# Gamified service exchange platform on blockchain for IoT business agility

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***Abstract*— In order to enable IoT solution providers to quickly adapt to market dynamics and improve business agility, in this paper we introduce the concept of a decentralized gamified service exchange platform where the solution providers can dynamically offer and request services in an autonomous peer-to-peer fashion. Cost and decision to exchange services are set during operation time based on gamification policies according to business goals. The proposed concept is based on blockchain technology to provide a tokenized economy where the IoT solution providers can implement gamification techniques using smart contracts to maximize profits during service offering and requesting.**

***Keywords—IoT, Blockchain, Gamification, Service Exchange***

## I. Introduction

In recent years, internet of things (IoT) solution providers have been challenged to quickly adapt to dynamic market requirements. An effective way to address the challenge is to improve the business agility by rapidly bundling and customizing the required software and hardware from shared and ready-to-use resources belonging to other solutions providers when its profitable to do so. For example, a sensor which is located in a certain place could be shared among multiple vendors. This will increase business agility by enabling quick response to market requirements and it can reduce costs for solution providers.

There have been efforts to achieve the above, mostly by utilizing centralized cloud services. Service oriented architectures (SOA) and platform-as-a-service (PaaS) are some examples where an IoT vendor can import and export data from 3$^{rd}$ parties to exchange data among heterogenous networks [1]. Recently, to enable sharing data among vertical markets, flexible architectures have been proposed [2] that allow deploying distributed applications on IoT networks. In [3], virtual vertical concept is introduced where the solution providers exchange data over cloud servers. In [4], inter-cloud broker idea is proposed where it addresses interoperability between IoT clouds. In contrast to the centralized cloud-based solutions, decentralized architectures have been proposed to enable peer-to-peer data exchange on blockchains [5] where the focus has mainly been to address trust and privacy concerns [6] [7]. The previous works describe various proposals for connectivity and exchange mechanisms without considering how the decisions are made in line with business goals to share data and services. This leads to a disjoint between business and technology layers. This paper tries to bridge the gap by proposing to utilize gamification techniques.

For many years, gamification techniques have been used to increase user engagement by motivating people to achieve their personal and organizational goals [8]. This is done by defining individual players goals considering big picture goals and designing game plays and mechanics to achieve the goals. It has also been widely applied to maximize user engagement with IoT devices in various fields such as energy conservation [9], healthcare [10], and safety [11]. The techniques are only applied at the application layer where humans interact with IoT solutions. The purpose is often to emotionally engage and motivate the end users to interact with the devices. The infrastructure of an IoT solution, such as cloud servers, gateways and devices, which provide the required services for the application layer is not included in the gamification. The main reasons are lack of human emotions as a decision-biasing factor and also absence of an enabler platform to run game plays and mechanics in the IoT infrastructure. With the current trend of technology where more intelligence is being built into devices [12] [13] [14] [15] more sophisticated and autonomous behavior from IoT infrastructures could be expected. The intelligence could be utilized for creating decision-bias toward an action where it maximizes the benefits for the solution provider business.

In this paper, we propose the concept of decentralized gamified service exchange platform (SEP) based on blockchain technology [16]. The motivation is to enable autonomous automatic peer-to-peer service exchange and directly relate the decision-making process to business goals.

## II. Service Exchange platform

The objective of our proposed SEP concept is to enable entities to trust, agree on rules, transfer value and exchange services without 3$^{rd}$ party involvement and also to allow implementing gamification strategies among entities. Figure 2 shows the proposed SEP overview. It is assumed that the entities are interoperable. The entities are generalized IoT service providers which can include one or more of the entity stack layers: business, devices, gateways, cloud and application. The entities can be autonomous, heterogenous and geographically dispersed. The entity stack layers are connected to blockchain oracles which are light software modules that act as a bridge between blockchain and other layers of an entity. Oracles of the entities provide connectivity to blockchain and invoke smart contacts to exchange services, transfer tokens using wallets, and decide to utilize internal or external resources based on the parameters obtained from business layer.

