TKT

A fair and transparent ticketing platform based on blockchain technology

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ABSTRACT

The ticketing industry is and has long been subject to counterfeiting and profiteering. The secondary market for high demand events attracts ticket scalpers, that hoard tickets and try to sell them at a price well above the face value. This can be seen as a normal market force, that allows quick movers to make a profit. However, it is a concern for many artists and organizers who lose control over their ticket pricing and distribution. For example, Ed Sheeran's Benefit Concert at Albert Hall (UK) in 2017 for the Teenage Cancer Trust was abused for heavy profiteering where tickets with a face value of 75 pounds have been resold for up to 2330 pounds (Davies, 2017). Beyond the reputation problem and fairness concern, the secondary market is also problematic due to fraud. Tickets are often fake or have already been scanned rendering them invalid.
Blockchain technology offers an opportunity to remedy these issues. We propose TKT, a trustless, decentralized platform for ticket sales and distribution. The system operates through smart contracts on the Ethereum blockchain, enabling users to verify the validity of tickets for a given event, ending counterfeit tickets and allowing the secure resale of tickets based on the organizers pricing to avoid ticket scalping.

1 Introduction

Today's ticketing market has a problem. The existing systems for distributing tickets are open for a lot of arbitrage during the time the ticket is sold until the event happens. This means that besides the primary seller of the tickets (e.g. event organizer) intermediaries make a profit by buying, reselling, stealing and counterfeiting tickets. The problem begins with the many parties that are usually involved in the organization and execution of an event. There are the actual content creators and their managers, bookers, venue managers, and ticketing organizations. All add to the value of the tickets but this fragmentation leads to price intransparency. For example, the primary ticketing organization can charge additional fees which are intransparent to the buyer.

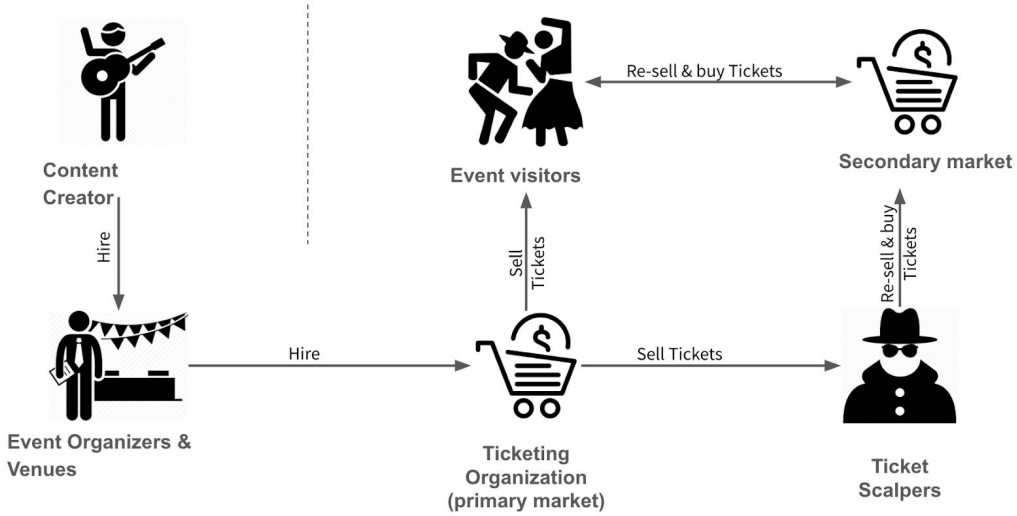

Figure 1: Current market situation

Figure 1 gives an overview of today's ticket market situation with all involved actors and how they interact with each other. It also includes the secondary ticket market and the scalpers that are active on it. The secondary market is where the major issues lie. This is where a lot of arbitrage happens and both the event organizers and the participants are hurt. Some of the problems are presented in the following list:

- Ticket scalpers buy large numbers of tickets and thereby create false scarcity. They can resell the tickets at a higher price. See Figure 2 for an example of the price differences in the primary and secondary market. If the scalper has bought the ticket in the pre-sale, his profit (after currency exchange) is around 170 EUR. Ticketing organizations might conspire with scalpers or create their own secondary market subsidiary with which they can create fake scarcity or create a black market pre-sale at higher prices. All for their profit maximization and not the benefit of the event organizers.
- Scalpers copy tickets or simply resell already redeemed tickets directly at the event venue to unknowing visitors.
- Scalpers can sell counterfeit tickets because the visitors do not have the ability to check the validity of a ticket.
- Scalpers have an incentive to steal and resell tickets because, again, the buyer is not given the ability to differentiate between a stolen and a legit ticket.
- All the above points lead to dissatisfied customers which hurt the event organizers, content creators, and event visitors.

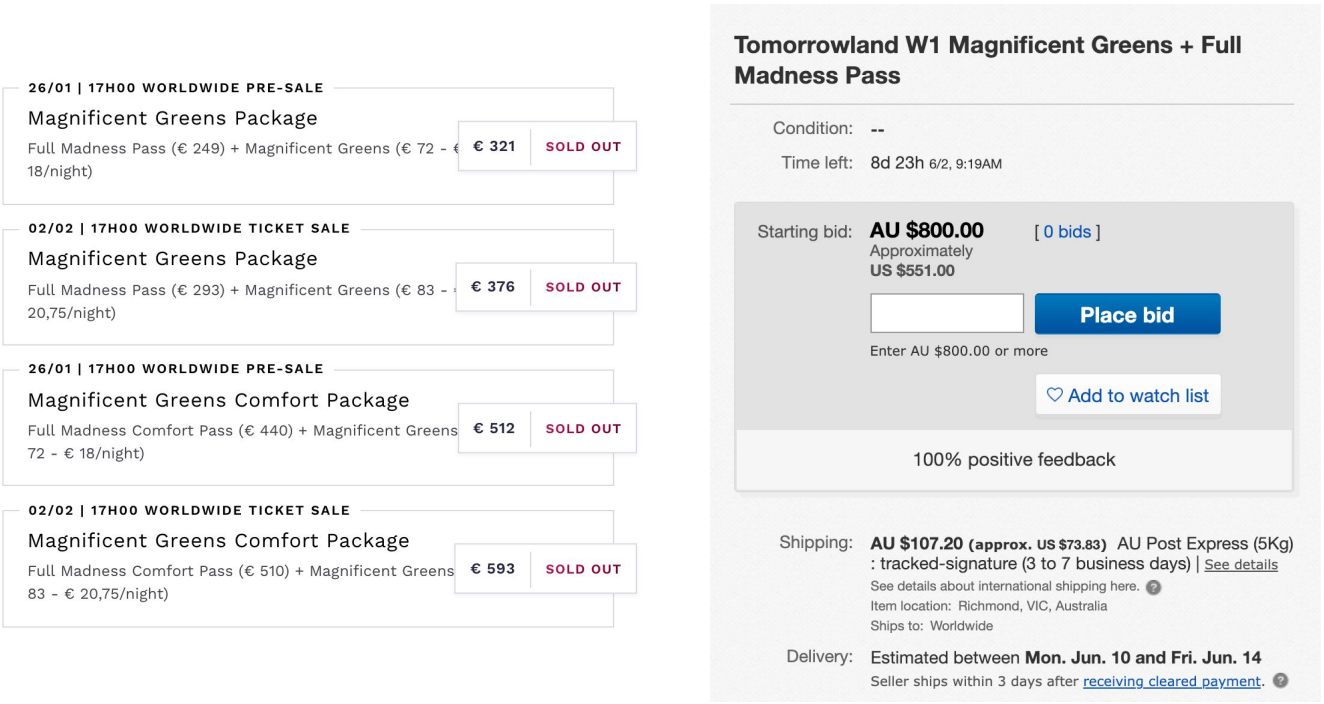

Figure 2: Comparison of primary (left) and secondary (right) market prices for a Tomorrowland Pass.

