ChainIDE 2.0: Facilitating Smart Contract Development for Consortium Blockchain

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***Abstract*—Nowadays, many novel blockchain-based architecture and frameworks are proposed to solve issues in computer science and financial service. Smart contracts with blockchain systems, especially consortium blockchain systems, can help to provide many reliable and efficient functions for existing systems like smart grid payments. The novel concept of smart contract as a service is proposed but the difficulty of developing smart contracts on various kinds of blockchain systems are also significantly increasing which brings the additional cost for both developers and infrastructure builders. In this paper, we present an updated cloud-based smart integrated smart contract development system, ChainIDE 2.0, for the ultra-efficient development of blockchain-based smart contracts on multiple kinds of blockchain systems. Not only we stay as the most popular cloud-based developing Integrated Development Environment (IDE) for the Libra blockchain, but also we introduce the consortium blockchain systems such as Ant Financial Open-Chain (Ant OC) and served as the first cloud-based IDE supporting the Ant Financial OpenChain test net. Today, we have served almost 1 million compiled smart contracts which makes us the most popular cloud-based blockchain development IDE in the world.**

***Index Terms*—Blockchain, Smart Contract, Cross-chain Platform, Libra, Consortium Blockchain**

I. Introduction

Since the first blockchain system, Bitcoin [1], was proposed in 2008, a huge number of novel properties and concepts were proposed based on the blockchain architecture. Since it allows for payments to be finished without any bank or any intermediary, blockchain can be used in various financial services such as digital assets management, remittance, and online payment [2].

Later on, more and more cryptocurrencies [3] appeared based on blockchain architectures which bring a revolution on many financial applications and technologies. The initial version of such blockchain-based cryptocurrencies is similar to the Bitcoin network where all nodes maintain a public ledger with verified transactions and are stored in a chain of blocks. New blocks are continuously appended to the chain and never removed; this raises an obvious scalability issue which in turn limits the efficiency of transactions. A bitcoin block size is limited to 1 MB and a block is mined with quite some latency (about every 10 minutes [4]). Consequently, the Bitcoin network is restricted to a rate of 7 transactions per second which cannot meet the needs of financial applications that require frequent transaction operations. The second question earlier was about the usage of blockchain systems except providing anonymous transactions with tamper-proofing and decentralization. Another practical issue is that becoming a new node for the existing blockchain networks such as Bitcoin is very costly since the existing ledger of blocks are already more than 250 GB and probably grow to 1 TB by 2030 [5]. Moreover, the mining process becomes very computationally intensive and it has been proved that miners can achieve larger revenue if they are able to hide their mined blocks for more revenue in the future [6].

More recently, several novel developments of blockchain were proposed. Firstly, the concepts are proposed such as the consortium blockchain and fully private blockchain to improve consensus, transaction efficiency, and blockchain system scalability. Then, more and more applications are being proposed to significantly extend the usage of blockchain concepts such as the decentralized games [7] and smart contracts [8]. Also, the structure of the blockchain network has evolved in several stages. The lightweight node and full node structures are proposed [9] and the systems for maintaining the blockchain networks are becoming more and more complicated. A blockchain-based smart contract is a cryptographic box that stores information, processes inputs, writes outputs and is only accessible to the outside if certain predefined conditions are met. For instance, as pointed out in [10], the smart contracts can be realized by inserting code comprising a Turing complete set of operations that will be executed by the Ethereum [11] network once a smart contract is called. Such a computation results in several outcomes: alteration of the state of the smart contract, returning a result, and transfer of monetary value.

With such great value, many smart contract systems are created by different entities and the concept of Blockchain as a Service (BaaS) is getting broad acceptance [12]. According to [13], the current situation for BaaS is that there are many blockchain-based smart contract services but the cost of developing smart contracts on these systems is very costly. Installing and configuration on the commercial BaaS systems are becoming a time-consuming process that actually creates the practical obstacles for smart contract users. For

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instance, before programming on the Libra blockchain [14], the setting up process is slow and inefficient since all clients must first download, setup, and build the environment which will consume more than one hour on average and Windows system is not supported.

