Demo: Blockchain-based Inter-Provider Agreements for 6G Networks

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***Abstract*—With their transparency and smart contract features, blockchain and Distributed Ledger Technologies (DLT) can pave the way toward a decentralized marketplace for multi-administrative domains. An open and decentralized marketplace can aid 6G use cases such as inter-provider agreements, where multi-administrative domains can lease or buy resources to meet the needs of consumers. These agreements between multi-administrative domains can be performed using blockchain, increasing trust and transparency for Service Level Agreement (SLA) management, penalty, or billing. In this demonstration, we present the use of the Ethereum smart contract for a use case where the consumer can buy resources from a provider. However, Ethereum suffers from high transaction costs and latency; therefore, we aim to leverage IOTA Tangle to reduce the cost of transactions on the Ethereum blockchain and minimize the latency. In particular, we show the process of domains registered on an Ethereum blockchain network, consumers selecting a service from the list of available services to buy, and finally, transferring the agreed amount after the services are delivered.**

***Index Terms*—Blockchain, DLT, NFV, Smart Contract, IOTA Tangle, 6G, Marketplace.**

I. Introduction

It is anticipated that future-generation networks such as 6G will have strict Quality of Service (QoS) requirements. Previously, 5G networks characterized network slicing as separating a physical network into different logical networks known as slices. Each slice can be customized with unique network capabilities and properties. Consequently, network slicing and function virtualization (NFV) enables cost and time-efficient solutions in 5G networks. However, supporting various services by a single service provider is a challenge as 6G networks are expected to increase the number of stakeholders in a service providing due to softwarization.

Therefore, deploying multi-domain network services demands the use of advanced solutions, i.e., *service federation*. Federation is the process of orchestrating services or resources across several domains in a multi-domain scenario [1]. The steps of federation provisioning are (i) service domain registration, (ii) service advertisement and discovery or announcement and negotiation, (iii) service deployment, and (iv) life-cycle management and fee-charging. Service federation is one of the critical features of the *5Growth* platform[1].

[1]http://5growth.eu/

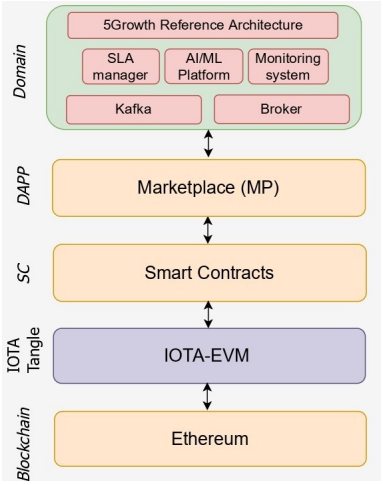

Fig. 1: Building blocks for blockchain/DLT-based inter-provider agreement

The current marketplace for resource sharing has challenges such as delays (due to activities being conducted manually), administrative expenses, and, in some instances, the need to deal with mediators. In addition, these open markets rely on a standard third-party broker to keep participants' private financial information and conduct the auction procedures that directly decide resource distribution [2] and [3]. To meet the demands of end users, stakeholders can create contracts and deploy VNFs/services through a marketplace.

Blockchain and Distributed Ledger Technologies (DLT) can address the challenges of the marketplace for the telecom industry and can further aid with Service Level Agreement (SLA) monitoring, and compliance [4]. The convergence of two technologies, such as blockchain/DLT and service federation, defines the complexity of a phenomenon that necessitates an in-depth understanding of the technologies involved and a clear understanding of how the underlying building blocks could interact for blockchain and DLT-based 6G network use cases. Therefore in Figure 1, as a stepping stone to understanding the characteristics of the underlying components, we illustrate the definition of high-level technology stacks of DLT/blockchain and administrative domains. The building