Due to the lack of good options, content creators and event organizers have to give control of the ticket sales over to the ticketing organizations which expose them to the aforementioned problems. Additionally, in most countries, there are no regulations to protect the event organizers from the secondary market exploits.
To counter the problems in the ticketing market, several properties must be added:

- The authenticity of a ticket needs to be validatable in order that everyone can check the authenticity of a ticket, e.g. at the entries to the event venue.
- The ticket must be bound to an identity and the identity to a single person. Although, it is not the goal to completely deny the possibility to offer a ticket back to the market in case a buyer cannot attend the event. However, the price cannot be higher than the original ticket price.
- The ticket should remain on the same platform independent if it is currently in the primary or secondary market. This improves traceability and transparency.
- The fragmentation of the ticket price needs to be transparent to the public so that everyone can check which intermediary gets what part of the price.

In this work, we propose a blockchain-based solution that addresses the aforementioned problems and implements the needed improvements to make the ticketing market a better place for event organizers, content creators, end users, and venue managers. The solution builds on the Ethereum blockchain and uses smart contracts to offer a platform on which event organizers and end users exchange tickets. Event organizers can directly create and control their events on the platform without the need for a ticketing organization. End users buy the available tickets directly from the platform and are connected to the ticket through the integration of an electronic identity service. Only the person that has access to the appropriate identity information can validate that they are the owner of a specific ticket. The platform also allows an end user to offer his ticket for resale. The conditions of that secondary market can be set by the event organizers. Intuitively, for re-selling a ticket, one would restrict the price to the face value or less to prohibit first buyers to make any profit. To evaluate the proposed solution a prototype was implemented.

The rest of this report is structured as follows. Chapter 2 explains the theoretical background on which the proposed solution is based and discusses the approach which was taken to design and implement the solution. Chapter 3 analyzes current trends in the ticketing market and ticketing systems and sheds light on existing approaches to reduce the problems in ticketing. Chapter 4 dives into the technical architecture of the solution and explains the envisioned business model that will be applied when bringing the solution to the marke. Finally, Chapter 5 evaluates the implemented prototype and proposes many interesting and valuable extensions.

2 Theory

2.1 Blockchain

Since the rise of Bitcoin, many different types and manifestations of blockchain have been developed. In the following, we describe the basic concepts about blockchain as it is implemented in Bitcoin or Ethereum since we intend to use Ethereum in our solution architecture. The blockchain can be seen as a distributed ledger. It is a state machine that is replicated over many peers in a network that communicate with each other. When the state is updated by one node the whole network validates the update and replicates the update. There is no single entity that can control the system and single-handedly influence the state. Instead, a consensus protocol is used involving all nodes to decide on the state transitions that are valid. The integrity of the blockchain is based on modern cryptography. State transitions or transactions in a blockchain network are packaged into blocks and then linked to each other in an append-only fashion. Each block contains a hash of all the transaction data contained within the block (also called the Merkle root), a timestamp when the block was created, and the hash of the previous block. The hash of a block is simply generated by hashing all the mentioned information together.
This design has several interesting properties. First, the blockchain is immutable. This is due to hashing the properties of the hash functions used. The hash of a block can be used to check the integrity of all the block's content. If something as small as a single bit changes, the hash looks completely different. Because blocks are references back through history, a change anywhere back in time would propagate through all the following hashes up until the current block. This makes tampering immediately visible to all peers in the network and renders the change invalid.
Hashing is also used to reach consensus on the ordering of transactions within blocks and the ordering of blocks themselves. All transactions created by any peer in the network are broadcasted and collected by so-called mining peers. Due to the network topology and the varying latency between peers, the ordering of transactions received differs from peer to peer. This is a problem because the network needs to agree on one single version among many different valid ones. To determine that version, the miners compete in a crypto puzzle to propose the next block. The puzzle requires miners to find a value which when concatenated and hashed with the hash of the latest block meets a certain target property. The difficulty of the puzzle varies based on how many peers are participating in minging. The more miners are active the more hashing power is employed by their machines and thus the harder the puzzle must be to keep block creation in a fixed interval.

Bitcoin is the first application of the above-described blockchain technology. Its main purpose is to allow transactions of monetary value. It solves the double spending problem without having to rely on a central authority to consolidate that someone actually owns what he claims. But the even bigger innovation potential in blockchain lies in facilitating more complex interactions between trustless parties beyond simple value transactions. That's where Ethereum comes into play. Ethereum is in its basics similar to Bitcoin but features a Turing-complete programming language that can be used to implement decentralized applications. These applications are called smart contracts and allow the implementation of complex business logic on the blockchain.

2.2 Smart Contracts

The name smart contact is a bit misleading. Smart contracts are nothing more than computer code meant for execution on a decentralized system, namely the blockchain. In the case of Ethereum, they have to be implemented in Solidity, a programming language specifically created for that purpose. But, there are other blockchains that allow implementations of smart contracts in common high-level programming languages, like Java or Python. What's more important is that the programmer has a fixed API at his disposal to make his program interact with the blockchain. Once the contract is written and compiled it needs to be propagated through the network. Every participating node will receive a replication of the smart contract. At that point, any user can call a function of that contract which will be executed on every node in the network. Because the blockchain is a trustless environment, every node needs to execute the smart contract in order to verify that the results received from other nodes are really correct. Basically smart contracts make use of the trustless nature of the blockchain. There is no need for a central authority to validate state changes triggered by a smart contract. Rather the whole network comes to a consensus and each node can validate that the state changes are valid.
For applications that require irreversibility and transparency of changes, and cannot rely on a trusted, central authority, smart contracts are a great option for implementation.

2.3 Electronic Identity (eID)

Identity differs in different contexts. When you set up an email account you create a very weak form of identity. It only consists of the email address and maybe your full name. This is accompanied by a password which is used to prove that you are the owner of that identity. In case you want to pay your taxes paperless via the internet the requirements to your identity in the tax application are stronger. The identity that is deposited in the tax application has to match your "real" identity, the

same you use in any other interaction with the government. Once set up, the mechanism to prove that you are the owner of that identity might still only be a password, as in the email example.
Our lives become more and more digital, and many interactions with the government and other institutions, that require identification of the involved person, happen through software. This gives rise to the need for a stable, secure, multi-purpose and standardized electronic identity. As soon as identity is digitized, security and privacy are of utmost importance. If the system is not secure, one's identity could be misused by a malicious actor. Different solutions are proposed to solve eID, some relying on blockchain and others being operated in a more centralized manner.