In this paper, we introduce the ChainIDE 2.0 that significantly improves the initial version of the ChainIDE platform by adding more functions and features. Also, with the more tutorial and introduction sections added, the development for multiple famous blockchain-based smart contracts is highly accelerated. Besides the 6 blockchain systems supported by ChainIDE 1.0 shown in [13], there are another 5 novel blockchain systems added including Ant BaaS from Alibaba [15]. Moreover, we also extended the usage of cloud-based blockchain-based services in our system. With a brief example, we show how the ChainIDE 2.0 system could support extended functions for banking applications. In summary, we are still the most popular cloud-based smart contract developing system for not only public blockchain systems but also for consortium blockchain systems.

The structure of this paper is as follows. In Section 2, we briefly introduce some background concepts and use cases related to our platform. In Section 3, we illustrate how our system is working and list the supported functions and features. In Section 4, we evaluate our current system with the updated operation statistics. In Section 5, we discuss and point out future perspectives based on our viewpoint. We give a conclusion in Section 6.

II. Background Knowledge and Related Works

In this section, some basic background knowledge is introduced. Firstly, the consortium blockchain concept is introduced. Then, we briefly present the concept of cloud-based BaaS concepts. Also, we would also like to briefly clarify the needs for the BaaS architecture to indicate the commercial and practical needs of the cloud-based IDE for smart contracts.

A. Public and Consortium Blockchain Networks

As mentioned in Section 1, there are many practical issues that appeared for public blockchain systems like Bitcoin. However, the decentralization and tampering-proof concepts are still very useful which introduced the concept of consortium blockchain networks. The consortium blockchain architecture could bring the scalability and efficiency to the applications but reduce the decentralization property compared with the public blockchain. However, the tampering-proof can still be achieved by carefully designing the entities involved.

For instance, the consortium blockchain has been investigated to be used for energy trading in the IoT use cases [16] such as the smart grid scenario [17]. By deploying the consortium blockchain, the time to create novel blocks can be flexible and the mining process will not be intensively needed since mining will not correspond to profit like Bitcoin. The current trend is that many Internet service providers are developing their own consortium blockchain systems along with their smart contract services like Libra from Facebook, Ant BaaS from Ant financial. This development of consortium blockchain systems maintained by the large enterprise can significantly improve the scalability of the smart contract systems but will potentially increase the developing cost since they are all relying on their own dedicated fundamental systems.

B. Blockchain as a Service (BaaS) and smart contract

According to [10], a smart contract defines the rules between different organizations in executable code. Combining with blockchain systems, the smart contract will be invoked and a series of transactions will be generated to be recorded on the ledger with verification. With such a proposal, the blockchain-based smart contract opened up a wide variety of new possibilities for industries [18]. Since a smart contract can implement the governance rules for any type of business object, they can be automatically enforced when the smart contract is executed. The execution of a smart contract on a blockchain system is more efficient than a manual business process and can provide properties like tamper resistance and reliability.

Combining the smart contract with the cloud computing [19], the blockchain systems can become a kind of service (BaaS) that can fully utilize the elasticity, high availability, and flexibility of cloud computing. Also, the trust from blockchain systems can be provided to achieve multi-party consensus and tamper resistance. Therefore, the BaaS can serve as the infrastructure of blockchain solutions in different industries and provide a reliable and solid foundation of trust. Some pioneer industrial platforms of BaaS are already built such as the Ping An had already a blockchain network with more than 20k nodes across China and handled transactions valued at over one-trillion RMBs, including over 90% of those for Ping An OneConnect and Ping An Group's fintech subsidiary [20].

C. Cross-chain Development

The need to participate in multiple, separate blockchain networks always exist as pointed by [21]. In order to join multiple blockchain systems, the practitioners will face different challenges since basically the programming languages for different smart contract BaaS are different. For instance, Libra uses Move, Fisco uses Solidity, Cocos uses Lua, IOST uses Js, Ultrain uses Ts, etc. Additionally, the configuration environment requirements for different blockchain systems are also different which are increasing in the difficulties for developers. Therefore, the cost for developing of smart contracts at a cross-chain use case is increasing along with the appearance of novel blockchain systems.

