Developing a service for urban waterway transport

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Abstract. This paper outlines the implementation of a service for passengers using urban waterway transport. The service is designed to provide users with aggregated information about the city's water infrastructure and facilitate communication between them. By doing so, it aims to improve the safety and comfort of using urban waterway transport. As part of this study, we segmented the users of passenger urban waterway transport and analyzed their information needs. Based on this analysis, we described the service data, using the example of St. Petersburg's water infrastructure. Finally, we implemented the service as a mobile application.

1 Introduction

The global interest in urban waterway transport is on the rise. For instance, in Hong Kong, a city with a population of 7,2 million, more than 29 million passengers use public water transport services each year. Similarly, in Istanbul, with a population of 14 million, this number stands at about 40 million passengers per year. In Venice, which has a population of only 264 thousand people, water passenger traffic reaches an impressive 55 million annually [1].

Currently, there is a significant surge in the popularity of river cruises on inland waterways throughout Europe. This trend can be attributed, in part, to the policies of individual countries focused on developing their water infrastructure. For instance, Serbia has adopted a Tourism Development Strategy, which aims to leverage the potential of the Danube River by increasing the number of berths and marinas and updating the river fleet [2]. Similarly, Poland is taking steps to develop its inland water passenger transport system on the river Oder, with a focus on creating tourist-communication and excursion concepts. A recent study conducted in the region has identified a strong interest among locals in utilizing such a system [3].

St. Petersburg is considered to have high potential for the development of urban waterway transport, thanks to its extensive hydrographic network and tourist appeal. As of the summer of 2020, there were approximately 46,000 registered small vessels in the city, according to the State Inspectorate for Small Vessels. During the 2022 navigation period, more than 3,5 million passengers travelled on water tourist routes within St. Petersburg, with regular rafting on rivers and canals in small paddlers or kayaks organized within the city. The improvement of the inland water transport system has a positive impact on St. Petersburg's image,

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contributes to the growth of popularity of the "Sea Capital" brand and attracts new tourists to the city [4].

The interest of cities in the introduction and development of urban waterway transport is primarily determined by its recreational and tourist appeal, as well as its environmental friendliness when compared to other modes of transportation [5]. Additionally, the possibility of building alternative water routes to existing land routes can help reduce the burden on public transport systems [6].

To enhance the safety and comfort of using passenger urban waterway transport, it is crucial to provide users with relevant information about water area facilities and their surrounding areas, current and anticipated weather conditions, texts of current local regulations governing vessel traffic, and other pertinent information. Providing a communication tool that allows passengers and vessel operators to promptly share news and coordinate events can also be beneficial. However, there is currently no unified publicly available service that provides these capabilities for users of passenger urban waterway transport within a single city [1, 7, 8].

This paper outlines the creation of such a service through the development of a mobile application using St. Petersburg's water infrastructure as an example. This work includes the segmentation of users of passenger urban waterway transport, identification of their information needs, description of water infrastructure data, and implementation of the application.

2 Materials and methods

2.1 Identifying the information needs of service users

In order to identify the categories of users of urban waterway transport systems and their information needs, a subject area analysis was conducted through extensive literature research.

2.1.1 Passengers using public water transport

Many cities provide public waterway transport systems that are commonly used by both residents and tourists. The routes of such systems can be categorized into three types: those built along the water barrier parallel to the coastline, those crossing water barriers, and those connecting the central part of the city with the suburbs [1].

The first type of route can often be used as an alternative to land-based public transport while providing scenic views of tourist attractions in the city. For example, Gothenburg's public waterway transport system provides such a route [1]. Passengers require information are described in the following subsection.

Routes of the second type are primarily used for crossing water barriers, and typically involve frequent vessel movements with shorter travel times and lower comfort levels. An example of such routes can be found in the Amsterdam waterway system [1]. Users of these routes are interested in information about the location of berths for crossings, time of operation, and frequency of ship movements.

Lastly, routes of the third type are typically long distances with low frequency of vessel movements but generally offer higher levels of comfort. Examples might include seasonal routes that link the center of St. Petersburg with its outskirts (such as Peterhof and Kronstadt) [1]. Given that such routes can only operate at certain times of the year and hours of the day, passengers require accurate information about their schedules. Additionally, they may need to know about amenities available on board such as restrooms, food services, internet

connectivity, accessibility for people with disabilities, cost of travel, and the current occupancy of the ship.

2.1.2 Tourists and rafters

Urban waterway transport system is primarily used for tourism and water recreation. Within this category, two types can be distinguished:
- Intracity and suburban cruise river tourism, which includes short excursion and pleasure routes. In St. Petersburg, this is the main passenger flow of urban water transport, with traffic on the routes taking place on river motorboats and small vessels [10].
- Water tourism using small rowing vessels, including group rafting in canoes, kayaks, and other types of vessels.

