Engaging the Public in Forest Fire Awareness Through a Mobile Application

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ABSTRACT

The widespread use of mobile devices has resulted in remarkable advancements in their capacity to offer and disseminate online information virtually anywhere. Users are increasingly open to installing applications that furnish valuable information to address specific situations. This paper describes joint efforts in research and development of a mobile application, called Citizen Engagement App (CEA), and related methods for engaging the public in forest fire danger awareness, data collection and presentation services. The primary objective is to provide insights into the developed methods and technologies employed. The methods are separated into two domains, namely the domain of citizen engagement approaches to educate people about forest fire prevention, and the domain of mobile application development employed for disseminating knowledge and reporting on hazardous situations in the forests. The evaluation of the mobile application took place both in the pilot demonstrations and meetings with the public to pinpoint any gaps and challenges.

Keywords

Wildfire, forest fire prevention, citizen engagement, forest fire reporting, mobile application.

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INTRODUCTION

The widespread use of mobile devices has resulted in remarkable advancements in their capacity to offer and disseminate online information virtually anywhere. The users are increasingly open to installing applications that furnish valuable information to address specific situations. Even though users' willingness at data collection attendance is considered to be low (Wenz, 2023), as the use of mobile technologies for personal purposes increases, including among older groups in the population, participation in survey-based activities using these technologies is likely to increase (Jäckle, 2019). As a general rule, globally only around 4% of all forest fires have natural causes such as lightning. In all other cases, humans are responsible for the fires - be it directly or indirectly, deliberately or due to carelessness (Hirschberger, 2016). Aforementioned facts about the increasing use of mobile applications as a communication information channel and that major cause of wildfires is a human activity was the main drivers for creation of mobile application for forest fire prevention. Since the preventive actions help to decrease the forest fire causes, the sharing the information about the existing forest fires may help to put the fire under control or have better situational overview. This paper also addresses the concern of people's willingness to install and actively use the application especially during the wilderness adventures. The presented work is being developed in scope of the SILVANUS project[1].

In the next chapter, the paper provides a related work done in the domain of citizen engagement for preventing forest fires using campaigns and the use of mobile applications for forest fire reporting/monitoring. The focuses on the design, development, utilization, and acceptance of a mobile application aimed at providing the useful information on wildlife safety, the importance of wildfire prevention and sharing information about hazardous situations in the forests. The following chapters are describing the methods raising public awareness about the importance of the forest fire prevention through various channels as social media, workshops, exhibitions and especially mobile application. The next chapter focuses on mobile application design with regard on user experience, followed by the fire reporting module design and implementation of backend services. Next chapters are devoted to providing overview on the information collection and distribution framework directly used by the mobile application and the main dashboard description. The last chapters of this paper discuss the prototype application evaluation and identified challenges along with the future work addressing the challenges.

RELATED WORK

The chapter summarizes scientific works related to mobile applications and citizen engagement for fire prevention and fire reporting/warning, and also reviews the existing mobile applications in this domain. The topics covered in reviewed works include the mobile apps, analysis of emergency notification apps, integration of mobile apps into emergency communication frameworks, examination of mobile crowdsensing technologies in emergencies, and recent developments in wildfire monitoring. The mobile application EscapeWildFire benefits was described (Kamilaris, 2023) and evaluated through simulations of wildfires in Cyprus and the 2011 Amarillo, Texas wildfire to aid in real-time wildfire evacuation. The work overviewed the app's wildfire-specific design requirements. The set of the most relevant emergency notification mobile applications were reviewed and analyzed (Romano, 2016) according to the shared data types and forms of communication with citizens. One of the conclusions states that people prefer to use multi-media to write a text or fill in the forms for notifying emergencies. In the scope of PEMEA project (Pemea, 2020), twelve mobile emergency applications are integrated to the communication framework defined by ETSI (TS 103 478) standard providing citizens with fast and intuitive access to emergency services. The work (Cicek, 2023) provides a comprehensive overview of the mobile crowdsensing technologies in emergency situations as well as research and development challenges. The work concludes with a finding that mobile applications and social media prevail in hazard/risk detection, evacuation/mapping, information exchange, situational awareness and data fusion. There was a recent effort in design and develop mobile application (Teguh, 2021) to control and monitor peat fires in the Central Kalimantan (Indonesia) thus providing firefighters with information support. The requirements study (Majlingova, 2022) enlisted specific requirements for mobile application relevant to wildfire management. The following citizen requirements were identified: notification about the fire occurrence in citizens' vicinity; ability to notify the fire location to the fire and rescue service; ability to notify the forest management services on human negligence; and ability to report a suspect fire with geo-location information, photos, and a brief description. The Smoke Sense project by the US EPA (Environmental Protection Agency) utilizes a mobile app to involve citizens at different tiers to mitigate the public health effects of wildland fire smoke, drawing motivation from personal, professional, and community contexts and collecting individual reports of smoke exposure. It underscores the necessity of aligning citizen science initiatives like Smoke Sense with partner organizations to tackle intricate problem areas effectively (Hano, 2020). Although forest fire reports can also be obtained from social media through topic extraction method (Messaoudi, 2022), the

[1] SILVANUS Horizon 2020 Green Deal project https://silvanus-project.eu/

recent evolution of security and privacy getting these sources more restricted.