On the other hand, since all BaaS providers like Facebook or Ant Financial are focusing on the development of their own BaaS products, the integration of developing on multiple blockchain systems is becoming more and more costly not only on learning the programming language but also configure the development environments. Therefore, the motivation of our work is to provide a cloud-based blockchain IDE to support many different BaaS development to save all the time consumed by downloading, setting up, configuration, etc.

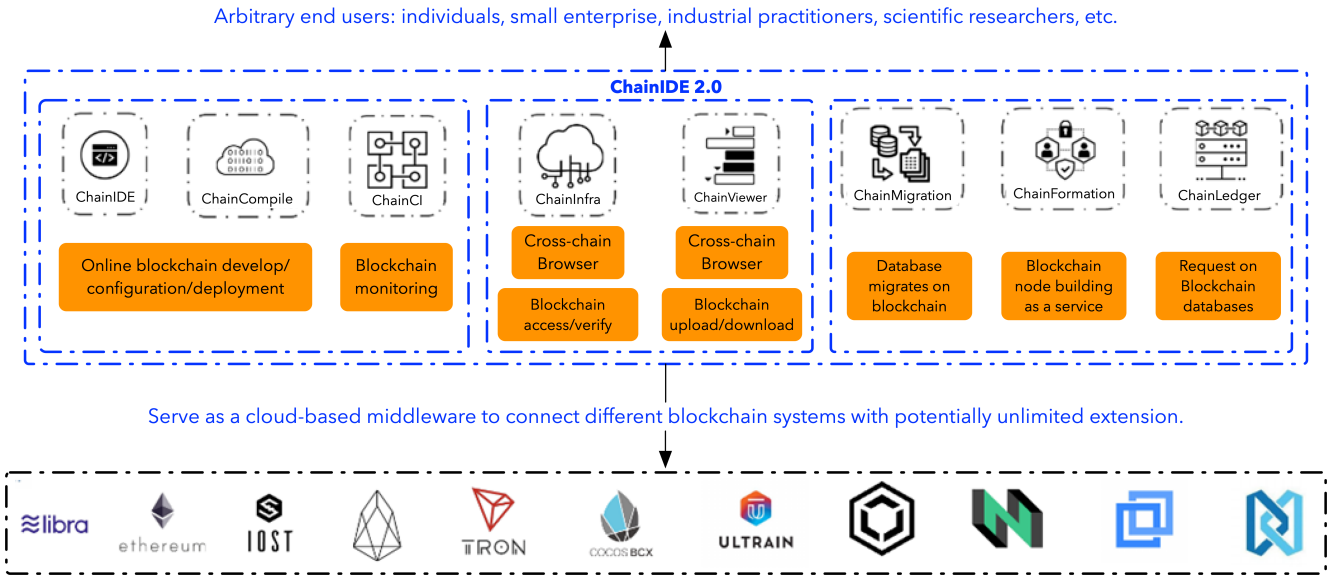

Fig. 1. The improvement of chainIDE: (a) current development on blockchain system requires complicated install, setup, and configure process on every blockchain system on every device; (b) chainIDE can support unlimited extension of blockchain system but users just need an Internet browser to develop.

III. System Architecture

As mentioned in [13], according to our knowledge, ChainIDE is the first in the world that can support cloud-based smart contract developing with unlimited extension and almost zero pre-requirements for developers. In this updated version of ChainIDE 2.0, we significantly improved the supported BaaS platforms by introducing novel six BaaS blockchain systems including Ant Baas from Alibaba [22]. Also, we extended the features and the functions of our system by introducing more services like building blockchain nodes and searching data logs in blockchain systems as shown in Fig. 1.

