Blockchain-based Wildlife Data-Management Framework for the WWF Bison Rewilding Project

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ABSTRACT
Mass digitalization, remote sensors, and flexible database solutions encourage organizations to look closer at new technologies as an efficient management tool. In these conditions, the leveraging of blockchain and wireless tracking devices represents a field of far-going technology development and can be used for wildlife data management. The purpose of this research is to introduce the applicable solution for the case provided by the World Wildlife Fund (WWF) regarding bison population rewilding in Eastern Europe. The goal of the paper is to create a data management framework, which combines information into one multi-integrated system visible to stakeholders. The paper theoretically extends the existing MIT OPAL blockchain-based model, which was implemented for the WWF bison rewilding project, showing a solution from managerial and technical perspectives. The proposed platform is able to provide secure geospatial wildlife data, increase intention to make donations to the project and facilitate the conditions for a better tourism experience. We found that such a system can have a positive effect on the project's cost reduction, flexibility in redirecting manpower within the region and become a useful tool for decision-makers.

CCS Concepts
• **Information systems → Transaction logging**

Keywords
Blockchain; rewilding; wildlife data security; data-management framework.

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1. INTRODUCTION
Technological innovations brought numerous benefits to the protection of nature and rewilding development. Artificial intelligence, remote sensing, big data, virtual reality, camera traps, acoustic sensors, and other inventions provide researchers, policy makers, and conservationists with reliable data for their decision-making processes. New tracking technologies enable gathering real-time data and giving stakeholders unprecedented insights into the life of wild animals at relatively low costs. The animals can be observed in a much higher resolution than with previous methods, especially in terms of space and time (Kshetri, 2017).

Nevertheless, some innovative technologies are also associated with threats to wildlife projects. One of the most broadly used equipment for the collection of geospatial data is GPS collars (Root-Bernshein et al., 2018). These tracking collars provide researchers with information about animals' location, behavior, habitats, etc. Scientists use collected tracking data to design programs for wildlife protection afterward (Frey, Miller, Ilic, Fleisch & Pentland, 2017). However, cyber-poachers constantly make attempts to hack the security system of servers with geospatial wildlife data for criminal purposes.

In the year 2013, in the Madhya Pradesh Reserve in India cyber-poachers tried to access the tigers' GPS collars data (Cooke et al., 2017), with which they could easily define animals' location and capture tigers. Since then the scientific focus shifted towards cyber-poaching and geospatial data security. Numerous scientists analyze the problem from the management perspective (Cooke et al., 2017), however, innovative technical solutions were also designed to tackle the problem of wildlife data protection.

Consequently, geospatial wildlife data was proposed to put on the blockchain within the concept of the wildlife data privacy-preserving framework (Frey, Hardjono, Smith, Erhardt & Pentland, 2017). Such system supposes to transmit code, not data. Only non-sensitive aggregated data leave the secure environment of wildlife monitoring center while sensitive raw data remains in protected databases.

We extend the abovementioned framework and apply it to the WWF bison rewilding project. For the current study, the following research question was set: *How blockchain can be incorporated into geospatial wildlife data management having a complex*

environment with various categories of stakeholders and be applicable within the WWF bison rewilding project?

Besides, our paper discusses:

1. Usage and sharing of geospatial wildlife data by various categories of stakeholders;
2. The difference between verified and general users of the wildlife tracking data;
3. Applicability of the blockchain-based virtual animal adoption for WWF bison rewilding project.

The paper is organized as follows. First, we categorize stakeholders of the rewilding project. Then we briefly describe the advantages of the extended blockchain-based wildlife data-management framework from the perspective of geospatial data security, the impact of the innovative technology on the local community, and fundraising through animal adoption. Afterward, we apply the extended framework to WWF bison rewilding project. Finally, the paper concludes with open discussions and overlook of further researches.

2. EXTENDED WILDLIFE DATA-MANAGEMENT BLOCKCHAIN-BASED FRAMEWORK

Rewilding as a type of restoration project aimed at species recovery in the functional ecosystems (Noss, 1992; Noss & Cooperrider, 1994) has a great impact on wildlife protection worldwide and includes various groups of stakeholders.

2.1 Potential Stakeholders

At this stage, we found it relevant to shape the scale of the rewilding project, including its major and potential stakeholders. Since one of the main features of blockchain technology is its shared database, it is important to define parties who are potentially interested in having a transparent database. This is the main way of achieving trust between parties since we exclude a need of a mediator — no central gatekeeper is required for keeping data or confirming transactions. Based on meeting sessions with wildlife protection experts, who have provided us with the assessment to level actors properly, we designed the structure of stakeholders in Table 1. We split stakeholders into a few main categories by their potential role: data and statistics collectors, and data users, as well by their reasons to participate in the project.

