Integration of Mobile and Web GIS Technologies to Promote Smart and Sustainable Tourism in Vietnam

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Abstract

Tourism is one of the most important factors in economic growth in Vietnam. However, it requires the balance between economics, social-cultures, and ecology because of their big impacts. In this paper, we propose a platform with mobile and web-based applications that can support smart and sustainable tourism in Vietnam for both local governments and visitors. The mobile application allows visitors to access location-based services to explore the visiting area, such as finding nearby natural attractions, as well as information to minimize the negative effects of tourism on the environment and the local community. It also enables users to report negative impacts to local government. The web application allows local authorities to monitor the status and trends of the habitant, natural environment, tourism infrastructure and activities in the area. The system uses geographic information systems (GIS) and remote sensing techniques to collect, analye and visualize various indicators of sustainability. The platform is developed with open-source technologies such as NodeJS, PostgreSQL, and Flutter. The paper demonstrates the feasibility and usefulness of the proposed platform through case studies in Hoa Binh and BacKan, two provinces have many attractive natural sites.

Keywords: *mobile GIS, WebGIS, location-based services, smart and sustainable tourism*

1 INTRODUCTION

Tourism is one of the most important factors in economic growth in Vietnam. However, it requires the balance between economics, social-cultures, and ecology because of their big impacts. Therefore, sustainable tourism is a growing concern in Vietnam, as well as in many other countries. The Vietnamese government has been realized the sustainability as a core part of the country's socio-economic development. In era of industry 4.0, there is a need of information technology and communication platform that supports not only the visitor to explore the visiting sites but also for local goverment to monitor and manage in order to mimize the negative impacts of tourism services.

Mobile and web GIS technologies are systems that enable the collection, analysis, visualization and dissemination of geographic information through mobile devices and web platforms. These technologies have various applications in tourism, such as: Providing location-based information and navigation services to tourists, such as points of interest, routes, traffic, weather, etc. Enhancing tourist experience and engagement through interactive and immersive features, such as augmented reality, virtual reality, gamification, storytelling, etc. Supporting the planning and management of tourism destinations by enabling real-time monitoring, evaluation and feedback of tourist activities, resources and impacts. Promoting tourism marketing and communication by facilitating the creation and dissemination of geospatial content, such as multimedia stories, maps, charts, etc. Fostering the participation and collaboration of tourists, local communities and stakeholders in the co-creation and sharing of tourism knowledge and value.

The development of mobile GIS and webgis technology has opened new possibilities for enhancing tourism experiences and promoting smart and sustainable tourism. Mobile GIS and webgis technology can provide tourists with real-time, loca-tion-based, and personalized information and services, as well as enable them to interact with other tourists and local communities. However, existing mobile and web GIS technologies in tourism face challenges such as data quality, privacy, security, interoperability, usability, and user acceptance. They also have limitations such as lack of integration, collaboration, innovation, and evaluation.

This study proposes a novel framework for integrating mobile and web GIS technologies to promote smart and sustainable tourism. The paper consists of four parts. In section 2, related work are summarized. Next, section 3 is the main part that present the design, implementation of the proposed system. Finally, the paper gives some conclusions in section 4.

2 LITERATURE REVIEW

2.1 Potential of Mobile and Web GIS in smart and sustainable tourism

Smart and sustainable tourism is an activity to achieve efficient, responsible, and sustainable use of tourism resources by developing suitable tourism activities and helping tourists become managers, designers and creators of tourism experiences. In particular, the integration of mobile and web GIS technologies can bring many benefits to the smart and sustainable tourism industry.

Mobile Geographic Information Systems (GIS) and web-based GIS (webgis) are modern technologies that can enhance the planning, development, management and marketing of tourist destinations. Mobile GIS and webgis can provide location-based services, mobile augmented reality, and social networking services for travellers and tourism businesses. These technologies help travellers to quickly access information about attractions, culture, scenery, promotions through their smart devices, and share their experiences with others online. They
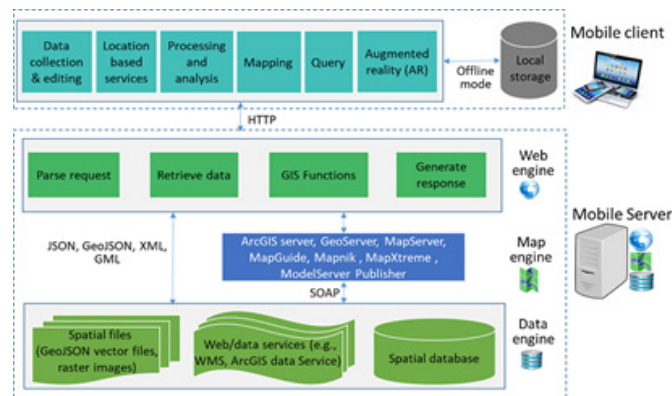
Fig. 1. The client-server architecture of a GIS [7]