2.4 Business Model Canvas

The Business Model Canvas (Osterwalder A., n.d.) is a tool used to analyze a company's business model in a straightforward and easy understandable way. The Business Model Canvas was created by Alexander Osterwalder, of Strategyzer. By strategically thinking about the different items of the Business Model Canvas and how they interact with each other, a company can come up with a suitable business model or find new revenue streams, value propositions or reduction of costs. This paper will use the Business Model Canvas to visualize the business aspect of ticketing sale application.

2.5 Design Research

To analyze our blockchain solution we are following a design science research approach. This method is sometimes referred to as "research for entrepreneurs" with the motto "learning through building/designing artifacts. It involves two main activities to understand the behavior and potential value of information systems. First, design science research involves the design and creation of a novel artifact. An artifact may take the shape of algorithms, users interfaces, design methodologies, and programming languages but is not limited to those. Second, the artifacts' use and performance are studied with reflection and abstraction to generate new knowledge. This approach is especially suitable in the highly entrepreneurial and experimental blockchain space. We developed a small prototype of our envisioned system on the Ethereum blockchain and analyzed its business potential with the business model canvas (Osterwalder A., n.d.).

3 Analysis

3.1 Trends

The trend strives for more digitalization but the presented solutions face the same problems. This digitalization not only offers more convenience but also saves costs on operations and paper. The ticketing industry has not been sleeping in that regard. Tickets are nowadays available in digital form and don't have to be printed at home or received as an official paper-based ticket. This change initially helped to battle the secondary black market because there was simply no infrastructure to exchange digital tickets. The ticket is issued to a certain name and thus can not simply be transferred to someone else. There was no eBay for digital tickets that would allow you to just change the owner name and transfer the ticket to a potential buyer willing to pay a multiple of the initial price. Of course, ticket resale was still possible due to a lack of identity checks by event organizers. Ticket scalpers could simply send the ticket by mail with their own name on it and new platforms that simplify the digital resale of tickets such as TicketSwap[1] or StubHub[2] (not surprisingly owned by eBay by now) have sprung up. StubHub has been named "the ticket scalper of the digital age" by ABC. Beyond StubHub, there are others such as Viagogo[3] that have been known to vastly inflate prices for tickets. So all that change to digital tickets has not affected the central problem for event goers: Massive demand for a limited supply of the most popular events, where scalpers operate bots to scrape ticket sales and resell them at a ridiculous markup.

3.2 Customer Demand

The problem in the ticketing industry is clear but what do stakeholders actually want? The following list is drafted based on our own experience, research and feedback from stakeholders in person and on online forums.

Stakeholder	**Wishes**
End User	- Fair prices for tickets - Fair chance of purchasing tickets - Secure and convenient shopping experience
Content Creator	- Sell tickets to the right audience - Increase event attendance - Ability to connect and interact with the fan community
Event Organizers	- Effective sales distribution channel - User data collection
Venues	- Easy and secure event entrance process - Ability to sell complementary products and services

Table 1: Customer Demands

3.3 Incumbents

There are many official ticket sales and distribution companies such as Ticketmaster[4] which operates globally or Ticketcorner and Starticket[5] just within Switzerland. These companies are working alongside artists and event organizers while there are independent reseller platforms such as the mentioned StubHub, Viagogo or TicketSwap. Our system is a threat to all of them as it offers a digital distribution channel as well as a resale market.

[1] https://www.ticketswap.com/
[2] https://www.stubhub-ch.ch/
[3] https://www.vivago.com/
[4] https://www.ticketmaster.com/
[5] https://www.ticketcorner.ch

3.4 Others Solutions and Competition

3.4.1 Non-Blockchain Based

There have been and there are many attempts trying to fight the ticket scalping and counterfeiting problem by big ticket sales and distribution companies themselves. Ticketmaster launched a digital ticketing system that required customers to prove their identity prior to purchase. This Credit Card Entry program asks the ticket buyers to present their ID and credit card at the entry to the event. Having to swipe your credit card to get access to the venue completely avoids the possibility of reselling tickets therefore also killing the secondary market problems. But being able to resell the ticket is important for event goers in case they are unable to attend for some unforeseeable reasons. There has been negative press about sacrificing those customer needs putting Ticketmaster's efforts in a bad spotlight (Pender 2017). Ticketmaster also has a program called Verified Fans where potential ticket buyers can sign up and supposedly get priority to buy tickets. However, this does not prevent ticket scalpers to sign up for the program. Ticketmaster claims to have a “real fan” selection process in place which only select subscribers that are likely to go the event rather than resale the ticket. However, how this is achieved it kept secret and it is questionable if it actually works at all. All the Verified Fan Program guarantees is to get fan mail which tries to market merchandise and other related fan products to you. There is no guarantee to be able to purchase a ticket.

Beyond the actual ticket sales and distribution companies, there is a secondary market place called Ticketswap which restricts the pricing to a maximum of 20 percent mark upon the face value of a ticket. This has turned them into a marketplace for ticket scalpers that are ok with just making 20 % profit and it not really addressing the counterfeiting problem.

3.4.2 Blockchain-Based

There is one company that is claiming to pretty much do what we are proposing called Blocktix. However, there is little information about the company itself and its product. Their publicly accessible Github project has not had any activity since 2017. It might be possible that they just did an ICO hit and run scheme during the blockchain hype phase.

4 Solution Design

4.1 Functional Architecture

Our proposed solution covers all basic functionalities of existing ticketing systems and integrates secondary market functionalities. In the following, these functionalities are described in more detail while referring to the diagram in Figure 3.

