Implementing a Modular Integrated System for Biodiversity Conservation and Promotion Using Web Technologies

Yorghos, E., Voutos*
Department of Informatics and Computer Engineering, University of West Attica, gvoutos@ uniwa.gr

Stergios, M., Palamas
Department of Informatics, Ionian University
spalamas@ionio.gr

Phivos, I., Mylonas
Department of Informatics and Computer Engineering, University of West Attica
mylonasf@uniwa.gr

ABSTRACT

In the context of promoting environmental wealth to visitors, this paper explores the development of a web platform, widening the visibility of local biodiversity and aiding in its preservation. We introduce a modular web platform, constructed from interconnected front-end and back-end modules and built upon open-source technologies. In the past, delivering captivating, media-rich user experiences, called for specific hardware and proprietary development tools. This study highlights how the latest in web technology, combined with contemporary web browsers (such as those supporting the WebGL standard), now allows for the rollout of these advanced services on everyday mobile devices using widely accepted web technologies like HTML, CSS, and JavaScript. The immersive qualities of multimedia and cutting-edge AR/VR technologies have enhanced the magic of natural sites and the attractiveness of points of interest. Under this notion, we've worked on a thorough investigation of how these paradigm-shifting discoveries might be used to make a virtual retreat for enthusiasts of ecology. The proposed platform's focus on the protection and promotion of biodiversity is the basis of not only improving the user experience but it also emerges as a tool for the preservation of the Ionian Islands' natural marvels as we delve into its architecture and capabilities.

CCS CONCEPTS

• **: n-tier architectures**; • **Development frameworks and environments**; • **Location based services**; • **Crowdsourcing**; • **Mixed / augmented reality**;

KEYWORDS

Biodiversity, ecotourism

ACM Reference Format:
Yorghos, E., Voutos, Stergios, M., Palamas, and Phivos, I., Mylonas. 2023. Implementing a Modular Integrated System for Biodiversity Conservation and Promotion Using Web Technologies. In *27th Pan-Hellenic Conference on Progress in Computing and Informatics (PCI 2023), November 24–26, 2023, Lamia, Greece.* ACM, New York, NY, USA, 5 pages. https://doi.org/10.1145/3635059.3635085

*Corresponding author

PCI 2023, November 24–26, 2023, Lamia, Greece

ACM ISBN 979-8-4007-1626-3/23/11.
https://doi.org/10.1145/3635059.3635085

1 INTRODUCTION

Several stakeholders are working together to lead responsible programmes that are focused on biodiversity protection and the ethical promotion of ecotourism [1]. This project addresses the noticeable absence of a dedicated platform for biodiversity preservation in the Greek digital landscape. Stakeholders collaborate to develop a comprehensive platform aiming to become a key reference point, promoting sustainable practices and local community participation in protecting Greece's natural beauty, particularly in the Ionian Islands.

The innovative digital platform covers regions like Corfu, Cephalonia, Ithaca, Lefkada, and Zakynthos, offering structured, user-friendly access to data and statistics. It stands out for its user-friendliness, scalability, and reliance on modern, cost-effective technology. The adopted modular and open architecture, supports interactive Augmented Reality implementations for environmental education, catering to both local and remote users.

The modular system allows independent updates, ensuring adaptability in the ever-changing digital environment. Privacy protections are a priority, guaranteeing the security of user data. Overall, the platform signifies a significant advancement in understanding Greece's ecological resources, showcasing technology as a valuable ally in environmental protection and promotion. The paper will further explore the project's aims, specifications, design, and architecture, concluding with the system's implementation.

2 STATE OF THE ART

Several infrastructures have been established to offer data and information connected to the execution and monitoring of EU biodiversity policies like the - focusing on information relevant to the EU Habitats [2] and Birds [3] Directives - Target Cross-linking tool [5], providing details on the connections between national biodiversity-related targets at the national, European, and global levels, interactive maps (web-GIS), and the Natura 2000 Network Viewer [4],

GeoIKP (Geospatial Information Knowledge Platform), a user-driven web platform, was presented by Leo et al. [6]. GeoIKP promotes nature-based solutions (NBS) for risk management and preparing for climate change. It offers configurable user interfaces for diverse profiles, from policy bodies to citizens, fostering collaboration among stakeholders through an interactive portal. Its standout feature is a flexible user interface allowing real-time visualization and layering of geo-referenced statistics. With an extensive NBS database, webGIS tools, analytical algorithms, and community-driven NBS adoption, GeoIKP pioneers a user-centric approach,

uniting stakeholders and facilitating NBS implementation against hydro-meteorological hazards.