Fig. 2. The development method Water-fall of the smart tourism system

can also help travel businesses improve their customers' visibility, competitiveness and trust by providing personalized and timely information and promotions.

Several studies have explored the use and potential of mobile GIS and webgis in tourism. [1] designed and implemented a tourism system using mobile augmented reality and GIS technologies for Android and iPhone platforms. The system integrated information from the Tourism Bureau, the Ministry of Economic Affairs and 500 local businesses to provide an intuitive and interactive interface for tourists. [2] examined the use of GIS and remote sensing in tourism, focusing on two case studies of Maasai Mara Game Reserve and Nairobi National Park in Kenya. They showed how GIS and satellite imagery can be used to assess the changes and impacts of human activities on the ecosystems and wildlife resources that are vital for tourism. [3] proposed a new idea of building information modeling (BIM) and GIS integration for smart city applications, which can also benefit tourism by providing 3D visualization and analysis of urban environments. [4] Therefore, the aim of this paper is to review geo-visualization-based solutions proposed in the literature and to propose a solution that can overcome the limitations related to the use of geo-visualization in tourism. The proposed system use the capabilities of the mobile navigations system and mobile augmented reality in combination with animation to represent the objects in motion in real time on the mobile interface. This research work contributes to create a smart geo-visualizations system that can be combined with mobile augmented reality to be used in the tourism domain. According to [5], the author has presented about the architecture and implementation of the Smart Tour Guide system. This system allows visitors to view map information, find locations, find videos and see the weather of each area. However, this system only works on Android-based smartphones and meets the basic features for travellers. The special issue of sustainability journal that contains several papers on the topics

of mobile technology and smart tourism development, such as mobile apps, social media, internet of things, augmented reality, location-based services, and smart destinations also discuss the impacts of mobile technology on tourism behavior, experience, marketing, management, and sustainability [6].

These studies demonstrate that mobile GIS and webgis can bring a variety of benefits to the tourism industry, such as enhancing tourist satisfaction, increasing destination attractiveness, supporting decision-making, improving resource management, facilitating communication and collaboration, and promoting sustainability. However, there are also several challenges and limitations that need to be addressed, such as data quality, security, privacy, interoperability, standardization, cost-effectiveness, user acceptance, ethical issues, and social impact. Therefore, more research is needed to explore the opportunities and challenges of integrating webgis and mobile GIS technologies to promote smart and sustainable tourism.

2.2 GIS for mobile application

Mobile GIS is considered an integrated framework for accessing spatial data and services through mobile devices. Mobile GIS makes GIS available from desktop and cloud-based software and services to anywhere in the world, allowing for GIS accessibility from any location. With the development of wireless communication technology, GIS applications can access and transfer data over high speed Internet. These applications can integrate powerful web-delivered GIS services, receive the latest GIS data updates, and regularly send the latest field information back to collection and dissemination systems server-side data. As such, Mobile GIS is increasingly being considered as a component of Web GIS. It has gradually provided more sophisticated online GIS functions and interactions accessible through mobile devices.