Apart from the scientific research, the table (Table 1) summarized the unique features of the most relevant mobile applications in wildfire monitoring and warning. The main purpose of the reviewed applications is to offer real-time updates on wildfire locations and status to keep users informed about the latest developments. The information is typically placed on the interactive maps where users can view fire incidents, evacuation routes, hotspots, and other relevant information. Another common functionality is receiving alerts and notifications about nearby wildfires, weather conditions, evacuation orders, and other critical updates. The applications commonly use satellite data for wildfire warning for global coverage or rely on fire department information sources used for local state coverage, specifically only for regions encompassing United States, Canada and Australia.

Table 1. Existing wildfire emergency applications.

	OS/Plan	Region	Summary of unique functionalities
Watch Duty	Android/iOS, Free	US	Relies on real people, including trained professionals like firefighters and dispatchers, to provide real-time information verified by humans rather than automated systems.
Fireguard Wildfire Tracker	Android, Ads	World	Global monitoring of wildfires using satellite-based activity tracking and provides near real-time updates on fire locations without requiring users to log in, but provides inaccurate/unverified alerts.
Fires Near Me Australia	Android/iOS, Free	AU	Focuses on monitoring nationwide bushfire threats in Australia and categorizes alerts into Advice, Watch, and Act levels based on the Australian Warnings System.
Wildfire Tracker	iOS, Ads/Paid	US, Canada	Provides detailed weather forecasts, air quality data, and an interactive map showing wildfire hotspots, along with push notifications and global updates.
Frontline Wildfire Tracker	Android/Free	US, Canada	Comprehensive situational awareness including event notifications and preparation checklists.
Fire Atlas	iOS, Ads/Paid		Includes additional maps from the Bureau of Land Management and the US Forest Service, with features such as offline mapping, thermal hotspots, and AccuWeather summaries.
Firespot: Wildfire app	iOS, Ads/Paid	World	Offers real-time global wildfire information with satellite and for US/Canada agency data, including perimeters, aircraft tracking, and customized alerts for subscribers.
Bushfire.io	Android/iOS, Free/Paid	AU	Provides immediate alerts, up-to-date maps, and collaboration with local authorities for verified data, along with features like emergency aircraft positions and wind forecasts.
Australian Fires	iOS, Free	AU	Aggregates data from multiple government agencies covering fire incidents across Australia, emphasizing the importance of staying informed through official channels.

CITIZEN ENGAGEMENT APPROACH

In our forest fire prevention efforts, we have implemented various strategies to engage citizens and raise awareness about the importance of wildfire prevention. One of our key initiatives involves the creation and distribution of informative posters in communities at risk of forest fires. These posters contain essential information about fire prevention measures, such as safe campfire practices, proper disposal of cigarette butts, and the importance of reporting any signs of smoke or fire promptly. By combining traditional outreach methods like posters with

modern technological solutions like the CEA application, we aim to foster a collaborative approach to forest fire prevention, involving communities in safeguarding our precious natural resources.

Overall Approach Overview

We view citizen engagement as a result of bidirectional communication, involving citizens, organizations, and authorities in wildfire management (Mojir, 2023). Media effects theory was incorporated into the definition of citizen engagement, viewing media as a means for audiences to acquire knowledge, attitudes, emotions, and behavior change (Bandura, 2001; Potter, 2012). The critical focus of the Citizen Engagement Programme (CEP) lies in determining effective communication means and channels. These tools are essential for informing citizens, aiding in wildfire preparedness, prevention, and protection efforts. Additionally, the program emphasizes active citizen participation in shaping wildfire prevention policies, supporting first responders, and engaging in post-disaster recovery activities. Figure 1 outlines simplified effects desired from citizen engagement, marked as "raising awareness," "changing attitude," and the more intricate "changing behavior" in the context of wildfire management. The figure also includes "Type of activity" aligns with these effects, including informing and educating for awareness, fostering safe practices for attitude change, and organizing assistance for behavioral change (Mojir, 2023). The desired effects are relevant in all phases of wildfire management including prevention, response and recovery.

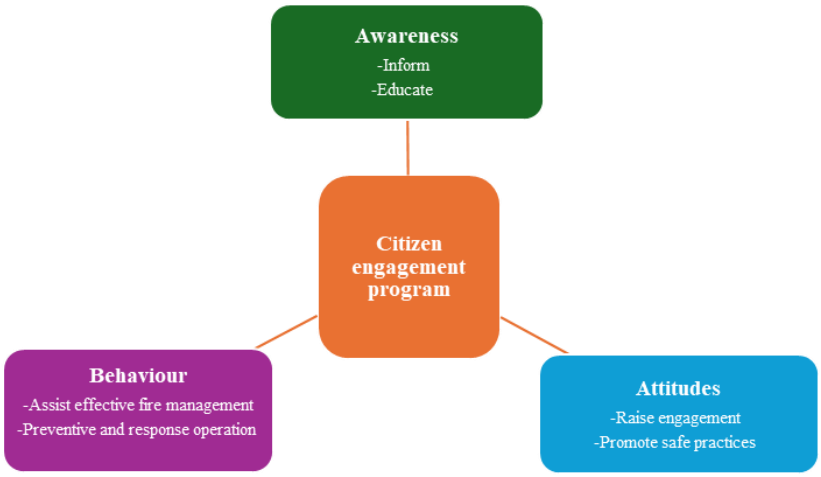

Figure 1. Simplified model of desired effects concerning citizen engagement program in wildfire management.

