Blockchain as Middleware for Exchange of Resources: The Cross-Company Loyalty Rewarding System Use Case

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ABSTRACT

Loyalty programs that allow customers to collect loyalty points are popular means for customer relationship building. At the moment, such points can be collected and spent only within the same shop (or shops from the same consortium), which makes it only interesting for customers visiting that particular store frequently. However, especially with the increase of e-shops, customers easily switch between stores. With this new shopping behaviour, such programs are less attractive and as such become less effective, requiring a more novel approach. One possibility could be to allow customers to collect and spent loyalty points across stores. In fact, this is just one use case of a more general issue. There are multiple cases in which people receive (digital) resources from organizations or other parties and want to use or exchange them across other organizations or parties. In this paper, we propose a generic framework that allows customers to exchange resources across different parties. We propose to implement this framework with a blockchain-based solution, making the customers in full control and awareness of their available resources as well as creating a decentralized, trustable and safe environment. We present the major research questions, the general concepts of our generic framework, the proposed solution, and a proof of concept of this solution.

CCS CONCEPTS

• Information systems ~ Data management systems

KEYWORDS

Loyalty systems, resource exchange system, customer resources, blockchain, smart contracts

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1 Introduction

Very often, during shopping (either online or in a physical store), customers receive loyalty points as a reward for purchasing items. Once they reach a certain threshold, these loyalty points act as credit that customers can use to get advantages within the store. These advantages include coupons, free items or other kinds of special offers. Stores offer these kinds of benefits to gain the loyalty of their customers, i.e. to encourage them to keep visiting their store. In most stores, registration is required (in order to get a membership card) to be eligible for collecting points. In general, shop owners use the registration info to send promotional material to the customers. For customers regularly visiting a particular store, this may be interesting. However, for customers who do not visit that store often, receiving all the promos may be annoying and loyalty points of that store may not have much value as it may be hard to reach the threshold. In addition, customers who visit lots of different stores need to manage many different cards (physically or in the best case electronically on their smartphone). Therefore, they may consider the registration as time-consuming and not worth the effort. This is a lose-lose situation: the customers miss out on the loyalty points that they would have earned otherwise, and the shop owners miss out on the opportunity to build a customer relationship with these buyers. Note that this situation does not only apply to physical stores but also for e-shopping where it is much easier to switch between online stores than in a physical environment.

Although some companies offer the service of a loyalty card that can be used in different shops (solving the issue of having an abundance of loyalty cards), the loyalty points are still collected and only usable within a single shop (or shops from the same consortium). This still does not provide a solution for the occasional customers and the shop hoppers. One way to overcome this issue, is to allow customers to make use of the different

loyalty programs more effectively: a solution that prevents them from missing out points by allowing them to consume the loyalty points collected in one store in another store and without the need of having a membership card for each store, in other words to have a cross-company loyalty rewarding system. But this raises several questions: How to exchange loyalty points between stores? The value of one loyalty point is not necessarily the same in all stores. Also, how will the earning of points in one store and spending them in another store be settled between stores? That means, if a customer buys a product in store A (and collects points) and spends the points in store B, how will store B actually get the money for its product and at which cost? Lastly, what are the benefits for the companies? This approach will also require a new business model.

In fact, the problem described is just one use case of a greater problem, which can be described as the need for a global system to store and exchange customer resources between organizations or systems. Resources can be any kind of digital information used by organizations and given as a kind of reward to their customers/clients/users, such as loyalty points, but also assets earned or purchased in a gaming environment, credits obtained in schools or from learning institutes, results obtained in serious games, penalty & bonus points used by social organizations or the government and much more. In such a global resource system, certain organizations are responsible for creating/awarding resources and others for letting the user consume these resources.

Our main goal is to create a generic framework for supporting the set-up of such an exchange platform. Such a generic framework can then be used by organizations to set up, in an easy way, a specific cross-company exchange platform, such as the proposed cross-company loyalty rewarding system, by configuring the components of the framework to the specific needs.

While storing and keeping track of resources is rather easy, the main challenge is to provide a generic solution for supporting the exchange of resources between different organizations, as this can require different conversions and agreements. For this we have developed a generic conceptual model that can be customized for the use case at hand. Furthermore, we have opted for a blockchain-based solution for supporting the exchange of the resources.

We opted for a blockchain-based solution primarily because blockchain allows to store data without the involvement of a central authority. Data in a blockchain is stored in a distributed manner and no single entity controls the data. Therefore, users can have full control over their data. For example, in the loyalty points case, customers are the authentic owners of loyalty points that they earned in stores. Therefore, they should be given full control over their points. Furthermore, a blockchain-based network ensures data integrity, since the current state of the data is constructed by examining transactions verified by all participants in the network. It also prevents data loss and maintains data security, since all participants maintain their own copy of the blockchain 'database'. We further explain this in section 5.