An overview of the system architecture is shown in Fig. 1. The main function we realized for the ChainIDE 1.0 was to provide a cloud-based Integrated Development Environment (IDE) for developing smart contracts or other blockchain applications for six famous blockchain systems including Ethereum, Libra, Cocos, IOST, Nervos, and Ultrain. The target of the initially proposed system is to build a cloud-based solution that provides the development environment as a web-based interface for the blockchain developers, which in turn interacts with the blockchain. The basic function of the ChainIDE was to build a system as shown in Fig. 1 to become a developing IDE between blockchain system users and the existing blockchain networks. Starting from the end user's observation, ChainIDE provides an online graphical developing interface that can easily interact with the complicated blockchain systems maintained by different entities.

Moreover, besides a website that owns an interactive graphical interface, we also deployed the techniques including cloud computing, cache mechanisms, and the Content Distributed Network (CDN) [23] to accelerate the developing process. Particularly, we used the Cloudflare [24] to accelerate the compiling process for special network environments. Therefore, with our proposed ChainIDE, end users can program on many different blockchain systems without any technical preparation steps as long as there is an Internet connection and their Internet browser supports JavaScript.

```
1  import 0x0.LibraAccount;
2  import 0x0.LibraCoin;
3  main(payee1: address, amount1: u64, payee2: address, amount2: u64) {
4    let coin1: LibraCoin.T;
5    let coin2: LibraCoin.T;
6    let total: u64;
7
8    total = move(amount1) + copy(amount2);
9    coin1 = LibraAccount.withdraw_from_sender(move(total));
10
11   coin2 = LibraCoin.withdraw(&mut coin1, move(amount2));
12
13   LibraAccount.deposit(move(payee1), move(coin1));
14   LibraAccount.deposit(move(payee2), move(coin2));
15   return;
16 }
```

Fig. 2. A piece of demo code with Move language of Libra [14] on novel ChainIDE 2.0.

Since the first version and release of the ChainIDE platform, our platform keeps serving the most quantity of the compilations of the newly released Libra blockchain system and become the most popular Libra blockchain online smart contract developing and compiling IDE.

Along with the release of the Libra, a brand new programming language dedicated to the Libra blockchain system, `Move`, is also released by Facebook [25]. According to [25], `Move` is the smart contract platform language mainly designed to (1) issue cryptocurrencies, tokens, and digital assets; (2) handling blockchain-based transactions; (3) managing validators. On our platform, Move language is well adopted and supported. In the first 30 days after we went online, there are totally more than 120k compilations on Libra through our

platform in the past and today we are still the most popular Libra extended development environment. We also give an example of the Move program compiled on Libra blockchain as shown in Fig. 2. The small `Move` program is used to pay multiple recipients with one transaction script.

In summary, the initial purpose of announcing Libra, according to Facebook, was to provide financial services to all the people that not live within the scope of current banking systems. However, the current Libra blockchain system is not very easy to use since the downloading and configuration process are not very efficient especially in some district with special network condition. For instance, as we tested in [13], the lest time consumed by the setup and build steps on three different machines including AWS ec-2 medium [26], AWS ec-2 small, and a Mac Pro PC was 45 minutes to set up and build the environment for only Libra blockchain. There are similar such issues on other many public blockchain systems which are usually caused by the diversity of the blockchain systems and many different network conditions which inspired us to provide such a cloud-based solution.

IV. Evaluations and Operation Statistics

As pointed in ChainIDE 1.0 [13], there are many practical obstacles for slowing down the developing on blockchain systems since the downloading and the configuration will cost time. In the last version, we measure the time cost by the necessary steps before one user could start developing with the examples on the Libra blockchain. However, in fact, there are still other costs that will increase the time consumed by developing smart contracts such as learning the documents and example codes from the websites of the blockchain systems. Therefore, on our updated platform, we provide better tutorials and codes for all blockchain systems with some proposed template codes. For instance, on the Ethereum of ChainIDE 2.0, there are `SimplePaymentChannel.sol`, `Token.sol`, `Purchase.sol`, and `BlindAuction.sol` for users as initial stage of development.

