EHMA 2024

Shaping and managing innovative health ecosystems

Implementing a Model of Digital Healthcare Ecosystem Based on Blockchain Technology – A Pilot Study

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Introduction

- The subject of this research paper is the implementation of the proposed digital healthcare ecosystem model that uses capabilities of blockchain technology.
- Technical solutions were designed and developed to ensure functioning of the proposed digital healthcare ecosystem model.
- Main goal – to implement a blockchain-based software application in a healthcare institution for a test period, and to evaluate the acceptance by users – identified stakeholders of the healthcare ecosystem.

Theoretical Background

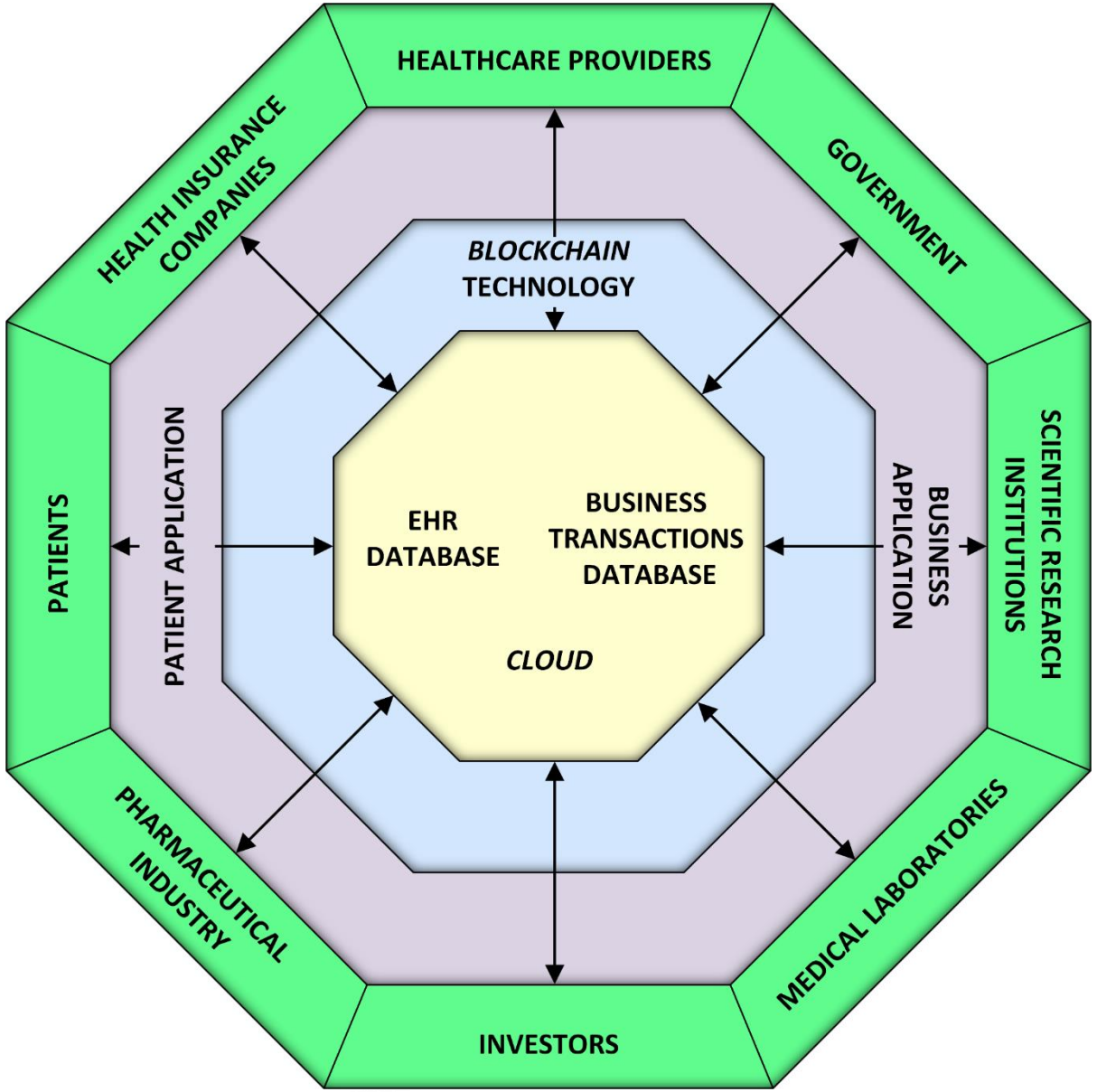
- Blockchain represents a reliable and transparent mechanism for data storage and distribution.
- Main concepts of blockchain technology that provide benefits are:
  - Decentralization of data, coupled with encryption, ensures that there are no single points of failure.
  - Data broadcasting is permissionless - anyone can contribute to democracy.
  - Consensus algorithms ensure that the most probable version of the truth is created.
  - Every transaction recorded is time stamped, providing a fully transparent, auditable chain of events.
  - By cryptographic hashing and crypto-economics, the record censorship is made free and incentivizes a good behavior.