St. Petersburg is an excellent example of a city with a high level of interest in recreational waterways. This can be attributed to the cultural and natural richness of the historic part of the city and its surroundings. Numerous landmarks and monuments are located adjacent to water barriers, making it convenient to view them while navigating by boat [11].

To enhance the quality of water trips, it's important to provide information support for the routes. This includes providing users of cultural recreation with detailed information about coastal sites [12]. Although tour group guides can offer such help to some extent, there is currently a trend towards increasing flexibility in tourist trips. Many people prefer individual excursions that allow for independent exploration [13]. Therefore, participants in cultural recreation are interested in finding both structured tours and self-guided routes. They also want information about coastal attractions as well as ongoing water cultural leisure activities.

Those who participate in rafting using paddles (kayaks) need access to regularly updated local regulations governing water traffic. Additionally, users of such vessels may face difficulties when organizing joint rafting trips and finding open rafting areas.

2.1.3 Operators of small vessels

Another significant category of users of passenger inland waterway transport are the operators of individual small vessels. In [7], their information needs, data structures, and sources for St. Petersburg were described. In addition to the results of this study, the need for individual vessel operators to publish and search for current transport events was identified. Such events could include ship breakdowns, traffic jams, poor visibility in the water area, and others [14].

2.1.4 General overview of the categories of users of urban waterway transport systems

There are four distinct categories of urban waterway passenger transport users:
- Passengers on public water transport.
- Participants of water-based cultural recreation.
- Participants of water rafting.
- Operators of small vessels.

Irrespective of their category, all users of urban waterway transport in the city seek information on weather conditions, emergency and support service contacts, as well as access to current local regulations governing waterway transport (as shown in Fig. 1) [7].

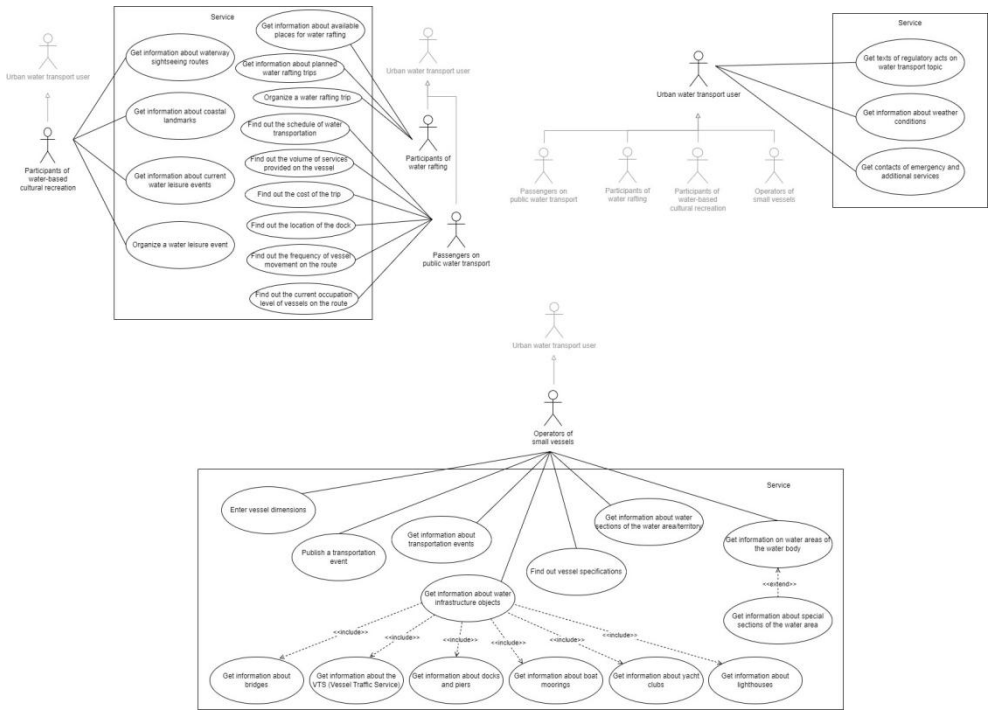

Fig. 1. Use case diagrams functionally describing the IS.

