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**CORRESPONDENCE/COMMENTARY**

# SmallForest mobile app: availability, functionality and use

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## ABSTRACT

The SmallForest mobile app was developed for both Android and iPhone operating systems which allows universal use for information exchange within one generalized database. Depending on the account level, users have a specific set of routines, tools and applications for defined activities, namely those that correspond to their account level such as 'ACTIVE', 'OBSERVER', 'USER' or 'ESTIMATOR' (excluding the basic version which has limited access to the exchange of attribute and graphical information). The information exchange system between users of the SmallForest app is provided for the users with account levels 'OBSERVER', 'USER' and 'ESTIMATOR'. The information transmission is performed through an intermediate server which provides temporary storage of messages until they are received by the user. As a rule, the provision of the appropriate account level and authorization is carried out by the mobile app administrator after consultation with the authorized persons of the state forestry enterprise. It is prohibited to obtain authorization for a specific access level arbitrarily. It is also possible to view information about authorized users and their access levels. The mobile app is based on a universal database where data exchange and processing is performed in accordance with specified and regulated rules and forms. Standardized forms for data input or exchange do not allow the input of unformatted or improperly written information. In addition, the mobile app allows the use of specific routines to input attribute and graphical information, or make changes to existing one. The SmallForest mobile application enables the user to process standardized attribute and vector data, and to perform additional calculations as well. The possibilities of editing the source data related to the forest plot depend on the user access level. This access level is provided by the application manager in agreement with the

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management of a relevant state forestry enterprise. The users, who are authorized to carry out economic activities, can use modules that neither affect nor change data on the assessment characteristics of the forest plot. Thus, the modules help calculate the volumes of individual logs, ranges, and also tree trunk parts. Application of the modules increases the accuracy of the calculation of the volume of wood and guarantees compliance with the current ISO standards. The mobile application is often used by forestry workers in Ukraine. The number of users is increasing every year. In total, there have been more than 10,000 mobile application downloaded since February 2020. Moreover, the application is used by more than 3,500 authorized employees of the forestry industry in Ukraine nowadays.

**KEY WORDS**

account, authorization, blockchain technology, data exchange, forest district, forest inventory and management data, state forestry enterprise

## Introduction and research objectives

There has been a significant development of various services and open data-based software solutions in Ukraine. The forestry industry has also been affected by the public access to information on forests. Changes to legislation have enabled the publishing of forest maps and provided new perspectives on the use of forest information (Aleksiiuk and Hrynyk, 2011; Aleksiiuk, 2012, 2016; Aleksiiuk *et al*., 2013, 2020).

The application contains attribute and cartographic data. Cartographic and general data about the forest stand, its age and composition is available to the general public. It can be mainly used in order to track user location and for the purpose of tourism. The access is not required in order to use this data. However, the mobile application is primarily intended for employees of state forestry enterprises. Attribute data can be changed using the application. Some changes can be made in the tree stand database as well. The user must be registered and have access in order to use the application for the purpose of forestry management. The level of access to information and the ability to change this data depends on the access granted to the professional user by the application manager.

## Materials and methods

The elements of both component-oriented and service-oriented programming were used in the course of developing the application software system (ASS). On the whole, an object-oriented programming method was used that determines the strategy of designing an object system. An object is a specific instance existing in different states and having a certain set of operations. The operations associated with the object provide services to other objects to perform certain functions, and their state depends on the values of their attributes. Objects are created according to an object class definition which describes all their attributes and operations.

Operations on objects are defined as follows:

– entering, saving, deleting objects, *etc.*, are operations of the object life cycle;
– object interaction operations by invoking object methods using the specified parameters on the multiple input and output interfaces.

The application software system is built on the following life cycle processes:

– analysis – building of an operating model (OM) of the subject area (SA) in which objects reflect real entities and operations on them;

- design – specification of OM and taking into account the description of the requirements for the implementation of specific tasks of the system;
- programming – implementation of OM using the selected Delphi XE programming language;
- support – application and development of the system by making changes to objects or methods;
- modification of ASS by adding new functionalities, interfaces and operations for its further support.

The above processes can be performed iteratively one after the other and with the ability to return to a previous process. Each process can use the same notation system which can be applied in each process. The transition to the succeeding process requires the adjustment of the results of the previous process through the development of the previously defined classes of objects and the addition of new objects in more detail.. Models represent relationships between objects, their states, and a set of operations to dynamically change the state of other objects, as well as their relationship with the environment.