Theoretical Background

- Blockchain offers an innovative approach to remodelling the healthcare system.
- Main areas for application in healthcare sector:
  - electronic health records that are patient centric,
  - supply chain transparency,
  - management and sharing of patient data,
  - drug traceability,
  - cryptocurrency payments.
- In terms of cybersecurity, blockchain technology can be used to minimize the possibility of compromising patient safety and healthcare services delivery.

Proposed Model

- We have developed a model of a digital healthcare ecosystem based on blockchain technology with the following characteristics:
  - The core of the model is represented by two databases – patient health records and data of business transactions carried out by the health institution with other stakeholders in the digital health ecosystem.
  - In relation to patients, the formulation of the model is patient-centric, thus promoting a qualitatively new level of data interoperability.
  - Institutional data interoperability is supported in the proposed model through the exchange of information of the healthcare institution with other stakeholders.
  - Key data transactions in the proposed model are based on the application of blockchain technology.


HEALTHCARE PROVIDERS
GOVERNMENT
SCIENTIFIC RESEARCH INSTITUTIONS
MEDICAL LABORATORIES
INVESTORS
PHARMACEUTICAL INDUSTRY
PATIENTS
HEALTH INSURANCE COMPANIES
BLOCKCHAIN TECHNOLOGY
PATIENT APPLICATION
BUSINESS APPLICATION
EHR DATABASE
BUSINESS TRANSACTIONS DATABASE
CLOUD

Software Application

- For the purpose of the proposed multi-layered model, we have developed a Web3 decentralized software application – *BCHealth* (BlockChain Healthcare), which uses the following main technologies:
  - IPFS (Interplanetary File System). Patient EHRs and business trlansactions data are cryptographically encoded and archived on IPFS. User accounts and documents metadata is stored in a complementary MongoDB Atlas database.
  - Ethereum blockchain network. Hashes of documents archived in IPFS are recorded in Ethereum, providing security and immutability. Ethereum holds application smart contracts, which allow management of blockchain stored data.
  - Metamask add-on software was used for coupling the application with Ethereum accounts and corresponding smart contracts deployed in blockchain.
  - JavaScript, Remix IDE, Truffle and Ganache were used for developing the application itself.

