Conceptual informing system architecture for drivers with reduced communication skills

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Abstract—**The main goal of the research is to design a system conceptual architecture for adaptive service with the aim to deliver information to drivers in traffic environment which form targeted user group (users with hearing impairment, speech impairment, dyslexia, dysgraphia, color blindness and physical impairment). The purpose of informing service is to offer a real-time information in traffic environment, road assistance service and to raise the quality of life of users and their involvment in traffic environment. The suggested service with its functionalities is based on contemporary technologies for delivering information in traffic environment and architecture is based on Cloud Computing concept. The proposed service is realized in the form of an application solution that provides the user with the necessary information adapted to their disability. With the suggested architecture, it is possible to raise the quality of life and mobility of the users in traffic environment.**

Keywords– information system, quality of life, cloud computing, mobility, assistive technology

I. INTRODUCTION

With the continuous development of information and communication technologies (ICT) there is an increasing supply of mobile applications and services tailored for all types of mobile devices (MD). Development of service for informing users which are moving in traffic environment doesn't affect only the quality of everyday life and mobility, but also the independence of using MD. While offering informing service to the users, it is necessary to take care of simplicity of using that service, functionalities, and the information adaptation for the targeted user group (TUG). This research proposes the conceptual system architecture for delivering informing service to the TUG which are moving through the traffic environment. The functionalities of the suggested service are defined by users' requirements. For this research, the questionnaire has been conducted to obtain users' needs. The results of the questionnaire were used for defining user's requirements of new service and defining the elements of the system architecture that are needed for its deliverance.

II. RESEARCH METHODOLOGY

Materials and methods which are used in this research are currently available scientific literature and questionnaire which collected data about TUG needs and their lifestyle, coping in traffic environment, possibility of education and use of new technologies. The research was conducted in cooperation with the Center for research, education and application of new technologies, UP2DATE. In the city of Zagreb there are 1.784 users with hearing impairment, from which 471 of them have severe hearing loss, complete hearing loss and loss of hearing which is lower than 60 [dB]. According to the Ministry of Interior, Croatian Autoclub, the Ministry of Health and associations of people with mentioned disabillities, the problem has been pointed out in terms of missing the database of total number of drivers who are TUG of this research. The data were collected through the questionnaire in a period from 03.02.2017. to 14.03.2017. and a total of 85 users were questioned.

A. An overview of current research and application solutions for informing users

The existing technologies are oriented on adaptation of the vehicles, but without special dedication to the informing system which is necessary for safe and comfortable ride. Nowadays, most of the drivers and passengers rely on application solutions to access information adapted to MD. Communication for people with hearing and talking impairment is based on application solutions for smartphones. In a case of accident, they send a message using smartphone device. The work of application is based on pictograms or icons in the shape of the signs for danger. To use such application, user must register, give basic information like name, address, gender, age, e-mail, and types of impairment and anamnesis so it can be seen which type of impairment user has [1]. Big challenge for persons with visual impairment is to detect and recognize objects in their environment, and inability to face such a challenge is making them stressed and uncomfortable. Systems based on RFID (Radio-frequency identification) technologies and computer vision are presented

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like solutions for recognizing objects for users with visual impairment [2]. Automatic configuration of application for users with physical disabilities proves that caregiver does not have to be with them to use the application, but the user can use it independently. Configuration is accomplished by using Cloud Computing (CC) technology and it is based on Windows Azure platform [3]. In this research, the main goal was to show positive aspects in which technology, which is constantly upgrading, can be used in the way of overcoming obstacles which persons with disability are facing everyday. Conclusion of that research was that technology would drastically increase quality of life of persons with disability [4]. The study about deaf drivers presents how they get along in traffic environment despite their disability, and what kind of habits they have while driving. Results show that regardless of having hearing impairment, drivers or passengers will adjust their communication methods to different conditions of driving [5]. Assistance, which is presented with mobile technologies for deaf users and users with hearing impairment is implemented on MD as multimodal device for alert named Vibe. Vibe receives information from environment and transfers them to the users, depending on their special needs through visual, tactile or hearing aids [6]. Further research is based on hypothesis that hearing canals are limited for deaf persons and according to that, hearing data must be presented in a visual shape, originally in a sign language [7]. The following research was conducted to determine the audible alarms of emergency service vehicles when they are near drivers who use tactile devices for displaying information. The study shows the speed of driver detection of a horn sound and his response time. Results show that using external tactile display for showing information can provide constant access to the sound of the siren of emergency vehicles to drivers who have hearing impairment [8].