2.1.1 Monitoring Center of the Wildlife Protection Organization

As a data owner, data collector and a validator, monitoring center has a central role in the project. It aims to create a community for a better tourist experience, connect governmental and wildlife protection organization.

2.1.2 Local Authorities

As a main data and statistics user, local authorities opt to save costs spent on manpower and land scouting, also having interest from bigger tourist flows.

2.1.3 Forestry Administrators and Rangers

As an active, but not a major data user, forestry administrators could be notified in advance of an animal approaching in real-time for more efficient planning of forestry roads and infrastructure.

2.1.4 Farmers

One of the main users of data. Local farmers opt to be notified of an animal approaching in real-time to take measures for personal property protection.

2.1.5 Research Institutions

As main users, research institutions have an opportunity to receive additional data for research analysis to demonstrate the impact of rewilding on natural processes.

2.1.6 Regional Tour Operators

Regional tour operators might ensure the sustainability of the business, and to do the planning of touristic activities.

2.1.7 Local Business

Local business representatives might have an expansion of product assortment, better involvement in touristic activities.

2.1.8 Tourists

As one of the main users, tourists are interested in receiving better travel experience and self-engagement in the rewilding project.

2.1.9 Virtual Animal Adopter

Being one of the main users of the application, virtual animal adopters are able to make donations to the wildlife protection project.

2.1.10 Media

As minor data users, media are capable to broadcast wildlife news and other media materials to the audience.

Table 1. Rewilding project stakeholders' categorization

Stakeholder	User Category
Monitoring Center of the Wildlife Protection Organization	Verified user
Local Authorities	Verified user
Forestry Administrators and Rangers	Verified user
Farmers	Verified user
Research Institutions	Verified user
Regional Tour Operators	General user
Local Business	General user
Tourists	General user
Virtual Animal Adopter	General user
Media	General user

Stakeholders are also categorized by the way they use the database: general users and verified users (Fig. 1).

The "verified users" category includes representatives of local government, farmers, rangers, and researchers, who would be capable to receive immediate real-time warnings from the system when it recognized an animal in the proximity of previously defined areas or special equipment with the verified access. These users complete a full registration process to receive permission to access specific types of data.

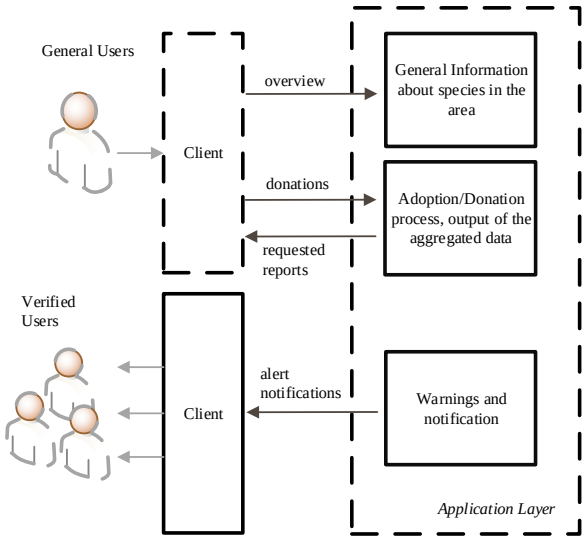

Figure 1. Stakeholders categorization: general and verified users.

The "general users" category includes all other stakeholders, who are not required to provide their full personal data for registration. It allows them to make donations to the project through virtual animal adoption application anonymously (Root-Bernstein et al., 2018). Virtual adopters receive daily updates about the animal (Veríssimo et al., 2017), as a result, the relationship between animal and its adopter may become stronger and the donations may increase or get more sustainable (Colléony et al., 2017). The blockchain-based application provides valuable advantages and opportunities for each of the category.

2.2 Technical Concept

Nowadays the role of data sharing in organizations and societies is indisputably significant. Nevertheless, the security of data transmission and storage appears to be a challenging task. Especially, if it is the sensitive geospatial wildlife data.

2.2.1 Aggregated Data

Modern concepts of data management suggest using aggregated data based on quire instead of providing raw sensitive data (Frey, Miller, Ilic, Fleisch & Pentland, 2017; Tapscott & Tapscott, 2018). In the paradigm – called MIT Open Algorithms (OPAL) – raw data never leaves its physical location or the control of its owner. Instead, nodes that carry relevant data-sets execute sub-queries and report on the result. Scalability is improved by logical clustering of nodes that carry data-sets of a given type or nature. Groups of clusters can, therefore, be engineered to achieve scalability and high response rates.

