate on the essential information and to save time.

If the location is a station the following inputs have to be made: the city where the station is located, which kind of station it is, the name of the station, and further location restrictions. We consider rail stations, bus stops, tram stops, underground stations, and city train stations.

If the locality is a transport the following inputs are required: the city of departure (to restrict the transports to a specific environment), the kind of transport (train, bus, tram, underground, and city train), the train number or the line, and further location restrictions of the transport, e.g., the wagon number or the seat number.

The determined event, this is the possible reason for sending an emergency message, could be divided into three categories: threat, hazard, and vandalism. To declare the reason for an emergency message, the event category and next a specific event from the predefined event list of the correlating category has to be chosen. If the actual event is not listed, the description text could be use to describe the specific event.

The transmission time and verified contact information are required, too. The latter are essential to make contact with the sender.

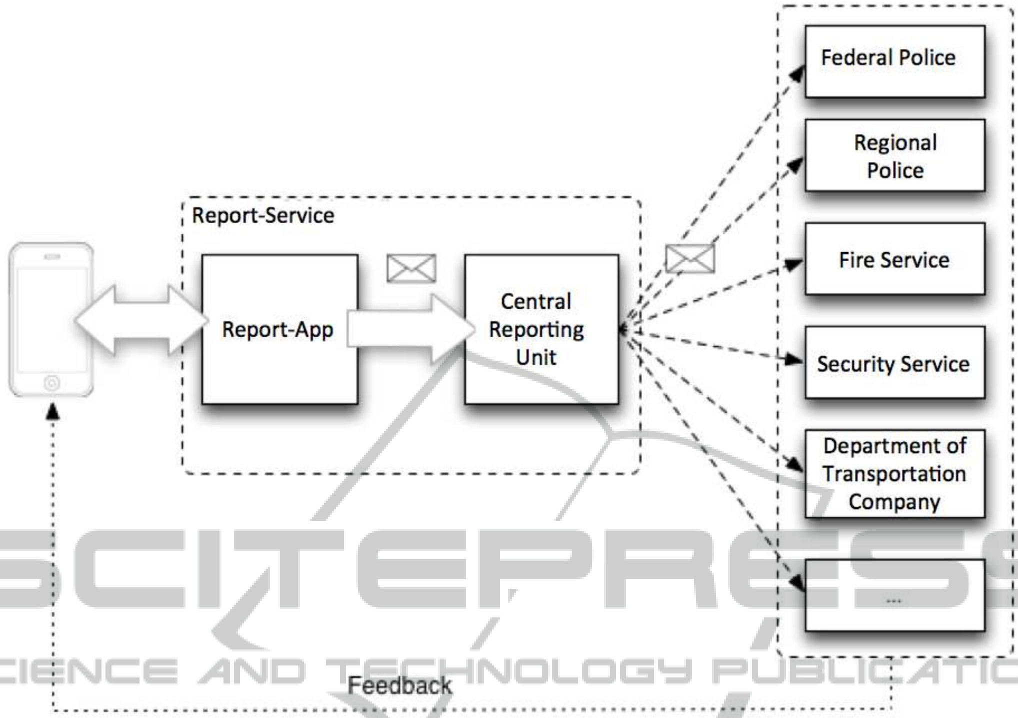

Figure 1: *Report*-Service in the Overall Context.

To realize time-critical actions, we take into account the following approaches:

- design a clear, structured, and intuitive user interface,
- involve hardware components of the mobile device to determine information in the background to minimize user input,
- choice options instead of user input,
- search bars integrated into table views,
- send partial information ahead,
- store personal information,
- and use the camera of the mobile device.

4.1.2 Complaint Messages

If the user of the *Report*-application notices deficiency states concerning the transportation company he is able to communicate it through sending a complaint message. This action is less time-critical, hence there are various possibilities to design the user interface but still the same information are required as for an emergency message. Still the user should be supported doing his inputs by the smartphone, not for time-critical reasons but to retain his willingness to forward such messages.

The required inputs to describe the location are the same as for emergency messages. Instead of events, we consider deficiencies which we divided into four categories: hygienic, architectural, functional and service deficiencies. It has to be distinguished between deficiencies concerning transports and stations. Just as for emergency messages, the description text can be used to input a deficiency not listed in the preselections.

