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Augmented Reality meets Non-Fungible Tokens: Insights Towards Preserving Property Rights

Mihai Duguleană
University Transilvania of Brașov

Florin Gîrbacia
University Transilvania of Brașov

ABSTRACT

Non-fungible tokens are one of the newest use-cases of blockchain technology. Ethereum Virtual Machine (EVM)-based blockchains such as Ethereum, Binance Smart Chain (BSC), or Polygon/Matic have standardized this type of tokens using interfaces such as ERC721 and ERC1155. This development fostered a connection between blockchain and Mixed Reality technologies, which can now coexist in cohesive applications. In this paper, we present the opportunities and challenges resulting from using Augmented Reality NFTs, with a particular focus on the preservation of property, whether it is physical or purely digital. We present a methodology that can ensure the protection of privacy and the preservation of intellectual property when transitioning assets from the virtual to the physical world.

Keywords: augmented reality, blockchain, property rights

Index Terms: D.2.11: [Software Engineering]: Software Architectures; K.5.1: [Legal Aspects Of Computing]: Hardware/Software Protection

1 INTRODUCTION

Augmented Reality (AR) is a technique that superimposes digital information over the real world. AR has arguably the most significant potential to offer applications high degrees of immersion and interaction [1]. AR is still at its dawn, with only a handful of specific initiatives in this field, such as Microsoft's Hololens 2 [2], Magic Leap's One [3] or Apple's IOS ARKit [4].

There are several ways that we can categorize AR, and one of them is based its relationship with geolocation. Considering a device used to enable AR (usually a smartphone), we have either location-unaware or GPS-enabled applications. Among both types (but emphasizing the latter), there are several issues related to privacy and property that researchers have mostly overlooked. As presented in [5], adding a digital layer over the physical one resulted in unwanted situations, such as hunting gas-emitting Pokemon Go characters in the backyard of the Holocaust museum [6] or battling boss monsters inside the Arlington National Cemetery [7]. A solution to this type of problem could be to implement better ownership management.

Non-fungible tokens (NFTs) have recently emerged in the technological world as a unique way of attributing ownership to a digital good, by employing technology based on blockchain. Unlike standard cryptocurrency, the main idea behind the concept of an NFT is that it is indivisible and unique, thus storing an intricate digital value that can be directly attributed to an entity, whether it is a real person or just another smart contract. NFTs are relatively new. The first one was created in 2014 (recently sold by Sotheby's for $1.4 million [8]), but the majority appeared after 2017.

Several frameworks can support the development of NFTs. Most of them are based on EVM-compatible blockchains, mainly due to the early implementation of interfaces within Ethereum Request for Comment (ERC) standards in Solidity, the main programming language used to develop smart contracts. Such a standard is the ERC-721 interface, a set of instructions that conveys essential requirements to all users that need to access the smart contract from multiple instances (either as owners, creators, administrators, or simple viewers).

NFTs can be used in various cases connected to the "tokenization" of unique individual assets. At their core, NFTs can represent both digital goods (such as gaming inventory, digital artwork, licensed software, event tickets [9]) as well as physical assets such as collectibles, memorabilia, luxury goods, cars, guns, and even real estate (in other words, NFTs can be seen as records connecting digital tokens to tangible assets).

NFTs have already undergone a massive evolution. They have started as simple blockchain cells that link an owner to a multimedia file. However, their metadata was extended on several occasions to include multiple information related to specific use-cases. One of these may be the use of 3D assets, with emphasis on Augmented Reality applications. AR NFTs provide immersive experiences, as long as users engage with custom built AR-enabled applications. The most common use cases of AR NFTs are in art (e.g. the work of Pascal Boyart [10]), fashion (the clothes sold by the company DressX [11]), and entertainment (i.e. the game Mist [12]). However, the main idea explored by these applications is the possibility to easily change the ownership, in a similar way to physical property. Nevertheless, creating and trading physical property comes with an array of conditions related to property rights and privacy policies, conditions that are not tracked within the digital space [13].

In this short paper, we explore the opportunity to tackle the AR property/privacy problem using NFTs. Due to the nature of EVM-based blockchains, standard attributes that come with such implementations (such as anonymity, transparency, immutability, and decentralization) prevent a straightforward solution to this problem [14]. Smart contracts that produce proprietary NFTs, as well as most of the metadata of any NFT, are public – that means anybody can duplicate, deploy, and use them on any blockchain without being held responsible [15]. The question that needs to be answered is "How we can use blockchain to store, convey and protect AR digital property and privacy?".

2 NFTS AND AR: OPPORTUNITIES AND CHALLENGES

EVM-based NFTs fulfill in essence the characteristics described in standards such as ERC-721 or ERC-1155. E.g., the ERC-721 standard implements several functions such as *balanceOf* (returns the number of NFTs held by an owner), *ownerOf* (returns the owner address of an NFT), or *safeTransferFrom* (allows the transfer from

*Corresponding author: mihai.duguleana@unitbv.ro

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one owner to another) and events (such as *Transfer*, *Approval* and *ApprovalForAll*). These standards create the architecture, the "skeleton" upon which complex applications can be built. They set the premises of owning a non-fungible digital good, allowing creation, transfer, lending and destroying functionality.