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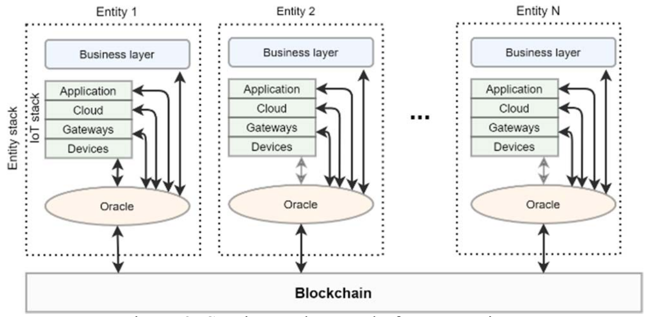


Figure 2: Service exchange platform overview.

The business layer provides the oracle with pricing, reward, legal requirements and duration of service. The reward will be determined based gamification policies and tracking returning entities when a service is offered on SEP for use of other entities. Also, the business layer provides internal cost of a service and preference parameters to the oracle during service requests. Devices, gateways, cloud server and application layers, collectively called IoT stack, are fitted with intelligence to package an atomic service which can either be imported or exported with terms defined by the business layer. Blockchain technology is utilized as the facilitator of peer-to-peer exchange of service and value. The proposed SEP architecture is independent of the blockchain infrastructure and can be implement on any blockchain that supports smart contracts.

## III. Service offers and requests

Each entity can offer and also request services. A service can include real-time data, offline datasets, and functionalities which are defined and offered by one or more layers of the IoT stack in an entity. The offered and requested services can be pre-defined at stack design time or adaptively occur during entity's operation. The services are packaged in an atomic form where they can start and stop on given terms without any dependencies before or after. Service offering and requesting procedures are initiated by IoT stack in an entity to export or import a service, respectively.

Offering a service is about making service information available to other entities and it is a two-stage process. At the first stage, the oracle advertises the service on blockchain using a SO structure where the other entities can find it. The SOs can be advertised on SEP blockchain using a marketplace smart contract that holds the references to SOs or on a separate cloud that solely acts as a marketplace and redirects the rest of operations to the SEP blockchain. The choice of SO advertisement implementation depends on underlying blockchain technology limitations such as transaction costs and processing durations. At the second stage, the unique ID of service requesting entity is received by the oracle of the offering entity and is passed to the business layer where the gamification policies are applied. Depending on the previous service usage of the requesting entity, the status and the relevant number of reward tokens are decided.

Requesting a service is defined as finding the cheapest way of addressing IoT stack requirements by comparing cost of available SOs and cost of using internal resources. Figure 2, shows the service request procedure. It includes discovery, handshake, and decision-making steps. In the discovery step, the IoT stack layers creates a SR, and explores the blockchain for matching SOs. The SEP matches service information except the reward field that will been obtained during handshake step.

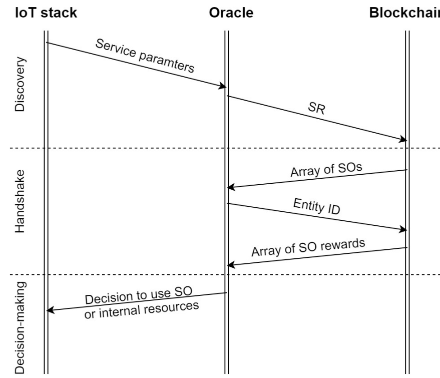


Figure 2. Service request procedure.

The discovered SOs are returned to the requesting oracle in form of an array. In the handshake process, ID of the service requesting entity will be broadcasted to the matching SO entities where the ID gets processed by the business layer to obtain the rewards for the specific SR entity. In the decision-making step, the SR entity will check the price and reward fields of the SOs and use the following optimization function to decide whether to use internal resources or the SO with minimum cost:

$$C = Min \begin{cases} C_{SO} = MinSO(C_i) \\ w \times C_{Internal} \end{cases} \quad (1)$$

$$where\ i = 1, \ldots, N\ ;\ C_i = SO_{P,i} - SO_{R,i}\ ;\ w = (0\ 1]$$

Where $N$ is the number of discovered offers and $C_i$ is difference of the $i$-th SO price ($SO_{P,i}$) and reward ($SO_{R,i}$) in terms of tokens. MinSO function iterates through the discovered SOs and returns $C_{so}$ which is the cost of the SO with the minimum cost. Next, $C_{SO}$ is compared with $C_{Internal}$ which is the cost utilizing internal resources for the same service obtained from business layer. $C_{Internal}$ can include quantized value of o time, hardware, power, cost of deployment and maintenance in terms of tokens. Preference weight from business layer, $w$, is applied to $C_{Internal}$ to bias the preference of using internal service where the value can vary from 0 to 1. The greater number gives more importance to using internal resources. Finally, $C_{SO}$ is compared to $w \times C_{Internal}$ using $Min$ function to decide on the method with the minimum cost of resolving a SR. If the cost of addressing a SR externally by a SO is less than the cost of utilizing internal resources, then the smart contracts on SEP are used to automatically forge a contract and start online or offline service delivery.