B. Application solutions and informing systems

Some of the currently available application solutions that have the purpose of informing users have been analyzed. The analyzed solutions could be useful for TUG in traffic environment, but their functionalities do not meet all their needs. *Dragon Speech Recognition Software* application allows the user to convert their tablet or smartphone into a wireless microphone. The disadvantages of this application are inadequacy for drivers with hearing impairment, difficulty in voice to voice communication and dyslexia. The application is insufficient for all user needs and requirements in terms of traffic informing [9]. *It's Accesible* application supports people with mobility problems who are looking for places like restaurants, hotels, and parking. The lack of application is inaccessible informing system for TUG [9]. *Red Panic button* is an application that, by pressing the red button, alarms all the contacts that the user mentioned in the application. The alarm arrives in the form of a text message, e-mail service, Facebook or Twitter. In addition to the message, a link to user location on Google Maps is also available. People with hearing or speech impairment can not use voice dialing, and alerting is not even adapted for the users with dyslexia, dysgraphia or color blindness. People with physical disabilities can not even leave the vehicle for photographing [9]. *Automobile Association* (AA) is an application for an English auto club that has the possibility to report a crash, Route Planner with travel information (only major traffic jams) and information about parking spaces in the center of the city. The advantages of this application are the ability to report a vehicle breakdown and one type of travel information. The disadvantage is that it is unsuitable for all TUG. The application provides information about parking spaces for standard vehicles but not information about parking spaces for disabled. Travel information provides information about traffic jams, but does not include possible road work and temporary traffic regulations on a specific route [10]. The *Avto-moto zveza of Slovenia* (AMZS) is a Slovenian automobile club that had application solution tailored to the needs of drivers with hearing impairment. The application was only available to members of the Slovenian AMZS. The application worked in the way that the call was converted to SMS, which was then sent to the Association for the Deaf and Hard of Hearing people who contacted the Roadside Contact Center, and later the Road Service. The disadvantage of this application is that when sending SMS request for help, it can not specify the location of the vehicle in malfunction, and in the case of travel information the operator must enter all the information manually and send it via MD to user [11]. In 2014., Hrvatski autoklub (HAK) has offered an application in which, besides the mParking service, the location of the nearest gas stations and other services important for traveling offers also roadside service and quick call for roadside assistance. The application has many advantages for providing traffic information and sending the location of users who need roadside assistance. Although it has numerous advantages for traffic users, it is still not fully adapted to all TUG. HAK has recognized the need to provide adaptive alert service for TUG and provided unique SMS number for them to get help on the road. The disadvantages are that user relies only on his ability to position himself on the map while calling for help which can cause imprecise positioning, manually entering of needed information and financial insignificance [12].

C. Availability of technology for targeted user group

The survey methodology was conducted on the use of contemporary ICT in the field of travel informing for TUG. Total number of respondents was 85, 48 of male and 37 of female respondents. Out of the total number of respondents, 84.7% are drivers. In the case of a vehicle breakdown on a road, 43.1% of the respondents would inform the family first, 34.7% would inform friends, and 30.6% the professional staff. Respondents most frequently reported vehicle malfunction via SMS 52.8%, via messaging applications 38.9%, via telephone call 33.3% and 11.1% via e-mail service. Half of the respondents do not use the informing system while driving. The biggest reason is the inadequacy of the content (58.3%) to the degree of disability, and often the problem is that the respondents are not sufficiently informed about the assistive technologies or the content is not technically accessible (41.7%). Figure 1 shows the overall level of user satisfaction with the system informing services.