When writing the program, dynamic models of the system architecture were used. The object-oriented system obtained was checked for quality indicators using test results and data collection on system errors and failures. Changing the method of creating an object or adding new operations to it does not affect other objects in the system, and therefore, can be reused.

The application uses efficiently open access databases of Forestry Production Association 'Ukrderzhlisproekt' (FPA 'Ukrderzhlisproekt', 2023) as well as data available in the Register of Logging Tickets (SE 'FIAC', 2019a) of State Enterprise 'Forestry Innovation and Analytical Center' (SE 'FIAC', 2019b). Digital maps in SHP format are used which have a number of advantages over ordinary maps, and data can be easily obtained as it is in the public domain (CMU, 2015; SFRAU, 2022) (during the period of martial law in Ukraine, free access to some electronic information services, in particular those containing cartographic information, was limited).

Presenting attributive information in forest maps from the survey unit database has become the main problem for many software products that are used today in forestry and forest management in Ukraine. The difficulty consists specifically in the relational model of the database, as well as in writing SQL queries in the tables. This problem is practically eliminated in the developed application. The application uses connections with the database of Forestry Production Association 'Ukrderzhlisproekt' based on the Microsoft SQL Server. Databases connected to the SQL server have code names which are used by the application. The forest management database is composed of 37 tables with indicators (records) that are presented in a specific column and those within the search object boundaries appear in the table directly in the application.

## Results

The idea for creating the SmallForest application emerged a long time ago as it is sometimes quite difficult to determine the location of a forest sub-compartment (survey unit) in the forest compartment. Similar free software with sufficient functionality was not available in Ukraine. The use of foreign applications still forced the adaptation of new attribute and vector information to the requirements of the relevant software. As a result, an application has been developed which is free and available for download from Google Play and the App Store that is now actively used by more than 250 forest users and 1,500 forest districts (FD).

The application provides the possibility of creating a user account where they indicate their affiliation to an individual forest user, *i.e.* the state forestry enterprise (SFE), and if necessary, to its structural unit – FD. The users also must specify their nickname and the account status level. As a result, this application allows the transfer of information between users of an individual enterprise.

In practice, a forestry engineer can enter information about a planned felling (or another activity) in the software, and the chief forester, the forester of the FD, his assistant, and the forest ranger will receive the same information on the map in their smartphones, regardless of whether it is an Android or iPhone (Fig. 1).

Messages are sent automatically, and if the recipient is not online for more than 30 days, the data is deleted. In fact, this is similar to blockchain technology because every FD user has complete information about changes in that FD and the SFD specialist obtains data on all FDs. The system allows multiple and simultaneous copies of information, and in case of failure of one phone, the data will not be deleted. It is also possible to send all existing data to another user with a new phone in the case of an emergency.

The application enables the division of users according to the status of their account in the system based on the following:

'WAITING' or 'VERIFIED': The user is not authorized or is being checked verified. All restrictions are applied to such a user which include: displaying of the assessment characteristics,; viewing of changes,; editing the assessment card,; creating of new forest sub-compartments (or plots), and; transmitting (receiving) of information to (from) other users.

'ACTIVE': The user is authorized and has the ability to view the assessment characteristics. The following restrictions are applied to such a user including the viewing of changes, editing (partial) of the assessment card, creating new forest sub-compartments (or plots), and transmitting (receiving) of information to (from) other users.

'OBSERVER': The user is authorized and has the ability to view the assessment characteristics and receive information from other users. The restrictions that are applied to such a user


**Fig. 1.**
Choice of the forest sub-compartment

include the editing (partial) of the assessment card, creating new forest sub-compartments (or plots), and transmitting information to other users.

'USER': The user is authorized and has the ability to view the assessment characteristics, transmit and receive information to/from other users, edit (partial) the assessment card. The restrictions that are applied to such a user are creating new forest sub-compartments (or plots) and editing the assessment card.

'ESTIMATOR': The user is authorized and has the ability to view the assessment characteristics, transmit and receive information to/from other users, create new forest sub-compartments (or plots), and edit the assessment cards.