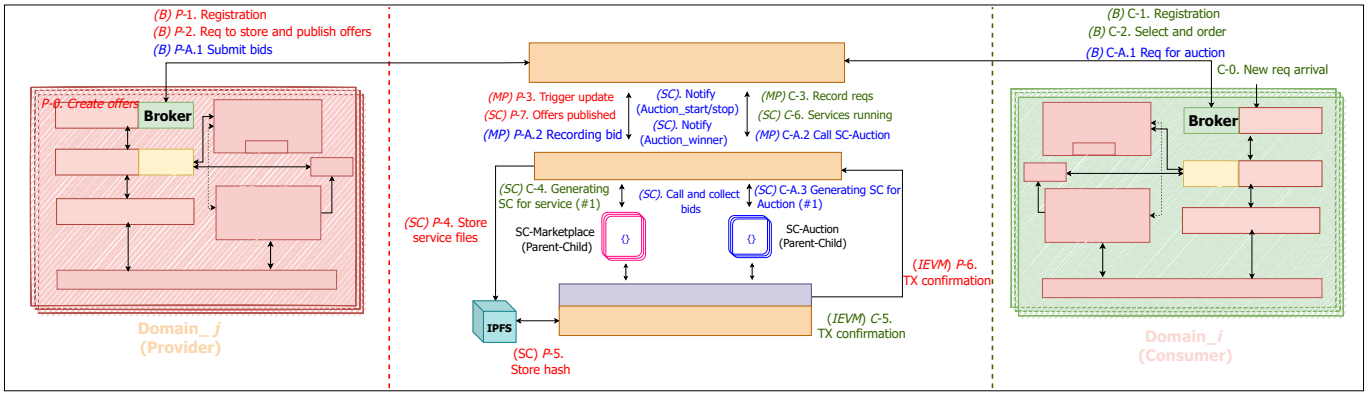

Fig. 2: Functional diagram of blockchain-based inter-provider agreement

blocks for a blockchain-based inter-provider framework are as follows (i) a Domain (provider or consumer), (ii) a Decentralized Application (DApp), (iii) Smart Contract (SC), (iv) IOTA Tangle, and (v) Ethereum blockchain. Here the initial block, *Domain*, is AI/ML platform and integrated into the management and orchestration (MANO) workflow of the 5Grwoth platform [5].

In this demonstration, we show the initial idea of a blockchain/DLT-based marketplace to provide DLT and Ethereum smart contracts to support and establish trust in open marketplaces utilizing DLT to share resources. In addition to automation and SLA management, blockchain technology and smart contracts eliminate the need for costly intermediaries, resulting in trustworthy inter-provider agreements. For this, we aim to leverage solutions that support the current limitation of Ethereum while keeping the concept of decentralization alive. Our solution combines IOTA Tangle [6], and Inter-Planetary File System (IPFS) [7] to minimize the overall cost for 6G use cases. However, transaction fees are a concern when incorporating blockchain technologies like Ethereum. Ethereum is highly decentralized (decentralization is critical for network security and preventing a blockchain from being hijacked by those validating it). Therefore, Ethereum remains the preferred choice for the majority of use cases [8]. Therefore, using IOTA Tangle and IPFS helps reduce the overall cost of the transaction.

To the best of our knowledge, this is the first operational demonstration of the Ethereum smart contract with IOTA Tangle to create a platform and smart contracts where resources are shared and inter-provider agreements are created. These smart contract-based agreements increase transparency and trust among the stakeholder. Furthermore, these agreements can further be used for SLA monitoring. In particular, this demonstration considers a multi-administrative use case scenario where resources can be shared among various domains using an open, decentralized marketplace using blockchain/DLT and smart contract.

II. System Architecture

Figure 2 presents the system under demonstration. This demonstration aims to show the enhanced capabilities of the blockchain/DLT-based framework for inter-provider agreements. An inter-provider agreement is required to support the orchestration of network slices across multiple administrative domains for secure and trustful processes. In this context, service providers are looking for new models (a platform or an NFV marketplace to sell, lease or purchase resources and services with defined SLA agreements) where the on-boarding of assets and resource sharing can be performed in an automated and cost-effective manner at the same time providing ways for accountability with transparency for these SLA agreements. To handle that, DLT can be a way to provide a way for decentralized and open marketplace for the stakeholders in the scenario of multi-administrative domains. The smart contracts store the information on the blockchain, which adds transparency for all stakeholders involved resulting in higher transparency while forming inter-provider agreements.

Figure 2 illustrates the interactions or transactions (a transaction is one of the primary activities that plays a crucial role since it can change or update the state of the smart contract) involved in this use case. These components include: Domain$_j$ as Provider (*P*), Domain$_i$ as Consumer (*C*), Broker (*B*), Marketplace (front-end) (*MP*), Smart Contract (*SC*) (a) SC-Auction, (b), SC-Marketplace, IOTA-EVM (IEVM), Ethereum, and IPFS.