4.2 Hierarchical Structure Classification of the User Interface

On the basis of the previous sections we can construct a taxonomy for information categories for the user input (see Figure 2 which depicts the taxonomy for emergency messages send from stations). From the taxonomy we can deduce, to which information category an input value belongs to. Furthermore the taxonomy provides a precise vocabulary, isolating information classes from each other, and coins class names for the implementation phase. The objects of the taxonomy can be mapped to hierarchical numbers as it is done in Figure 2. With this technique we can use the taxonomy analogously to a *Management Information Base* (MIB). Dynamically adding those hierarchical numbers depending on the sending procedure, they can be used as routing information at the central reporting unit (see 4.3).

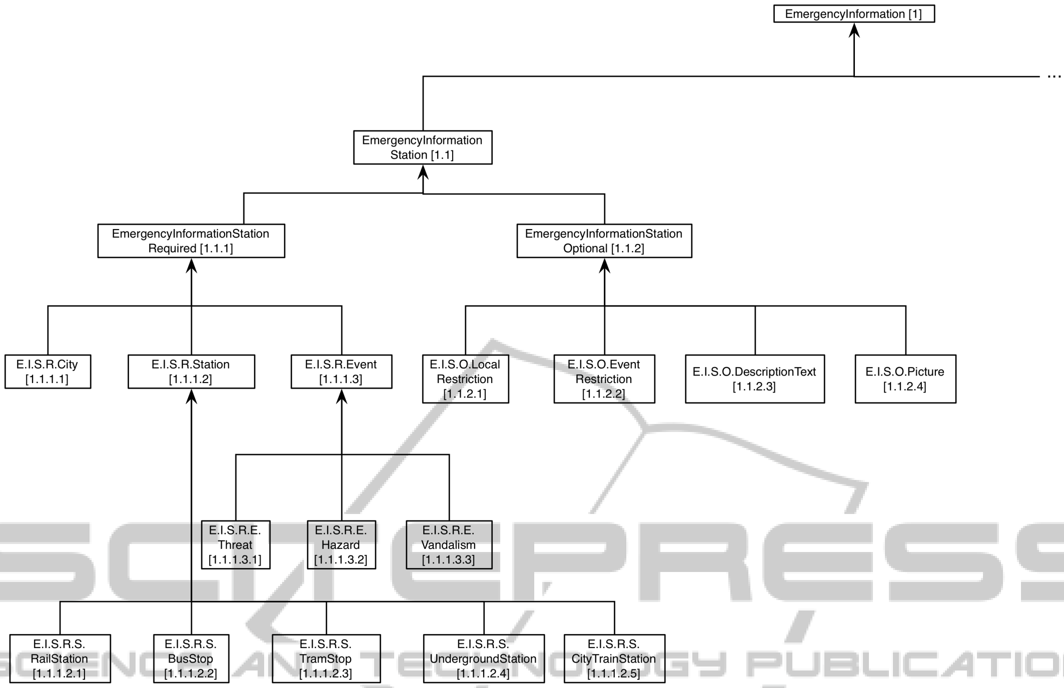

Figure 2: Taxonomy for Emergency Messages from Stations.

4.3 Basic Concepts for the Central Reporting Unit

For the implementation of the central reporting unit the SOA-design pattern *Intermediate Routing*, applied in the area of *Content-Based Routing* (CBR), is suitable. An incoming message at the *Content-Based Routing Agent* (CBRA) is forwarded by its content using decision logic.

The numbering we introduced in Section 4.2 enables us to use the taxonomy for a *Management Information Base*. Each object is called a *Managed Object* (MO) and its number is called *Object Identifier* (OID). For clarity, the OID of each MO is depicted as complete string from the beginning of the root object, e.g., 1.1.1.3.**1** instead of 1. The advantage of employing the MIB pattern is that existing network protocols can be used to integrate and handle OIDs without modification.

The central reporting unit uses the OID of incoming emergency and complaint messages for routing purposes, this is to decide to which instances the message has to be forwarded. It is denoted as $x = x_1.x_2.x_3. \dots .x_k$.

In the following we assume that an emergency message consists at most of two messages, the first one with the required and the second one with the optional information. A complaint message consists of one single message. The OIDs can be extended to specific events and deficiencies by appending an additional number to the OID string of the father object for each of them.

Figure 3 depicts how the central reporting unit could be realized applying the *Intermediate Routing* pattern. A detail view of the *Content-Based Routing Agent* demonstrates how the progressive process of message forwarding proceeds. On the first stage we distinguish between emergency messages from stations and transports and complaint messages. Complaint messages are forwarded immediately to the transportation company. For emergency messages there is a second stage to determine the event category. If events are not specified any further ($x_6 = NULL$) the message includes the first part of the emergency message which is send ahead and forwarded to the responsible instances. If $x_6 \neq NULL$ the message is forwarded depending on the selected event.