Software Application

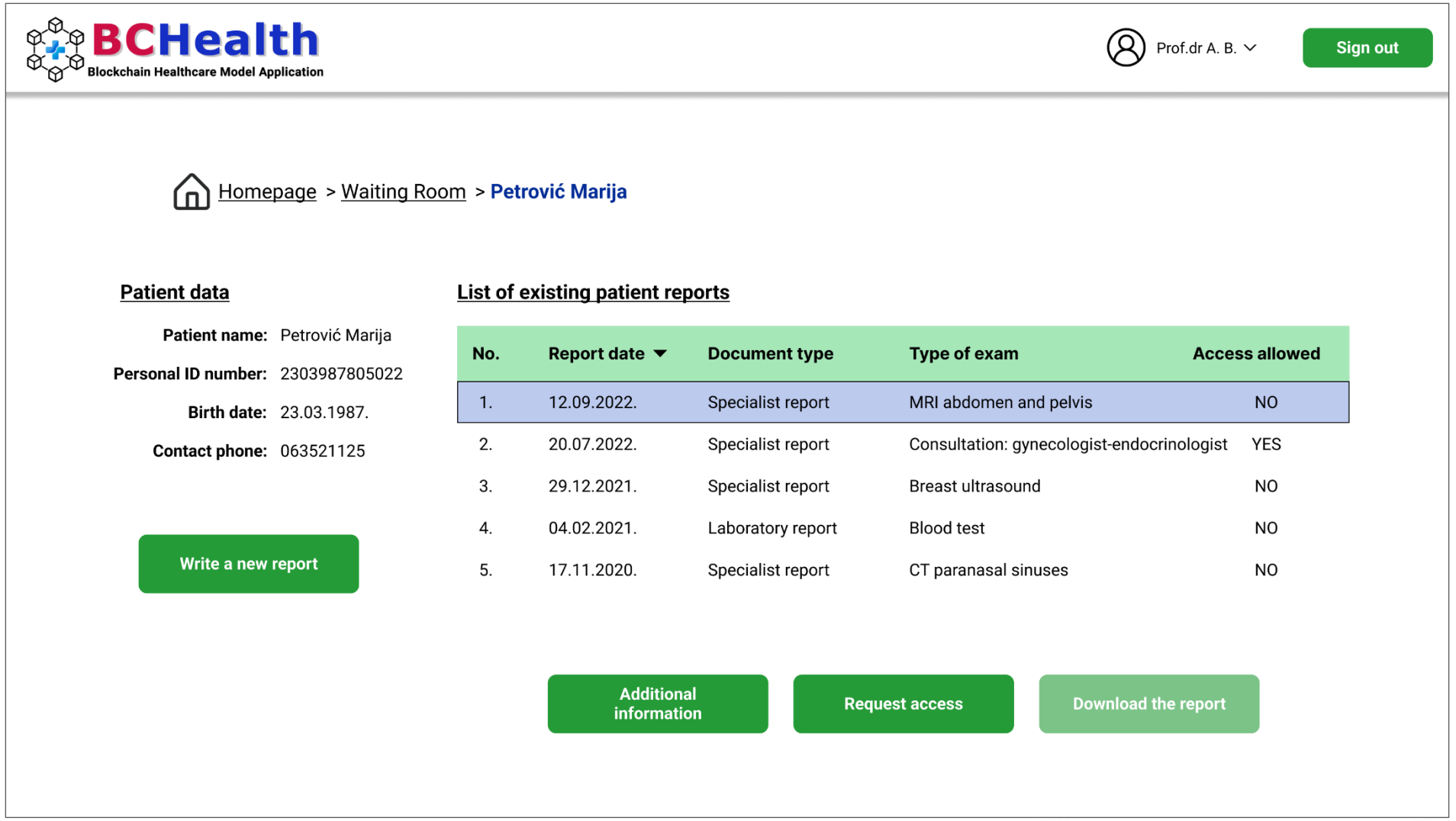
- Main components of the developed *BCHealth* application are:
  - Healthcare provision – used by medical personnel to generate and securely store health reports, and by patients, to access personal EHRs.

    Patients are owners of their EHRs, with the possibility to share them with interested stakeholders.

  - Business correspondence – used by stakeholders of healthcare ecosystem to securely store documents generated in business transactions.

    The owners of safely stored business documents are stakeholders involved in a particular transaction.


