

Digital Passport for Unmanned Vehicles

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Abstract—In this work, a system for issuing digital passports for unmanned mobile robots was developed. The system uses Ethereum Blockchain and peer-to-peer technologies to send messages. As a result of registration of an unmanned robot (for example, an unmanned aerial vehicle or an autonomous marine vehicle), a person receives a copy of the passport and a unique and immutable identifier protected by cryptography methods. The system is completely decentralized, so it is not affected by the disadvantages of a centralized system such as a single point of failure.

I. INTRODUCTION

Today, individual countries have different solutions to the problem of unmanned aerial vehicles (UAVs) accounting. For example, in the USA there is the Federal Aviation Administration, which allows to register drone [1], in Belgium there is a Belgian Aviation Register [2], and similar structures exist in other countries.

More accurately, FAA proposes to register an unmanned areal vehicle via their website [1]. A person who is willing to register a drone must provide the following information:

- Email address;
- Credit or debit card details;
- Physical address / mailing address;
- Model of your unmanned aircraft.

After the registration FAA gives a unique identifier which should be put on the drone. Belgium has a similar system. In Russia, the law on the registration of UAVs requires the registration of any drone weighing 0.250-30 kg, and registration is carried out for a full 10 days [3]. Thus, such systems are country specific and fully centralized solution, so there aren't an analog of fully decentralized and country free registration system for mobile robots.

According to the forecast for 2025, the number of drones will only grow [4]. In addition to drones, other mobile unmanned platforms appear, such as autonomous marine vehicles designed to collect data on the state of water.

Therefore, the field of registration of unmanned vehicles will face great challenges. Firstly, state regulators form only local registers of unmanned aerial vehicles, so this passport does not allow the use of UAVs outside the country. Secondly, a growth in the number of unmanned vehicles will only increase the cost of bureaucracy. Thirdly, the current registration method does not guarantee unambiguous binding of an unmanned device to its owner. Moreover, it does not provide a record of the devices activities at all, which may be

necessary, for example, in legal matters or in recovering a case of violations.

Thus, in the near future, a unified global accounting system for mobile unmanned robots with the binding of working data to a specific device and owner will be required.

II. USED TECHNOLOGIES

In fact, the system is multi-layered and represents a rather complex interconnection of some technologies. Two main parts can be distinguished:

- Decentralized application (Dapp) — an application that provides user interface based on Ethereum JavaScript API similar in functionality to a regular website;
- Registration software which separated from user (relatively speaking the backend part).

The basis of backend part is the blockchain platform Ethereum. Blockchain is a distributed data structure comprising a chain of blocks [5]. Blockchain acts as a distributed database or a global ledger which maintains records of all transactions on a network.

Ethereum Blockchain introduces new term — smart contracts [6]. They are small programs placed in the blockchain. Contracts allow to do some useful work by sending transactions and storing a valuable data structure. To interact with them, decentralized applications are usually developed.

IPFS (InterPlanetary File System) [7] is used for two tasks: 1) to organize the exchange of messages about demand and offers between network participants; 2) to store useful data that is too large to be placed directly on the blockchain.

Finally, the Dapp provides the connection between the user and the smart contract. Depending on the task, the Dapp can send transactions to the address of the smart contract or read the necessary information [8].

III. SCENARIO DESCRIPTION

The agent works in the network of Robonomics protocol [9], which takes care of message delivery and standardization of the communication. Let's take a brief look at the main points.