## IV. Conclusion

In this paper, concept of a service exchange platform based on blockchain technology has been proposed. It enables peer-to-peer gamified decision making to automatically buy and sell services at operation time for IoT service providers. This could increase financial gains for SO entities by optimizing price and retaining users. It could also benefit SR entities by getting reward for reusing a service and increasing business agility.

## REFERENCES


[1] L. Atzori, A. Iera and G. Morabito, "The Internet of Things: A survey," *Elsevier Computer Networks,* vol. 54, no. 15, 2001.

[2] R. Girau, S. Martis and L. Atzori, "Lysis: A Platform for IoT Distributed Applications Over Socially Connected Objects," *IEEE Internet of Things Journal,* vol. 4 , no. 1, 2017.

[3] F. Li, M. Voegler, M. Claessens and S. Dustdar, "Efficient and Scalable IoT Service Delivery on Cloud," in *IEEE Sixth International Conference on Cloud Computing*, 2013.

[4] P. Grubitzsch, T. Springer, T. Hara, I. Braun and A. Schill, "A Concept for Interoperable IoT Intercloud Architectures," in *7th International Conference on Cloud Computing and Services Science*, 2017.

[5] K. Christidis and M. Devetsikiotis, "Blockchains and Smart Contracts for the Internet of Things," *IEEE Access,* vol. 4, 2016.

[6] W. Chen, M. Ma, Y. Ye, Z. Zheng and Y. Zhou, "IoT Service Based on JointCloud Blockchain: The Case Study of Smart Traveling," in *IEEE Symposium on Service-Oriented System Engineering (SOSE)*, 2018.

[7] Z. Huang, X. Su, Y. Zhang, C. Shi, H. Zhang and L. Xie, "A decentralized solution for IoT data trusted exchange based-on blockchain," in *3rd IEEE International Conference on Computer and Communications (ICCC)*, 2017.

[8] B. Burke, Gamify: How Gamification Motivates People to Do Extraordinary Things, Routledge, 2014.

[9] T. G. Papaioannou and e. a. Dimos Kotsopoulos, "IoT-enabled gamification for energy conservation in public buildings," in *Global Internet of Things Summit (GIoTS)* , 2017.

[10] M. U. Ahmed, S. Begum and W. Raad, Internet of Things Technologies for healthcare, Springer, 2016.

[11] K. Bahadoor and P. Hosein, "Application for the Detection of Dangerous Driving and an Associated Gamification Framework," in *IEEE International Conference on future Internet of Things and Cloud Workshops (FiCloudW)*, 2016.

[12] S. Gheitanchi, F. Ali and E. Stipidis, "Trained particle swarm optimization for ad-hoc collaborative computing networks," in *AISB 2008 Convention Communication, Interaction and Social Intelligence*, 2008.

[13] T. Qiu, N. Chen, K. Li, M. Atiquzzaman and W. Zhao, "How Can Heterogeneous Internet of Things Build our Future: A Survey," *IEEE Communications Surveys & Tutorials ,* 2018.

[14] F. Jalali, O. J. Smith, T. Lynar and F. Suits, "Cognitive IoT Gateways: Automatic Task Sharing and Switching between Cloud and Edge/Fog Computing," in *Proceedings of the ACM SICOMM Posters and Demos*, 2017.

[15] D. Schatsky, N. Kumar and S. Bumb, "Intelligent IoT Bringing the power of AI to the Internet of Things," Deloitte, Dec 2017. [Online]. Available: https://www2.deloitte.com/insights/us/en/focus/signals-for-strategists/intelligent-iot-internet-of-things-artificial-intelligence.html. [Accessed May 2018].

[16] H. Diedrich, Ethereum: Blockchains, Digital Assets, Smart Contracts, Decentralized Autonomous Organizations, CreateSpace Independent Publishing Platform, 2016.