BCHealth
Blockchain Healthcare Model Application
Sign in
An authorized Ethereum account is required to use the system.
For further information, please contact the system administrator.
admin@bchealth.net


BCHealth
Blockchain Healthcare Model Application
Prof.dr A. B.
Sign out
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Patient data
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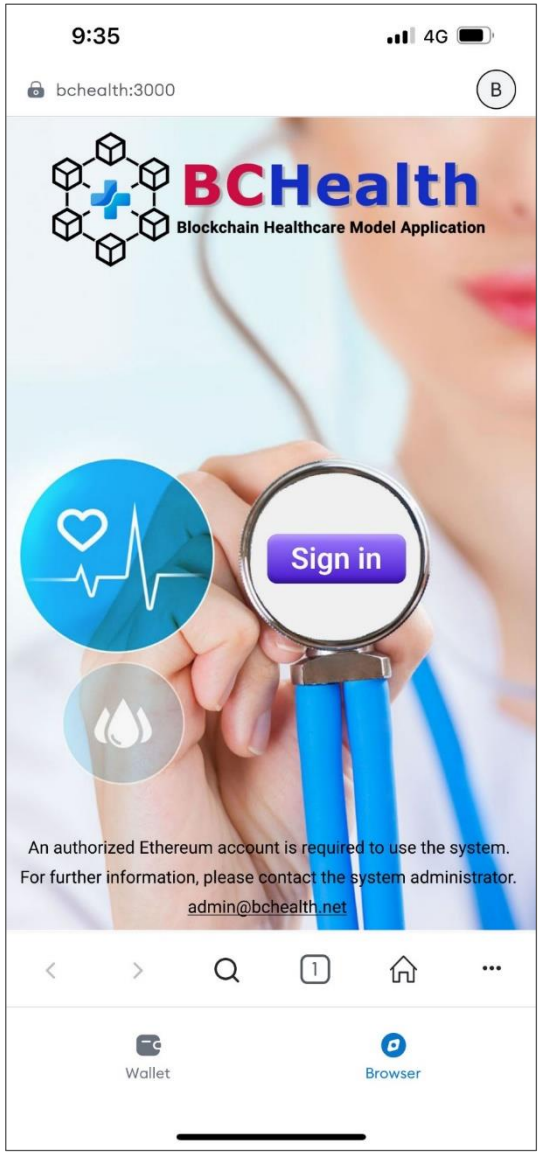
Personal ID number: 2303987805022
Birth date: 23.03.1987.
Contact phone: 063521125
Write a new report
List of existing patient reports
No. | Report date | Document type | Type of exam | Access allowed
1. | 12.09.2022. | Specialist report | MRI abdomen and pelvis | NO
2. | 20.07.2022. | Specialist report | Consultation: gynecologist-endocrinologist | YES
3. | 29.12.2021. | Specialist report | Breast ultrasound | NO
4. | 04.02.2021. | Laboratory report | Blood test | NO
5. | 17.11.2020. | Specialist report | CT paranasal sinuses | NO