"Biologer," a user-oriented open platform for collecting and storing biodiversity data, is presented by Popovi et al. [7]. Biologer enables scientists, naturalists, and the public to exchange crucial observations on diverse species and habitats. Its user-friendly interface promotes greater involvement and real-time data input, connecting to regional and global biodiversity databases for enhanced data compatibility and quality. The specific study emphasizes Biologer's role as a user-driven platform shaping the future of ecological knowledge and biodiversity data collection.

Pimentel's [8] research explores the use of augmented reality (AR) for wildlife interactions and conservation. The study assesses the feasibility and value of employing AR technology to support conservation efforts by providing users with unique and engaging experiences. By analyzing the viability and effects of AR-based interactions with animals, the article sheds light on a promising approach in international efforts to save and preserve species. This study advances our understanding of the intersection of technology and conservation by offering insights into potential AR-driven strategies to increase public understanding and participation.

Additionally, Dunn et al.'s [9] research, investigates the impact of augmented reality (AR) mobile gaming on pro-conservation behavior. Focusing on the AR game "Wildeverse," the study assesses its potential to motivate pro-conservation behavior by creating immersive gaming experiences. Analyzing the game's influence on participants' habits and attitudes, the findings underscore the significance of innovative approaches to engage people in environmental stewardship. This study sheds light on the transformative impact of gamification and AR technology in encouraging real-world conservation acts, providing unique insights at the intersection of technology, gaming, and conservation as a creative strategy for environmental contributions.

Prathast et al. [10] present a cutting-edge near real-time web-based forest monitoring system, combining satellite data, mobile community monitoring, and forest disturbance detection. Implemented in Ethiopia's UNESCO Kafa Biosphere Reserve, it transforms ground observations and communication via social media. Utilizing open-source technologies, the system processes satellite images, integrates ground observations, and provides maps of forest change hotspots. This research highlights the vital role of near real-time forest monitoring in effective management, ensuring swift responses to disturbances and sustainable resource utilization. The system's success lays the groundwork for a nationwide monitoring system, with significant implications for REDD+ MRV applications, marking a pivotal moment in forest conservation.

Furthermore, Frehner et al.'s [11] work introduces the Virtual Database, a novel solution in environmental data management addressing the need for improved interoperability and sharing. Unlike existing Internet solutions, it stands out by providing advanced spatial analysis capabilities for distributed environmental data. Notably, its commitment to openness and modularity ensures adaptability and sustainability. This paper heralds a visionary approach to ecological data management, empowering professionals with tools for an interconnected world and paving the way for a more resilient future in environmental data management.

The web platform developed under the Green Visions Plan project [12] marks a new era in environmental planning. Its mission is to promote equitable park access, protect biodiversity, and enhance watershed health. Central to its success is the Interactive Park Analysis Tool, offering customized reports on potential park user demographics at the parcel level. This user-friendly platform combines geospatial data with a client/server system architecture, empowering decision-makers with valuable insights, as demonstrated in a compelling case study. The GIS mapping tools, including the Interactive Park Analysis Tool, enable real-time scenario exploration and impact assessment. A game-changer for conservation, this platform serves as a crucial resource for municipalities and community groups. In summary, the Green Visions Plan project's web platform is a groundbreaking tool for biodiversity conservation, equitable park access, and watershed health, promising further expansion and impact beyond Southern California.

These results demonstrate how technology and user-generated platforms can shift conservation perspectives.

3 SYSTEM DESIGN AND ARCHITECTURE

The system provides stakeholders with a cost-effective platform to enhance ecologically significant destinations with valuable biodiversity information and multimedia content. This not only attracts potential visitors but also enhances the experience of those already present. By highlighting the area's biodiversity, it encourages individuals to discover, share information, and actively participate in preserving native plants and animals.