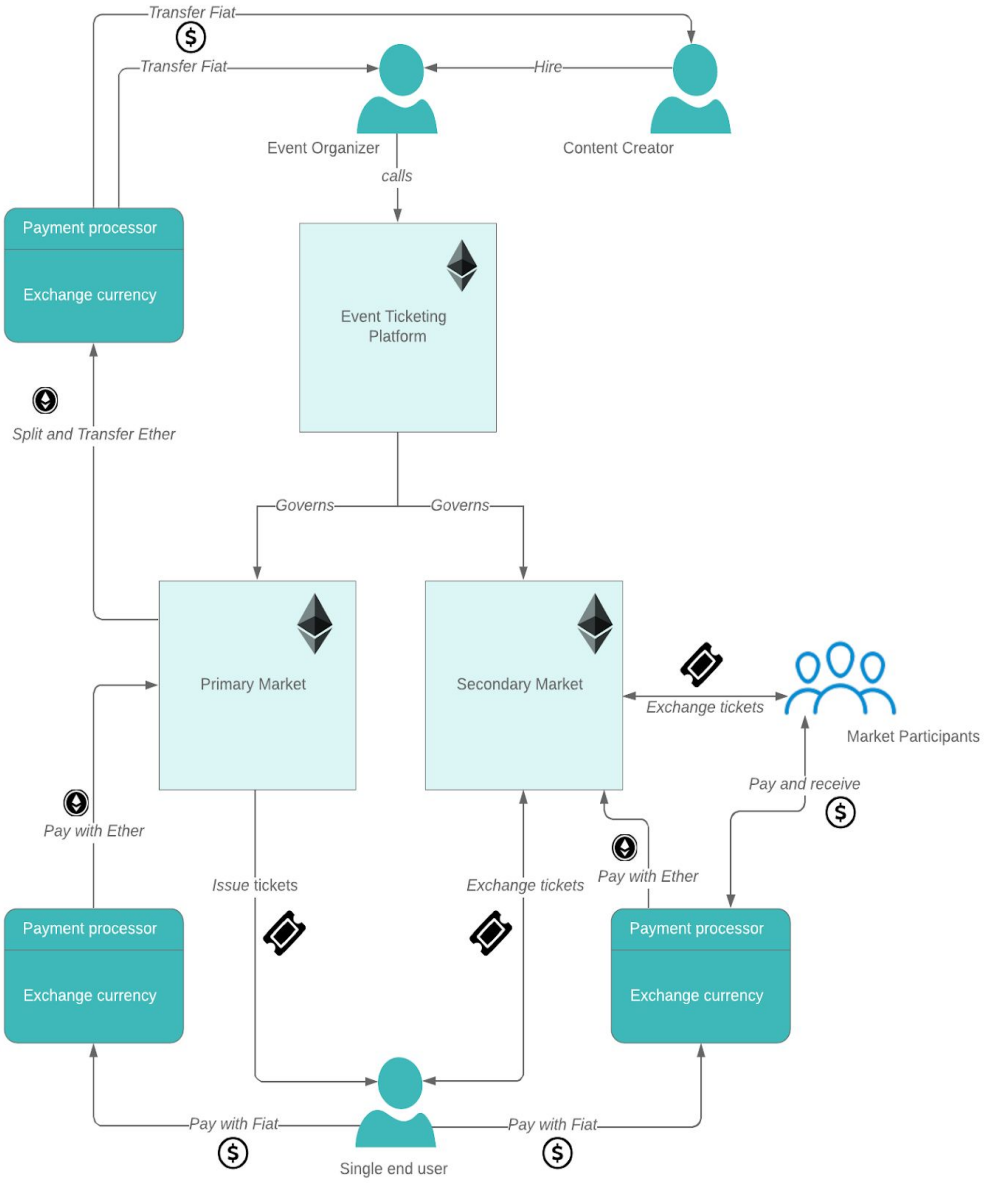

Figure 3: Functional Architecture

We begin our journey with the event issuer that wants to make an event public and sell tickets. Through a web application, he can set up his event on the ticketing platform that is implemented via smart contracts on the Ethereum blockchain. There he defines details about the event, including event date, ticket sales period, and ticket specifications, the number of available tickets, ticket price, and which parties (issuer, content creator, venue, etc.) get what fraction of the price. Once the event exists on the platform it is ready for issuing tickets.

At first, the ticket is not connected to any identity and is issued on the primary market. The end user (at the bottom of Figure 3) can search for the event through a web application and buy tickets from it. Because the ticketing platform lives on Ethereum the payment happens in Ether. So, in case the end user does not hold any Ether, an intermediary payment processor is used to convert fiat currency to cryptocurrency. The payment is attributed to the parties that were included when creating

the event on the platform. Each party gets a fraction as defined in the event. Again if the parties want their profit in fiat currency a payment processor is used to exchange the Ether paid out from the platform.

Once a ticket has been bought from the primary market it is attached to an electronic identity. That is the identity of the buyer, or whatever identity the buyer provided when buying the ticket. The identity is checked for example at the event entrance. The buyer must be able to verify that he is the owner of that identity, otherwise, he can't use the ticket. This removes all the issues with malicious ticket scalpers that try to copy, steal or fake tickets. A scalper cannot sell a ticket to another visitor without proving that he has control over the identity that owns the ticket. Without the identity prove the ticket is useless. A scalper would have to provide the ticket and at the same time handover control over the identity with which he bought the ticket. So, we rely on a robust eID service that is able to prevent a market of fake or stolen IDs.

After the ticket has been sold on the primary market, it can be exchanged on the secondary market. This opens up the possibility for end users to sell their ticket if they change their mind about the event, can't attend or have bought too many tickets. But the price at which a ticket can be sold back to the secondary market is defined by the event issuer. Intuitively one would set the maximum price at which an end user can re-sell his tickets to the ticket face value. This prevents scalpers from making a profit. But we can imagine more useful price structures in which the ticket price increases or decreases when resold on the secondary market. Additionally, the event issuers could be awarded with a small fraction of the ticket price everytime the ticket is resold. This pricing logic is defined when the event is created on the platform and enforced by the smart contracts the platform consists of.

As Figure 3 shows, the primary and secondary market are both governed by the same ticketing platform and the tickets always "remain" on that platform. I.e. one cannot transfer a ticket without taking the path over the platform.

4.2 Technical Architecture

Figure 4 shows the simplified technical architecture of the ticketing platform. In the following sections, the four components represented in the image are discussed in more detail.