Introducing further routing variables regarding cities, stations, and transports as well as using company-internal *Content-Based Routing Agents*, a precise forwarding to local branches and departments could be realized.

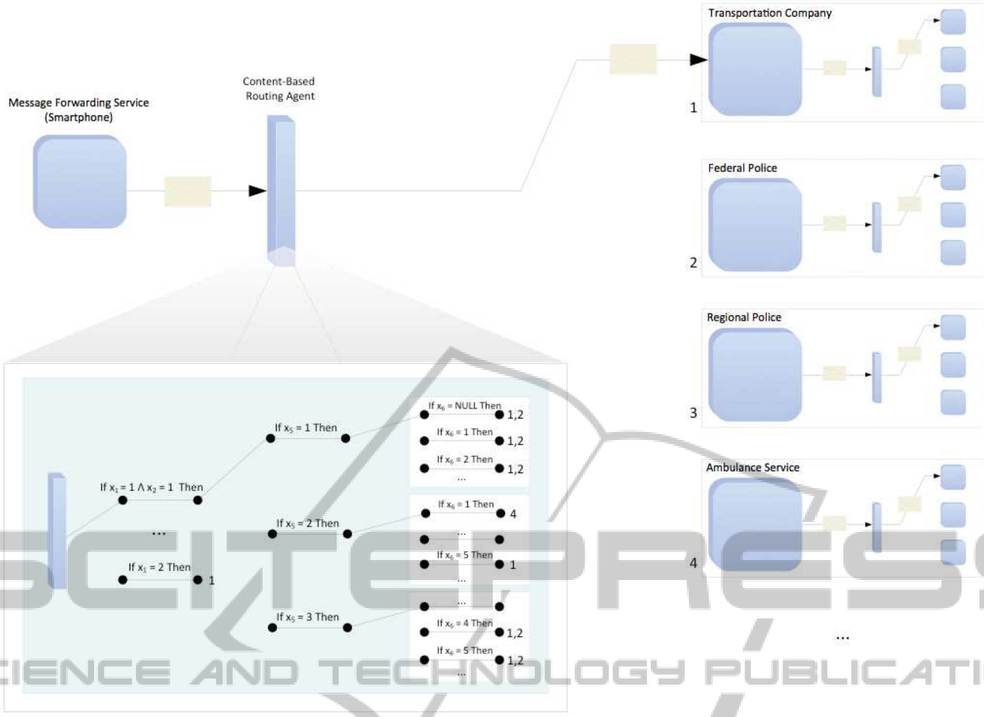

Figure 3: Dynamic Message Forwarding.

5 MOBILE APPLICATION PROTOTYPE

In this work we used the concept of evolutionary prototyping, this is continually enhancing an initial prototype. The criteria for extendings, modifications, improvements, and new concepts were gained by intermediate usability tests of paper prototypes which provide scenarios the *Report*-application can be used for. Using paper prototypes we were able to simulate the application for the end-user, demonstrate concepts, examine design decisions, and localize problems.

In the following we present a sophisticated paper prototype basing on the fundamentals of Section 4 and its evaluation. The evaluation has been carried out with ten persons which regularly making use of local transports and owning a smartphone.

5.1 Paper Prototype

Fig. 4 and 5 present the sophisticated prototype. Fig. 4 provides the prototype for sending emergency messages. The user starts with view 1 where he has to specify the location of the event (station, transport).

If the location is a station it has to be specified in view 2. Via tables with an integrated search bar providing options, the city and the station's name can be selected. The location can be restricted, e.g., by commitment of the track, the passage, or the forecourt (see view 3.1 and 3.2). Pressing the button 'use position' activates a routine which automatically determines the user's position utilizing on location based data provided by the smartphone and enables to restrict the location options in view 3.1 and 3.2.

In the next view (view 4), the event has to be determined, a description text, and a picture can be added to the emergency message which is sent after pressing the 'send'-button.

If transportation is selected the prototype works similarly except instead of determining the station, the transport and the location within the transportation have to be selected.

Figure 5 provides the prototype for sending complaints. View 1,2, and 3 behave accordingly to the prototype for emergency messages. Furthermore, in view 4, first the category of deficiencies is selected whereupon in view 5 the specific deficiency with respect to the specified location can be selected with the help of a picker. The following views (6,7) ask the user to add a description text or a picture to the complaint-message. View 8 presents the transacted inputs grouped by the information area. This view enables the user to verify his inputs and to send the message.