Most GIS software for mobile applications is usually developed based on client-server architecture [7]. The client side
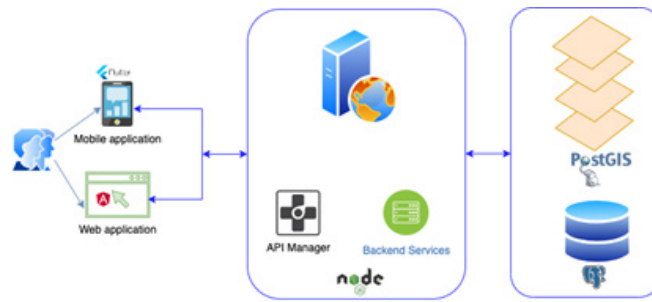
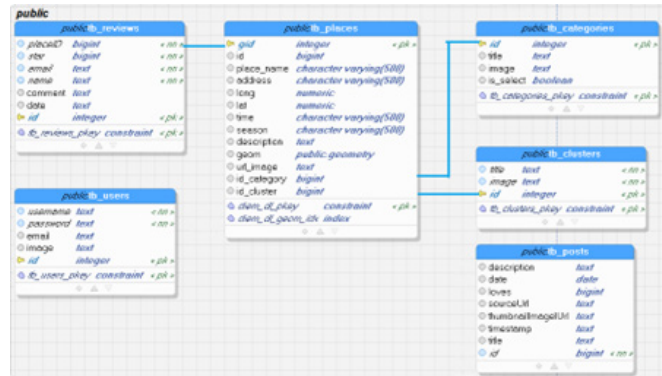Fig. 3. The architecture of the proposed system

Fig. 4. Data models of non spatial data

includes a GPS enabled mobile device and mobile GIS software with a user interface that allows manipulation of the map through the device. Compared to a typical mobile application, a GIS mobile user interface needs to provide spatial data layers, as well as simple mapping functions, typically enabled through APIs. and SDKs like the Google Maps API. The server side usually includes three main tools namely: web engine, map engine and data engine. These tools may or may not be available. For data transfer between server and client, XML and JSON data formats are commonly used.

2.3 Cross-platform mobile application

A cross-platform mobile application is one that is accessible through a large number of different end devices. It provides the ability to write code once and then run it anywhere for a variety of other platforms.

There are many different cross-platform mobile app development frameworks out there nowadays like Flutter, React Native, Ionic, etc. According to the 2021 developer survey [8], Flutter is the most popular cross-platform mobile application development framework used by developers globally. Flutter is an opensource, cross-platform software development toolkit developed by Google. It is being used to create apps for Android, iOS, webbased, and desktop apps. Flutter uses Dart, which is a modern object-oriented programming language. Dart uses various compilers to compile the corresponding machine code [9].

3 BUILDING A SMART AND SUSTAINABLE TOURISM SYSTEM WITH MOBILE AND WEB GIS

3.1 Development method

To build the system, the paper follow the Water-fall model for sofware development as illustrated in Fig. 2. . It consists of 4 phases as folllows

Analysis phase: Analyzed all requirements of the system and made a review of the current state of webgis and mobile

applications in tourism fields that are summarized in Section 2. The technique is used for the software is object-oriented analysis and design.

Design phase: We start with system architecture design, then design all the component of the system following the analyzed requirements. There is also a requirement for a open system that can be contributed for community developers. Thefore, we decided to choose open-source frameworks and platforms to develop the system in this field.

Implementation phase: Coding the design with selected technologies and programming languages.

Testing phase: Testing all the developed functionalities to find bugs.

3.2 System Architecture

Figure 3 depicts the overview architecture of the smart tourism system.

The smart tourism system will consist of three main layers. The first layer is front-end one. It provides users access way to the system via a mobile application and web browers. The mobile application is built on top of Flutter while front-end technology of the web application bassed on Angular framework. The second layer is for server processing written with NodeJS. It has two components: API manager and backend services. The former is responsible for handling API between server and clients (mobile and web applications), the latter are backend services and processes the database and GIS layers. It also has the role of providing and controlling the processes that access the system's resources. The final component is a database built on PostgreSQL integrating the PostGIS extension to be able to work with spatial data.