Additional information
Request access
Download the report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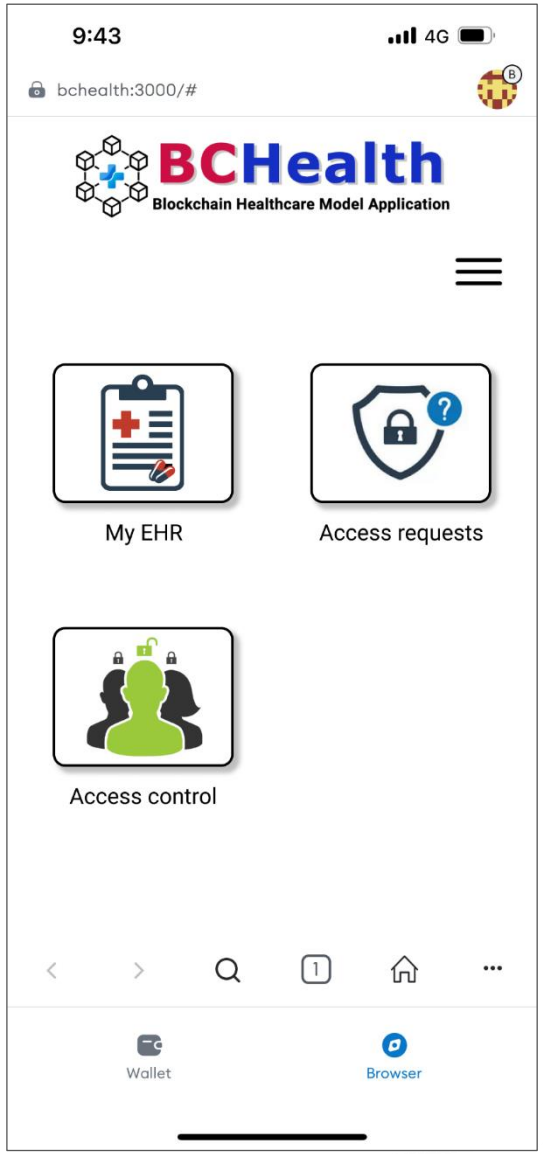
4G
bchealth:3000
BCHealth
Blockchain Healthcare Model Application
Sign in
An authorized Ethereum account is required to use the system.
For further information, please contact the system administrator.
admin@bchealth.net
Wallet
Browser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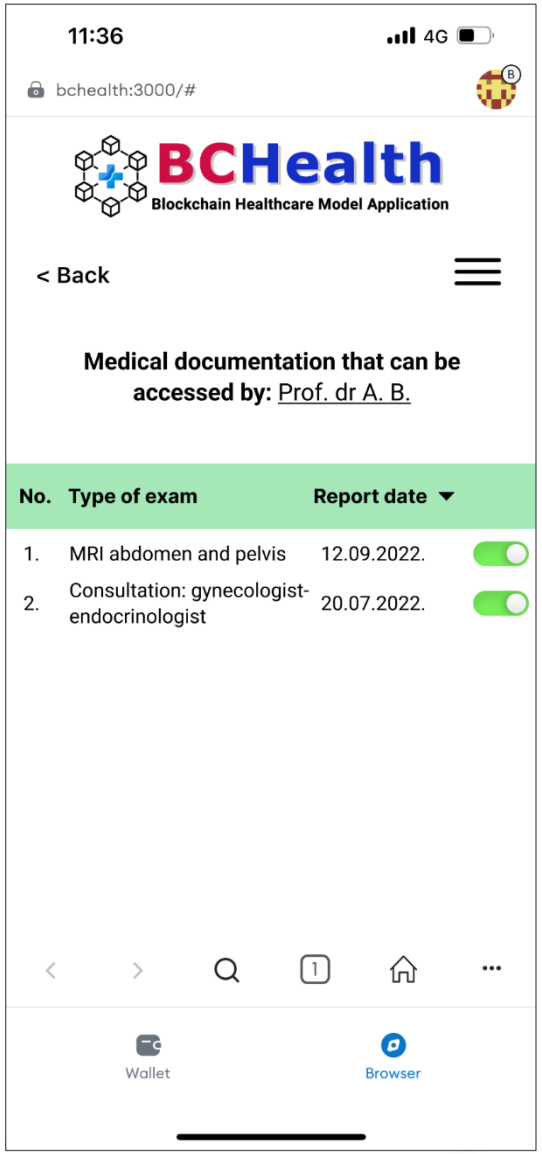
BCHealth
Blockchain Healthcare Model Application
My EHR
Access requests
Access control
Wallet
Browser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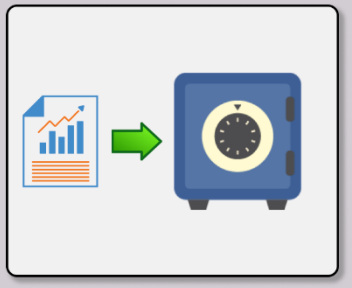
BCHealth
Blockchain Healthcare Model Application
< Back
Medical documentation that can be accessed by: Prof. dr A. B.
No. Type of exam Report date
1. MRI abdomen and pelvis 12.09.2022.
2. Consultation: gynecologist-endocrinologist 20.07.2022.
Wallet
Browser