Since the example regarding a loyalty reward system is a good use case for the more general problem, we will keep referring to it further in the paper, and we will demonstrate the feasibility of this solution by an implementation of this loyalty reward use case.

The paper is structured as follows. In section 2 we discuss related work. Next, we discuss the issues and questions related to the development of such a generic framework and the research methodology applied (section 3 and 4), as well as our design decisions and the general architecture of the generic framework (section 5). We conclude by showing our contributions and future work (section 6).

2 Related Work

In the financial domain, blockchain technology receives a lot of attention for exchanging both digital currencies and (mobile) payment information (see [11]). Although related, the main goal of these systems is different.

Blockchain platforms are also considered in the domain of Internet of Things (IoT), (see [5] for an overview). In such applications, the blockchain technology is used to control the exchange of virtual as well as real world objects, such as energy, or e-bikes. In [3], a blockchain platform that enables the development of different distributed and peer-to-peer manufacturing applications in the context of IoT is presented. It claims to supports different applications. The closest related to our purpose is the registration of manufacturing assets & inventory.

In the context of loyalty programs, the company Joyn provides a loyalty reward system, which makes use of a so-called master card [9]. It offers various ways to allow customers to collect points in different participating stores. Users can request a physical card, or can download the smartphone application. An advantage of this system is that customers do not have to manage many different cards anymore. However the points of stores are not interchangeable. Points collected in a store can only be spent in that store. Hence, this is not a cross-company solution.

Open loyalty is a web portal which allows to build web applications regarding loyalty programs [6]. They claim to provide a highly customizable framework: rules allow to customize how and when points can be earned; levels allow to categorise customers into groups based on, for example, the number of owned loyalty points. It is not clear whether they allow for cross-company loyalty programs.

In [7], the authors discuss an exchange platform for digital assets. Although they have the same goal, giving users full control over their assets to be exchanged, the work seems to be in rather preliminary stage. The work is also focussing on a particular use case, while our aim is to create a generic framework for such exchange platforms.

To the best of our knowledge, the development of a generic framework for cross-company resource exchange systems, providing true ownership to their clients, based on blockchain technology has not yet been considered.

3 Problem Statement

As explained in the introduction, the loyalty reward system is just one use case used to describe the bigger problem: How can organisations/systems allow customers to use their collected resources across these organisations?

Resources can be any kind of digital information used in the organizations and rewarded towards their customers/clients/users, such as loyalty points, assets earned or purchased in a gaming environment, credits obtained in schools or from learning institutes, results obtained in serious games, penalty & bonus points used by social organizations or the government and much more.

To solve this problem, we aim to provide a generic solution that can be adapted by organizations to their specific use case. We opt for this approach because different use cases may have quite different requirements and implementing a single solution would be either too restricted or provides too many different features not needed in most cases. However, such a generic solution requires an easy to use customization mechanism. It should allow:

1. To specify the participating organizations
2. To customize the concept of "resource", as well as its "value" for each organization
3. To specify which organizations permit to exchange resources (not all participating organizations may be willing to exchange resources with all other participating organizations). It may even be required to limit the scope for the exchange. For instance, in our loyalty system, a store may allow to use the loyalty points collected elsewhere for its regular products but not for its exclusive products.
4. To specify the exchange rules for mapping the value of resources between organizations. Per use case, it may be useful to have some default rules, but exceptions should be possible, per organization as well as per product (family), as well as to specify settlement contracts between the participating organizations for the exchange of resources.
5. To customize the end-user (customer/client) interface according to the specified exchange rules, which should allow the end-user to inspect his wallet of resources and the possibilities to spend the resources.

Next to the customization mechanism, the generic solution should provide functionality for the actual data storage and resource exchange process, as well as providing functionality to be in line with privacy and data protection regulations, such as GDPR [13].

4 Research Methodology

We follow the six steps of the Design Science Research Methodology [10]: (1) problem identification and motivation, (2) definition of the objectives for a solution, (3) design and development, (4) demonstration, (5) evaluation, and (6) communication.

The problem identification and motivation have been addressed in the introduction, and we have elaborated on it in the problem statement. The aspects of the proposed solution will be presented in section 5. Currently, the design step focused on the architecture of the approach. We have demonstrated the approach by applying it in the context of a specific domain, namely the loyalty points use case. Next steps are the development of the generic framework and subsequently demonstrate and evaluate it. The design, implementation and evaluation will be done in an iterative way, where each iteration step improves on the previous one. For communication we will use the regular academic channels.

5 Proposed Solution

In this section we present the proposed generic solution, discuss the underlying technology used and demonstrate it by the loyalty points use case. We start by discussing the technology, as this will ease the explanation of the solution.