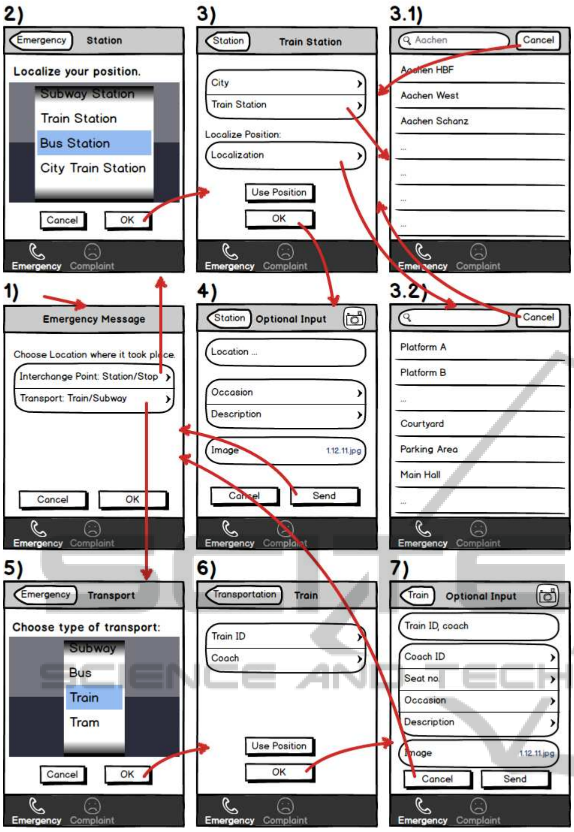

Figure 4: Sophisticated Paper Prototype (emergency).

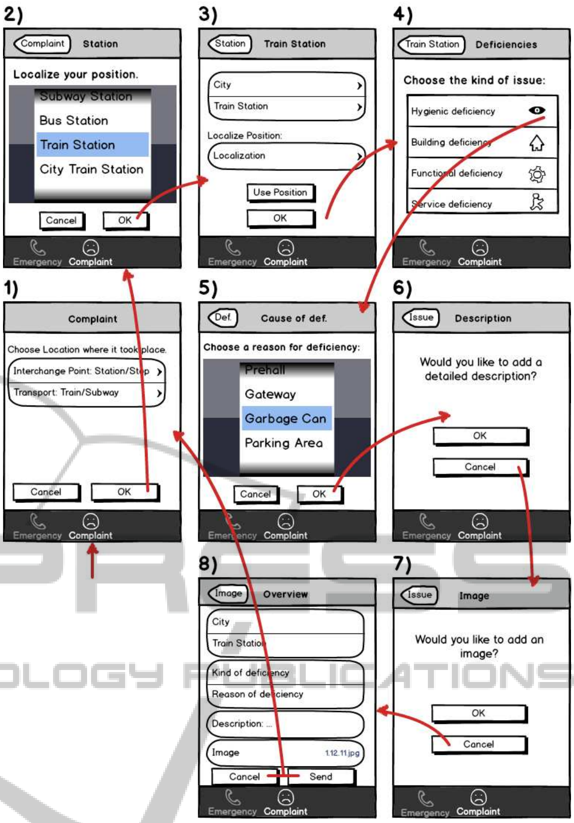

Figure 5: Sophisticated Paper Prototype (complaint).

Table 1: Evaluation of the Emergency-Prototype.

evaluation of	**1**	**2**	**3**	**4**	$\bar{x}$
clarity	1	9	0	0	1.9
understandability	1	9	0	0	1.9
simple operability	0	2	7	1	2.9
user guidance	1	7	2	0	2.1
no surprises	8	2	0	0	1.2
predictability	9	1	0	0	1.1
not fussy	2	7	1	0	1.9
efficiency of user guidance	1	6	3	0	2.2
efficient operability	0	3	5	2	2.9

Table 2: Evaluation of the Complaint-Prototype.

evaluation of	**1**	**2**	**3**	**4**	$\bar{x}$
clarity	4	6	0	0	1.6
understandability	3	7	0	0	1.7
simple operability	1	4	5	0	2.4
user guidance	3	6	1	0	1.8
no surprises	9	1	0	0	1.1
predictability	9	1	0	0	1.1
not fussy	4	5	1	0	1.7
efficiency of user guidance	3	5	2	0	1.9
efficient operability	1	5	4	0	2.3

5.2 Evaluation

The usability test consists of four tasks. Task 1 and 2 describe scenarios the prototype is applied to. Subsequently the users have to rate the operationality, the predictability, and the efficiency. With task 3, asking the user to describe how specific views could look like, we obtain information about the consistency of our user interface. In task 4 there are some contextless views the user has to embed into a context. The evaluation bases on the grades the users assigned, and their oral and written comments.