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	E-mail	Messaging applications	SMS	Telephone call
Very unsatisfied	25,0%	12,5%	27,8%	29,2%
Unsatisfied	26,4%	22,2%	16,7%	20,8%
Neutral	29,2%	27,8%	26,4%	15,3%
Satisfied	16,7%	33,3%	27,8%	30,6%
Very satisfied	2,8%	4,2%	1,4%	4,2%

Figure 1. User satisfaction with the system with information services

In most cases roadside assistance was needed by 66.7% of respondents, 54.2% needed travel information, 44.1% technical advice, while 11.1% of respondents did not need any help. The accuracy of the information received via SMS, 25% of the users rated 1, while grade 5 gave 5.6% of respondents. Technical accessibility of SMS services was rated with grade 5 by 29.2% of respondents. With a phone call service, 34.7% of respondents rated the accuracy of the received information with grade 5, while grade 1 gave 4.2% of the respondents. Technical accessibility of the call service with grade 1 was rated by 29.2% of respondents, while 2.8% of respondents rated this service with grade 5. Respondents evaluated the accuracy of the information received, the speed of information received, and the technical accessibility of the Messaging application. The accuracy of the information obtained with grade 1 was rated by 15.3% of respondents, while grade 5 gave 6.9% of the respondents. The speed of receiving information 22.2% of respondents rated 1, and 5. was rated by 5.6% of respondents. Technical accessibility for messaging applications 25% of respondents rated 1, and 2.8% of respondents with grade 5. Figure 2 shows the preferred type of information while waiting for roadside assistance.

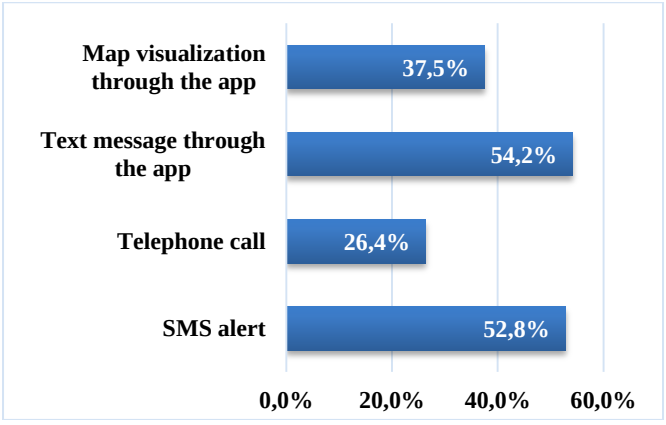

Figure 2. Desired type of information in a time of waiting for road assistance

According to obtained data from the conducted survey, 91.7% of people use a Smartphone device, of which 68.1% use Android operating system, so the service should be based on it. The survey results show that currently available solutions do not meet the TUG needs. The results point to the need for designing new ICT services and they are basis for designing it.

III. Conceptual Informing System Architecture for the Delivery of Information Services

The elements of the system architecture for providing informing service to TUG were defined based on the collected questionnaire results. The proposed system architecture is shown in Figure 3 and consists of relevant elements for delivering information services: computer, mobile device, GPS, mobile application, web application, user database, information database, and functionality of the service. ICT for delivering informing services to user can be divided into: technologies to determine location, communication technologies, and technologies for data processing and storage (CC concept). GPS technology enables accurate location of the user's location with 95% location accuracy (location errors are 8.5 [m]) [13]. These locating errors can have negative affect in navigating pedestrians and for this reason GPS technology is used in combination with other technologies such as Automatic Identification and Data Capture (AIDC) and Bluetooth. 3G and 4G technologies affect location enhancement with the help of the base station and the signal between it and the mobile device. By using LTE technology, it is possible to provide a better quality of real-time services and services based on the user's location [14]. For the purposes of data processing and storage, a CC concept is used, which ensures the availability of information in real time. The user database is in the CC environment and contains user's data and their content accessibility requirements. The information database contains all the data that are used for creating the information for end users. System stakeholders have the option to enter and view the data.

