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# Sharing Physical Objects Using Smart Contracts

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**Abstract**

Networked digital *sharing economy services* enable the effective and efficient sharing of vehicles, housing, and everyday objects. However, contemporary online sharing platforms face several challenges related to the establishment of trust among peers, as well difficulties to deal with the growing number of intermediaries (e.g., payment, insurance) needed to ensure an adequate service delivery. We designed and developed “Just Share It” (JSI), an interactive system that enables the sharing of personal physical possessions (e.g., power tools, toys, sports gear) by directly connecting lenders and borrowers, as peers, through mobile technology. The JSI system utilizes a blockchain ledger and smart contracting technologies to improve peer trust and limit the number of required intermediaries, respectively. In this submission, we briefly review emergent challenges in this space, describe the JSI prototype system and its trust model, and reflect on future architectural opportunities for an eventual “in the wild” deployment.

**Author Keywords**

Sharing economy services; blockchain; smart contract; smartphone app; trust; disintermediation.

**ACM Classification Keywords**

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

## Introduction

With the rapid adoption of online sharing economy services such as Airbnb, Uber, and Peerby, people increasingly share physical artifacts, such as apartments and rooms, vehicles and rides, and, more broadly, everyday objects (e.g., power tools). The convergence of social, mobile, and cloud computing has enabled efficient and effective access to shared resources and lowered the entry barrier for consumers. However, prior research has identified two key challenges within sharing economy services: (1) the weak levels of trust among peers [8]; and (2) the burden of dealing with intermediaries (e.g., insurance companies, financial institutions), especially when services or goods have been inadequately delivered [5].

Today's digital sharing services address the issue of trust by incorporating reputation systems into their online platforms [13], where peers can rate each other in the form of textual summaries, numerical scores and imagery. These reviews guide end-users' decision-making to engage in an online transaction, and influence perceived trustworthiness of the peers [11]. Nonetheless, online marketplaces receive a growing number of "fake reviews" [7], which in turn aggravate the issues of trust among participants in sharing economy platforms.

To limit the need for intermediaries, several sharing economy services provide (limited) insurance to protect owners of the shared resources against misuse, damages, or theft. However, these often come with convoluted terms and conditions [12]. Similarly, dealing with "traditional" insurances (e.g., home, vehicle, household contents) can be equally confusing. Besides that, many "insurance gaps" exists in which owners of the shared

resources are covered neither by an online sharing platform nor by personal insurance (e.g., when a driver is *en route* to a specific passenger) [2]. Moreover, grassroots sharing initiatives and local sharing communities (e.g., municipal libraries of shared things) with no centralized platform in place might not have any means to offer own insurances.

Today's popular blockchain technology and its smart contracting feature may help to (1) increase trust within online sharing communities; and (2) simplify the process of dealing with various intermediaries, especially in the case of a dispute. To explore this potential, we created "Just Share It" (JSI), a system and smartphone application that facilitates the sharing of physical objects using smart contracting technology. Firstly, JSI implements a reputation review system using the blockchain's immutable storage technology, which offers review integrity and prevents retrospective review editing. Secondly, it provides a platform for conflict resolution (using smart contracts) in order to resolve potential disagreements between a lender and a borrower regarding the state of a shared item.

## Related Work

Related work falls into two main areas: (1) studies of local sharing economies involving personal artifacts; and (2) nascent research that looks into applying of blockchain-based technologies for social sharing.

### *Local Sharing Economies of Personal Artifacts*

The recent development of sharing economy platforms and services enabled people to temporality access and experience underutilized physical resources, such as housing, fertile land, and vehicles [1]. Beyond well-known commercial enterprises such as Uber or Airbnb,



**Figure 1.** Envisioned scenario. Skis, person, touring ski, confused, bank icons by Sergey Demushkin, Vaibhav Radhakrishnan, Marc Serre, Andrew Doane, Icon Fair, from thenounproject.com.

an increasing amount of community groups and organizations have formed collections of shared things such as tools coops [4] and toys libraries [9]. Those grassroots initiatives often prioritize environmental, social, and cultural values over economic gain [6]. However, these local communities face several challenges related to their creation, maintenance, and nurturing [8]. In this work, we focus on the technological challenges that pertain to establishing inventories of shared things and handling sharing transactions using secure and transparent distributed ledger technologies.