2.2 Data on the urban water infrastructure

To meet the information needs of users, the service should aggregate and visually represent the following data:
- Data on the city's water facilities and areas, including water infrastructure, landmarks adjacent to water barriers, and water bodies. This information is rarely updated.
- Regulations, background information, and emergency/support services contacts related to urban waterway transport within the city. This includes documents defining special water areas with restricted traffic. Usually, the regulations are regularly updated and published on institutional websites without additional explanations.
- Current events and news related to water transport, which are updated regularly.
- Information on water routes and available rafting facilities, such as tourist water routes passing through the city's landmarks, recreational water routes, and rafting routes for paddles (kayaks) and sporting water equipment. This data may be supplemented and updated.
- Real-time weather conditions, which require constant updating.
- Background information on ship schedules for public waterway transport routes and services provided on board during the journey.

For the service developed for St. Petersburg's water infrastructure, data on water facilities and areas is obtained from the authors of [7]. Regulatory acts and background information are extracted from official institutional websites. Weather and news reports are obtained through aggregator services via an API interface. Other data sources include open map services and web resources.

3 Results

3.1 Client-side of the service

Due to the specific nature of the subject area, the service needs to be accessible from portable devices, as users may need to access the system while travelling on a ship. In this case, a mobile application is the most suitable means of interaction with the service. Currently, Android is the most popular mobile operating system in Russia, so the client-side of the system has been implemented as an Android application. The application code was written using Kotlin language and Android Studio development environment, and the Google Maps SDK library was used to work with maps.

The development of the mobile application aimed at providing user-friendly experience, and therefore included support for filtering data according to the user's information interests. Additionally, the application provides the ability to identify and visually represent water areas available for traffic on vessels with specified dimensions, taking into account regulatory and natural restrictions such as depth of areas and height of bridges. Furthermore, the application enables users to publish and search for events related to water transportation topics, as well as organize thematic events.

The Android application that has been developed is structured as follows (as shown in Fig. 2):

- Background information section: This section provides the user with information on the weather at the current moment, as well as a forecast for the upcoming day with an hourly breakdown. Additionally, this section includes a map frame that graphically displays information on wind, temperature, cloud cover and waves. Furthermore, users can access characteristics of the custom vessel according to entered dimensions, including navigability, stability, buoyancy reserve, hull strength and rigidity, manoeuvrability, as well as emergency and auxiliary service contacts.
- Agencies subsection: This section lists agencies involved in inland water transport in the city, along with descriptions of their functions and links to web resources with archived documents for each agency.
- Regulations subsection: This section provides a list of the main regulations on water transport, along with descriptions and links to the text of the documents.
- Locations section: This section contains a list of the city's water areas, including water infrastructure, rafting spots, and attractions, with detailed information on each of them.
- Routes section: This section provides information on sightseeing and hiking trails, as well as rafting routes. Each route has a description, coordinates, and related locations such as points of interest. Users can follow a route, in which case the location of the user determines the nearest location to the route, and information about the location is displayed on the screen.
- Events section: Through this section, app users can publish news and announcements of upcoming events, as well as water rafting events. When creating an event, it is possible to specify a description, contacts for feedback, location, and time of the event. Additionally, routes or individual locations can be linked to events. Once published, events become available in the general event feed.
- Map section. The Map section utilizes an interactive map to visually represent aggregated spatial feature data. Labels on the map indicate the location of different places and user events, while polylines are used to represent routes, and water areas are displayed using polygons. In certain water areas, movement can be restricted, in which case the corresponding polygons on the map are highlighted in a special color. Small-sized vessel managers can input their vessel dimensions and visualize the available water area for movement, with the application taking into account the depth of the areas and height of bridges in the water area. To avoid visual clutter when displaying a large number of objects at small zooms, clustering

is employed. Additionally, interactivity is achieved by enabling users to access object descriptions displayed on the map by clicking on their labels.

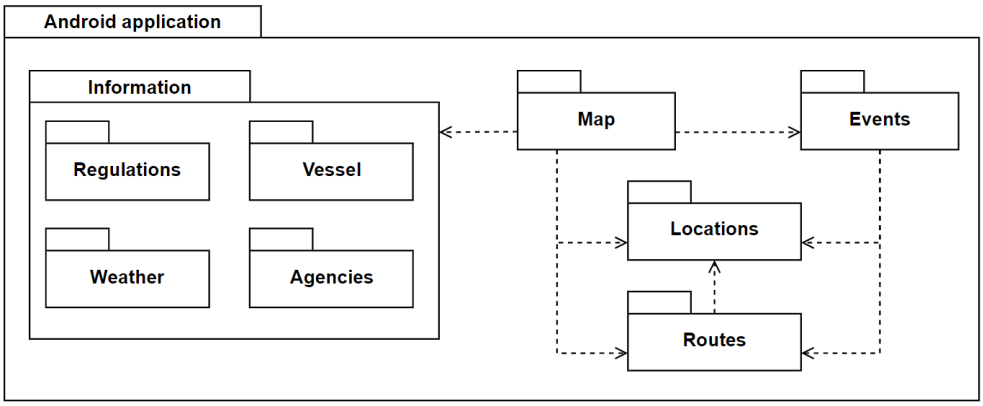

Fig. 2. A package diagram describing the overall structure of the client-side of the service.