The information exchange system between users of the SmallForest app is performed for users with the account statuses 'OBSERVER', 'USER' and 'ESTIMATOR'. The transmission of information is performed by an intermediate server which provides temporary storage of messages until they are received by the user. The exchange system functioning is worth further description. Sending messages is based on the data of the recipient's account. If the recipient of the data has indicated his affiliation to a particular FD, then the data that he can receive from another user of the SFE must relate to that FD, and the user who did not indicate the FD receives data from the entire SFE. In the app settings, it is possible to view all users for this enterprise (Fig. 2).

As there are several users, information about changes in the forest fund is duplicated on several devices which minimizes the risk of information loss in the event of a breakdown or loss of a mobile device.

The completeness of entering and editing information in the mobile app depends on the user's status. 'USER' has the ability to enter only the status of the business activities, notification of damage to the forest stand, and add a general note (Fig. 3). 'USERS' are also prohibited from creating new forest sub-compartments and plots.

Full editing of information about the assessment forest sub-compartment or area is available with the 'ESTIMATOR' user status. Editing involves changing both the map data and the attribute information, *i.e.* the assessment characteristics.

Mapping can be edited in two ways: 1) moving points on the map using a manipulator (a mouse) or using a touch screen panel; 2) entering coordinates according to GPS data for the points to be moved on the map (Fig. 4). The points entered can be edited by the user in case of inaccuracies and errors.