#### *The Use of Blockchain Technology*

Recent work of Elsdén et al. [3] offers a typology of blockchain-based applications, including crowdfunding, payment services, voting, copyright management, supply-chain tracking, authentication services, and distributed organizations. Researchers emphasize that all of these applications have to deal with issues of establishing online identity, managing online privacy, and peer-to-peer online collaboration [3]. Pazantis et al. [10] specifically explore the potential of blockchain technologies in the context of the sharing economy and detailed the concept of value creation in peer-review and peer-evaluation systems. They have also argued for the importance of maintaining human interactions in “trustless” blockchain ecosystems, especially in the context of sharing personal resources and assets. Drawing on their recommendation, in our JSI smartphone application we instruct the peers to enter their contact details (e.g., a phone number, an email or an instant messaging handle) in order to get in contact with each other to arrange necessary details of a transaction, for example to reach an agreement about an item’s delivery and return.

#### **Scenario**

A potential lender (Alice) is interested in making some extra money from her infrequently used high-end ski-touring gear. She thus creates a listing in a local sharing economy service. Bob responds to the ad, gets in touch with Alice, borrows the equipment (Figure 1a), and eventually goes on a ski-touring trip. During his trip he damages the gear on rocky terrain (Figure 1b). Once Bob returns the gear, Alice asks Bob to pay for the damages. While Alice’s insurance will not pay as the skis were rented out, Bob finds out that his insurance does not pay as he opted out of the “gross negligence option” in his premium (Figure 1c). In the end, Bob agrees to pay half of the amount Alice asked for. Both remain unhappy with the overall transaction.

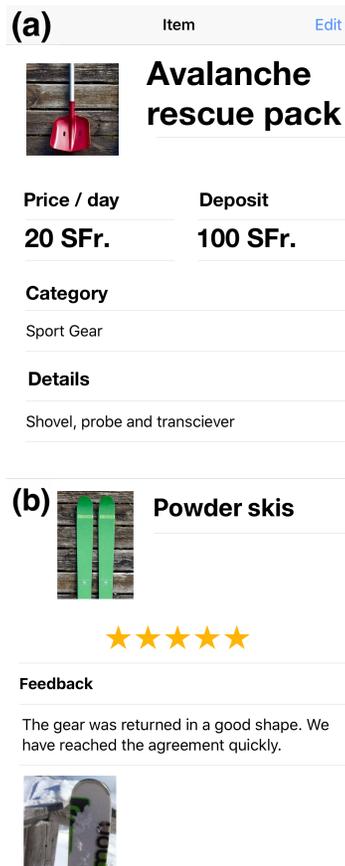
#### **JSI Ecosystem**

“Just Share it” (JSI) is a software ecosystem to support the efficient sharing of personal physical objects. It is comprised of three components:

1. A cross-platform smartphone application that connects lenders and borrowers.
2. An underlying layer of smart contracting technology (using the Ethereum platform), which facilitates online contractual agreements.
3. A backend server that handles account management and maintains personal inventories of shared items.

#### *Mobile Application*

The smartphone app allows lenders to create personal inventories of items they would like to lend. A lender can assign a name, a category and an item description, and set a security deposit and optional period-based