The application utilizes a tagging system that is categorized by type (with separate tags for events, locations, and routes), category (for instance, the following categories are used for tags of the "event" type: rafting, transport event, event, announcement), and blocks (which group tags of one category; for example, within the "rafting" category, there are blocks of tags such as "vessel type", "difficulty level", "age of participants", and others). Tags are linked to the objects displayed in the application, making it easier to comprehend object descriptions, simplify search functionality, and allows users to configure display filtering. A demonstration of the application interface can be found in Fig. 3.

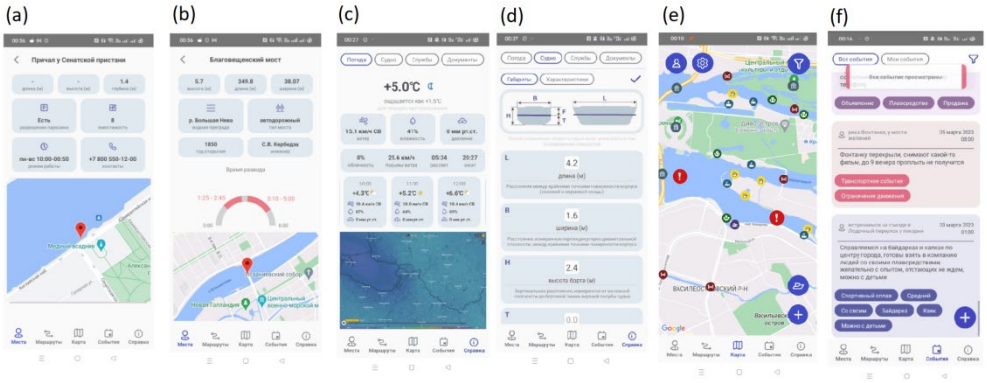

Fig. 3. Demonstration of part of Android application screens with data for St. Petersburg water area, (a,b) screens showing information on infrastructure objects, (c) screen with weather information, (d) screen for entering vessel dimensions, (e) screen displaying city water area object labels and custom event labels on the map, and (f) screen with a custom event ribbon.

3.2 Server-side of the service

The data required by users of the developed Android application is stored and accessed using a Microsoft SQL Server DBMS and a web service created using the ASP.NET Core framework.

Data on water routes, objects, and water areas of the city are stored in the server part of the database. However, because these data are subject to the least amount of change and are

considered conditionally permanent, they are cached in the Android application. When the Android application starts up for the first time, it requests this data from the web service and stores it on the device; repeated requests to update the data on the client side take place only in case of changes on the server side.

Event and water routing data are updated regularly, so storage of these data is only done on the server side without caching on the client side. Similarly, information about regulations is stored; in this case, for a specific document, an entry is added to the database with the type of document, description, and link to the location of the text online. The text of the document itself is not stored due to its large volume. Initially, normative acts are published on the official websites of the relevant agencies. A module that reads the HTML pages of these websites and parses them has been implemented to obtain information on which documents have been added.

Weather data is subject to the most variation, and it depends on the specific location for which the weather is requested. Therefore, such data is not stored in the server part or in the client part. When a user needs to display the weather data, the Android application performs a corresponding request to a web service, which in turn redirects it to a third-party weather API service for the result, and then returns it to the Android application. Similarly, a news bulletin is received.

The web service also allows for user accounts to be maintained. The ASP.NET Core Identity system and the JWT standard are used for this purpose. Only authenticated users are allowed to publish content on the Android application.

4 Discussion and conclusions

As a result of this paper, a segmentation of the users of passenger urban waterway transport was carried out and their information needs were determined; the technology of the service was described, which provides passengers and vessels operators of urban waterway transport with information on the water infrastructure of the city, and allows them to communicate, publish news and organise events on waterway transport topics. The service has been implemented with data on the water infrastructure of St. Petersburg.

The use of the service will increase the awareness of passengers and vessel operators about the water infrastructure of the city or region, thereby favorably affecting the safety and comfort of their use of urban waterway transport. The described service technology and structure of data required by users is applicable to any city that has an inland waterway transport system [15].

There are prospects for extending the service for the development of the tourism industry in the region. The created service can be extended to analyze the environment of the region in accordance with the work [16], be used to analyze the perception of tourist objects through digital technology [17], be extended by introducing data from travel agencies [18], and become part of the general aggregator of tourist GIS [19]. In the described service, the technology for the automatic compilation of tourist itineraries by water transport can be added [20].

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