5.1 Blockchain Technology

5.1.1 Blockchain Principles. A blockchain is a decentralized 'database' of records, which is shared among participating parties [12]. This is also known as a public ledger of transactions. In order to add records to the database, a transaction needs to be made. Each transaction in the public ledger is verified by consensus of a majority of the participants in the system and once entered, information can never be erased. Also, a copy of the ledger of transactions is kept on many different places ("full nodes") [1], which covers the "decentralized" aspect of the blockchain. This differs from the "distributed" concept in the sense that in a distributed system, data chunks of a record are being stored on different physical locations. In order to fetch or reconstruct the data, all physical locations should be available and accessible. If one data chunk is missing, the data cannot be constructed. In a decentralized system, the data record as a whole is being stored on multiple places (i.e. on full nodes). That implies that if one node goes offline, the system is still up and running. Furthermore, blockchain uses an asymmetric cryptography mechanism to sign and validate the authentication of transactions [14]. In this way, only the "owner" of the record can publish valid transactions with respect to that specific record.

5.1.2 Advantages of Blockchain. In this section we discuss some of the advantages of using blockchain technology and why they could be advantageous for our solution.

First, as explained in the introduction, blockchain ensures true ownership (the owner has true control over its data). This would be an advantage for the customers, since organizations should not have full control over the resources, once awarded to the customer. Second, since the blockchain is decentralized, a copy of the ledger of transactions is stored on all nodes that participate in the network. In other words, a backup of the data is kept on many different places. This offers data protection, i.e. being safeguarded from corruption, compromise or loss, since data is being stored in a redundant manner. Third, blockchain ensures that data

tampering is not possible, since only the owner of the data can publish valid transactions on the blockchain with respect to that data. Hence, the blockchain does not allow attackers to tamper with the data (up to a certain degree, depending on the blockchain algorithm used). This tackles the problem of data security. Fourth, as mentioned above, blockchain is a decentralized system, which makes sure that when one or more nodes (i.e. participants of the system) leave the blockchain, the network remains stable. Hence, as long as enough nodes are participating, the blockchain remains reliable (robust).

In a blockchain, data is stored in a so-called chain structure. Every data modification requires a transaction that propagates through the network and changes the state of all the participants (nodes) of the network. A transaction stays in the blockchain forever and cannot be removed. For our solution, this would enable traceability of the resources used.

5.1.3 Smart Contracts. In the sections above, we have explained what blockchain is and how it can be advantageous for our solution. Applications can interact with the blockchain to store information about their assets, like they do with a traditional database. Bitcoin, a digital coin, is the most known monetary application based on the blockchain [4]. A public ledger keeps track of the balances of the wallets of each bitcoin owner. Only the owner of the wallet can execute transactions (by means of a private key), which ensures that he has full control over his "money". Another popular application is smart contracts. A smart contract is a piece of program code, executed by an external system, which interacts with the blockchain by executing transactions [5]. It describes how and when a transaction should occur and what conditions are tied to it. In such a transaction, digital assets are exchanged between two parties. You can compare it to a situation in which a house (the asset) is sold, involving a buyer and a seller (the participants), audited by a notary (the smart contract). A smart contract replaces the need for a trusted third party (the notary), since the settlement of the contract is digitally verified.

Because our framework needs to be able to exchange, in a trusted way, resources between participants and modify properties of these resources (e.g. the ownership of the resources), smart contracts could be a good solution for this.

5.2 Generic Framework

We have designed a generic framework that can handle and process the awarding and exchanging of customer resources between different participating organizations. The core of the framework processes all information needed to keep track of and exchange resources. The information itself and the executed transactions will be stored on a blockchain (as explained above). For the current implementation (loyalty points use case), we have opted to use Hyperledger Fabric [2], an open-source blockchain-based framework with contributions of various engineers and tens of organizations such as IBM.

Figure 1 shows a high-level conceptual model (ORM formalism [8]) of the most important key concepts of our solution: the Participants of the system (Organizations & Customers) and Resources, as well as Transactions, together with their relationships. Note that we allow for different types of Resources. These concepts need to be configured when implementing a use case. We refer to either Organizations or Customers as Participants. In our example use case, the Participants are the customers and the shops. Resources are digital assets that can be exchanged between Participants by means of Transactions. In our example, Resources are the loyalty points of each store but also other types of Resources are possible, such as vouchers or gift cards. A Transaction may involve a number of Participants and Resources.