**Figure 2.** (a) The lender’s view of an item; (b) The review left to a borrower after the transaction is completed.

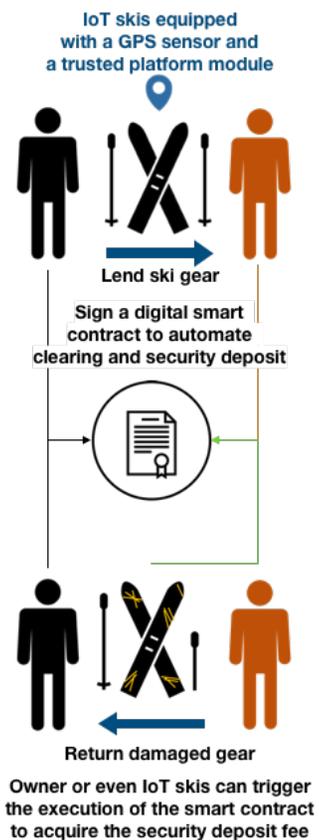
price (Figure 2a). A borrower can search for an item in her vicinity and subsequently make a request to borrow it. The lender can then accept or reject the request. In the current iteration of the prototype we did not provide a private messaging functionality within the app, but rather rely on existing services such as WhatsApp, E-mail, or simply a phone call for parties to come to an agreement (e.g., to arrange an item’s pickup/delivery and return) – in-app messaging could obviously be trivially integrated into a future version. Our mobile application was in part inspired by our Roaming Objects system [4], a tool-sharing platform that provides an online presence to everyday objects by augmenting them with the borrowers’ personal experiences in the form of user-generated reports/reviews. Drawing on the successful deployment of Roaming Objects, we incorporated the reputation review mechanism in the JSI app. Lenders and borrowers can rate their overall experience of interaction with each other in the form of images, ratings, and textual descriptions (Figure 2b). The purpose is twofold: borrowers provide “histories of use” for a given shared object, while lenders can report whether the object was returned in good condition. If needed, the app implements a dispute resolution mechanism to resolve potential transaction conflicts (see the *Trust Model* section). JSI uses the Web3 JavaScript framework to interact with blockchain smart contracts, which we explain in more detail below.

#### *Blockchain Smart Contracts*

JSI uses two types of smart contracts: *transaction smart contracts (TSC)* and *rating smart contracts (RSC)*. A TSC models the state of a transaction from the moment a borrower’s request is accepted by a lender, to the moment when the shared item is returned. When a lender accepts a borrowing request, a

new TSC is created containing both numerical identities of lender and borrower, as well that of the requested item. At this stage, the security deposit and the usage fee as specified by the lender are automatically transferred from the borrower’s account to the TSC. Note that, we use an external service ([www.coinmarketcap.com](http://www.coinmarketcap.com)) to automatically convert all fees from user’s base currency (e.g., Swiss Francs) to Ether cryptocurrency. Once the sharing period is over and the item is returned, the lender can request to terminate the TSC. At this point, the item usage fee will be transferred from the TSC to the lender’s account. In case of a damaged or non-returned item, a lender can also request the security deposit that is “stored” in the TSC. All payments require a 2-out-of-3 multi-party agreement. Typically, both the lender and the borrower agree and hence can trigger the payout or payback. However, in the case of a disagreement, a trusted third-party can break the tie and decide on who receives the fee and/or deposit, thus terminating the TSC. Until then, the all fees are locked in the TSC.

After terminating a TSC, both lender and borrower may rate each other’s services regarding the shared item. Rating results are kept in users’ individual rating smart contracts (RSCs), which are created as a part of users’ registration. To minimize blockchain processing overhead (and minimize transaction execution costs), we combine blockchain-based RSCs with off-chain storage. Detailed rating data (textual and image-based reviews) are stored in an off-chain database, while a single rating score (i.e., an average) is committed to the user’s RSC. To ensure the integrity of the detailed rating data, its fingerprint (computed using a hash function) is also committed in the user’s RSC. Each RSC has a built-in access control mechanism which prevents users to rate



**Figure 3.** Future use case, where the lender (in black) provides the GPS-enabled ski-touring gear to the borrower (in red), and eventually executes smart contract once received damaged equipment back. Skis, person, contract icons by Sergey Demushkin, Vaibhav Radhakrishnan, Chameleon Design, from thenounproject.com.

themselves or to rate a fictitious sharing experience (i.e., “fake reviews”), but also to retrospectively modify their historical ratings.

We designed both TCS and RCS using Solidity, a contract-oriented programming language. We deploy contracts to an Ethereum blockchain testnet through Infura – a service provider for Ethereum infrastructure (see *Permissioned vs Open Blockchains* section for reflections on “in the wild” deployment opportunities).

#### Backend Server

The backend server administers inventory, storage and retrieval of the shared items for each user, and handles its profile data. It is implemented using JavaScript-based frameworks (Node.js and Express.js) and non-relational database (MongoDB) to enable robust deployment and scaling. The server can be accessed using a RESTful API. As in the mobile client, we use the Web3 framework to manage smart contract interaction at the server side. The backend uses a push notification mechanism to inform users throughout the transaction stages (accepted, rejected, returned, in-dispute).