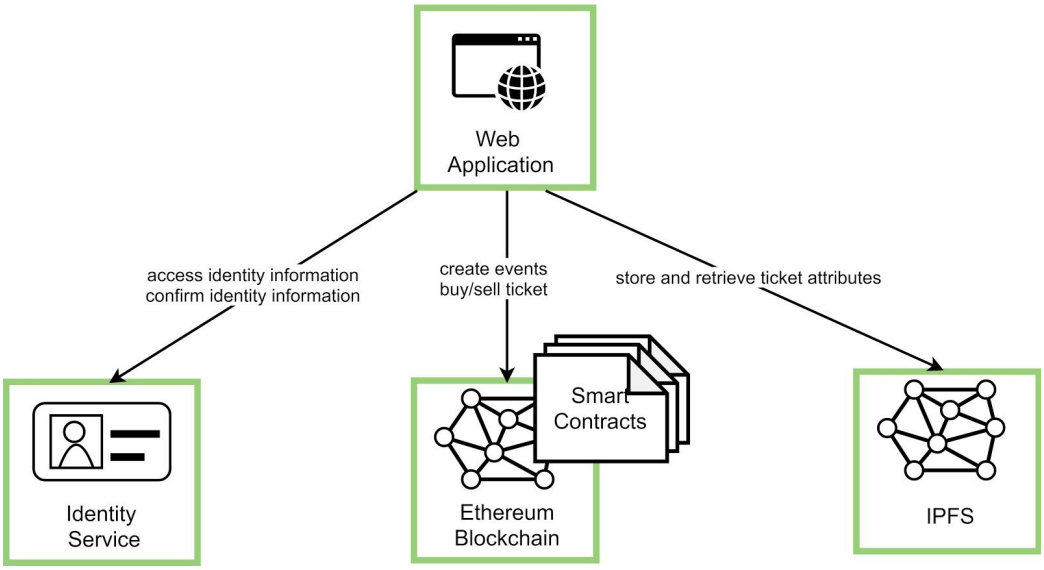

Figure 4: Simplified overview of the technical architecture

4.2.1 Ethereum Blockchain

The core of the ticketing platform runs on the Ethereum blockchain. The Ethereum blockchain is a permissionless, public blockchain that allows the deployment and execution of smart contracts. At the time of writing this report, Ethereum is one of the smart contract-enabled blockchains with the largest and most active community and the most advanced developer tools for building decentralized applications with smart contracts. Thus, Ethereum is chosen to realize this project.
Smart contracts are executed on every node that participates in the Ethereum network. The smart contracts are replicated on each node and every node can validate the contract's state. If a smart contract is properly implemented, it is guaranteed that no single entity can maliciously manipulate the contract's state to his advantage. An application implemented on Ethereum is called a decentralized app (dApp) and can consist of one or more smart contracts that serve some specific purpose to its users without the need of any central authority.

The described properties are a good fit for the proposed solution. By implementing a ticketing platform as a dApp we can remove the current ticketing organizations as the intermediaries. There will be no central trusted party that has control over the ticket sales. Furthermore, transparency is achieved because the applications state can be validated by anyone participating in the Ethereum network. For example, the specific distribution of the ticket value to organizers, venues and content creators will be publicly available in the dApp. Ethereum's native cryptocurrency, the Ether, makes payments an integrated part of the ticketing system. There is no need for external processing of payments. All monetary transactions happen right on the blockchain where the dApp lives.

4.2.2 Interplanetary File System

Because storage on the Ethereum blockchain is expensive, a separate storage medium is needed for ticket and event information and artifacts, like images, connected to the ticket. Only the hash[6] of the actual content is stored on the blockchain/smart contract, while the actual data is stored on the separate medium.
In order to keep a central party from manipulating the stored ticket data and make the whole application as decentralized as possible, the Interplanetary File System (IPFS)[7] could be used for storage. The IPFS is a decentralized, peer-to-peer file sharing system. It already handles data replication and removes any single point of failure.
The technical feasibility of using IPFS in our application has yet to be fully evaluated and confirmed. In case it is not an option a simple alternative is to host the ticket data on dedicated storage that are managed by our company.

4.2.3 Electronic Identity Service

For taking part in transactions on Ethereum, one does not have to provide his real identity. A simple pseudonym in form of a public key is the only thing that is revealed about the transacting parties. But our application requires that a ticket must be linked to a unique identity which again is linked to a real person. Otherwise, ticket owners could just sell their Ethereum address with which they have bought tickets. This would again lead to an off-chain secondary market with the same possible exploits as in today's ticketing systems. Thus, the integration of an electronic identity service is needed. The service needs to provide identity objects that can be stored with a sold ticket and a function to verify those objects by the person behind the identity (e.g. at the venue entrance).
Rather than building such a service ourselves, we intend to embed an existing decentralized e-identity service.
There are a few eID solutions based on distributed ledger technology that are currently developed. For example, the Swiss company Procivis AG[8] is working on a solution that enables individuals to access digital services provided by the government and the private sector. We must further investigate, which eID service fits our needs best.

4.2.4 Web Application

The fourth part of our solutions architecture is the interface through which users will interact with the platform. This is realized as a web application and a mobile app version thereof. The web application directly interacts with the platform's smart contracts on Ethereum. It combines the three systems, namely the ticket data storage, the eID service, and the blockchain in order to provide a seamless and intuitive user experience, giving the impression of a single platform.
The technologies used are JavaScript and the library ReactJS[9].
For executing transactions on Ethereum in the user's interest, the web application needs access to the user's cryptographic key pair and of course the user's consent before executing each transaction. Metamask[10] is a browser plugin which allows exactly that. The web application can use Metamask as an interface to the Ethereum chain, while Metamask will prompt the user every time the web app wants to issue a transaction. Because Metamask is not available on all devices it is not a fixed part of our technology stack but it is an important piece that makes the interaction with the application more convenient. For example, on mobile devices Metamask is not yet available and an Ethereum-enabled browser is necessary such as the Status[11] or Trust[12] browser.

4.2.5 TKT Buy Button

We are dedicated to develop a JavaScript library as well as prebuilt components for ReactJS, Angular[13], and ViuJS[14] that lets artists easily integrate our service directly on their homepage. A Buy-Button can easily be embedded in a website with just a few lines of code. How such a button would look like is shown in the following image.

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[6] Fixed length string that is obtained by running a data object through a hash function like SHA-256.
[7] See https://ipfs.io/
[8] See https://procivis.ch/eid/
[9] See https://reactjs.org
[10] See https://metamask.io/
[11] See https://status.im/
[12] See https://trustwallet.com/dapp
[13] See https://angular.io/
[14] See https://vuejs.org/

Figure 5: TKT buy-button for integrating the TKT platform within existing websites

The artist's website can be kept simple as there is no need for complicated integration of a payment processor, checkout process, etc. It is only required to have Metamask installed or the website is visited on a Web3-enabled browser such as Status or Trust.

4.2.6 Stable Coin Integration

As the price of Ether and other cryptocurrencies has great fluctuations, an event organizer does not have the certainty to cover his expenses when the price of Ether suddenly drops. Therefore, it would be desired that a ticket can also be exchanged for a stable cryptocurrency. We compared several stable coins and the most suitable is Maker Dai[15], which is an asset-backed, decentralized cryptocurrency on the Ethereum blockchain.

The functionality of instantly swapping Ethers for Dai is intended to be added to the smart contract. This allows an event organizer to accept Ethers but is paid out in a stable currency such as Dai. The Uniswap Exchange Protocol[16] would be an option to look further into. This protocol offers a simple way of swapping ERC20 tokens in a free, decentralized manner.

4.3 Business Model Canvas

4.3.1 Value Proposition

The value proposition of this decentralized ticket app is manifold. As was mentioned previously, ticket prices for concerts and festivals can reach staggeringly high prices on the black market. This is where TKT comes into play. We create a transparent cost structure that benefits event organizers, the content creators as well as the ticket owners. The respective cuts for the event organizer, the platform itself and the bands are clearly indicated and public (see Figure 6). This combined with a maximal ticket price for the first sale as well as every subsequent ticket resale guarantees a fair ticket distribution and undermines the creation of a black market.

The creation of this secondary black market gets completely prevented due to our utilization of blockchain technology. Every ticket lives on the blockchain and its lifecycle is governed by its smart contracts. This approach disables the creation of a secondary market and prevents black market sellers to create fake tickets, protecting our customers from having to deal with ticket fraud. This single point of sale strategy is supported by a simple mobile application which will be used to access and display the ticket. In case of an unforeseen incident preventing the ticket owner from attending the event, he can easily find a buyer for the ticket through the mobile application.

