Demo: Blockchain-Based NFT Resource Marketplace for Efficient 6G Network Slicing

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***Abstract*—As 6G networks introduce increasingly diverse and complex applications, network slicing is a key enabling technology for partitioning network resources to meet these dynamic demands. However, efficiently managing and allocating these finite resources has become vital. This necessity drives the adoption of an open marketplace model. To address the business and technical complexities associated with such open marketplaces, this paper presents the demonstration of a non-fungible token (NFT)-enabled resource trading marketplace tailored for 6G network slicing. The proposed solution is implemented on an Ethereum-based blockchain system to assess its viability.**

***Index Terms*—5G, 6G, Network Slicing, Blockchain, NFTs**

I. Introduction

As the telecommunications industry transitions from 5G to 6G networks, the complexity of network resource management continues to grow. Network slicing, introduced in 5G, allows for the division of a single physical network into multiple virtual slices, each designed to cater to specific service requirements. This capability is important for supporting diverse applications, optimizing resource use, and generating new revenue streams. In 6G, network slicing is expected to play an even more significant role by handling a wider range of applications while reducing capital and operational costs for communication service providers (CSPs), network slice providers (NSPs), and mobile network operators (MNOs). However, this expanded ecosystem also brings new challenges, including the need for effective collaboration among multiple stakeholders such as infrastructure network providers (InPs) and other MNOs. Open marketplaces, where resources are leased or shared, demand higher levels of trust, transparency, and accountability. Traditional, centralized methods of managing resource allocation, service level agreements (SLAs), and interactions between stakeholders struggle to meet these needs efficiently. Issues like trustworthiness, multi-party coordination, accountability, and traceability continue to hinder the full potential of network slicing in such environments [1].

To address these challenges, blockchain technology presents an innovative solution that offers secure, transparent, and decentralized record keeping. When combined with NFT, the blockchain can provide enhanced capabilities to track resource ownership, verify provenance, and maintain auditability [2]. By representing network resources as NFTs, stakeholders can trade, lease, or manage their resources with greater transparency and control. This paper demonstrates an NFT-enabled resource trading marketplace tailored for 6G network slicing, which is proposed in our work [3]. This marketplace automates resource orchestration, enforces SLAs, and ensures traceability throughout the lifecycle of the resources. The proposal provides a comprehensive approach to solving the trust, orchestration, and accountability challenges present in multi-stakeholder environments. Through this demonstration, we show how NFTs can be used to simplify resource management, improve transparency, and foster collaboration in a decentralized and open marketplace for 6G network.

II. System Architecture

Our demonstration of the marketplace is built on the Ethereum blockchain, a widely adopted platform known for its suitability for public blockchain applications. The system architecture, as shown in Fig. 1, outlines the key components of the Proof of Concept (PoC) developed for this marketplace. In this setup, resource sellers and buyers interact with the marketplace through a decentralized application (DApp), which operates in a web3 environment enabled by Metamask. This DApp provides an interface that allows participants to access the marketplace functions deployed on the blockchain. We utilized Hardhat, a local development and testing environment that simulates an Ethereum blockchain network.

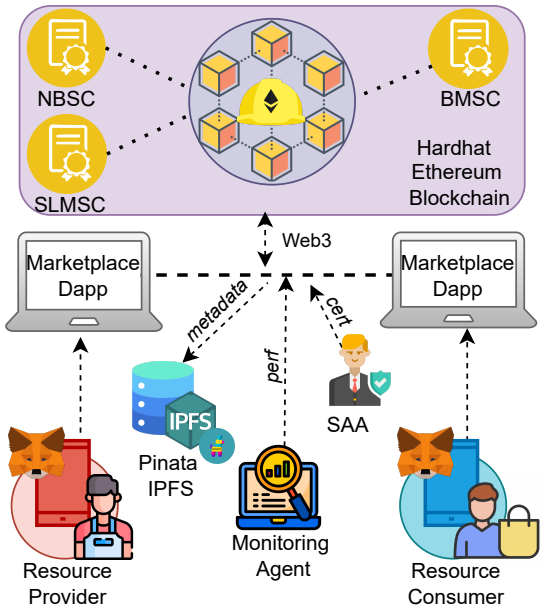


Fig. 1: Prototype setup of the NFT-based resource trading marketplace

The core operations of the marketplace, are executed through three main smart contracts (SCs) each responsible for handling distinct tasks as listed below. These SCs were developed using Solidity, a language optimized for Ethereum.