The primary objectives of the system include: **(a) Providing a backend web platform/application**. Following the model of a Content Management System (CMS), content providers will have the capability to post, connect, and refresh multimedia content pertinent to their featured locations, through an intuitive web application interface. **(b) Introducing a cross-platform mobile application** developed with web-based, open-source technologies, featuring modern presentation methods such as Augmented Reality and 360-degree multimedia content. Travelers, both on-site and remotely connected, can use the app to interact with system content, gain knowledge, participate in gamified activities showcasing local biodiversity, and contribute essential content and feedback, adding a crowdsourcing dimension to the platform.

The main system requirements include: **(a)** Compatibility across major desktop and mobile operating systems and popular web browsers, **(b)** Support for modern multimedia content formats e.g., streaming video, 360 photos and video, 3D objects, **(c)** implementation of state-of-the-art presentation methods such as Augmented Reality, **(d)** modular structure that ensures both adaptability and cost efficiency, and (e) user customizability, with feedback and crowdsourcing mechanisms.

The system is built on a modular framework, comprised of a series of interoperable components, each contributing a part of the overall functionality. The system architecture (Figure 1) follows the 3-tier architecture paradigm, that many web applications are based on: (a) Mobile Application, managing content display and user interaction / feedback (presentation tier/client side), (b) Multimedia Content Digital Repository/Database, taking care of information

Table 1: JavaScript libraries/frameworks used for the implementation of the mobile application.

Subsystem	Library/Framework	Short Description
Mapping	Leafllet [16] & OpenStreetMap [17]	Leaflet provides a JavaScript programming interface for the development of interactive maps, while OpenStreetMap provides open-source GIS/Mapping ser-vices
3D Mapping	CesiumJS [18]	CesiumJS is an open-source JavaScript library for creating 3D globes and maps with performance, precision, and visual quality.
Augmented Reality	AR.js [19]	AR.js is a lightweight library for Aug-mented Reality on the Web, featuring Image Tracking, Location based AR and Marker tracking.
User Interface	OnsenUI [20]	OnsenUI provides a framework for the development of web and hybrid mobile applications, with the look-and-feel of native Android and iOS mobile apps.

storage and management (data tier), (c) Content Management Application, providing the backend infrastructure and functionality, such as a web-based content administration tool, user profiling and contribution, content personalization features, and the API utilized by the mobile application to get access to the back-end functionality (application tier).

4 IMPLEMENTATION

4.1 Implementation of the back-end infrastructure

The back-end infrastructure (Figure 1) relies on MySQL[13] for multimedia data storage and management. Dublin Core's elements have been tailored accordingly, in the platform's DSpace [14] based digital repository, in order to meet the specific requirements of our metadata application profiles. "CakePHP" [15], a web project framework, streamlined development with reusable PHP components. A RESTful web API serves as an access point for the Client Mobile Application, facilitating communication with back-end services. Data is transmitted using JSON for efficient processing through JavaScript in the mobile client application. Serious games (Gamification Module), integrating content from the system's multimedia database, can be developed using web technologies (HTML,CSS, Javascript) or even GameEngines (e.g. Unity), in order to support educational activities and providing a modern and attractive means to promote the significance of biodiversity preservation and raise awarness.

4.2 Implementation of the User Mobile Application (Client)

The mobile application, serving as the client for the system's back-end, utilizes the REST API to exchange data, access module functionalities, and contribute user insights and feedback. It represents the presentation layer in the 3-tier architecture. Developed as a web-based, mobile-friendly application, it relies on HTML5, CSS, and JavaScript. JavaScript frameworks provide essential functionality for building various subsystems, detailed in Table 1 and depicted in Figure 2. Custom JavaScript code ensures seamless integration of subsystems and manages core functionalities like geolocation and communication with server-side modules via the API.

5 DISCUSSION

Overall, the integration of technology into environmental conservation efforts is a powerful tool for promoting sustainability. It allows for the efficient gathering and dissemination of information, fostering a deeper connection between people and the natural world. This type of initiative is vital for addressing environmental challenges and working towards a more sustainable and ecologically conscious future. The platform can play a crucial role in several ways: Education and Awareness, Data Collection and Monitoring, Community Engagement, Policy Support, Tourism and Sustainable Development, Partnerships and Collaboration.

The system employs open-source tools and is based on a modular, open architecture providing upgradability, scalability, and ease of maintenance.