Finally, there is the possibility for third parties to integrate our service to their websites. A band with an open ticket sale can integrate a button on their website, directly connecting to our ticket selling application. This combined with our pure online strategy, which makes third-party payment processors as well a ticket distributor obsolete, creates an easy and hassle-free ticket sale for any event organizer.

[15] See https://makerdao.com/en/
[16] See https://uniswap.io/

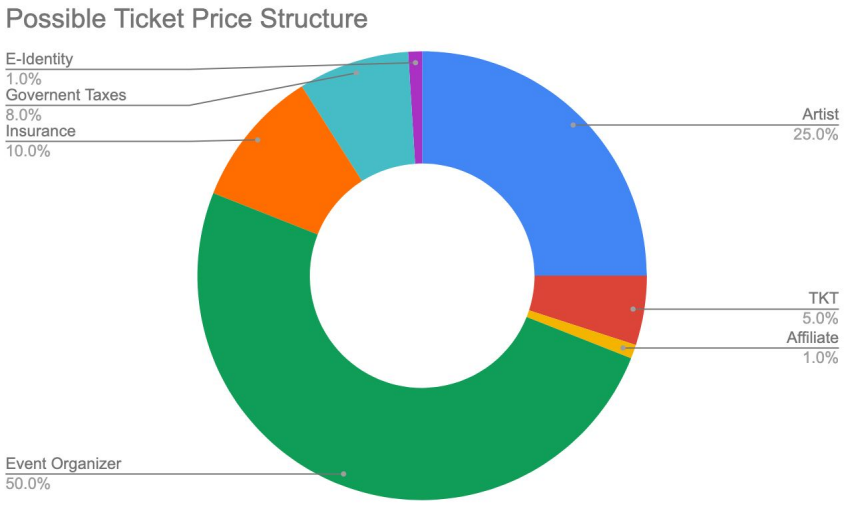

Figure 6: Possible price structure

4.3.2 Customer Segments

Due to the platform style service that we offer, there are multiple customer segments that we target. On the seller side, there are the event organizers. When looking closely, we can see that they can take different forms. There are companies that organize festivals and big concerts with multiple artists, venue owners who sell tickets to their events or just artists themselves. It is important to know the differences between these event organizers, allowing us to quickly react to their unique wishes and requests and providing them with the specific service they need.

In like manner, the buyer side also displays some different sub-groups. The most obvious group is the regular event attendee, just looking to buy a ticket. But there are also affiliates, brand ambassadors and influencers who may need special ticket access. Finally, there are third-party ticket distributors, like Starticket[17] who may want to buy tickets from our platform to resell on their own terms. Again it is important to know and understand these different sub-groups to quickly resolve any problems or needs they have.

4.3.3 Customer Relationships

Our different customers obviously have different expectations. But there are some quality characteristics that are relevant to everyone. Both the seller as well as the buyer side expect a reliable service, but problems sometimes can still arise. In that case, our customers expect a quick, and efficient solution, delivered in a professional manner, that alleviates their struggles. The easiest way to start gaining new customers is by focusing on the attraction of smaller artists and their fanbase. Successfully fulfilling their expectations will create a viral loop (Blanks 2012) due to these customers posting on their social media or more traditional word of mouth communication. This, in turn, attracts customers from new fanbases and new artists alike, creating a positive cycle. To kickstart such viral loop influencers and brand ambassadors can be incentivized to start spreading the word.

But attracting these new customers cannot be the end of this endeavor. The customers must be drawn into our ecosystem repeatedly. To achieve this, their unique needs and wishes must be cared for in a timely and professional manner. An active community manager guarantees that customers with problems get a fast solution or are redirected to more specialized personnel that is able to assist them. Furthermore, this community manager can also gage the emotions and feelings of our customers through big data analysis and collect new ideas that the community came up with or wishes for.

This close interaction with our customers can be tightened by offering loyalty bonuses, discounts, and gamification.

4.3.4 Channels

Our online focus gives us a variety of channels to explore. The website, as well as the mobile application, will provide our customers with the same services and functions. Here the event organizers can create and manage their events. The event attendees, on the other hand, can buy new tickets, manage owned ones and sell them if they are not needed anymore. At the time of entrance, the mobile application will also be used to gain admittance to a concert, by showing the ticket on the mobile phone. But these two channels can be further utilized by displaying event reports from past events and promotional messages for future festivals and concerts. Creating a hub for all the relevant information. On mobile push notification can be used to

[17] https://www.starticket.ch/en

inform the user with up-to-date information and remind him of upcoming events and new developments of buying and selling tickets.
Social Media, like Twitter, Facebook, Instagram, and Snapchat can be used to interact with the community. The different ways these channels can be used is described in the previous section about customer relationships. Finally, there is the TKT-button that third parties can integrate on their website. This simple button acts as its own kind of promotion and it allows us to reach customers that may not have known of our service.

4.3.5 Key Partners

Obviously, we cannot and do not want to provide all the mentioned services by ourselves. This is where our key partners come into play. The first one is the most obvious, different event organizers. We need them to enable our core business, selling tickets for events. Then, there are the affiliates, brand ambassadors and influencers. We certainly need them to kick-start our business, but even later on, they provide good marketing opportunities and a close relationship benefits both of us.
The last partners are related to the technical aspects of the services we offer. We need to closely work with e-Identity providers. This allows us to leave the authentication of a customer to the third party, while we just attack the provided identity to the ticket that is sold. To guarantee our customers the best experience, but also to prevent a lock-in effect on our side, we will cooperate with a number of different e-Identity providers.

4.3.6 Key Activities

Our key activities closely relate to the topics that were discussed in previous sections. The most important of these activities is undoubtedly software development. We first and foremost an online service provider, therefore it is important to focus at least our initial effort on the creation of a solid framework that enables our decentralized ticket selling service. After a bug-free experience has been created for our users, new features and services can be implemented.
The other two key activities pertain to building up our user base. We need to stay in close connection with a number of different social media personalities. The interaction with these social media influencers is also a part of our social marketing effort. This way upcoming events and event reports of past happenings a be presented directly to our customers in their preferred media format, allowing us to gain their attention and subsequently their engagement. On the other side, there are the event organizers who have to be cared for. By assisting them with their problems and frequent improvements of the platform we can guarantee their continued support.

4.3.7 Key Resources

All our activities require a minimal amount of material resources. Neither the development of new features nor social marketing is dependent on physical material. Therefore it is clear that the key resources for this company are its employees and software assets. As for the employees, it is of utmost importance to keep them happy and continuously invest in their development. This increases our employee retention rate, creating a stable and trustful work environment.

4.3.8 Cost Structure

There is almost no material cost connected to this company. The only physical objects that have to be purchased are the one-time acquisition of laptops, mobile phones and office supplies for our employees. Theoretically, all employees can do home office, but it is also possible to provide a working and meeting space for our employees by renting out an office building. Furthermore, we have recurring costs. This includes the hosting of the website and CRM systems as well as the personal cost.