BCHealth
Blockchain Healthcare Model Application

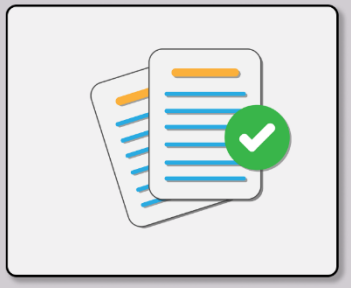
A. N.

Sign out

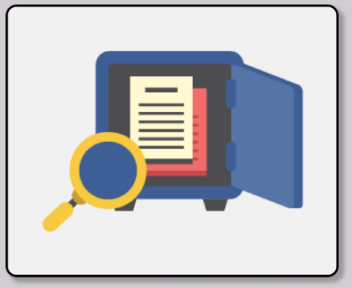
Homepage



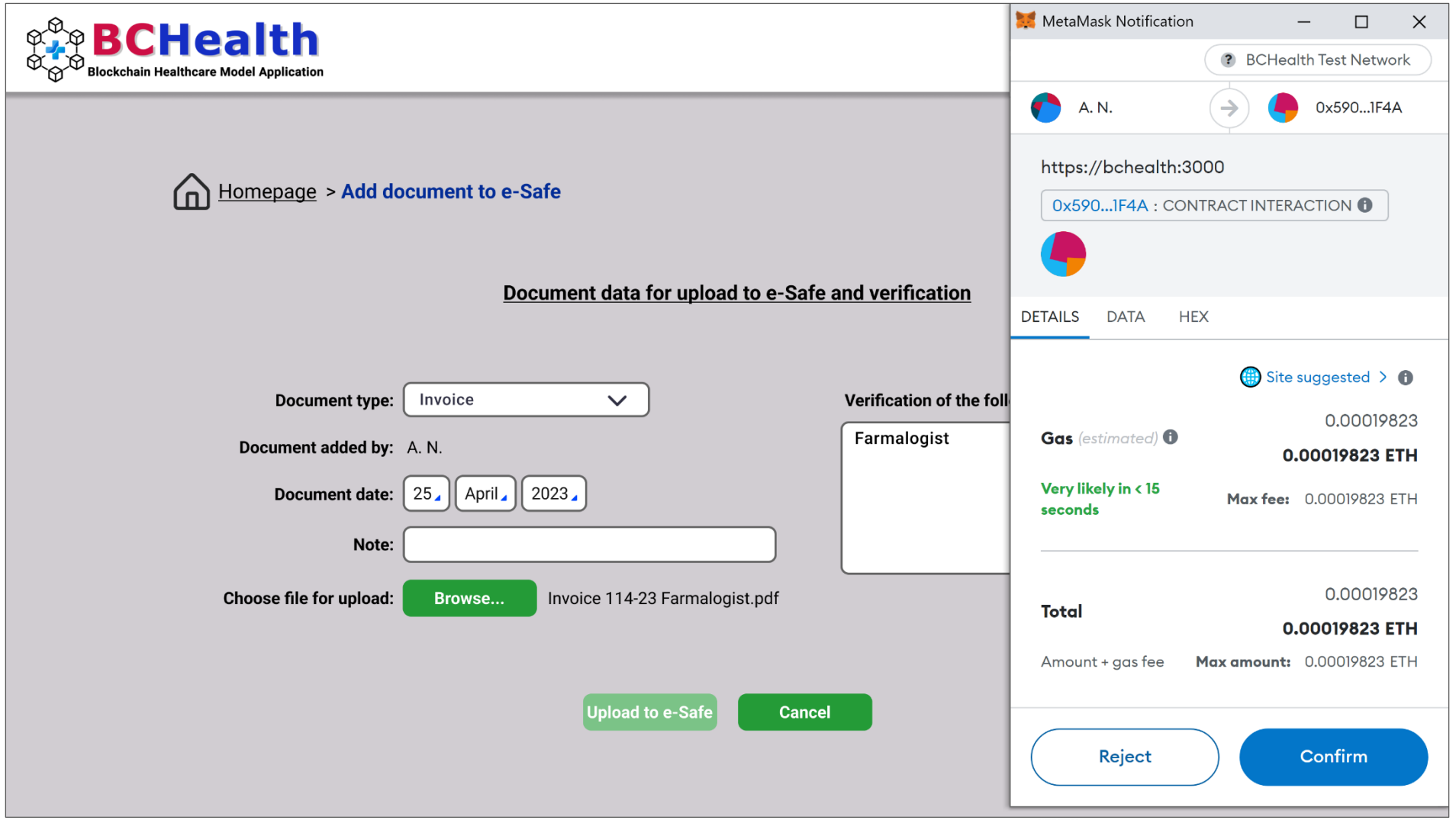
Add document to e-Safe



Document verification



Archived documents overview


BCHealth
Blockchain Healthcare Model Application
Homepage > Add document to e-Safe
Document data for upload to e-Safe and verification
Document type: Invoice
Document added by: A. N.
Document date: 25 April 2023
Note:
Choose file for upload: Browse... Invoice 114-23 Farmalogist.pdf
Verification of the foll
Farmalogist
Upload to e-Safe
Cancel
MetaMask Notification
BCHealth Test Network
A. N.
0x590...1F4A
https://bchealth:3000
0x590...1F4A : CONTRACT INTERACTION
DETAILS
DATA
HEX
Site suggested
Gas (estimated)
0.00019823
0.00019823 ETH
Very likely in < 15 seconds
Max fee: 0.00019823 ETH
Total
0.00019823
0.00019823 ETH
Amount + gas fee
Max amount: 0.00019823 ETH
Reject
Confirm

Implementation

- BCHealth system was implemented in a test environment set-up in a private healthcare clinic in Novi Sad, Republic of Serbia.
- The process of practical application of software solutions was carried out through the following stages:
  - I Initiation phase,
  - II Stabilization phase,
  - III Phase of functional application.
- Both healthcare and business components were tested by corresponding users – medical and administrative staff and patients.

Evaluation

- The evaluation process of the proposed model was carried out through two phases:
  - evaluation of the implemented solution,
  - identification of key factors that influence the implementation process of the presented model and mapping of cause-and-effect relationships important for the implementation process.
- Based on Benefits Evaluation Model (Canada Health Infoway), key indicators of application functioning were defined and monitored during and after implementation:
  - System quality,
  - Information quality,
  - Service quality,
  - User satisfaction,
  - Achieved quality,
  - Productivity.

Evaluation

- To evaluate the model, a structured interview and assessment scale were created according to the identified key performance indicators.