Examples of Content and Achievements

As part of the CEP, social media campaigns and a poster exhibition in different cities were held, involving the creation of impactful messages with visuals to prompt immediate realization or comprehension. The team, now including members with communication and graphic design expertise, manages these campaigns on social media. Additionally, work is underway to develop an online citizen engagement course based on microlearning, set to be published soon for citizens' use in various settings such as workshops, training sessions, or as a self-study course. The online course serves as a valuable tool for engaging citizens in wildfire prevention, response, and recovery. It provides educational content, empowers citizens with knowledge and skills, raises awareness, and encourages participation. A mobile application was also designed, primarily to enable citizens to assist in wildfire management processes. The mobile application will be explained in more detail. Figure 2 provides examples of published posters on social media.

Figure 2. Examples of posters designed for social media and exhibitions

CITIZEN ENGAGEMENT MOBILE APPLICATION

The primary objective of the mobile application is to provide a comprehensive guide for users moving through forested areas. The app's aim is to equip the users with essential information and guidance on how to effectively handle unexpected situations that may arise during their outdoor activities. Users may access up-to-date information about the local environment to make them sure that they can be well-prepared for expected conditions. This includes details about potential hazards and specific guidelines to mitigate risks. Whether it's dealing with common issues like sunburns and injuries or accessing region-specific information, the application strives to enhance the overall experience and safety of users exploring nature.

In addition, the application encourages users to share valuable information to the local community by reporting and sharing observations related to potentially hazardous events like forest fire or wild animals in the forest areas, which contributes to the collective safety. Through a user-friendly interface, the app seamlessly integrates essential features, such as an emergency hotline, first aid tips, and location-based services. The goal is to empower users to make informed decisions while promoting a sense of responsibility towards the environment and the local community. By combining practical guidance with community engagement, the mobile application strives to make forest exploration not only an enjoyable experience but also a safer and more sustainable one for everyone involved.

Design and Navigation in the App

The Citizen Engagement App (referenced as the App) is developed to enhance user experience and accessibility, every feature or module is designed to facilitate smoother navigation and interaction for the users.

In general, the App enables a user to navigate using bottom bar to show main or home, map and configuration panels. This navigation provides users with quick access to the modules withing the app, allowing seamless switching between the different panels. The App's central panel provides a home screen presenting a comprehensive array of features, including informative news updates, detailed guidelines covering a variety of topics relevant to forest navigation, practical tips to enhance user experiences, and engaging quizzes designed to educate and entertain users as they explore forest environments. Every feature is presented to users with a visually appealing and informative card. Each card features an image and a concise description along with intuitive navigation option. This design aims to improve user engagement and streamline access to relevant content (Figure 3).

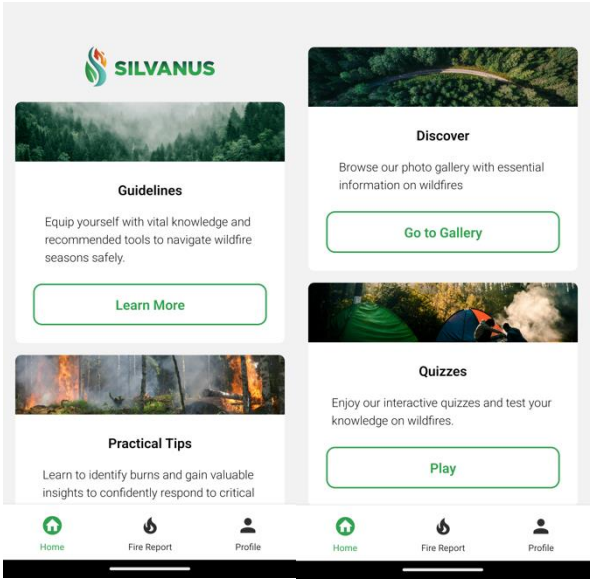

Figure 3. Screenshots of the home screen, showcasing the cards for the different modules.

Withing the configuration or profile panel there is a list of three clickable cards providing users with access to different functionalities. First, the language settings where users are presented with a dropdown menu offering a selection of languages. This feature enables users to customize the app interface and content according to their preferences. Enhancing accessibility and usability. Second, a Privacy Policy that redirects user to the documentation of the app. Third, the Q&A card provides users with access to frequently asked questions and additional information about the app and its underlying project (Figure 4).