4.3.9 Revenue Streams

There are two main revenue streams that can be explored. The first one is a fee on every ticket sold. This allows us to maintain our infrastructure, pay our personnel and develop new features and services. The percentage of the cut that we take has yet to be decided, but must be similar to competitors and preferably lower. The second revenue stream is from advertisements. Space on our website, mobile application and social media accounts can be sold to event organizers to promote their upcoming events.

5 Evaluation

5.1 Mock-Up

We developed a prototype to demonstrate the basic functionality of the system. The prototype is built on the Ethereum blockchain and uses ReactJS[18] for interacting with the smart contracts.

When visiting the website, the user sees all the currently available events. By clicking on the events, more detailed information about the event is displayed as well as a button to buy a ticket. If there are tickets still available from the ticket organizer, the buyer receives such a ticket. If no more tickets are available from the organizer but another ticket owner decides to sell a ticket, the buyer is matched with this seller with the principle of first-come-first-serve in mind.
A ticket can be bought even when there are no more tickets available at this moment. By depositing the ticket price in the smart contract, a user then enters the buying queue. Being the head of the buying queue means that one is matched with a seller as soon as there is a ticket available. If nobody is willing to sell a ticket until the event, the deposit of the ticket is refunded.

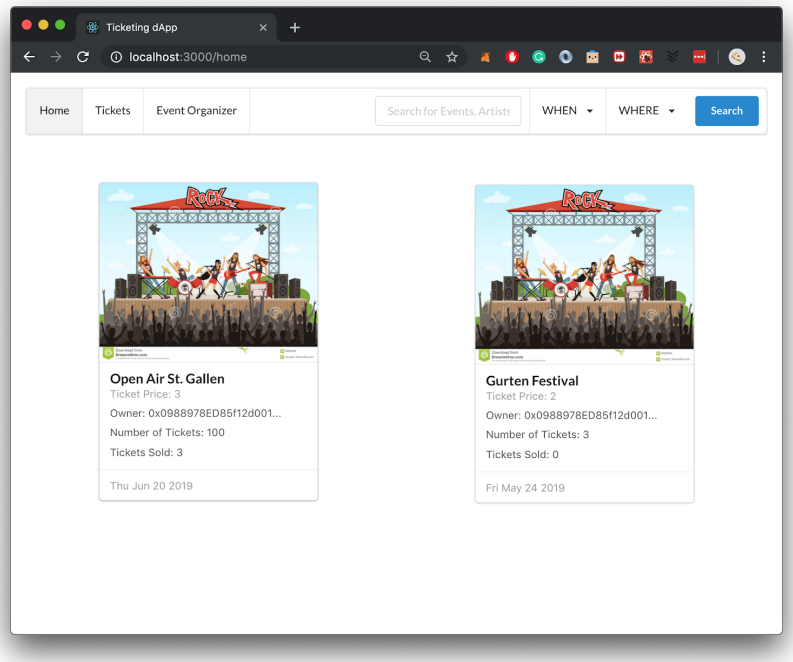

Figure 7: Prototype event overview

The user can see all the bought tickets in the *tickets view*. Within this view, it is also possible to sell the ticket. If the buying queue is not empty, the ownership of the ticket is directly transferred to the new buyer as well as the Ethers are transferred back to the initial owner.
If the buying queue is empty, the ticket is added to the selling queue. Being the head of the selling queue means that the ticket is sold to the next buyer. In the future, it will be possible to set a custom reselling price. This price must always be smaller than the original price. More on this is described in Section 5.5.
Furthermore, a ticket can be redeemed. This feature is necessary for the access control to the event.

[18] See https://reactjs.org/

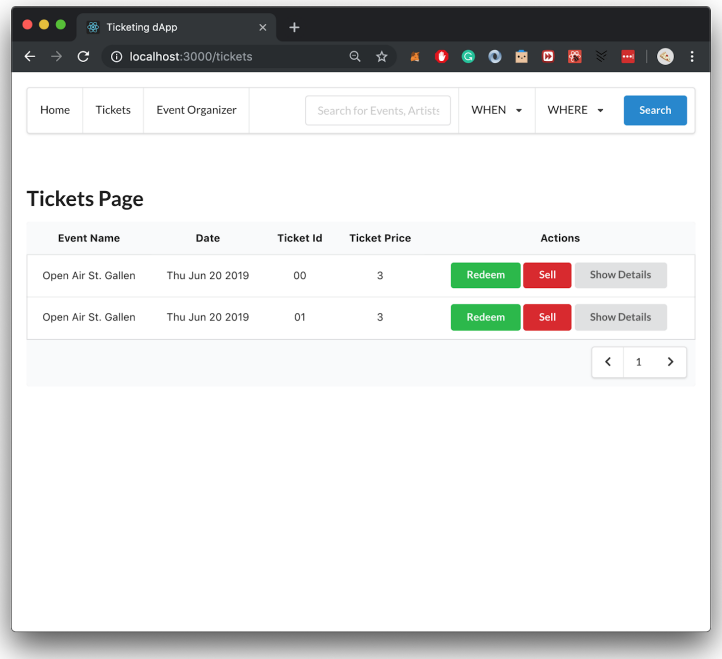

Figure 8: Prototype ticket overview

An event organizer has its dedicated section in the app, where the events can be managed. Right now, it is only possible to create new events. In the future, it is possible to issue more tickets, update event information, etc.

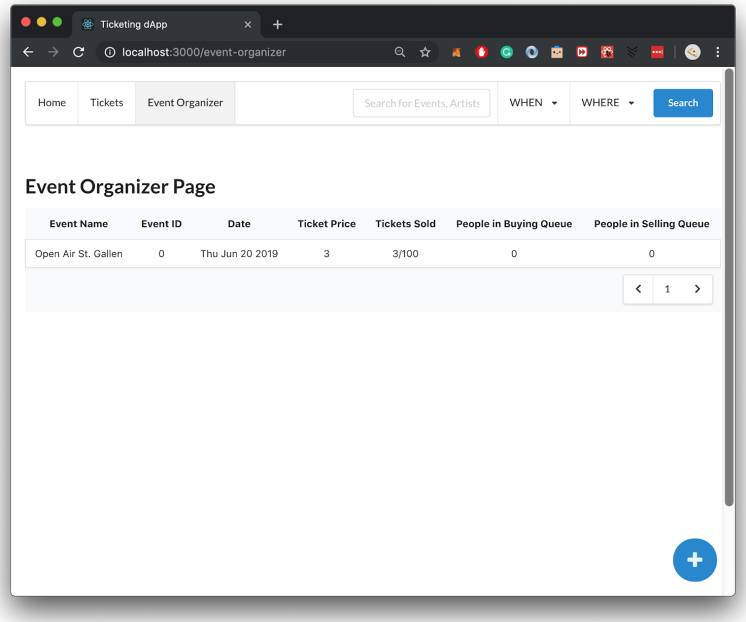

Figure 9: Prototype event organizer view

By clicking on the button right button, one can create a new event with the form which is showed in the next illustration. This form will also receive more fields in a future version of the protocol such as different ticket categories, affiliate marketing (this is described in more detail in Section 5.3.4.), etc.