2.2.2 Blockchain Technology

Blockchain technology provides a mechanism to log and store both users' requests and answers, and to provide a powerful tool to support transparency and accountability for post-audit procedures (Kshetri, 2017). Once requested the data, the user activates the algorithms of cryptographic hash creation, and so do the repository database, sending the save-answer. Moreover, if data-collecting organizations want to monetize their datasets, the technology is able to provide them such benefits by its characteristics and capabilities (Morabito, 2017; Zhao et al., 2016). Among one of the main ones is an opportunity to connect money and data flow with diminutives transaction costs.

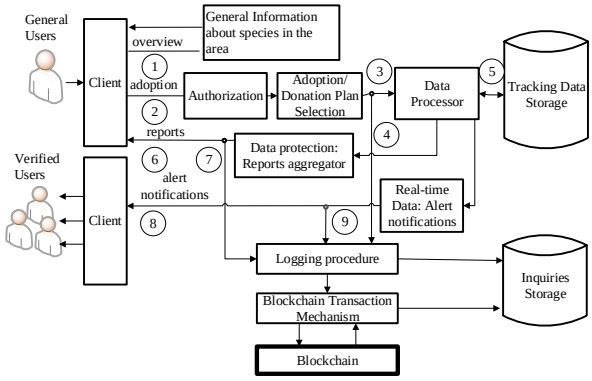

Figure 2. System Architecture. Adapted from MIT OPAL's (Frey, Hardjono, Smith, Erhardt & Pentland, 2017).

2.3 System Architecture

The architecture of our proposed model which is shown in Figure 2, is based on the MIT OPAL's (Frey, Hardjono, Smith, Erhardt & Pentland, 2017) system architecture. The OPAL Data Server represents the core of the model, where the user sends one or more requests to the data server (i.e. tracking data storage), which sends aggregated answers only as safe-queries. The flow within the model is summarized as follows:

Step 1. The user receives an overview of animal living in the rewilding area. The overview contains general information and entertaining facts about species, their habitats and role in nature.

Step 2. The entry to the adoption/donation procedures.

Step 3. Based on the chosen adoption/ donation plan the request for data analysis is directed to the data processor.

Step 4. The approved data of the user and his/her chosen adoption/ donation plan is coded, verified and stored in the secure database with the signing footprint located on the private blockchain.

Step 5. The data processor connects to the storage of the tracking data.

Step 6. The data is aggregated, coded and delivered to the user.

Step 7. The copy of the aforementioned data is coded, verified and stored in the secure database with the signing footprint stored in the private blockchain.

Step 8. If bison are detected nearby the highlighted areas (farms, infrastructural objects, etc.), the warning message would be sent to specific verified users.

Step 9. The copy of the above-mentioned warnings is coded, verified and stored in the secure database with the signing footprint stored in the private blockchain.

To sum up, the described system is using sensitive raw data to generate answers for users' inquiries. In practice, users send requests and receive generated reports. The system returns the code, not data. Thus, it solves an anonymization and security problems.

3. WWF-ROMANIA BISON REWILDING PROJECT

The case given by WWF-Romania covers an issue around the population of bison within the Armenis suburb area, the Southern Carpathian Mountains. Bison are placed into the 300-acre fenced enclosure of forest and once animals adapt and acclimatize to their new surroundings, WWF releases them into the wild. WWF fits animals with GPS collars to fully track relocation activities. Such information allows WWF to create a planning system and be able

to redirect manpower within the area operatively. It can save costs and increase efficiency for local authorities who are responsible for such procedures.

One of the main aims of the project goes towards engaging tourists into the community i.e. personal connection to the project for the donor. It could be achieved by the bison adoption program by rewarding the donor with true impact measurements and showing real-time ecosystem changes. Also, it would boost the local economy within the region.

WWF sees above-mentioned activities run through a trustworthy system where the general public, specific partners, industries, businesses, and decision-makers can see how certain actions are impacting the state of nature, how a certain intervention is shaping the wellbeing one way or another. On a larger scale, the goal is to create an integrated system for storing scientific data on the blockchain enables public access to analysis and provide the ability for key stakeholders to use data in policy work, regional strategies development.

We held numerous exchanges and meetings with WWF representatives and experts, who provided us with the case related insights. During these meetings, it became clear that the proposed system should be able to solve three main challenges: to increase program's fundraising through the development of virtual animal adoption application, involve the local community of the region, and to protect geospatial data from cyber-poaching.

3.1 Verified and General Users of the Project

Based on the extended blockchain-based wildlife data-management framework, such verified users of the project as local farmers are able to receive warning notifications if bison is tracked in the special areas nearby their farms and grounds. Thus, they are capable to provide expedient additional protection of their properties and to avoid possible obsolete consequences. Moreover, in case of potential damage made by bison to facilities or lands, farmers have a trusted mechanism for insurance compensation's support.