The evaluation for the emergency-prototype and the complaint-prototype can be found in Table 1 and 2 (1 is the best rating, 4 the worst). On average the results for the complaint-prototype are a bit better, but the tendencies stay the same. It becomes clear that especially there are shortcomings concerning the operating and the user guidance. Hence, the problematic aspects of both prototypes coincide, we cover them all by concentrating on those which resulted from the evaluation of the emergency-prototype.

View 1. To select the kind of station before the city is selected turned out to be unfavorable because in many cities there is no underground, suburban train, or tram.

View 2. There are deficits in the user guidance. In view 2, input related to the station is requested. In view 3, the city and again information concerning the station are required.

View 3. There is the possibility to create wrong input: It is possible to enter the city and next the station in this city. Afterwards the city can be changed again. The station will be an invalid one for that city.

View 4. The 'use location'-button is positioned inconveniently because it counteracts the operating sequence. To list the chosen location once more proved to be annoying because it wastes the restricted display space. An option to choose a specific event required. So far it is only possibly to specify an event using the description text. The association between the photo button, located in the navigation bar, and the corresponding table entry couldn't be deduced contemporary.

View 6. To consider trains generally instead of restricting them to the departure location turned out to be unfavorably.

View 7. Similar problems to view 4 occurred. Furthermore the grouped table view should be used to separate synonymous information.

Generally. It came out that there are areas for improvement considering the distribution of information requests. For now, it is not possible to send urgent information, e.g., the precise location, ahead and process them appropriately. Furthermore it is not obvious which requested information are required and which are optional.

5.3 Solution Approaches

The following solution approaches describe how to circumvent the problematic aspects listed above.

We discarded the 'use location'-button. If GPS coordinates are available, the city is determined in the background and filled into the appropriate table cell automatically. Furthermore, the spatial data is used to determine nearby stations and transports whose course of the road coincide with it to restrict the preselections. There is still the possibility to change those data manually. If the smartphone is not able to determine spatial data this has to be communicated to the user early.

Furthermore we relinquished the repetition displaying data to give an overview. For time-critical activities, duplicated information are counterproductive.

Instead of providing a photo-button in the navigation bar, a picture can be taking by interacting with the corresponding table entry in view 4.

The absolutely required information for emergency messages is the city, the station or the transportation, and the event category.

The focus of the occurred problems is on the structure of the user interface. It has to be redesigned to accommodate the requirements. View 2 and 5 were discarded. If the station option is selected in view 1, the required information a requested: city, station/transportation, station's name/train number/line, and the event category. This view is completed with a 'send' button which sends the required information ahead. Afterwards, the user is able to fill in optional information: a restriction of the location, a restriction of the event, a description text, and taking a photo. Those data can be send independently of the required data. For complaint-messages the same information are relevant but they don't have to be categorized by urgency. Instead they are retrieved by context.

6 CONCLUSIONS AND FUTURE WORK

This position paper presents basic approaches and concepts to implement a central service for mobile devices to send emergency and complaint messages in the area of local public transport. The next step would be to implement this approach for a specific mobile platform followed by an evaluated field test.

There are other non considered fields, the *Report*-service could be applied to, e.g., the urban space. The *Report*-service could be used to improve the urban security architecture and the civilian security by enabling message forwarding to the police, the fire service, the regulatory agency, and contract cleanings to call attention to crime, dangers, vandalism, and pollution. Especially, this approach can be utilized to improve the sense of security in areas of critical infrastructures.

The *Report*-service could be extended to an information platform regarding behavior in critical situations, sensitization of citizen for hazards and dangers, and to communicate improvement suggestions concerning the urban design.

The question rises how to motivate customers and citizens to make use of the *Report*-service. On the one hand, there already is the demand of such a *Report*-service in Germany (see (Lange, 2011)). On the other hand, the idea of providing feedback can be elaborated. It could be used to inform of and hand out of premiums if the transportation company benefits from the forwarded information.

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