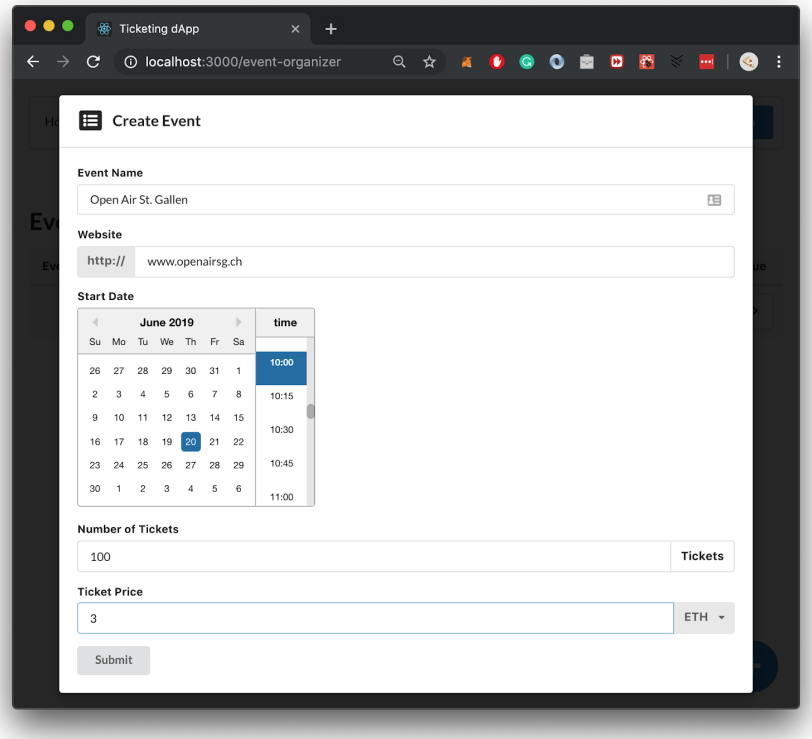

Figure 10: Prototype create event form

Every interaction that modifies the smart contract such as buying a ticket or creating an event costs gas and requires a confirmation from within Metamask.

5.2 Smart Contract and Source Code

The smart contract that issues tickets and transfers their ownership is the core functionality of our business. The following code snippet illustrates the buying process of a ticket.

1. When calling this function, the event id is passed as an argument, as well as some Ethers for the ticket price as the variable *msg.value*.
2. The smart contract checks if the sent amount of Ethers matches the ticket price.
3. If not all the issued tickets from event organizer are sold, the ticket is bought from the event organizer.
4. Otherwise, the smart contract checks if there are other people willing to sell their ticket. If that is the case, the attached Ethers are directly sent to the person and the ownership is transferred to the buyer. The selection of the seller is based on the First-In-First-Out principle. This resembles a queue, meaning that the buyer is matched with the seller, that puts himself first in the queue.
5. If there is nobody willing to sell his ticket, you directly enter the buying queue. The attached Ethers are stored in the smart contract until there is a seller found or the date of the event is reached. As soon as someone wants to sell a ticket, the person in the buying queue is automatically matched with that person.

```
function buyTicket(uint _eventId) public payable{
    Event storage e = events[_eventId];
    require(msg.value == e.ticketPrice, "The value does not match the ticket price.");

    // if not all tickets have been issued, the buyer automatically buys from the event owner
    if(e.ticketIndex < e.numTickets){
        issueTicket(e, msg.sender);
    }

    // if people want to sell tickets, the buyer automatically buys from the earliest seller
    else if(e.sellingQueueTail != e.sellingQueueHead){
        buyFromSellingQueue(e, msg.sender);
    }

    // if nobody wants to sell yet, the buyer joins the buying queue
    else{
        joinBuyingQueue(e, msg.sender);
    }
}
```

Figure 11: Solidity code for in the smart contract for buying a ticket

The full source code for the prototype can be found on Github with the following link:
https://github.com/simibac/ticketing-dapp

5.3 Future Ideas

5.3.1 Lottery for Presale Distribution

One big problem that ticket platforms face is the overwhelming rush on tickets when the presale of a popular event starts. This presale phase can be handled in a much fairer way using the blockchain. We envision a system, where people can register for the presale. These people would not receive the ticket until the ticket release date. If at the ticket release date the demand for tickets is higher than the maximum number of tickets, a lottery is held by the smart contract. This lottery uses future block hashes in order to provide on-chain randomness.
Such a feature would result in less frustration for customers since the lottery cannot be manipulated and can be transparently be re-traced on the blockchain.

5.3.2 Dynamic Ticket Pricing

When an event organizer creates an event, a fixed ticket price must be set. Whenever a ticket owner decides to sell his ticket, the ownership of the ticket can only be transferred through the smart contract. The price of the resold ticket can only be the price set by the event organizer. However, we envision a system where ticket owners can set a lower reselling price if the demand in buying queue is low. This allows them to resell their ticket even if they cannot attend the event and creates a free market for the tickets. However, the market is defined by the maximum price of the ticket set by the event owner. Thus, buying tickets and selling them for a higher price is not possible.
On the other hand, if the demand for tickets is low, one can enter the buying queue with a suggested price. The smart contract then matches the first seller in the selling queue offering the ticket for the suggested price. This works similar to a decentralized exchange system.

5.3.3 Direct Tax payments

We expect that the government will adopt more to distributed ledger technology in the future such that the government has its own Ethereum address. This allows paying government taxes directly from within smart contracts. The government benefits from the certainty that every sold ticket pays taxes. And event managers have less administration overhead.

5.3.4 Affiliate Integration

As marketing plays an important role in today's event economy, an affiliate program is to be integrated into the protocol. Thus, the event organizer should have the ability to allow other parties to advertise the event. In return, these companies, influences would receive a predefined percentage of the ticket price.
Influencers and marketing firms can create a unique affiliate id in the smart contract. This id is then used to track from where the customer comes from. When the function in the smart contract for buying a ticket is called, an additional argument with

the affiliate id is included. When the smart contract registers the affiliate id, it directly dedicates a percentage of the ticket price to the linked Ethereum address.
As the affiliate program is included in the protocol, the payout is transparent, guaranteed and instant.

5.3.5 Social Event Insurance

Insuring your event always comes at a high cost for the event organizer as there is always an insurance company involved. We envision an event economy where events can insure each other where no third party is involved. In such a system, a percentage of each ticket earnings is paid into a separate smart contract that handles the insurance. I case of an event cancellation, the smart contract would directly pay the event organizer and the ticket owners. For such a system an oracle is necessary to prove that the event did not take place.
This concept is hard to introduce and must be investigated much further.

5.3.6 Gamification

In a future version of the protocol, we envision that event attendees and event organizers are compensated for committing to our platform. Thus, the rates for recurrently creating events or buying tickets can be lowered. Other aspects of the application can be gamified in order to engage the users.

6 Literature

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