The first stage is a formation of the message. A person (promisee) fills in all the required fields in message, and then the Dapp forms a message. The message includes a unique identifier for the registration system, all fields from a promisee,

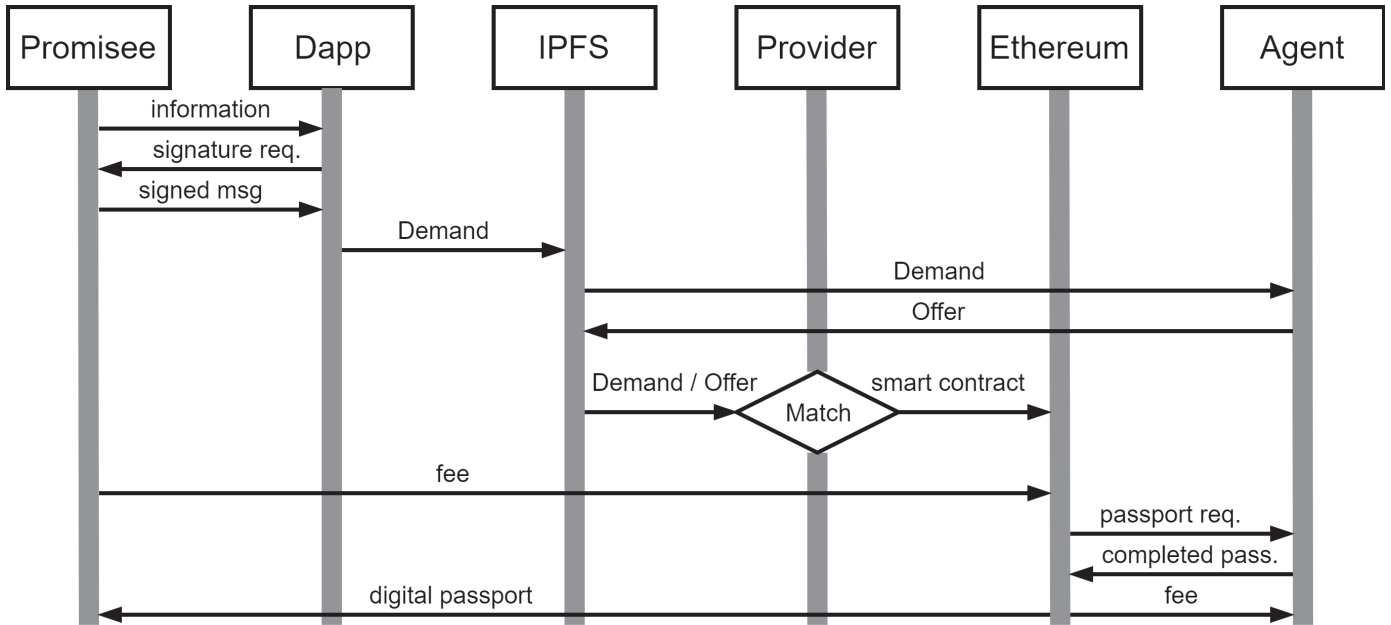


Fig. 1. User scenario, the order of stages is indicated from top to bottom: 1) Promisee enters all the necessary information in Dapp; 2) Dapp forms a message and offers to sign it to the promisee; 3) The promisee signs a message with private key; 4) The message called Demand is broadcast in IPFS network; 5) The agent catches the message and sends the corresponding Offer message; 6) A liability smart contract in Ethereum blockchain is created via provider; 7) Funds for the service are transferred from the promisees account to the liability contract; 8) The agent fills in the required fields in the digital passport and sends it; 9) Funds are transferred to the agent’s account and the promisee receives an email letter with a link to a unique identifier.

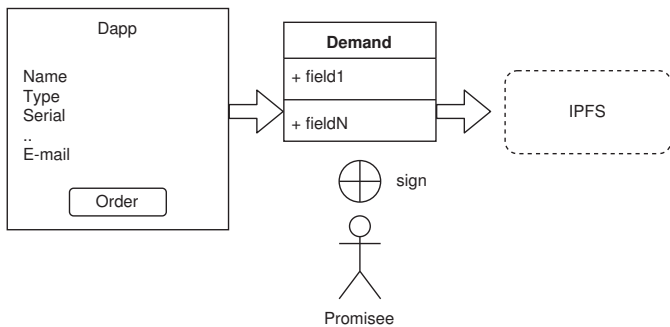


Fig. 2. Formation of the message

token address, price, deadline of process and digital signature of a promisee.