Along with farmers, local government is able to use bison's tracking data to design wildlife protection policy in the region and to support farmers' compensation requests. Moreover, local authorities have a system of notifications if bison approaches infrastructure areas or other restricted zones. The received information can be used in the decision-making process about ecological or infrastructure projects' development. Furthermore, the collected geospatial data and its analyses can have a positive effect on the cost reduction and flexibility in redirecting manpower within the region.

Authorized rangers, who take tourists to the frontline of wild nature, are able to receive the updated real-time data based on the geolocation. As a result, the quality of provided services increases, as well as touristic satisfaction. In addition to this, all previously verified WWF partner organizations involved in the conservation project are able to have direct access to the aggregated wildlife data to conduct the research.

As for the general users, the blockchain-based application allows them to receive profound information about bison, and to provide financial support for the rewilding project through the virtual adoption. From the users' perspective, the application has two sections. The first one serves to provide general information, which includes a description of bison species, their preferences, habitats, and other important information. The main goal of the feature is to increase the user's awareness about the project and bison themselves. The second section is a mechanism for the trusted and easy-to-use process of bison conservation project's support. The main objectives of the sections are threefold; (1) to provide a trusted and secure adoption/donation mechanism; (2) to manage and analyze data received from the GPS collars of bison; (3) to engage users and to improve users experience through aggregated data application. In order to reach the aforementioned goals, the application works as follows. To sum up, general users are people from all over the world who wish to virtually adopt a bison. The blockchain-based application attracts potential adopters with the help of a promotional video produced by WWF (Shreedhar & Mourato, 2019) and suggests different types of donation packages.

3.2 Bison Virtual Adoption

All users who are willing to apply for the donation program and to have access to the aggregated data of the bison tracking, have to pass the authorization procedure. Once authorized, users have a chance to choose between different options of financial support for the rewilding project. Such financial support might be provided through a bison adoption mechanism or direct donations to research organizations and conservation project coordinators. The information about user's donations is logged, added to the blockchain, as well as it is securely stored in the private database, and can be provided to local authorities for the tax-reduction procedures by request.

Based on the number of donations, users are granted access to the data on a certain period of time. Taking into account the importance and the cases of illegal use of such sensitive data by cyber-poachers (Messenger, 2013; Ingber, 2013), the system includes algorithms which protect and limit data spreading among all stakeholders. Instead of providing raw-collected data, the system is sending aggregated data, based on user's request. Moreover, the output data is provided based on previously collected data with a defined delay in time. The received data is used by users on its purpose. Among which are gamification, research, and others.

Finally, all information about users, including their requests, donations, and mined data is logged and written on a private blockchain. In sum, all transactions of sensitive geospatial wildlife, as well as financial data are protected, and, at the same time, the register of all stakeholders of the system is transparent and trusted.

3.3 Effect of the application

We held various exchanges and meetings with WWF representatives, who provided us with related data-management insights. During these meetings, it became clear that the proposed system has the potential to solve three main challenges of the rewilding project. First, to provide flexibility in redirecting manpower within the region and to become a useful tool for decision-makers. Second, the application can influence the local economy, boosting up local business and engaging farmers into the system as well as research institutions and local authorities. And the third, the proposed solution is able to increase intention to make donations to the project and facilitate the conditions for a better tourism experience.

4. DISCUSSION, LIMITATIONS, AND FUTURE RESEARCH

Global digitalization shifts the world technology progress, making it more affordable and functional within time. Blockchain seems to be an appropriate ground for keeping data, broadening the field of upcoming innovations. Moreover, it already attracts a lot of attention from private business, showing a range of ongoing projects regarding wireless devices and data tracking. Specifically,

a key aspect of implementing such technology within bison allocation is visibility and audibility of all transactions, presenting all actions in the form of time-stamping. Thus, required parties can be aware of all actions happening in real-time and be notified in advance, minimizing time delays, service, and production costs.

In the paper, we have theoretically extended the framework of blockchain-based wildlife data-management system and applied it to the bison rewilding project. As a result, there were defined two major categories of stakeholders: verified and general users of wildlife geospatial data. The proposed model overcomes the limitations of the existing framework and gives an opportunity to authorized research institutions to study the raw wildlife data in an open-ended manner to detect patterns and regularities.

Furthermore, our platform is able to increase the intention to financially support the project. The system's innovation can improve the conditions for better tourism experience and scientific research. We discovered that the system built on blockchain have a positive effect on cost management, level of transparency of financial and data flow, and to become an important trusted tool for local government and community.

There are a few limitations, which lead to opportunities for future research. First, the research has not incorporated the measure of the real use of the animal adoption application. The second limitation concerns the users' acceptance and other behavior of the proposed blockchain-based technology.

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