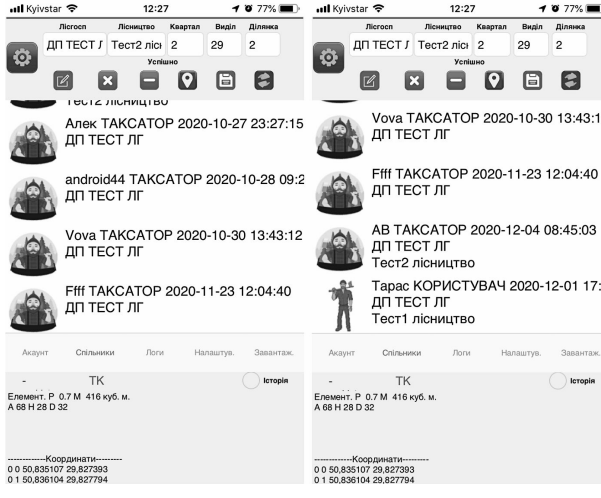


**Fig. 2.**
Information transmission (exchange)

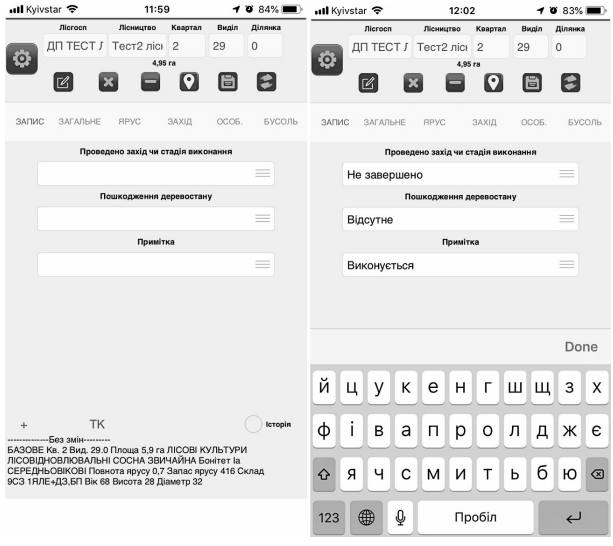


**Fig. 3.**
Information on business activities

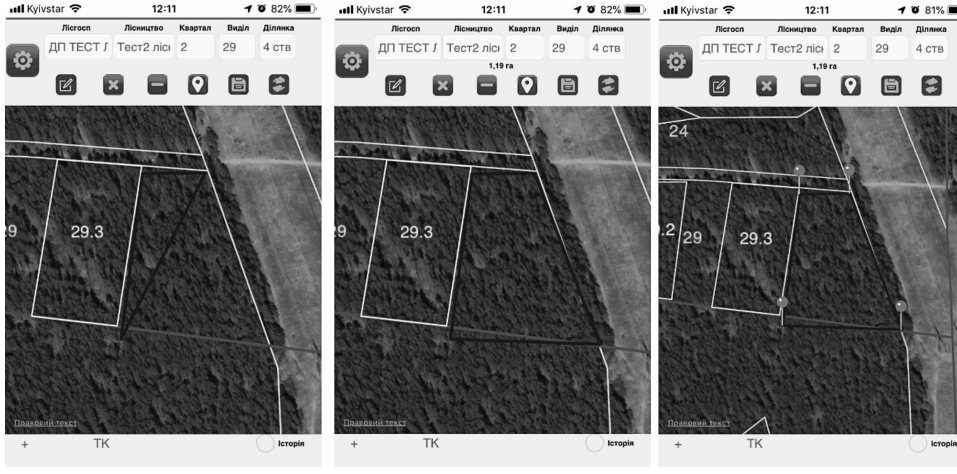


**Fig. 4.**
Map editing

Nowadays, the compass survey of areas is used in the allocation of felling sites by permanent forest users. The assessment card provides the possibility to translate the coordinates of the area into the compass survey and vice versa which allows the creation of a high-precision outline of the new area (Fig. 5).

There is also a function for contour adjustment by finding common points of other sections which avoids overlap between adjacent sections.

There are several tabs for editing or creating a new assessment of the forest sub-compartment on the assessment card. General data contains information on the category of land and forest, age group, quality class, forest type, *etc.* (Fig. 6).

The Tier Tab provides the ability of entering information on the presence of forest elements in this area. A list of values in which options are offered is given for ease of use. The user can also change the location of the rows containing data (Fig. 7).

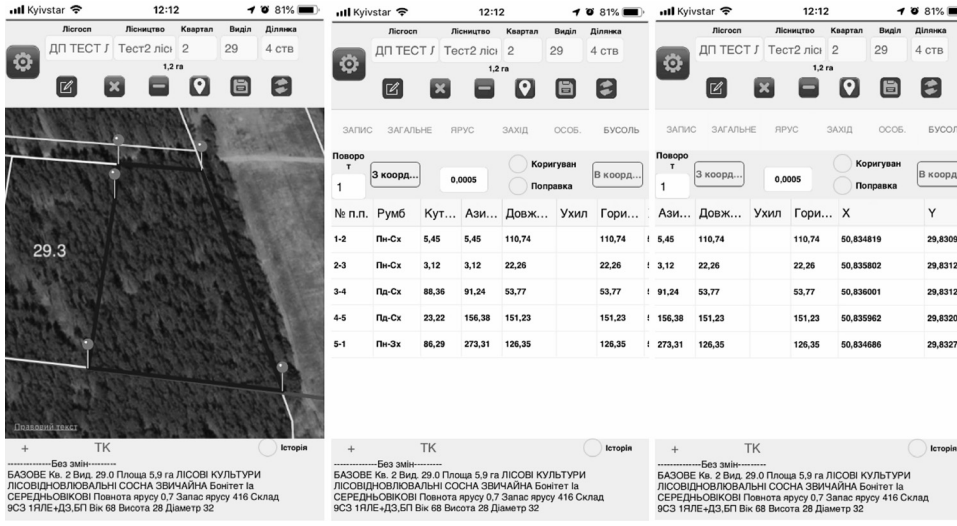


**Fig. 5.**
Compass survey data

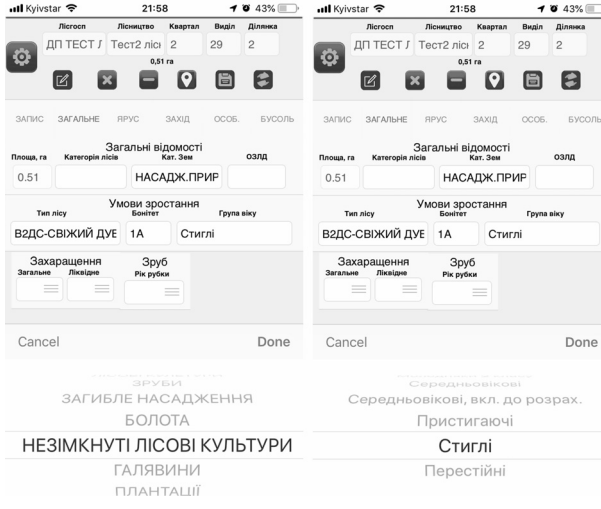


**Fig. 6.**
The assessment card editing

It is also possible to enter information about the business activities that are planned or already completed, as well as to indicate damage to the forest stand (Fig. 8).