Back-end services use modern web application technologies, with a REST API linking to the client-mobile application via efficient JSON data exchange.

The client/mobile application showcases the viability of sophisticated, location-centric, multimedia, and augmented reality applications using web technologies like HTML, CSS, and JavaScript.

Contemporary JavaScript frameworks enable the integration of advanced features. However, the dynamic nature of programming frameworks, especially in JavaScript, necessitates consideration of factors like community support and backing from major corporations for successful project development. Given the evolving trends in Virtual and Augmented Reality, continual monitoring is essential for leveraging new resources.

ACKNOWLEDGMENTS

The financial support by the European Union and Greece (Partnership Agreement for the Development Framework 2014-2020) under the Regional Operational Programme "Ionian Islands 2014-2020", for the project "Smart digital applications and tools for the effective promotion and enhancement of the Ionian Islands bio-diversity - ERMIS" with MIS code: 5034557, is gratefully acknowledged.

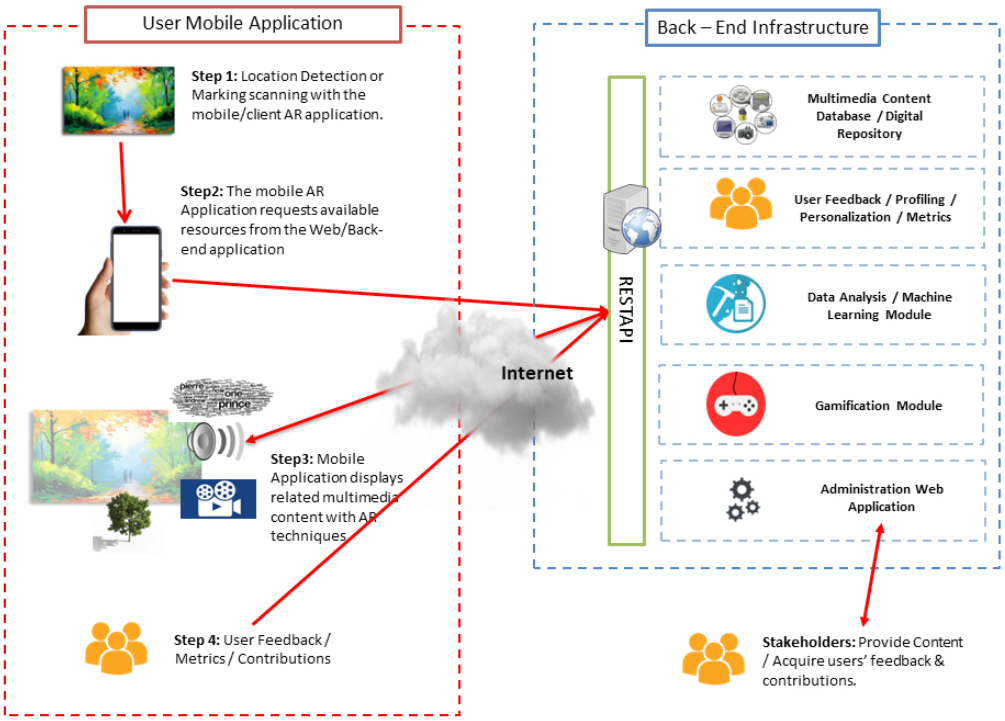

Figure 1: System architecture, modules and user scenarios

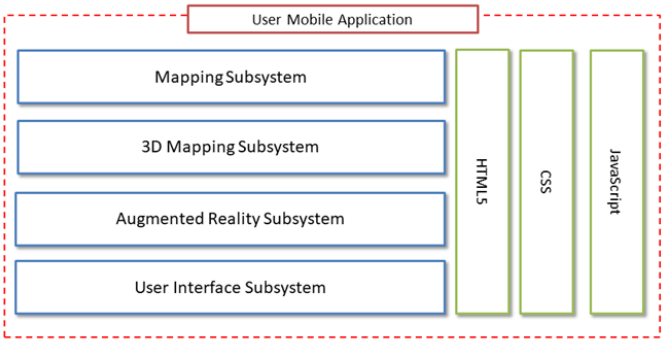

Figure 2: Subsystems of the User Mobile Application

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