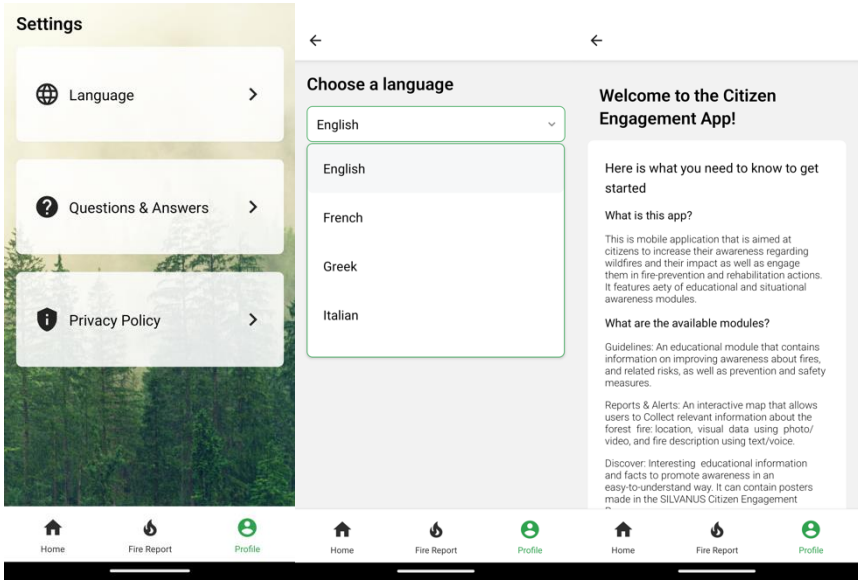

Figure 4. Profile panel. From left to right: main profile menu. Language configuration. Questions and answers information.

The map panel unwraps into the separate module used for reporting and receiving information using subscribed information channel mechanism (described in chapter Fire Reporting Module). The App's design feature is to display relevant information incorporated into the map. While focusing on the specific functionality of fire reporting, the information channels may collect information about different topics, which do not necessarily have to relate to the fire reporting.

Information and Guidance Modules

The guidelines module provides users with essential information and instructions related to wildfire prevention and safety measures. With a focus on empowering citizens residing in forested areas, this module offers

comprehensive guidance on various scenarios, including appropriate actions to take upon encountering a wildfire and post-fire instructions for safety and recovery. Upon accessing the Guidelines module, users are presented with a selection of eight topics covering a range of pertinent subjects. Navigating within each topic reveals a swipe mechanism, allowing users to seamlessly browse through informative cards that encapsulate key guidelines. Each card presents concise and actionable advice, with up to three guidelines displayed per swipe. For users seeking detailed information, a prompt button is available to access the complete list of guidelines within the selected topic (Figure 5).

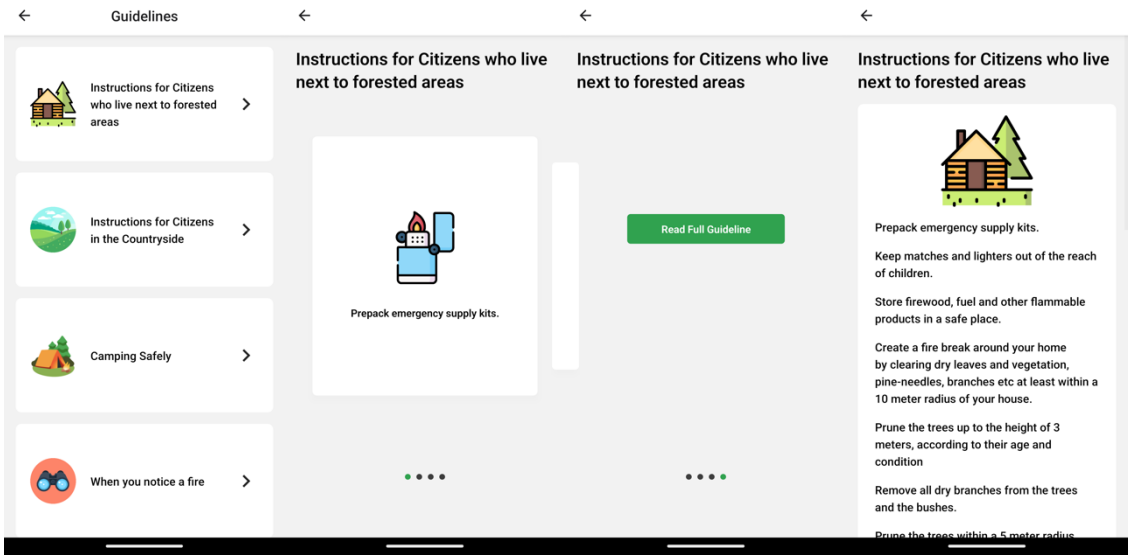

Figure 5. Screens for the guideline module. From left to right navigation of the screens.