Information on the features of an area is also important and can be noted in the tab 'Peculiarities of forest sub-compartment', so that the vegetation that is present in the area can be input (Fig. 9).

Amongst various app technical capabilities, it is possible to verify the correctness of the information entered, *i.e.* an automatic determination of the class of productivity index and stock of the stand (Fig. 10). The mechanism implemented for the backup storage of the edited assessment card allows the saving of the entered data in the case of an unexpected closure of the app. If necessary, it is possible to view the history of changes in a particular area over time along with the coordinates.

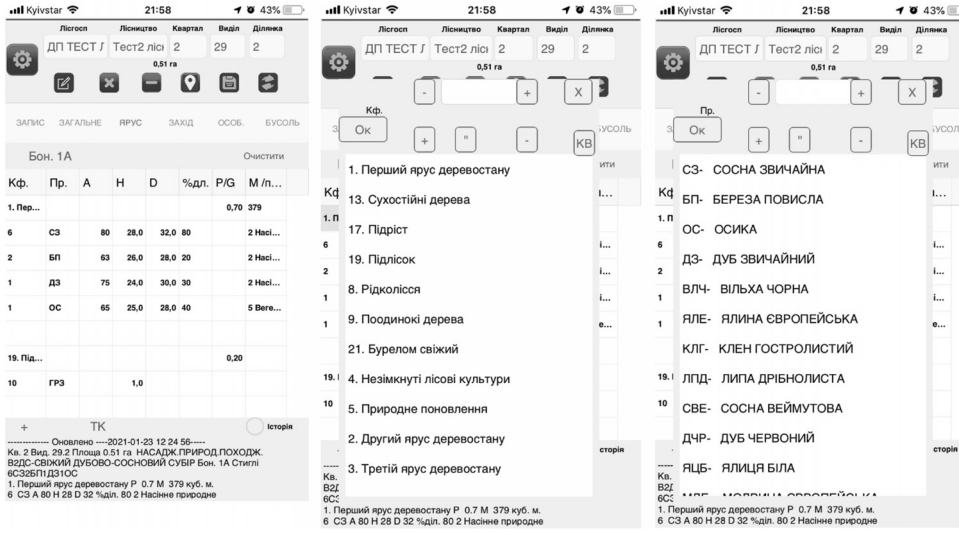


Fig. 7.
Editing by elements (tiers) of the forest stand


Fig. 8.
Information of business activities undertaken

## Discussion

The emergence of forest databases applications in different countries often has the potential for dual use. Due to the presence of identifying marks in the forest (such as compartment posts stating compartment and survey units numbers for which photos are often available in the same software products), tourists can determine their location in the forest or plan their travel routes based on natural conditions using timber trackways. Mapping information very often focuses on purely touristic, cognitive or educational directions such as places with berries, natural monuments, campsite availability or information on hunting grounds.

Attention for application development was mostly in neighbouring countries, in particular Poland, Belarus, Russia and Estonia. Such applications are most commonly available in Belarus with tywo generations of GIS Formap 1.4 and Formap 2.2 that have already been used here in

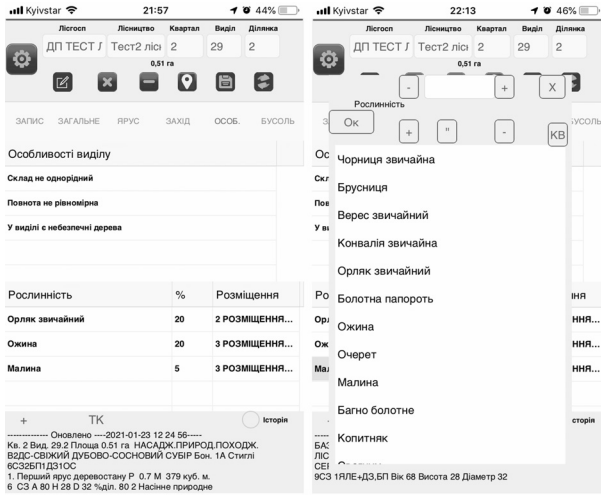


**Fig. 9.**
Information of business activities undertaken

Belarus (Belinvestles, 2015, 2019). In addition to pure GIS functionality, applications allow the use of compass survey modules and the survey of damaged trees, as well as the possibility to attach attribute information (assessment data), independently create/edit a database, enter additional information, and work with satellite images. Moreover, it is possible to work both online and offline (Belgosles, 2015).