Therefore, on ChainIDE 2.0, we would like to further reduce the developing cost by adding more support sample codes and tutorial documents. The comparison between the ChainIDE 1.0 and 2.0 is given in TABLE II. Currently, we have 5 more supported blockchain systems including both the public blockchain and consortium blockchain systems linked to our platform. The compilations are from more than 100 countries in the world and now we are proposing all the tutorial documents and sample codes for all blockchain systems on our platform. Same with Libra blockchain systems, there are instructions for all other blockchain systems that can help users easily perform the direct development of smart contracts on ChainIDE.

Currently, there are a huge number of developers on our platforms from academics and industries. In the past, there are totally almost **1 million smart contracts** compiled from **more than 100 countries** on the chainIDE system. Based on the updated statistical results, currently, the most frequent compiled smart contracts are still on Libra blockchain. The category distribution of the 1 million compiled smart contracts is given in TABLE I. Libra is the most popular and mostly used the blockchain system for deploying smart contracts. Particularly, there are more than **400k smart contracts compiled on Libra blockchain** in the past on the chainIDE.

TABLE I
Distribution of compiled of smart contracts in ChainIDE 2.0.

Category	Smart Contract	Tutorial	Dapp Games	Others
Quantity	990,343	806,040	128,745	55,558
Ratio	100%	81.39%	12.99%	5.62%

We also list the category distribution of smart contracts compiled on the chainIDE in TABLE I. According to our statistical analysis, there are more than 806k compilations (more than 81%) are based on the tutorial codes of smart contracts which means there are many beginners to program on smart contracts. Then, for the other categories, the most popular smart contracts are used for the Decentralized games (Dapp games [27]). There are more than 128k compilations (more than 12%) for Dapp games which means the Dapp games are very popular today. This is due to the decentralized topology of a blockchain system that could help to avoid the gaming rules manipulated by the big game companies and the cheating [28]. For the other categories, the Decentralized Finance (De.Fi) [29] is also a popular kind of smart contracts for financial use and is seen as one of the next-generation financial services. This is also the most popular smart contract on Libra blockchain for the online decentralized digital banking.

TABLE II
Comparison between ChainIDE 1.0 and ChainIDE 2.0.

System version	Compiled smart contracts	Original countries	Supported blockchain	Online tutorial
ChainIDE 1.0	310k+	50+	6	60%
ChainIDE 2.0	990k+	100+	11	100%

V. Discussions and Research Perspectives

In the recent several years, blockchain has become a fundamental technology and many extended systems or concepts are proposed to build powerful tools. Based on the novel consortium blockchain and smart contract concepts, there are more and more practical use cases and scenarios proposed in recent research works and real-world industrial. In this section, we present the two most popular real-world use cases with the research situations and the future perspectives including FinTech [30] and medical big data.

A. Blockchain with FinTech

Many revolutions are brought by these novel systems or concepts to change the classical solutions in computer science and the financial domain (FinTech). Also, the practitioners are also becoming various kinds instead of the initial tech teams which brings the needs for a service-oriented architecture of blockchain-based techniques. For instance, as smart contracts could solve many issues and improve the efficiency in many

existing traditional use cases, the difficulty of developing smart contracts is rapidly increasing as well. Therefore, the concept of smart contract as a service was brought by enterprises like Ant Financial. Also, the consortium blockchain-based system for improving the banking system especially the banking transfers will also need help from the blockchain practitioners. We believe that the other blockchain-based technologies have a similar situation and building a service-oriented system to reduce the cost for both users and infrastructure builders is very necessary. In this paper, we proposed an updated version of ChainIDE supporting the smart contract developing on both public blockchain and consortium blockchain and the statistics we have already achieved. For future work, we believe by building the cloud-based developing IDE for blockchain infrastructures and potential clients, financial services especially the consortium-based banking systems will be developed rapidly with our ChainIDE in the future.