5.2.1 Settlement Contracts. Another important key concept is the notion of settlement contract, as pointed out in the problem statement. A settlement contract is used to digitally capture how the exchange of resources should be compensated between participants. Imagine that, in our example, a customer buys a product in one store, store A, and is rewarded with loyalty points. He would like to consume these points in another store, store B, which is an independent organization and not related to store A. In this scenario, store B should reward a product to a client who might not even have purchased anything in this store. In fact, store B is rewarding customers of store A, which leaves store B with nothing but loss (products given away for free, without any benefit). Obviously, store A needs to somehow compensate this, so that store B will gain benefits or at least will not make any loss. How exactly this compensation should be done should be part of a new business model and is outside the scope of the paper, but a settlement contract allows to describe this.

The format that will be used for the settlement contracts is still subject to research. Allowing to establish any type of settlement contract between organizations is not easy since it heavily depends on the use case and on the organizations involved. The formalism used for the protocol and its implementation is work in progress and is not yet supported by our system. For the formalism, we are searching for related work and are investigating several use cases to identify important key concepts and parameters used by organizations in such contracts. For the implementation, we are considering smart contracts (see section 5.1.3).

5.2.2 Exchange Rules & Value Mapping. Resources may have different values for different organizations/participants of the system. Therefore, there is a need to define the "value" of each resource in the system. If resources have different values, we need to have a conversion system in order to allow the exchange of the resources. In our example, the value of loyalty points in one store does not necessarily map to the value of the loyalty points in another store. Imagine that store A claims to have the highest quality (and/or branded) products, while store B claims to be the store with the cheapest (non-branded) products. When buying the same product in each store, the price tag will differ. Hence, for the same amount of money, one can earn more loyalty points in store A than in store B (since the product is more expensive). Obviously, this may raise issues. One way to solve this is to give a higher value to the loyalty points of store A and provide a mapping system to convert loyalty points between organizations.

There are two approaches for such a mapping. The first approach is to have a mapping for each two organizations that expresses the translation of points between the two organizations. E.g. 1 point in store A is worth 1.5 points in store B and vice versa. A second approach is to introduce/use a common currency for the loyalty points, let us call it Loyp. Then the value of the loyalty points can be expressed in Loyps. For example, in store A, a loyalty point is worth 2 Loyps, while in store B, it is worth 3 Loyps.

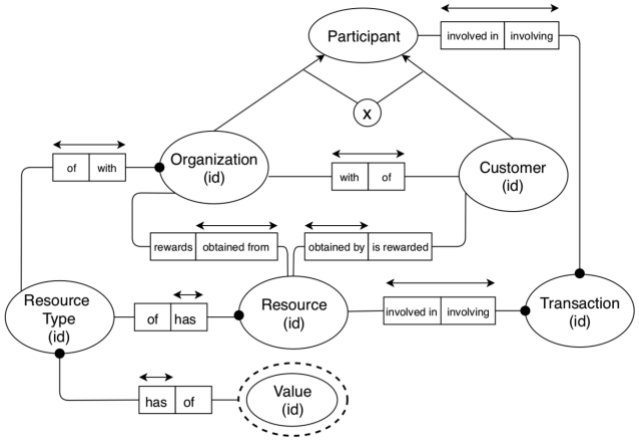

Figure 1: Conceptual Model in ORM format

5.3 Proof of concept

As a first proof of concept, we have implemented the loyalty points example based on the concepts of the framework. We have implemented transactions for three different scenarios: purchase of a product (with cash), purchase of a product with loyalty points, and loyalty gifts (transferring loyalty points to a friend).

To implement the use case, we opted for Hyperledger Fabric, which is an open-source blockchain-based framework to make transactions between multiple businesses more efficient [2]. Like any blockchain, Fabric records a history of transactions in a network, in an immutable ledger. Assets are resources of which the properties are being held in the ledger. Modifications of asset properties, such as change of ownership, are being recorded in transactions, initiated by chaincode, which is a piece of program code, called a smart contract (see section 5.1.3), which holds the business logic of an application.

We have based ourselves on Fabric as it has lots of advantages compared to other blockchain systems, such as its novel blockchain design and the ability to write smart contracts in general-purpose programming languages and the fact that it is using a permissioned blockchain, which is a blockchain network in which the identity of the participants is known, as opposed to public blockchains, in which anyone can participate. Also, a permissioned blockchain enables securing interactions between groups that do not fully trust each other, but which have a common goal.

6 Contributions & Conclusions

We have proposed and described a generic framework that allows the exchange of customer resources across participants. Our framework provides an easy way to customize solutions for the implementation of various use cases. Blockchain technology offers true ownership and control over the resources owned by customers, instead of having organizations controlling customers their resources. Hence, our research contributes to research on innovative information integration and web-based services.

We implemented the loyalty award use case as a proof-of-concept for our framework to verify the feasibility of our solution. The main work in progress is the identification of the required formalism to express the settlement contracts between participants. Furthermore, the customization interface should be designed and implemented to allow organizations to easily apply the framework for their specific use case.

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