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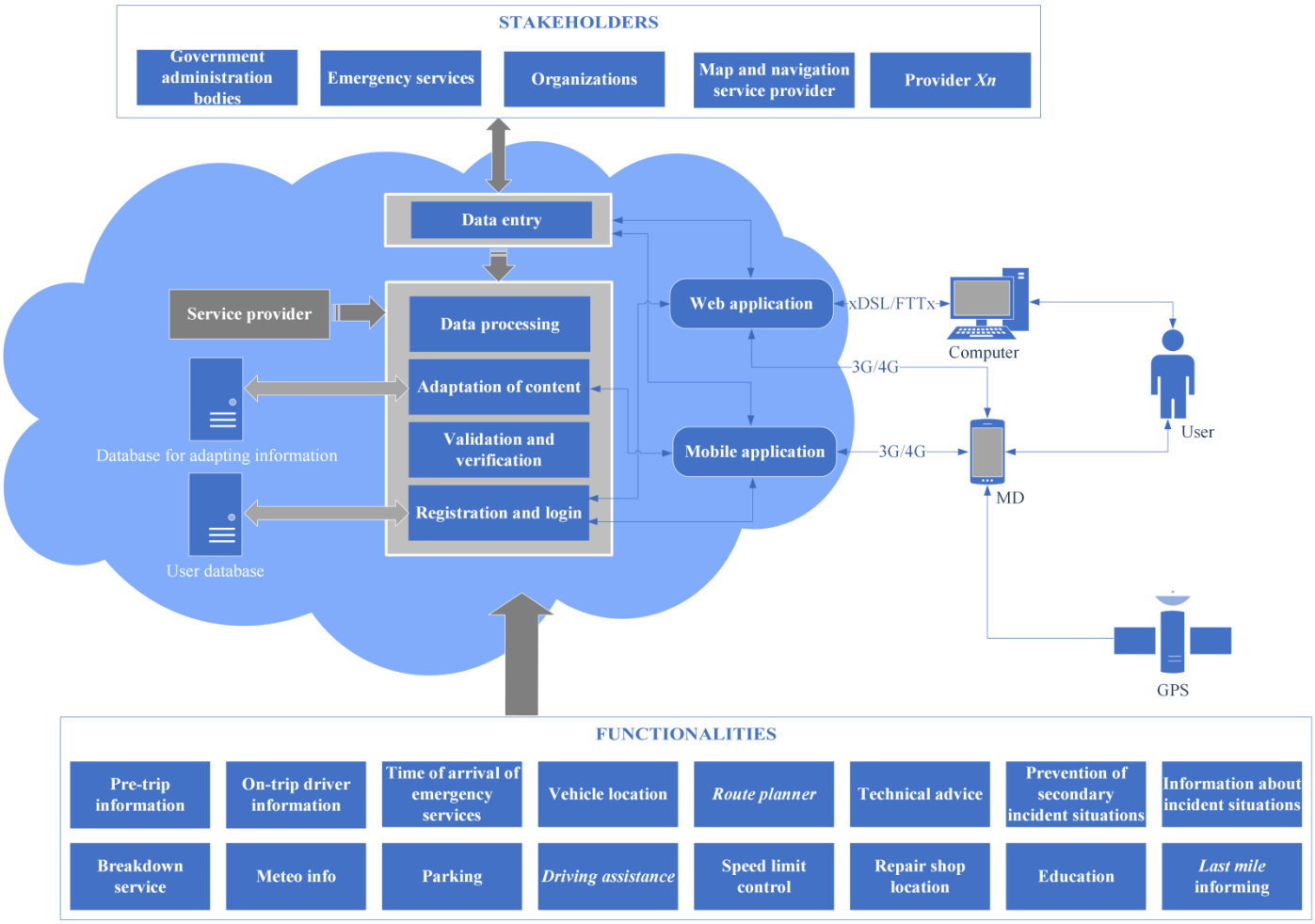