Polish analogues of the application are mostly available at the user level without the possibility of making changes to the database (BULiGL, 2013; BDL, 2019). Limited functionality is also possible only when an active internet connection is available. Any changes can only be made by authorized employees of accredited forest management organizations BULiGL (BDL, 2019).

The analogue used by Russian foresters is in fact an adapted version of TopoL-L which is a GIS applied for continuous cover forestry. Additionally, it allows the performance of a whole complex of work such as creation, editing, analysis and further support (support in the current state) with separate forest sub-compartments' combined assessment and cartographic databases based on forest inventory and management data. The TopoL-L complex includes GIS TopoL version 10 (TopoL Software, s.r.o., Czech Republic) which is an universal GIS, and program LesIS Software version 2.0 (Forest Information System) which provides full range of work with attribute data (assessment descriptions, forest fund evaluation, *etc.*). The program comes in two versions – Basic (for forest management) and Digit (for forestry) (Lesis, 2019).

The Estonian RMK Loodusega koos app (RMK – the State Forest Management Centre in Estonia) allows searching by types of RMK's tourist visiting objects location according to the type of RMK tourist facilities and their location, and also according to the user location. The app includes RMK's visited object descriptions, amenities with photos, descriptions and routes of RMK hiking trails. In addition, a special functionality of the app enables a direct link to the RMK app with a map of forest works, source maps from the Land Department and information on the location of protected areas. The app is available in Estonian, Russian and English (RMK, 2018).

As we can see from the review presented, each country is characterized by the use and application of relevant mobile apps, most of which are available in Android and Apple in the relevant Play Market service and free of charge. At the same time, the apps used in Belarus and Russia

are mostly paid and highly specialized with rather limited functionality for recreational or tourist purposes.

## Conclusions

The developed mobile app has many functions and can have various purposes for users. First of all, both the functions and the tasks they perform depend on the account level or the user access level. By default, after installing the mobile app, the account is provided to the user as an unauthorized user. In this case, the user can receive non-commercial information including cartographic which allows for the faster use of the app for tourist or recreational purposes.

In case of authorized user (depending on their status, position or performance of certain regular functions as an employee of the certain SFE or FD) they get access at a specific level applicable for use of the relevant software products and level for making changes and receiving information. As a rule, the determination of the appropriate level for the type of account and authorization is carried out by the administrator of the mobile app after consultation with the authorized persons of the SFE. It is not possible to obtain authorization for a specific level arbitrarily. It is also possible to view information about authorized users and their access levels.

Employees of state forestry enterprises in Ukraine undergo authorization and become authorized users. They can perform the production functions assigned to them in the application. The function of confirming the performance of economic measures is also available for them. Depending on the level of access, employees can also additionally apply programs for accounting and measuring the volumes of tree trunks, ranges and individual logs. All these features are not available to unauthorized users.

The mobile app is based on a universal database with the exchange and processing of data being carried out in accordance with clearly defined and regulated rules and forms. The versatility of using the database, and obtaining and exchanging information between users of different authorization levels allows the correction of inaccuracies. Existing standardized forms for entering or exchanging data do not allow entering unformatted or improperly written information. The mobile application for the users of the appropriate access level allows making certain series of steps in order to make input new not only attribute but also and graphic data. Some certain procedures to change existing data are also provided.

Significant progress in the development of the app allows the ability to obtain structured regulatory information in the form of existing ISO which in turn increases the efficiency of working time and the efficiency of calculations. This includes determining the volume of timber and assortment in order to divide the tree trunk in accordance with current regulations into standardized logs as well as calculations of their volume using additional programs in the SmallForest mobile app.

Therefore, the developed app is universal and accessible to almost the entire community of vested parties as its application does not require additional user skills or additional capacity of the mobile device. Depending on the account level, the user gets the appropriate level of access to information. Further, they gain the ability to use relevant functions and subroutines that almost completely replicate the functionality required for SFE workers to perform calculations, use information in graphical form, and exchange necessary data within the SFE.

## Authors' contributions

I.A. – project conception, program development, writing; H.H. – project conception, analysis, writing original draft, writing review and editing; preparation of manuscript; T.D. – methodolo-

gy, writing; O.H. – literature review, writing; preparation of manuscript; A.Z. – formal analysis, material collection.