In addition to the Guidelines module, the Citizen Engagement App features a Practical Tips section tailored to provide users with actionable insights for handling various emergency situations commonly encountered in forest environments. This module offers practical advice on topics such as first aid treatments for minor injuries, recognition of heatstroke symptoms, and understanding the causes of burns. Similar to the Guidelines module, the Practical Tips section consists of seven distinct titles, each focusing on a specific aspect of wilderness safety and emergency preparedness. Upon selecting a title, users are presented with a series of swipeable cards containing detailed tips and recommendations relevant to the chosen topic (Figure 6).

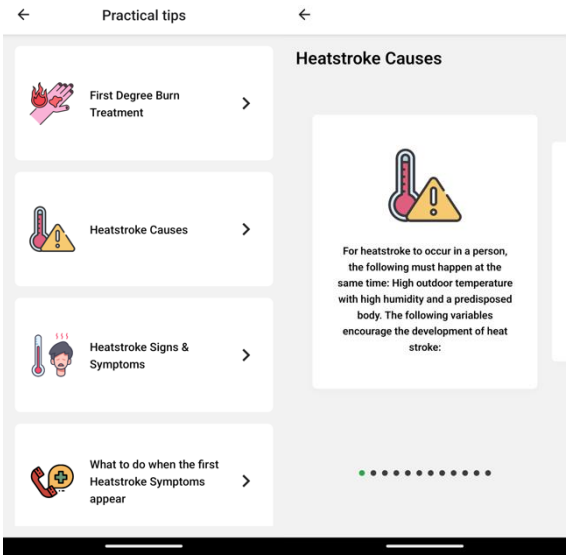

Figure 6. The screens of practical tips module. Left menu with titles. Right swipe screen.

The discover panel is designed to resemble a gallery, showcasing a range of content related to forest safety and wildfire prevention. Aiming to enrich user exploration and understanding of key topics through visual storytelling.

Upon accessing the Discover module, users are greeted with a selection of four distinct titles, each highlighting a specific theme relevant to forest safety and emergency planning. These titles include "Effects of Wildfires", "Protect Our Home from Wildfires", "Making a Family Emergency Plan" and "Causes of Wildfires." Under each title, users encounter a horizontal scrolling gallery of images, providing a glimpse into the associated topic's visual narrative. Clicking on an individual image opens it in full-screen mode, allowing users to immerse themselves in its details. From here, users can swipe horizontally to navigate through the entire collection of images within the selected title, enabling a seamless exploration experience (Figure 7).

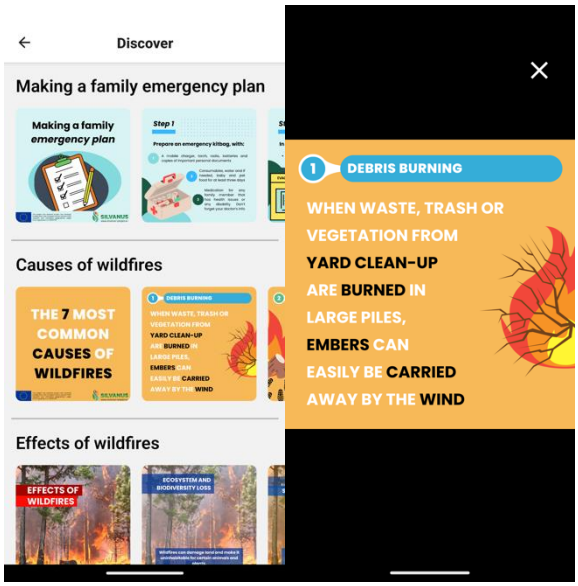

Figure 7. Screenshots of discover module. Left image gallery of photos. Right image full-screen mode.

The quizzes panel offers users an interactive and engaging way to test their knowledge on wildfire safety and emergency response procedures. With two quizzes currently available, the "Burns Quiz" and the "Heatstroke Quiz", this module provides users with an opportunity to assess their understanding of critical topics related to wilderness safety. Upon selecting a quiz title, users are presented with a visually intuitive interface featuring a progress bar indicating the number of questions completed out of the total. Each quiz consists of multiple-choice questions designed to challenge users' comprehension of key concepts and best practices. Upon completing the quiz, users receive a summary of their performance. If more than half of the answers were correct, users are congratulated with a message indicating their success and encouragement to continue their engagement with the app's content. In contrast, if more than half of the answers were incorrect, users are provided with constructive feedback and encouraged to explore other modules within the app to improve their knowledge and future quiz scores. This iterative approach encourages continuous learning and reinforces key safety principles in forest environments (Figure 8).