Figure 3. Conceptual informing system architecture for informing targeted user group

The user accesses the mobile application through MD, while access to the web application is possible via a browser on the computer or MD. A mobile application with its functionality and universal design provides customized content to all forms of TUG disabilities. User registration is required to use a mobile application. The registration process includes the entry of basic user information and information on the type of disability. After registration, user data is stored in the user database. When user signs in the application, a validation and verification process is performed to check the accuracy of the entered data. After the successful checkup, the content gets adjusted to user requirements for accessible information. By defining the degree of user's disability, stakeholders are provided with this information to know how to communicate with the user. The role of stakeholders is to participate in the exchange of relevant information and information required for TUG in the terms of accurate and real-time information.

A. *Functionalities of the informing system and the application solution*

The informing system functionalities are divided into two groups: basic functionalities and additional functionalities. The functionalities of real-time information cover incoming and outgoing travel information and information about the time of arrival of a service provider in case of roadside assistance. Additional information service reporting in weather conditions is closely related to road conditions and guides users to adjust speeds during unfavorable weather conditions. Vehicle breakdown entry is possible via SMS, Messaging applications, calls or e-mail services that include vehicle location information, service provider arrival time, technical advice and breakdown service and locations for repairing vehicles. Users who use voice to voice communication have the SOS call option that has priority over other calls, ensuring fast and efficient help in case of vehicle breakdown or incident. Additional functionalities of the system include: last mile information, information about free parking slots adapted for people with disabilities, education about driving through architectural barriers, weather services, Route planner and driving assistance. To use the before mentioned functionalities, it is necessary to use the mobile application, and it is necessary to perform a user registration beforehand. The registration process involves entering basic user data and defining forms of disability and difficulty. Figure 4. shows the appearance of application solution (user registration, breakdown service, home screen).

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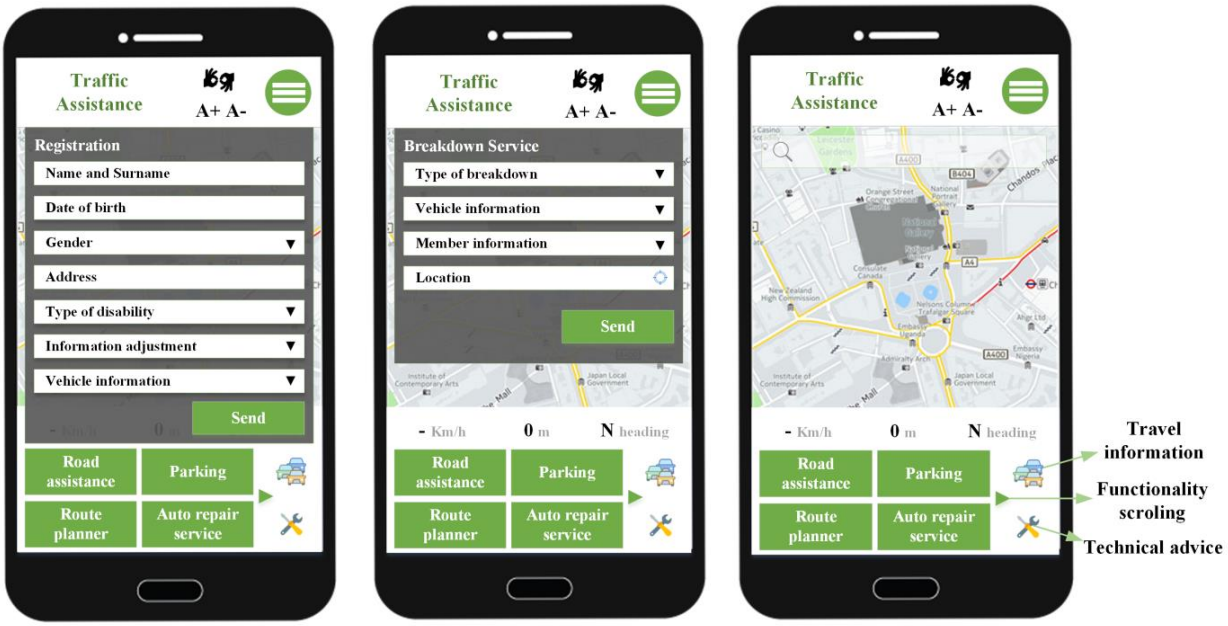