- The results of the interviews and the analysis of the ratings on a scale from 1 to 10 for the healthcare component of *BCHealth* system indicated a high degree of estimated quality of the application by the users - medical staff and patients/clients, as well as high satisfaction with the use of the application.
- The results of the conducted interview and assessment on a scale of 1 to 10 for the business component of *BCHealth* system indicated a high rating of the application's performance, as well as its acceptance by the users.

Evaluation

- In order to determine the key factors that influence the process of implementing the developed model and map the cause-and-effect relationships, a survey was conducted after the application of the software solutions.
- Choice of variables for survey was based on TAM (Technology Acceptance Model) and UTAUT2 (Unified Theory of Acceptance and Use of Technology) modification.
- Structural Equation Modeling (SEM) was used to examine the dependence between the constructs used in the model and the expected user behavior when it comes to the implementation of blockchain technology in healthcare.
- Using the PLS-SEM algorithm (SmartPLS software), the measurement model was evaluated.

Evaluation

- By analyzing the evaluatory data, key motivating factors for the adoption of blockchain technology in the healthcare sector were identified, namely:
  - Expected effort,
  - Social impact,
  - Price value and
  - Expected performance.
- In the further work and follow-up research, attention should be paid precisely to these constructs.

Conclusion

- The applied technical solutions, which ensure the functioning of the proposed model, have shown that advanced operation, cooperation, and trust among stakeholders, founded on the security of both healthcare and business data flow, can be achieved by using the blockchain based digital healthcare ecosystem.

- Promotional strategy for the application of blockchain technology in the healthcare sector of the Republic of Serbia can be based on:
  - highlighting the security that blockchain technology provides and the justification of investing in the development of healthcare applications based on this technology,
  - indicating the impact on increasing the quality of services and business in the health sector by applying blockchain technology.

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Thank you!

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