3.3 Database Design

We have explored and made many field trips in two provinces, i.e, Bac Kan and Hoa Binh, to collect the data for natural sites. We also have classified them into 8 groups:
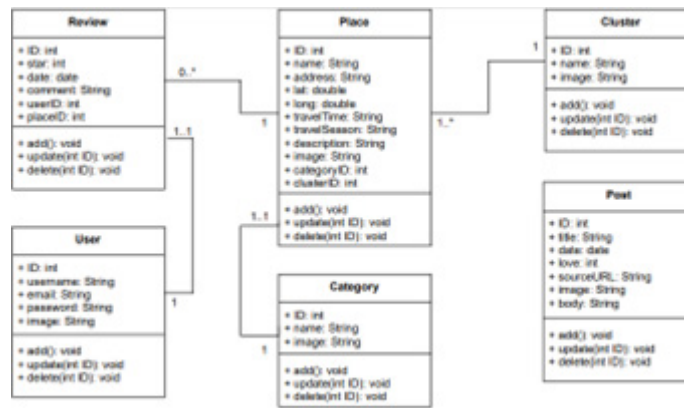
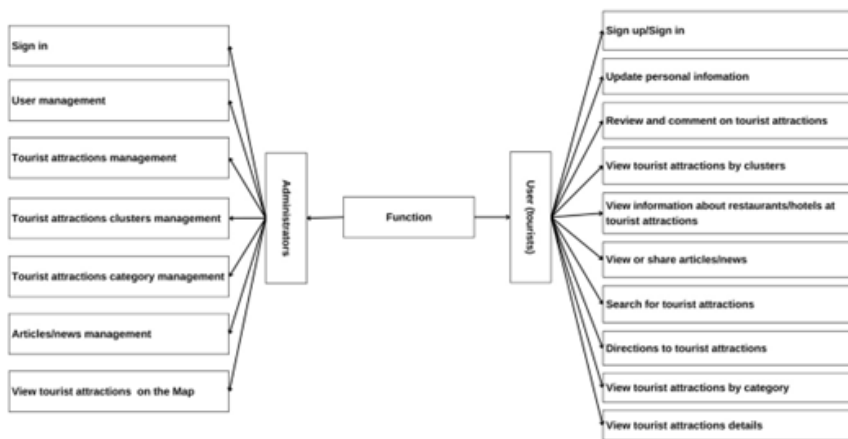Fig. 5. Class diagram of smart and sustainable tourism system

Fig. 6. Main functions of the smart and sustainable tourism system

- Karst caves
- Warm mineral water sites
- terraced fields
- geo-heritages sites
- cultural sites
- water-falls
- Natural reserved sites
- Resort and ecological sites

These groups are mapped into 8 GIS layers in the database. In order to make spatial analysis, we also have insert more layers as basics such as: river, forest, residences, roads... into the GIS database. Morever, the non spatial data models are define as Fig. 4.

3.4 Class diagram of the system

The class diagram describes the type of objects in the system and the different types of relationships that exist between them. The Smart Tourism System that integrates mobile and web GIS technology is defined to include main classes such as: Review, Cluster, Place, User, Category, Post. Fig. 5 below details the classes and their relationships.

3.5 The system implementation

The system is used by two actors: Admin and Traveller. The functional diagram of the system is depicted as shown in Figure 6 below:

The user interface of the application is developed using the Flutter SDK. Map operations (loading and displaying maps, zooming in, tapping, etc.) are built on the Google Maps SDK.

Map data edited as shapefile or geodatabase will be loaded and stored on the server. The mobile application will interact with the map data through APIs. Figure 7 depicts the implementation of a smart tourism system that integrates mobile and web GIS.

3.6 Results and Discussion

The research system has been successfully installed on popular platforms such as Android and iOS. Figure 8 below depicts some of the main interfaces of the smart and sustainable tourism system based on mobile and web GIS. A system built on Cross-platform applications provides the main functions such as: (1) lookup, display information of tourist sites; (2) categorize places by different categories; (3) Integrated Google Map map to visualize the locations; (4) Share news, articles related to tourism in Hoa Binh province; (5) Suggesting travel itineraries for tourists, etc. In addition, the system also provides the ability to share data via APIs in the form of GeoJSON standard.

The cross-platform smart and sustainable tourism system has been tested by the authors in a real environment with more than 230 attractions and tourist services classified under different categories such as Geo-heritage, Humanistic, Community tourism, Ecological area, Resort, etc. in Hoa Binh and Bac Kan provinces (Figure 9, Figure 10). The mobile application work stably on Android and iOS operating system with many features such as scheduling, directions, search on the map, etc. The tourists can use their smartphones to provide feedback, ratings and preferences about their travel experiences. Service providers can use sensors to monitor the availability and quality of their facilities and services.