Figure 4. Proposition of application solution

When registering, the user defines the type of disability that is used to adapt the information available within the application solution. The home screen shows a map showing the location of the user, and below the map are some of the functionalities that the user can use. If user chooses functionality that is based on a vehicle location, it is immediately applied to the map. Stakeholders participating in the delivery of information receive a user request for a breakdown report. Users can enter detailed information such as type of breakdown, vehicle information, and member information.

B. Additional functionalities and stakeholders

Last mile information is an additional functionality that has the purpose of informing TUG before the end of their travel. It provides drives with information about locations close to their destination such as hotels, resorts, sights, venues, restaurants, etc. One of the additional functionalities is information about free parking space. Service on the number of free parking spaces is intended for users who need a parking space that is adapted for people with disabilities. It provides a locating service for free parking spaces that are the closest to the user's destination and are adapted to their needs. Another additional functionality that this application solution would provide is education. It is intended for users with physical disabilities that use wheelchair to obtain information on how to drive safely on a road that has architectural barriers. It's is also intended to inform them about weather conditions and how to drive during the bad weather. Users would be educated in safe conditions (on a polygon, in safe driving center, etc.). Meteo info is another additional functionality that provides the TUG with real-time information about weather conditions. It provides them with suggestions to lower the speed during the rain, turn on the lights during the mist, etc. It also includes the speed control system to prevent incident situations caused by unattended speed in adverse conditions. Route planner is the functionality that allows the TUG to determine which route will be the fastest to reach the service for repairing vehicles. It is related to the functionality of locating auto repair services. It also provides them with the information on how to reach the destination by showing the travel route. This functionality has the ability for providing trip information to the user only for the route they chose so that they are not distracted with other, unnecessary information. Driving assistance is a feature that warns the TUG in case they exceed the speed limit. It also provides them with short-term information as a reminder of road signs such as the possibility of animals on the road, close proximation to a school, etc. Functionality offers a service of memorizing short-term information and greatly helps drivers with dyslexia, dysgraphia, and color blindness which, due to the slower flow of information, do not pay much attention to these warnings. In case of incident situations, service provider informs TUG about accidents on their travel route. By providing this information, it increases the driver's attention and lowers the possibilities of secondary incidents, thus eliminating chain collisions or traffic accidents in which the TUG would potentially participate. If it's possible, the drivers are redirected to another route to prevent the secondary accidents. The relationship between TGU, system stakeholders and additional functionalities is shown in Figure 5.