## Conflicts of interest

The authors declare no conflicts of interest.

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**STRESZCZENIE**

## Aplikacja mobilna SmallForest: dostępność, funkcjonalność, użytkowanie

W Ukrainie obserwuje się rozwój usług i rozwiązań programistycznych opartych na otwartych danych. Na branżę leśną wpłynął również publiczny dostęp do informacji o lasach. Zadanie polegało więc na opracowaniu oprogramowania, które łączyłoby praktyczne i konkretne zastosowanie platformy informacyjnej dotyczącej lasów Ukrainy. W trakcie tworzenia systemu oprogramowania aplikacyjnego (SOA – ASS) wykorzystano elementy programowania zorientowanego zarówno

na komponenty, jak i na usługi. W całości wykorzystano obiektową metodę programowania określającą strategię projektowania systemu obiektowego. Aplikacja korzysta z ogólnodostępnych baz danych Specjalizowanego Przedsiębiorstwa Leśnego (SPL) „Ukrderzhlisproekt", a także z danych dostępnych w Rejestrze Kart Wyrębu Państwowego Przedsiębiorstwa (PP) „Leśne Centrum Innowacji i Analiz". Wykorzystuje ona połączenia z bazą danych SPL „Ukrderzhlisproekt" opartą na Microsoft SQL Server. Bazy danych połączone z serwerem SQL mają nazwy kodowe, których używa aplikacja. Baza danych dotyczących urządzania lasu przedstawiona jest w 37 tabelach. Wskaźniki (rekordy), które są prezentowane w określonej kolumnie i w granicach obiektu wyszukiwania, pojawiają się w tabeli bezpośrednio w aplikacji.

Pomysł stworzenia aplikacji SmallForest pojawił się już dawno, ze względu na występujące trudności z określaniem położenia pododdziału leśnego w oddziale leśnym. Aplikacja jest bezpłatna i dostępna do pobrania z Google Play i App Store, korzysta z niej ponad 250 nadleśnictw i 1500 leśnictw (użytkowników). Daje ona użytkownikowi możliwość założenia konta, w którym wskazuje on przynależność do indywidualnego użytkownika lasu, jakim jest Państwowe Przedsiębiorstwo Leśne (State Forest Enterprices – SFE), a w razie potrzeby do jego jednostki strukturalnej – leśnictwa (Forest District – FD). Użytkownicy muszą również określić swój nick oraz poziom statusu konta, dzięki czemu aplikacja umożliwia przekazywanie informacji pomiędzy użytkownikami pojedynczego przedsiębiorstwa.

W praktyce inżynier może wprowadzić informację o planowanej wycince (lub inną) do telefonu, a nadleśniczy, leśniczy i jego pomocnik oraz pracownicy otrzymują te same informacje na mapie w swoich telefonach – niezależnie od tego, czy jest to Android, czy iPhone (ryc. 1). Wysyłanie wiadomości odbywa się na podstawie danych konta odbiorcy. Jeżeli odbiorca danych wskazał swoją przynależność do konkretnego FD, to dane, które może otrzymać od innego użytkownika SFE, muszą dotyczyć tego FD, a użytkownik, który nie wskazał FD, otrzymuje dane z całego SFE. W ustawieniach aplikacji można wyświetlić wszystkich użytkowników dla tego przedsiębiorstwa (ryc. 2). Kompletność wprowadzania i edytowania informacji w aplikacji mobilnej zależy od statusu użytkownika. „UŻYTKOWNIK" ma możliwość wpisania jedynie statusu prowadzonej działalności, zgłoszenia uszkodzenia drzewostanu oraz dodania dowolnej notatki (ryc. 3). Użytkownikom zabrania się tworzenia nowych pododdziałów i leśnych działek taksacyjnych. Pełna edycja informacji o pododdziale taksacyjnym lub obszarze lasu jest dostępna ze statusem użytkownika „TAKSATOR". Edycja polega na zmianie zarówno danych mapy, jak i informacji o atrybutach, czyli cechach taksacyjnych.