Fig. 7. Illustrating the deployment of smart and sustainable tourism system
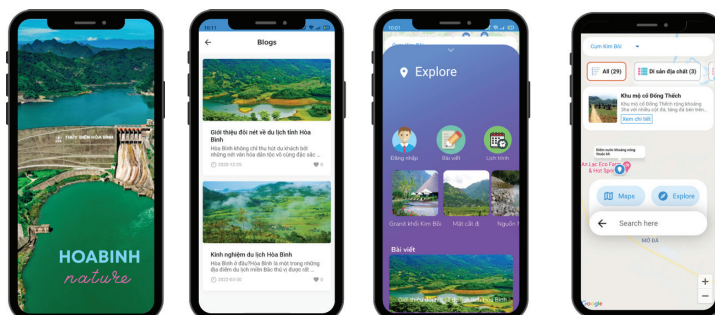

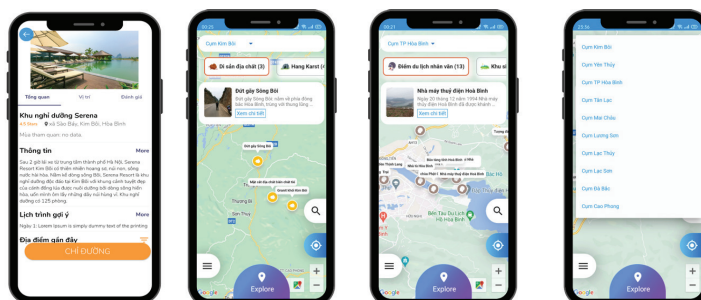Fig. 8. User interfaces of smart and sustainable tourism system

Fig. 9. Management of attractions and tourism services by thematic groups of Geoheritage, Humanistic Tourism
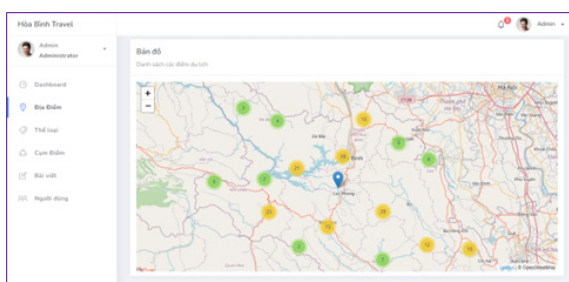

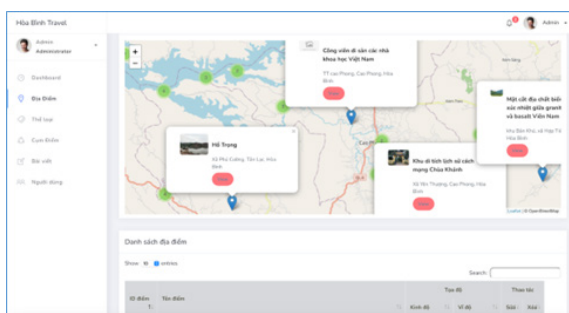Fig. 10. List of tourist spots in Hoa Binh province

Fig. 11. The spatial distribution and density of tourist spots

The data visualization feature of system uses web GIS and interactive maps to display the analysed data in an intuitive and user-friendly way (Figure 9). Another feature is data dissemination, which enables sharing the data and the results with different stakeholders and users through web services and mobile applications.

The results indicate that the integration of mobile and web GIS technologies can enhance smart and sustainable tourism by providing tourists with more information, services, and opportunities to interact with the destination and other tourists. The results also suggest that the integration of mobile and web GIS technologies can improve the tourist experience and behaviour by increasing their satisfaction, and environmental awareness.

4 CONCLUSION

Mobile GIS and web GIS technology are emerging as powerful tools for smart and sustainable tourism. They enable tourists to access, share and interact with spatial information anytime and anywhere, using their mobile devices. They also allow tourism managers and planners to monitor, analyse and optimize the tourism resources and activities in real time, using web-based platforms. In this paper, we propose a framework for integrating these technologies into a comprehensive tourism information system that can support for smart and sustainable tourism. We illustrate the potential benefits of this framework with some examples from existing projects and studies. The results show that the system works stably, meets many users, and accesses quickly and accurately. Spatial data is displayed on the map in an intuitive and diverse manner. Our smart tourism system will help to enhance the tourism experience, improve the tourism management and promote the tourism sustainability by providing smart and personalized services, optimizing the use of resources and reducing the negative impacts of tourism activities. In the future, the authors will continue to research and apply some machine learning technques for recommendation systems and give futher spatial analysis for local goverments in planing and developing tourism more sustainably and efficiently.

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