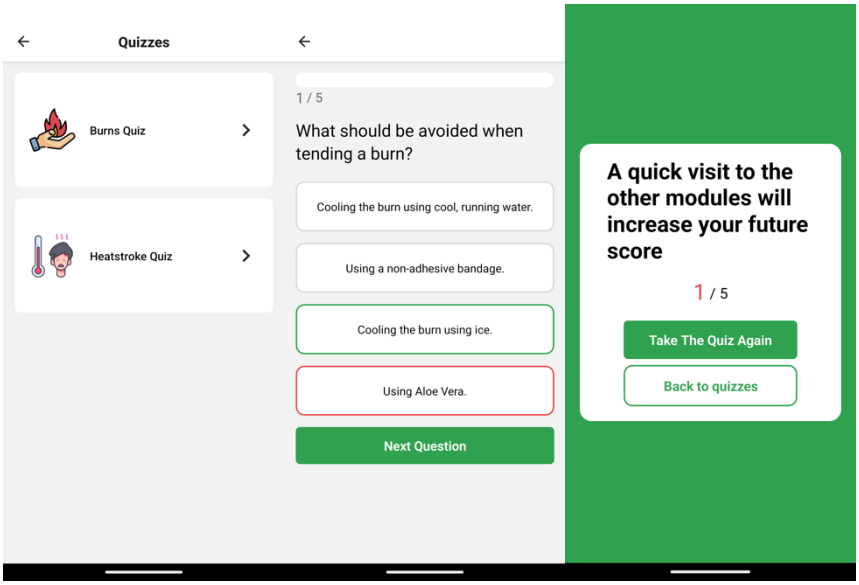

Figure 8. Quizzes module. Navigation through one quiz.

Fire Reporting Module

The Fire Reporting module is designed to provide valuable information on the main map (the first picture in Figure 9) while also facilitating the sharing of information across various information channels. The map interface shows a zoomable vector map featuring the user's current location. Positioned at the bottom right corner of the map is the fire reporting icon, which, when selected, places a fire icon at the center of the map. Through a long touch gesture, the user can update the fire icon location to accurately reflect the incident's location. Upon selecting the fire reporting icon once again, the information collection form is displayed (the second picture in Figure 9). Here, users are provided with the opportunity to select images from their smartphone's gallery or capture new photos using the device's camera. After selecting at least one thumbnail of the chosen picture and composing a brief message, users can transmit the data into information poll by clicking the submit button. The data transmission process is described in detail in the subsequent section, outlining the various parameters and mechanisms involved in the communication process.

The Channel screen (the third picture in Figure 9) serves as a hub for managing available information channels via services provided by the EmerPoll system. Within this screen, users can search among the available channels and based on their preferences, subscribe or unsubscribe to/from any channel. Subscribing to an information channel triggers the download of the corresponding poll template, which is then added to the user's active channels. Each poll template within the subscribed channels contains detailed instructions on how to construct the visual form, including visual icons and form data, as well as guidance on assembling the data packet for poll replies. Subscribed channels also influence the icon set displayed on the main map, but the behavior of the information reporting process remains the same as described for fire reporting albeit with different objectives.

The Message screen (the last picture in Figure 9) provides users with a list of messages sent or received. Here, users can review the details of each message apart of the message related location.

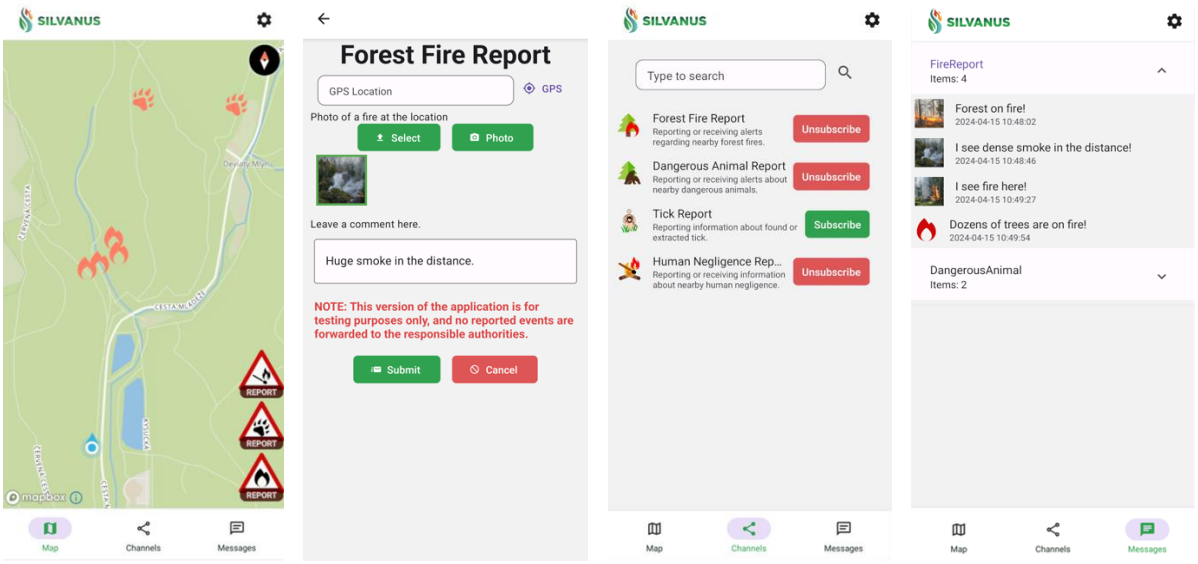

Figure 9. The screens of Fire Reporting module. From left: main map used for localizing the event, reporting form, channel management screen and message screen.

Implementation of Content and Backend Services

Implementation of mobile application based on the React Native and Expo frameworks, which allow development and deployment of mobile applications for both Android and iOS systems.