III. Demonstration

This demonstration shows the blockchain-based inter-provider agreement for a 6G network use case. To illustrate this feature, we consider an inter-provider scenario. We consider both sides, the provider side (P) on the left and the consumer side (C) on the right. In addition, we illustrate the interaction with the blockchain in the center. This use case examines blockchain, and smart contracts support inter-provider agreements for 6G networks using a marketplace (Smart Contract (SC)-Marketplace) and auction mechanism Smart Contract

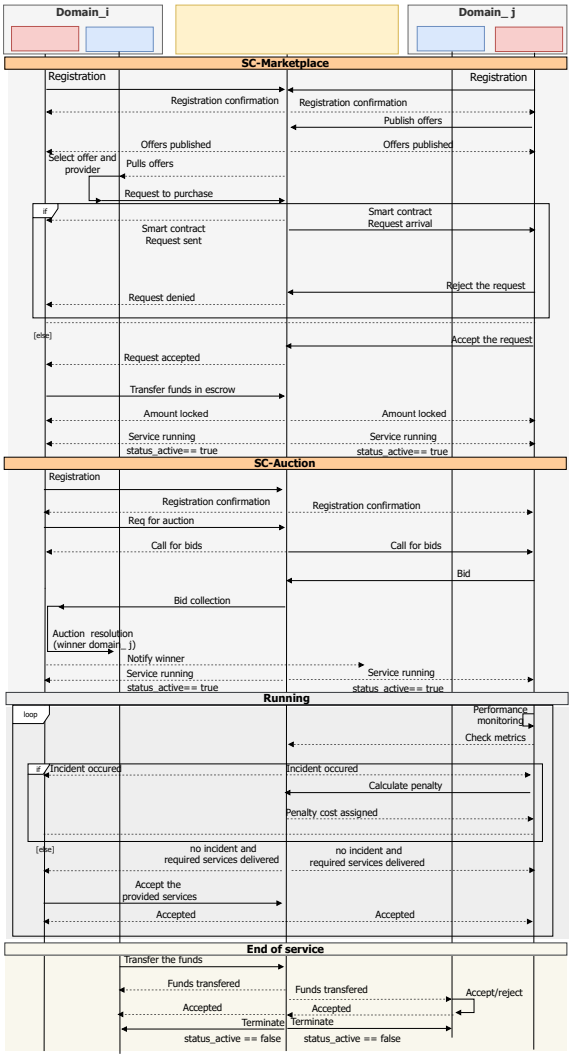

Fig. 3: Smart contract interactions

(SC)-Auction). The initial step on the left side of the Provider (*P*) is the process that starts with OSS/BSS as (step 0) to create offers in Figure 2. Next, we show through the demonstration that the Broker registers the provider domain on the blockchain (step 1).

Once registered, provider P requests to store and publish service offers on the blockchain via smart contract (step 2). Afterward, the process is addressed by Marketplace (MP). First, the MP triggers an update SC (step 3) to store service offers. Next, the SC component stores the service offers files in the IPFS (step 4) and hash these files in the Ethereum (step 5). Once the process is completed, the IOTA-EVM component (*IEVM*) adds this transaction to the ledger (step 6), and *SC* can notify that the offers have been published (step 7).

As mentioned above, this use case aims to provide the consumer (i) select and order from the listed services or (ii) initiate a request for submissions of bids and start an auction to address the consumer's needs. Therefore, we consider two scenarios generating two different smart contracts: 1) SC-Marketplace and 2) SC-Auction. However, the scenario SC-Auction is not part of this demonstration. Therefore, on the right side of the Consumer (*C*), the process starts with BSS/OSS as step 0. This new request can be for resources listed on the marketplace, VNFs, or a slice. Next, *Broker (B)* registers the consumer domain on the blockchain as (step 1).

In this demo, we consider scenario 1 for SC-Marketplace. Once registered, Broker selects one of the available services on the listed service and places an order (step 2). The (*MP*), records the request to *SC* (step 3). The SC component generates a smart contract for the specific request arrival (step 4). Once the new SC-Marketplace is created, the (*IEVM*) adds this transaction to the ledger (step 5), and *SC* can notify that the services are running (step 6). Lastly, the consumer *C* accepts the provided services and assumes that the SLA requirements are met; the agreed amount then can be transferred to the provider *P* (step 7).

Similarly, if a consumer wants to initiate a request for the auction, the smart contract then starts an auction and collects the bids from the available providers. The steps for the auction are mentioned in Figure 2. Also, the sequence of events using a smart contract is presented in Figure 3 for both SC-Marketplace and SC-Auction.

During this demonstration, we show via explorer of successfully added transactions in the blockchain and the result of the successive demonstration steps mentioned above.

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