However, most of the NFT makers use a simple mechanism for NFT creation, which relies on uploading a media file (usually an image, a short movie or a GIF) onto websites already established in the ecosystem called NFT markets (such as OpenSea or Rarible). This can be essentially done by anybody, since there is no mechanism ready to check for copyright issues before (or even after) the release of the new NFT. The same can be said about deploying a duplicate smart contract on the blockchain. Implementing a verification on the blockchain layer would be counterproductive due to several technical reasons. For starters, array parsing is poorly implemented in Solidity. Moreover, using filters could raise the gas prices exponentially. Last but not least, blockchain data is decentralized (whereas property rights and privacy are basically solved by central authorities in the real world). Several attempts have been made to use blockchain to protect property as much as possible. One idea was to store a hash, an unique code of the art, directly on the blockchain, linked inside the smart contract of the NFT, and to host the corresponding digital file on IPFS (the InterPlanetary File System - a decentralized file system linked to EVM blockchains). The main arguments against the efficiency of this solution are the same: the high cost of storing raw data on the blockchain and the possibility of storing data without knowing if it is original or not.

Concluding, although the blockchain alone cannot host a verification layer, it guarantees uniqueness and ownership. This is an important part that is solved thanks to the consensus mechanism of distributed ledgers. The consensus mechanism prevents any attempts to falsify the data stored by one of the 2 mechanisms: proof of work or proof of stake. This mechanism ensures that it either requires too much work or it is enormously expensive to try to change a transaction happened in the past.

Moving on to AR, this is a technology used to display digital assets in a certain way, which doesn't have anything to do with securing intellectual property or caring for privacy concerns. Having a mix between AR and blockchain results in no apparent solution to enforce property interests. Leaving security issues (such as the augmentation of the transfer function, or smart contract wrapping/hacking) and legal issues (such as the evidence of creatorship, the ownership of trademarks and patents) aside, the straightforward action is to improve the current state of things by proposing an augmentation of the actual methodology used for creating AR/NFT decentralized applications (Dapps). Although this idea is not new [16], the opportunities resulted from the intersection of these technologies are worthy of investigation.

3 Proposed Methodology

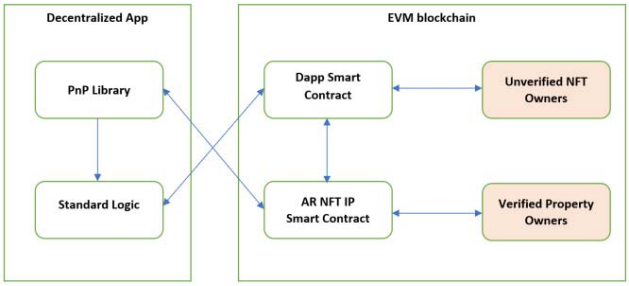

Figure 1: AR NFT decentralized application architecture.

Our proposal revolves around the creation of a new infrastructure at all the levels of a Dapp, including the creation of a custom smart contract and the use of an additional library to be included within the higher application stages.

3.1 Dapp Smart Contract

The Dapp smart contract is the regular smart contract or the suite of smart contracts used by the decentralized application that, besides extending standards such as the ERC-721 or the ERC-1155, ensures the connectivity to the AR NFT IP smart contract. We have purposely kept the 2 entities apart, as current contracts can be easily upgraded to the new logic. All aspects concerning the creation, transfer, and burning of NFTs remain in the hands of this contract and consequently, in the hands of the unverified NFT owners, users, and administrators that interact with this contract.

3.2 AR NFT IP Smart Contract

We see this as a global smart contract that can and should be used by all the decentralized applications that plan to develop AR NFTs. Instead of hosting verification functions, this contract merely hosts data inputted by verified users. The data may contain several pieces of information, such as e.g. protected geolocation points, together with Euclidian distances (from which AR assets should not appear, should be approved before appearing, or should pay a tax for appearing), classifiers used by indoor AR, fees regime and so on. Information from this contract should be retrieved via public view functions, meaning that they don't require gas fees to be called.

This data can be curated either by a central authority (such as a third party organization - i.e. on Etherscan.io, contracts are verified by editors who receive applications from owners, together with their social profiles and email addresses), or by smart contract governance, a new paradigm that engages all token owners of this contract in a voting process.

3.3 Verified Users

Speaking of verified contracts, we propose a secure interaction with the AR NFT IP smart contract, by priory verifying and approving users who want to interact with it. That means that, i.e. if the Holocaust museum staff would want to prevent a Pokemon Go gas-emitting monster from appearing onto its premises, all they have to do is to verify an account, set perimeter geolocation points, and then restrict the access in the predetermined area. Homeowners, business owners and even local authorities could undergo the same process.

3.4 PnP Library

We see the PnP library as a mandatory inclusion in the upper layers of the decentralized application. This library should facilitate the interaction with the AR NFT IP smart contract, and carry out the actual location filtering and privacy inspection processes, using the data received from the blockchain. Including PnP should be stated in the development guides of mobile operating systems such as Android and IOS, as this library will communicate with the global smart contract in real-time.

4 Conclusion

The emergence of blockchain technology came with answers to some of the most important problems faced by our digital endeavors related to scalability, interoperability, and privacy. AR can highly benefit from the latest blockchain product, NFTs, by using the already employed ownership mechanisms to secure digital property. NFTs ground online property just as physical documents ground offline property [17]. With slight adjustments, NFTs will able to mirror the physical environment laws inside the virtual space. We have presented a methodology for using NFTs

together with AR, in order to add the missing intellectual property and privacy layers needed to create a complete application.
NFTs are more than a niche technology - they present a good solution on how people will be able to make use of their personal property. Although there are still more details that need to be sorted, the idea of using NFTs to safeguard AR worlds is what will enable the creation of digital property aftermarkets.

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