In the future, the most interesting topic will be using consortium blockchain-based architectures to improve financial services like banking systems. Since 2015, several famous international financial institutions have begun to start the system building with the blockchain architectures. Many famous banks established their own blockchain systems with their own blockchain laboratories. Therefore, many different blockchain industrial consortiums have shown up to develop blockchain-based applications and the most famous one is the R3 blockchain consortium [29] which involved more than 40 of the world's leading financial institution. Later in 2015, the NASDAQ conducted its first-ever blockchain shares trade using its new, proprietary platform called Linq [31]. In May 2016, Ping An Bank and China Merchants Bank (CMB) have also joined the R3 blockchain consortium.

The most feasible use case for the financial system is to build the consortium blockchain networks for the bank transferring system. There are several advantages to deploy blockchain concepts into banking use cases [32]. First, an important point is about reliability since the traditional centralized systems can fail due to a single point of failure. The decentralized architecture with consortium blockchain could build a distributed ledger with an unalterable series of coded blocks protect against hacks and fraud in today's IT ecosystem. Also, using blockchain architecture can significantly improve the efficiency of authentication, verification, and approval of any transaction or contracts instantaneously compared with the manual operations in today's financial systems. The expensive and time-consuming third-party verification along a payment process can be avoided as well. Transparency and risk management can also be guaranteed and improved.

In summary for the future of the FinTech development, with blockchain architecture, a secure, efficient, and decentralized financial data system will solve many of the emerging concerned issues for financial systems like banks. Error and fraud rates will drop while administrative costs decrease, while also near-eliminating the need for redundant storage of customers' sensitive financial data.

B. Blockchain with Medical Big Data

The other practical use case involved with the development of the consortium blockchain system is the medical big data storage [33]. Nowadays, with the developing of Electronic Health Record (EHR) [34], many applications based on the medical big data transmission and sharing are now deployed. According to [35], the cloud-based EHR data storage and patient data protection have become more and more important [36]. However, current existing EHR data management or sharing systems are always relying on the centralized data management system to control access for private EHR data which is not the optimal solution. Firstly, the rapidly increasing EHR data will lead to a huge computation cost of the centralized data management system which is also vulnerable to a single-point failure. Secondly, the poison or the corruption of the EHR database will also threaten the usage of the EHR big data-based applications. Also, due to different trust regulations in different regions, the contract of using and protecting the EHR data will also be very costly.

In fact, since several years ago, blockchain technology is redefining the data management and storage in many healthcare applications. One scenario is especially being considered that the medical tests are always required to be done in different hospitals or medical institutes repeatedly. In fact, such test results are so important that the medical investigations and decisions of patients are all relying on them. Unfortunately, today, the results of such investigation or tests are rarely shared widely with all of the medical institutes as a part of the patient's EHR data [37]. The main reason is that basic trust is required to be built for such data sharing. Nowadays, consortium blockchain architecture has provided the possibility of secure, efficient, and reliable EHR data management and sharing. There are applications like [38] already to provide blockchain-based medical sharing especially the test results sharing between nodes of trust medical institutes.

Therefore, with the consortium blockchain system develops, there will be more and more efficient and reliable EHR data sharing and transmission system for not only the test medical data but also the EHR access management. Also, with the smart contract built on such consortium blockchain systems, there will be more and more convenient EHR data sharing applications to help the efficient and secure EHR data management [39].

VI. Conclusion

In this paper, we mainly presented an improved version of ChainIDE, ChainIDE 2.0, which integrated more than ten blockchain systems for developing with multiple tasks. First, we stay as the most popular smart contract development platform for the public blockchain system and served almost 1 million smart contract compiles including more than 400k smart contracts on Libra. Particularly, we introduced consortium blockchain systems including Ant Financial OpenChain (Ant OC) and served as the first cloud-based IDE to support the Ant Financial OpenChain test net. With ChainIDE 2.0, we significantly reduce the time cost for various kinds of developing

on blockchain systems. In this paper, we also discussed some real-world applications of consortium blockchain systems and smart contracts which we already or can potentially work on. We believe in the future version of ChainIDE, we will keep introducing different kinds of blockchain systems to provide support for public and consortium blockchain developers and blockchain infrastructures.

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