Mapowanie jest edytowane podczas wprowadzania współrzędnych poprzez kliknięcie na ekranie urządzenia lub na podstawie danych GPS (ryc. 4). Wprowadzone punkty mogą być edytowane przez użytkownika w przypadku niedokładności i błędów. Współcześnie pomiar busolowy wykorzystuje się przy wyznaczaniu miejsc wyrębu przez stałych użytkowników lasu. Karta taksacji daje możliwość przeliczenia współrzędnych terenu na pomiar busolowy i odwrotnie, co pozwala na stworzenie precyzyjnego obrysu nowej działki (ryc. 5). Karta ta zawiera kilka zakładek służących do edycji lub tworzenia nowego taksacyjnego pododdziału leśnego. Dane ogólne zawierają informacje o kategorii gruntów i lasów, grupie wiekowej, wskaźniku bonitacji, typie siedliskowym lasu itp. (ryc. 6). Zakładka Tier (Piętro) udostępnia funkcję wprowadzania informacji o występowaniu elementów leśnych na tym terenie. Lista wartości, w których oferowane są opcje, jest podana dla ułatwienia użytkowania. Użytkownik może również przetasować linie (ryc. 7). Możliwe jest też wprowadzenie informacji o planowanej lub już podjętej działalności gospodarczej, a także wskazanie uszkodzeń drzewostanu (ryc. 8). Istotne są również informacje o cechach tego obszaru, dlatego można je odnotować w zakładce „Cechy pododdziału leśnego", a więc wskazać występującą tam roślinność (ryc. 9).

Wśród możliwości technicznych aplikacji znajduje się opcja weryfikacji poprawności wprowadzonych informacji, czyli automatycznego określenia klasy produkcyjności oraz wskaźnika zasobności drzewostanu (ryc. 10). Zaimplementowany mechanizm przechowywania kopii zapasowej edytowanej karty taksacji pozwala na zachowanie wprowadzonych danych w przypadku nieoczekiwanego zamknięcia aplikacji. W razie potrzeby istnieje możliwość podglądu historii zmian danego obszaru w czasie oraz jego współrzędnych. Aplikacja jest uniwersalna i dostępna dla niemal całej społeczności zainteresowanych, jej zastosowanie nie wymaga specjalistycznych umiejętności ani dodatkowej pojemności urządzenia mobilnego.

Aplikacje stosowane w krajach sąsiednich, w szczególności w Polsce, Białorusi, Rosji i Estonii, poza funkcjonalnością GIS umożliwiają korzystanie z modułów pomiarów kompasowych, pomiary uszkodzonych drzew, a także możliwość powiązania informacji atrybutowych (danych taksacyjnych), samodzielne tworzenie i edytowanie bazy danych, wprowadzanie dodatkowych informacji czy pracę ze zdjęciami satelitarnymi. Możliwa jest praca zarówno online, jak i offline. Każdy kraj wykorzystuje odpowiednie aplikacje mobilne, z których większość jest dostępna w wersjach na Androida i Apple w odpowiednich usługach Play Market i jest bezpłatna. Aplikacje używane na Białorusi i w Rosji są w większości płatne i wysoce wyspecjalizowane, o raczej ograniczonej funkcjonalności do celów rekreacyjnych czy turystycznych.

Aplikacja mobilna może być wykorzystywana przez użytkowników do różnych celów, jej funkcje zależą od poziomu konta lub poziomu dostępu użytkownika. Domyślnie po zainstalowaniu aplikacji mobilnej konto jest udostępniane użytkownikowi nieautoryzowanemu. W takim przypadku może on otrzymywać informacje o charakterze niekomercyjnym, w tym kartograficzne. Ta opcja pozwala na szybsze korzystanie z aplikacji w celach turystycznych lub rekreacyjnych. Znaczącym postępem jest również możliwość uzyskiwania ustrukturyzowanych informacji regulacyjnych w postaci istniejących ISO, co z kolei zwiększa efektywność czasu pracy oraz wydajność obliczeń, w tym określania miąższości tarcicy i sortymentów. Można to również wykonać za pomocą dodatkowych programów aplikacji mobilnej SmallForest. W zależności od poziomu konta użytkownik otrzymuje odpowiedni dostęp do informacji oraz możliwość korzystania z odpowiednich funkcji i podprogramów, które niemal w całości odwzorowują funkcjonalność wymaganą od pracowników SFE do wykonywania obliczeń, wykorzystywania informacji w formie graficznej oraz wymiany niezbędnych danych w ramach SFE.