The backend services supporting the fire reporting module (depicted in Figure 10) are designed to prioritize scalability and straightforward deployment processes. Central to this infrastructure is the MQTT gateway, secured over an SSL layer facilitated by the EMQX server. This gateway serves as the primary communication channel, enabling the application to facilitate the transmission of polling messages of various channels with EmerPoll services and the user community registered to specific channels via MQTT topics. The polling message payload comprises of JSON-encoded data, primarily consisting of form data, accompanied by polling details, user information, and channel metadata. For immediate message overview, thumbnail images are included into the messages. File Storage service is employed to facilitate large binary data transfer, typically pictures, audio and video recordings captured by smartphones. This data is encoded into ‘multipart/form-data‘ format and transferred by secure HTTPS protocol. Uploaded binary data become accessible by the Nginx Web Server via links provided within the metadata of MQTT messages.

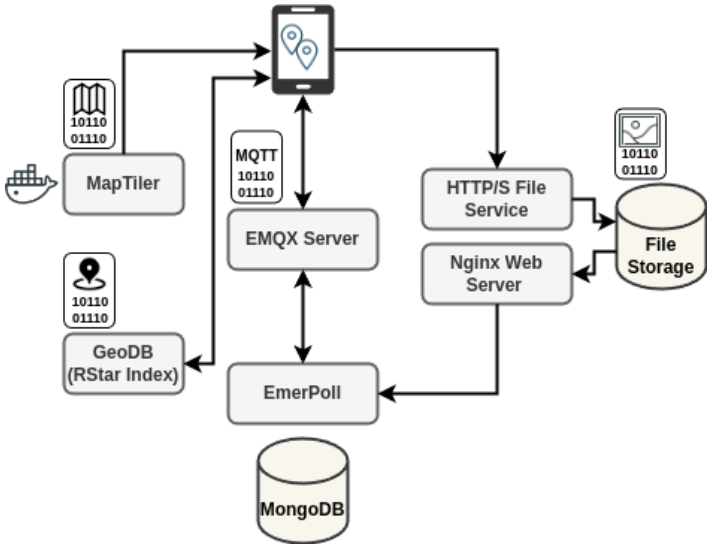

Figure 10. Fire reporting module backed services and data flow schema.

The CEA mobile application utilizes vector map tiles sourced from a containerized MapTiler server to render the Map screen. Geo-spatial information embedded within overlaid data is stored and queried using the R-star Tree

method, optionally supported by a key-value store like Leveled DB. This approach ensures efficient data management and seamless integration of spatial information within the application's interface.

INFORMATION COLLECTION AND PRESENTATION

Information Collection and Distribution Methods

Information collection method is based on the principles of Polls, Channels and Templates as described in (Balogh, 2016) and later extended by the information sharing protocols proposed in (Balogh, 2023). Actual integration with the CEA application follows the same principles that allow users to search and subscribe to information channels even other than for a wildfire warning and reporting as described in this paper. The operations such as information channel search use dedicated MQTT topic mimicking request-response communication. Information channel management actions use the MQTT topic infrastructure to facilitate the subscription process. EmerPoll utilizes the external services of the Storage Abstraction Layer (SAL), a component developed within the SILVANUS project, to facilitate the transfer of data to and from shared storage resources. SAL empowers EmerPoll by providing notifications regarding the availability of specific data, enabling seamless access for processing. This asynchronous capability allows data to be both sent and received efficiently, enhancing the overall functionality of EmerPoll.

Dashboard Data Integration Methods

Dashboard is a web-based, graphical interface created for SILVANUS platform, which is the main access point for the user to obtain and interact with outcomes of data produced by SILVANUS' various modules. Dashboard consists of layers representing the current status of chosen area of operation on the interactive map. Each layer is dedicated to individual types of data and events produced by a single User Product.

Data from EmerPoll is aggregated on the layer called Mobile Subscribers, representing emergency events reported by users in an area where occurrence of fire or smoke has been spotted. Events are visualized as a connected pair of pins representing the position of a user along with the position where the fire is taking place from the perspective of the user. Each of the singular events can be further inspected, presenting more details provided by the user. Embedded information is presented in the menu on the side, which contains exact coordinates to the location of the event, date, time, picture, description and status. Both description and picture are optional, depending on the action of the user. Example of the Mobile Subscribers layer from Dashboard is shown by Figure 11.