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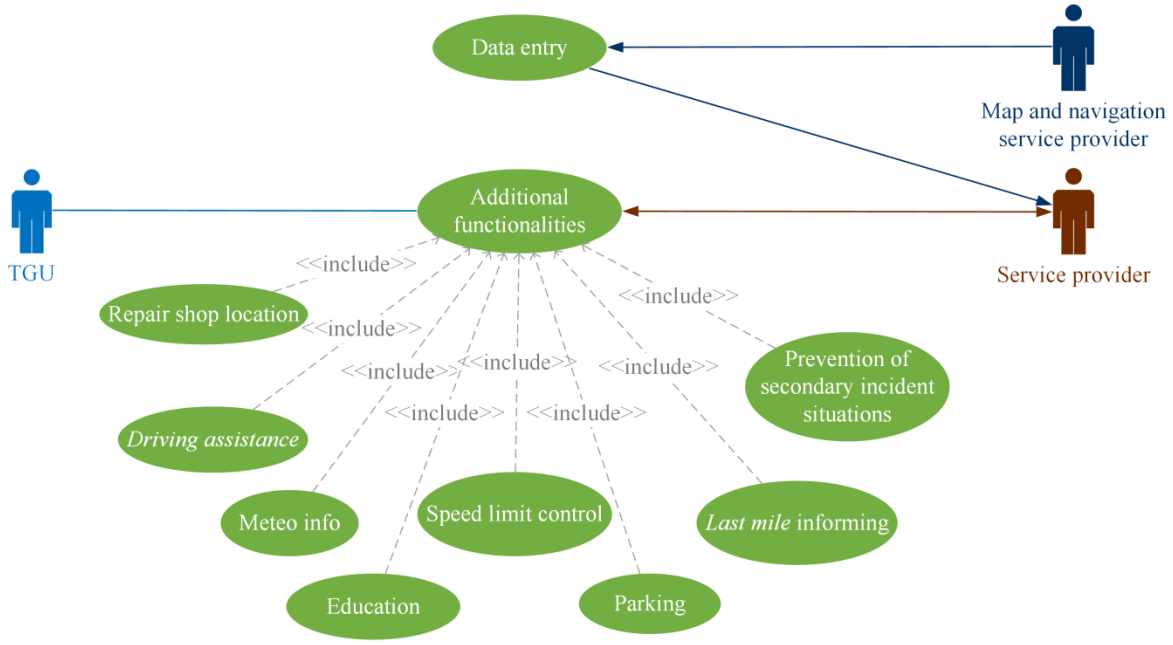

Figure 5. Relation between stakeholders and additional functionalities

When TUG logs in the application, mentioned additional functionalities are available for usage. By picking each functionality, user initiates information exchange with service provider. For some functionalities (repair shop location, parking, prevention of secondary incident situations etc.) there is a need for locating and navigating information. This information is obtained from map and navigation service provider and delivered to the user through service provider.

IV. Discussion

The conducted research has determined that TUG requirements can be met by proposal in the form of an application solution for MD. The described application solution is a part of an information and communication system that offers a service of informing users in traffic environment that is adapted for TUG. Research shows a steady growth and development of information and communication systems for informing users in traffic environment. It also shows that all available solutions with their functionalities does not meet TUG requirements and needs. It has also been pointed out that there is no TUG database, so all user requirements were obtained through a conducted survey. Parameters of simplicity, adaptation of information delivery and desirable functionalities were determined based on the results of questionnaire. They need to be taken into consideration during the development of informing system for users with reduced communication skills in traffic environment. Regarding to currently available market solutions and existing modern technologies, proposed architecture of informing system is based on CC concept. Great advantage of this informing system is the ability to adapt for all TUG needs and requirements, especially for users with multiple types of disabilities. This eliminates the need for installing multiple applications because this application solution would have all adapted information for the TUG needs.

V. Conclusion

Each TUG has different requirements and needs for information delivery in traffic environment. Because of that there is a need for creating a simple application solution that would contain functionalities that would adapt for each group requirements and needs. Currently available application solutions analyzed in this paper does not meet all TUG requirements with its functionalities, neither do they provide adapted information delivery. Due to the many forms of disabilities, the biggest disadvantage is that users need to install more application solutions. There is also a great disadvantage that there are no guidelines for designing such informing systems and that there is no available TUG database. Database like that could be used as a source for future research. Functionalities of the service are divided into basic functionalities and additional information. The implementation of this kind of application solution would increase the availability of information for all users in traffic environment (24/7). This research is a good basis for creating guidelines for informing TUG in the traffic environment. It is also the basis for future researches that aim to develop such services with the goal of raising the quality of life of users. Future research should focus on testing, developing and actual deployment of proposed application solution and system for informing TUG. Testing should concentrate on data safety, realibility and accuracy of informing system. Additionaly, the future research should focus on the interoperability of the system.