At the second stage the agent sees this message in the IPFS network and sends the corresponding Offer message.

At the third stage a provider joins the process. The provider in the Robonomics network listens to all messages such as Demand, Offer and Result (in our case — link to digital passport). If it sees two messages with the same behavior model, parameters, token and price, it creates a liability smart contract in the Ethereum Blockchain. At this stage, the funds are transferred to the created liability contract, and the agent receives a new registration task.

Then, the agent fills in all fields, passport is issued in full and the link to passport is sent to the promise e-mail.

The liability contract becomes a digital passport, and its blockchain address becomes a unique identifier. The liability contract contains the fields presented in the Table I.

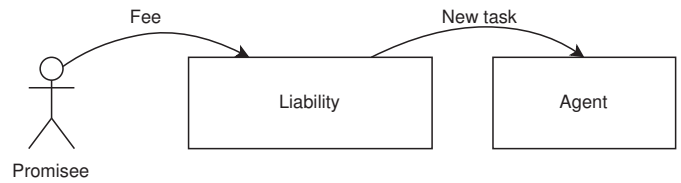


Fig. 3. Transfer of funds to a smart contract

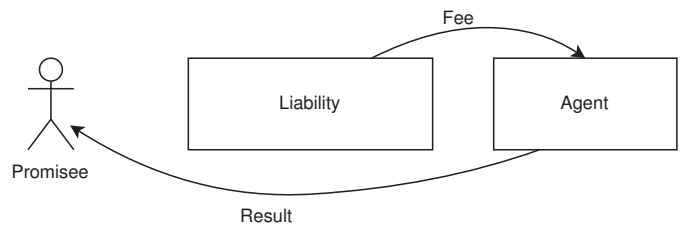


Fig. 4. Transfer of funds to the agent and sending of result to the promisee

So the entire Table I is a digital passport for a specific robot and owner. Some fields in the Table need an explanation:

- Lighthouse — this is a named communication channel in the Robonomics network. It organizes the work of providers.
- Validator — third party registrar which can check the result.

If a validator is specified, then only it can establish the correctness of the digital passport. Until the validator has signed the result message with its own private key, the tokens will not be transferred to the agent’s address.

TABLE I. THE LIST OF LIABILITY SMART CONTRACT FIELDS

Field	Type	Meaning
address	Ethereum address	Smart contract address in Ethereum
model	IPFS hash	Behavior model (unchangeable)
objective	IPFS hash	Dynamic parameters (changeable)
result	IPFS hash	Result with main fields of the digital passport
promisee	Ethereum address	Promisee address
promisor	Ethereum address	Registration address of agent
lighthouse	Ethereum address	The address of the lighthouse
token	Ethereum address	Payment token address
cost	number	Amount of tokens
validator	Ethereum address	Validator address
validatorFee	number	Number of tokens for validator

Writing all the information to the blockchain is very expensive, so only IPFS-hashes of the files is entered in the passport. However, these files are replicated to several machines, thus achieving high system reliability.

Due to the peculiarities of blockchain systems and hash functions, it becomes impossible to replace such a passport or receive it on another day. And digital signatures of all participants make the registration and issuance process transparent.

IV. RESULTS

The example of the system can be seen here [11], there is also a video demonstration [10]. We tried to register our drones at this address: <https://etherscan.io/address/0x321407A52b8c0B041E0df5331EbFdA2dCe946299>. Then we used the address to link the route to the drone in the Dapp [11].

The source code of the system is posted on Github [12].

V. CONCLUSION

Thus, the digital passport system has been developed that uses peer-to-peer technology and cryptography in its work. With the help of the identifier, it becomes possible to directly link information about the robot's actions with a specific robot.

For example, we can link with the passport the flight log of the UAV or hash of the video that it recorded.

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