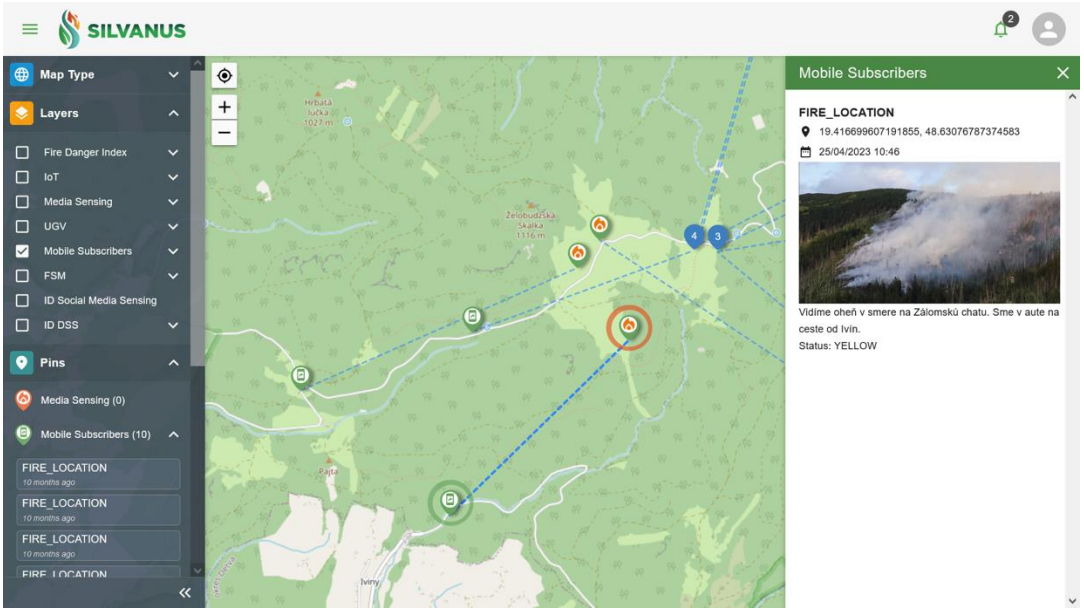

Figure 11. Mobile subscribers Dashboard layer.

The data for the Mobile Subscribers layer is available both live and archive, through the adequate message queue in the SILVANUS Storage Abstraction Layer.

Upon recognizing the danger in the area, Dashboard allows the operator to communicate directly with EmerPoll,

requesting a Poll to send a warning message to the subscribers of chosen channel.

EVALUATION AND CHALLENGES

The concept of the mobile application was first demonstrated during the Slovak pilot exercise located in Poľana region in the central Slovakia. The CEA was presented as a part of information collection framework called EmerPoll used for crowdsourced data collection and aggregation. The fire reporting data (photos and notes) were displayed on the interactive map of Dashboard Layer. The concept of pushing the wildfire warnings to smartphones was also demonstrated. The second evaluation of the technology was performed in autumn 2023 in Ostrava region located in north-east part of Czech Republic, where developed technologies was deployed in the remote command and control vehicle used to evaluate fire reporting functionality by CEA application during the fire fighters exercise. During the first evaluation phase, the coverage of mobile data connection and even slow transmission data rates was found as a limiting factor of the CEA application. To mitigate the factor of mobile data network intermittent connection along with slow data rate, the CEA adopted the off-line message acquisition using the MQTT protocol (e.g. messages are delivered as soon as the mobile data recovers) and also transmission of reported photo overview (picture thumbnails) in a single MQTT message, while full resolution picture is transferred using HTTPS protocol independently. The mobile data network coverage is panned to put as an overlay into the CEA interactive map to help users to find the places with mobile data connection in the forest area. During the second evaluation phase, the challenge with reporting the precise location was identified, where a user of mobile application may struggle to put a marker on interactive map in a correct direction. As a remedy to this situation, the virtual compass will be put into the interactive map along the distance estimation of the user from places marker for reported fire.

FUTURE WORK

The plans for future work were guided by the discussions with the potential users and first responders during the meetings and during the pilot exercises, as mentioned in the previous chapter. Specifically, the CEA is planned to be extended with the virtual compass and mobile data coverage map. The CEA application will be extended with customizable alerts that notify users of fire hazard events near a user-defined location. CEA is being prepared to acquire and display data containing evacuation routes and wildfire area temporal evolution, which will be provided by SILVANUS services. The Profile or Configuration panel's current functionalities are limited, future iterations will incorporate user authentication features, allowing users to access personalized settings and account management options. This panel serves as a centralized hub for users to configure their app preferences and access essential information, contributing to a seamless and user-centric experience within the Citizen Engagement App.

Future continuation of the developed method is foreseen in the adaptation and configuration of additional information channels, e.g. wild animal and human negligence reporting are in the preparation and testing phase. Information channel about tick reporting is being developed to help users to protect from the potentially dangerous pathogens transferred by the ticks.

CONCLUSION

This paper describes the methods for citizen engagement (Mojir, 2024) specifically incorporated with the mobile application described in the work. The content of the paper focuses solely on the citizen engagement methodologies related with the development of CEA mobile application. The current state of related existing applications focuses on warning about the forest fires and a bit neglect the prevention from the forest fires. Except the Watch Duty and Fire Atlas, the applications focus more on data sharing than on gathering relevant data from mobile users. The content of the CEA distinguishes also with the variety of useful content (practical tips and guides) for situations which may happen during outdoor activities. We also believe that providing more functionality with adaptable content will attract more people for the real use of this application. CEA application is focused on sharing the information about wildfires and other hazardous situations within a community of subscribed users with specific role of the fire and rescue authorities which supervise the crowdsourced data and share validated information (fire hazard areas and escape routes) with citizens.

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