References

[1] N. Hosono, H. Inoue, M. Nakanishi, Y. Tomita, “Urgent Communication Method for Deaf, Language Dysfunction and Foreigners,” Proceedings of the 14th International Conference on Computers Helping People with Special Needs, ICCHP, pp. 397-407, Paris, France, 2014.

[2] S. A. Ali, R. Jafri, “A Multimodal Tablet-Based Application for the Visually Impaired for Detecting and Recognizing Objects in a Home Environment,” Proceedings of the 14th International Conference on

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10.18638/rcitd.2017.5.1.103

ISBN: 978-80-554-1375-4

Computers Helping People with Special Needs, ICCHP, pp. 356-359, Paris, France, 2014.

[3] P. Heumader, R. Koutny, K. Miesenberger, K. Kaser, "Automated Configuration of Applications for People with Specific Needs," Proceedings of the 14th International Conference on Computers Helping People with Special Needs, ICCHP (2), pp. 234-237, Paris, France, 2014.

[4] M. Hersh, "Inclusive settings, pedagogies and approaches in ICT based learning for disabled and non-disabled people: introduction to the special thematic session," Proceedings of 16th International Conference on Computers Helping People with Special Needs, ICCHP, pp. 470-474, Linz, Austria, 2016.

[5] P. Hamilton, "Communicating through Distraction: A Study of Deaf Drivers and Their Communication Style in a Driving Environment," Thesis, Rochester Institute of Technology, 2015.

[6] U. Ravid, P. Cairns, "The Design Development of a Mobile Alert Device for the Deaf and Hard of Hearing," UCL Interaction Centre, University College London, 2008.

[7] M. Hilzensauer, "Information Technology for Deaf People," Intelligent Paradigms for Assistive and Preventive Healthcare. Studies in Computational Intelligence, vol. 19, N. Ichalkaranje, A. Ichalkaranje, and L. Jain, Eds. Springer, pp. 183-206, 2006.

[8] M. Karam, "Evaluating Tactile-Acoustic Devices for Enhanced Driver Awareness and Safety: An Exploration of Tactile Perception and Response Time to Emergency Vehicle Sirens," Universal Access in Human-Computer Interaction. Aging and Assistive Environments, vol. 8515, C. Stephanidis, M. Antona, Eds., Springer, pp. 729-740, 2014.

[9] Disability Horizons (2016, June 05). Top 10 apps for disabled people. Available at: http://disabilityhorizons.com/2016/09/top-10-apps-disabled-people/

[10] The Automobile Association, Available at: http://www.theaa.com/apps

[11] Zveza Društev Gluhih in Naglušnih Slovenije (2014, February 03) Available at: http://www.zveza-gns.si/novice/slovenija/okvara-vozila-uporabite-amzs-pomoc/

[12] Hrvatski Autoklub, Available at: http://www.hak.hr/smartphone/hak http://www.hak.hr/

[13] M. Periša. "Dynamic guiding and routing of disabled and visually impaired persons in traffic", PhD Thesis. Faculty of Transport and Traffic Sciences, University of Zagreb, 2013.

[14] R. A. Amineh, A. A. B. Shirazi, "Estimation of User Location in 4G Wireless Networks Using Cooperative TDoA/RSS/TDoA Method," Fourth International Conference on Communication Systems and Network Technologies (CSNT), pp. 606-610, Bhopal, India, 2014.

10.18638/rcitd.2017.5.1.103

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