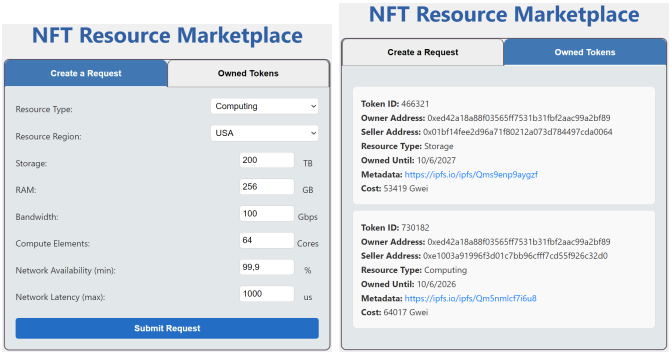
Seller Lifecycle Manager SC ($SLMSC$): registers the details of the resource provider, which are verified by the stakeholder attestation authority (SAA). These details provide insights into the capacity and availability of their resources. In addition, $SLMSC$ adjusts the seller rating score based on feedback from the external monitoring agent. This agent monitors the adherence of sellers to SLAs. $SLMSC$ increases the compliance rating and decreases it for any violation. **NFT Broker SC ($NBSC$):** receives resource requests from buyers and advertises to sellers. Then, sellers send tailored NFT-based resource offers to the marketplace. Next, $NBSC$ validates these requests and selects the optimal seller based on the rating score and the offer price. Finally, it mints a particular NFT and securely hosts the associated metadata in the IPFS. **Billing Manger SC ($BMSC$):** handles NFT transactions, including purchases, billing, and ownership transfers. $BMSC$ uses an escrow mechanism where the buyer sends the service fee, which is held by the contract until the end of the service period. Based on the seller's performance, reflected by their rating score, $BMSC$ calculates the final service fee. For example, in the case of any SLA violations, compensation is sent to the buyer, with the remaining balance going to the seller. At the end of the usage period, the NFT is returned to its original owner.

In our implementation, we used the ERC721 token standard from the OpenZeppelin library to guarantee secure management and transfer of NFT ownership. This standard is widely recognized and commonly applied for handling NFTs within the Ethereum blockchain ecosystem. To manage off-chain data, the PoC integrates IPFS through Pinata. Pinata simplifies the process of hosting files on the IPFS network, where we upload JSON files that store NFT metadata. Each file is assigned a unique Content Identifier (CID), enabling retrieval across any IPFS node. In addition, Pinata automatically generates a new CID whenever the content is updated, ensuring that users can always access the most current version of the data.

III. Demonstration

In this demonstration, we showcase a specific workflow of the NFT-enabled resource trading marketplace for 6G network slicing, focusing on the fundamental properties of our proposed approach. The demonstration highlights key features such as optimal resource provider selection, ownership transfer, and payment processing. Simulating the interaction between a resource consumer and resource providers, this scenario is processed entirely through the Marketplace DApp.

1) **Resource request submission** The demonstration starts with a resource consumer connecting to the marketplace using their Metamask wallet. The consumer then submits a resource request through the Marketplace DApp. As shown in Fig. 2, the user interface allows the consumer to request resources and view their owned tokens. Once the request is submitted, the marketplace logic is triggered, processing the request and notifying resource providers to submit their tailored offers.
2) **Resource providers submit offers** Once the request is processed, resource providers can submit their offers. In the demo, we simulate the submission of two resource offers as if they were sent by two different resource providers, designed to meet the consumer's requirements.
3) **Processing of resource offers** The system evaluates resource offers based on price and seller rating, then the DApp selects and outputs the chosen resource provider.
4) **Minting the NFT** After selecting the resource provider, the marketplace mints an NFT representing the resource offer. This NFT is tied to the chosen seller and includes all necessary details. The NFT metadata, stored in JSON format, is uploaded to Pinata IPFS.
5) **Purchasing the NFT** Next, the resource consumer proceeds to purchase the minted NFT by making the required payment using ethers (test ethers used for the demonstration). Upon successful payment, the proposed system handles the ownership transfer of the NFT.
6) **Transfer of ownership** After the payment is completed, the NFT's ownership is transferred from the resource provider to the resource consumer. This transfer can be confirmed by checking the Metamask wallets of both parties. The NFT will no longer be owned by the seller, and will now be visible in the resource consumer's wallet.



(a) Resource request (b) Owned tokens

Fig. 2: Marketplace DApp user interface of a resource consumer

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