#### Trust Model

Trust in JSI comes from two factors. Firstly, each user has a (pseudo-)identity (e.g., picture, name, location) as opposed to the completely anonymous alphanumeric identities used in many other blockchain applications (i.e., Bitcoin). Secondly, reputation scores and reviews allow peers to build-up a reputation, thus allowing others to assess their perceived level of trust prior to engaging in a sharing transaction.

Obviously, this is far from guaranteeing a conflict-free sharing experiences. A malicious lender can fail to de-

liver an item after accepting a borrowing request and then claim for compensation of her allegedly lost item, or incorrectly report that a returned item was damaged by the borrower. A dishonest borrower may equally refuse to pay the security deposit for an item she broke. JSI thus relies on “multi-party” smart contracting, similar to Bitcoin’s OP\_CHECKMULTISIG payments, to resolve such disputes. In case of a disagreement between the lender and the borrower, a trusted third-party<sup>1</sup> is needed to resolve the dispute by deciding who gets how much of the already pre-paid fees for the disputed transaction.

Ultimately, we imagine that the role of this trusted third party would be delegated to the borrowed things themselves. In an IoT-enabled future, a “smart thing” would feature sensing, computing, and communication capabilities, allowing it to detect its own state throughout its use (Figure 3). Should a dispute between the involved peers arise, the smart contract would then resolve any disagreement based on evidence from the actual borrowed object. While such a solution would effectively remove any intermediaries from the system, it would need to carefully assess (and address) any vulnerabilities of a malicious peer bypassing an item’s self-sensing system.

#### Permissioned vs Open Blockchains

The original blockchain model (e.g., Bitcoin and Ethereum) is “open” – anyone can join the network and participate in the consensus-building process when executing a transaction (i.e., appending a new data block,

<sup>1</sup> The assigned intermediary can listen to both parties and inspect any system logs for evidence. Note that, however, a detailed description of how one can resolve a dispute is outside the scope of this work.

creating new smart contracts, or editing existing ones). This model is referred as a “permissionless” (or public) blockchain. In this model, network participants do not trust each other, and they are not required to reveal their true identity. However, they rely on a computationally expensive protocol (“Proof-of-Work”) to achieve consensus in order to maintain the integrity of the chain and to build up trust.

Contrary to this, there is the “permissioned” (or private) blockchain, which restricts who can join the network and who can participate in the transaction execution process. Here, new transactions are validated by a subset of recognized entities, resulting in a more efficient consensus-building protocol. However, this model assumes that there exists some level of initial trust among network participants.

In both versions, performing a blockchain operation requires a user to pay a monetary fee. In the permissionless version, this fee acts as an incentive for network participants to validate a transaction: the lower the fee, the longer it will take for “the blockchain” (i.e., the community of participants) to commit a transaction to the ledger. As a consequence, the amount of money paid by peers for their transaction directly influences how quickly their contract would be executed.

Conversely, in the permissioned model, transactions are executed only by a recognized set of participants (and/or by the blockchain infrastructure provider). As a result, one can agree at the beginning on a fixed execution cost for all future transactions (e.g., by means of contractual agreement with the blockchain provider), removing the need for an incentive-setting pricing model. This would ensure constant transaction execu-

tion times and potentially reflect positively on the overall user experience with JSI.

In summary, depending on which blockchain model we select (permissionless vs. permissioned), there are several factors that can potentially impact a user’s experience with our system. Among such affected factors are: 1) user waiting times before an operation can be committed to the blockchain, 2) the initial trust level towards those that ensure ledger’s integrity, and 3) the level of active user involvement (i.e., cognitive load) when dealing with blockchain-based operations.

## **Conclusions and Future Work**

In this submission we outline the rationale, the design, and the architecture of the “Just Share It” (JSI) application. The JSI client runs on a mobile platform and incorporates blockchain and smart contracting technologies (using Ethereum, an open-source distributed computing platform). In a permissioned blockchain setting, JSI may offer reasonable costs and usability.

In a next step, we plan to conduct in-depth user studies with users of various established sharing communities (e.g., Peerby, Sharely). The aim of such studies is to identify challenges and opportunities related to the use of emerging blockchain-based ecosystems in digital sharing economy services; to evaluate the app’s usability, perceived usefulness and perceived trust; and to inform the design of mobile technology based on smart contracting.

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