Neural Distributed Ledger

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***Abstract*— In this paper, authors present a suite of solutions to both build and interconnect blockchain networks in big data environments authors call Neural Distributed Ledger (NDL) given its similarities to neurons aggregation. The solution presented here adopts a ledger-of-ledgers approach to perform the interconnection of multiple ledgers. Beyond interledger operability, it also enables the development of own blockchain-based solutions providing controlled costs and scalability while retaining decentralization and security. This solution has been tested in real environments with promising results.**

Keywords: Blockchain, Interledger

■ INTRODUCTION

Blockchain is evolving towards maturity and wider applicability. This distributed ledger technology (DLT) supports collaborative processes by means of a shared, distributed and trusted dataset. Blockchain appeared back in 2008 designed by Nakamoto, when the famous Bitcoin cryptocurrency implemented this technology to be able to track and store transactions in a decentralized way. The implementation is based on a list of records of transactions sustained by means of a distributed consensus mechanism (Proof of Stake, Byzantine Fault Tolerance Algorithm, Proof of Work…) implemented over a peer-to-peer network.

Nowadays this technology has been applied in various domains, industries and problem spaces [1], [2] with remarkable success. Recent studies also underline the crucial impact of this technology by granting a transformational role across most industries within five to 10 years [3].

Blockchain now presents a variety of platforms (Ethereum, IBM Blockchain, Hyperledger Sawtooth, OpenChain, Hyperledger Fabric, Quorum …) that are considered the second generation of blockchain [4]. These platforms are playing a crucial role in blockchain adoption allowing software practitioners to develop blockchain apps with ease. Developers adopt these platforms based on standard factors like previous experience, supported language, cost of operation, popularity, type of network or support. The result of this variety of platforms is the fact that diverse blockchains are operating in parallel and some more will appear in the arena to complicate even more the current panorama. In this scenario, interconnecting blockchains in a secure and efficient way is key in order to guarantee a universal, unified, and non-segregated realm for distributed ledgers [5]. The so-called, third generation of blockchain solutions is aimed to improve the known flaws of previous generations, e.g. interoperability and network speed.

In this paper, authors present a suite of solutions to both build and interconnect blockchain networks in big data environments authors call NDL given its similarities to neurons aggregation in the creation of interconnected subsets. The solution presented here adopts a ledger-of-ledgers approach to perform the interconnection of multiple ledgers. However, beyond interledger operability, by means of a suite of products, the technology also enables the development of own scalable blockchain-based solutions while retaining decentralization and security.

THE APPROACH

Information silos are traditional problems in information systems from the very beginning of computing [6]. In recent times, fragmentation and lack of interoperability are major issues in several scenarios including DLT-based solutions. According to a recent paper [5], blockchain interledger approaches can be divided into the following categories:

1.Atomic cross-chain transactions. This is normally performed by means of atomic swaps that, in a nutshell, encompasses launching transactions in the different blockchains ensuring atomicity through hash-locks and time-locks without the need to trust a third party.

2.Transactions across a network: Lightning and Raiden. Both solutions are based on the interconnection of micropayment channels, the first depending on the Segwit Bitcoin extension and the second on the Raiden Network.

3.Layered value transfer protocols (World Wide Web Consortium Interledger Protocol, ILP). W3C issued a generic and open protocol intentionally limited in scope to deliver the aspects necessary to perform a payment from a source to a destination over an interconnected system of ledgers

4.Bridging approaches. These approaches entail modules running on the nodes of the two interconnected chains considered hierarchically equal. Examples of these implementations are Blocknet, Wanchain or ARK.

5.Sidechains. Normally used to move assets from one main blockchain to other sidechain. The reasons behind this decision are lower transaction costs, different functionalities and the most common one, better confirmation times. There are different implementations of sidechains including Cardano, Liquid or Plasma.

6.Ledger-of-ledgers approaches. This approach is based on the introduction of a super-ledger acting as the intermediary when two ledgers need to communicate. Adopting this solution will provide same previously reported benefits but also entails a high complexity. Implementations include Cosmos, Uberledger and Polkadot.

The latter is the approach adopted in the solution presented in this paper that includes two different components designed to work together. Firstly, a new implementation of blockchain designed to be applied in massive environments (NDL Retis) and, on the top of it, a blockchain network adopting a ledger of ledgers approach aimed to connect different blockchains (NDL Integra). In what follows, a description of the solution is provided.

Firstly, it is proposed a multidimensional and collaborative blockchain environments (NDL Retis) designed to work in massive environments. Specifically, it presents the following features:

•The network is divided into interconnected subsets of groups working in parallel, allowing to process as many blocks as working groups per unit of time, thus, maximizing the number of transactions in the network.

•Intersections between sets or working groups protect the network in a similar way to what a block protects the previous ones in the traditional blockchain.

•It is possible to scale vertically by adding new nodes to the different work groups.

•Scales horizontally by adding new sets of nodes without compromising network performance.

•Allows programmed obsolescence of information in the network but also provides mechanisms to store relevant information by means of policies.

•A rise in the number of nodes increases the storage capacity of the network.

•Distributes the information in domains and fragments along the network.

•A node does not have all the information records in the database (security).

•Implements two different consensus algorithms, one that rules the working group and one for the entire network, aimed to merge information present in different working groups.

•It is designed to work just in private networks.

As a consequence of these features, Retis presents the following advantages compared to traditional blockchains:

•Work is segmented among working groups leading to better throughput and scalability. Apart from that, in cases in which data to handle by the blockchain is heavy (e.g. documents, video…), traditional blockchains could collapse after just some transactions.

•Given the structure of working groups, when the network increases in number of nodes, the overall throughput is higher, confronting with first generation blockchains.

•Not all nodes present the same information and information is distributed among nodes so average storage capacity of the network is not "the minimum storage capacity of the nodes". Moreover, actualization or addition of new nodes does not require high bandwidth and update time.

•There is a policy-based mechanism to set obsolescence to certain data including the storage of such obsolete data into specific storage nodes, so there is not a need to build another blockchain network when the current is collapsed given the impossibility to erase data (traditional blockchain is append-only).

The second component of the solution is NDL Integra. Integra makes possible to connect different blockchain networks in a transparent, certified, secure, auditable and fully traceable way by means of a ledger-of-ledgers approach. By means of an API, Integra is capable of providing a set of standardized actions in the network including update, composition, decomposition, transfer, erase or history. In a NDL Integra network, each node collaborates to maintain the global register of actions applied to all stored value object (GVL - Global Value Ledger) while connecting as a client to one or more DLT networks.

By connecting to a NDL Integra network, each node acts as a delegation broker, which allows users to operate on objects hosted on that network, even if they do not have their own access and operation certificates. Thus, the node receives the order to act on an object and executes the operation whenever the minimum security requirements stipulated by the network that hosts it are fulfilled, recording the result of the operation in the GVL.

In the network, each node also acts as a certified oracle that facilitates the automated incorporation of data in the client network. A node in an integrated environment is a normal blockchain node (NDL Retis node) enriched with features to connect to other networks and with the Broker and Oracle behaviors. This makes the extensibility of blockchain networks just dependent on configuration under this schema. In other words, Integra is a specialization of Retis with the purpose of interledger connection.

In sum, by means of Retis and Integra, it is possible to build a cluster of blockchain networks to get advantage of the following benefits and contributions:

•Greater ability to serve clients in parallel.

•Decrease in the average registration latency. Each network in the cluster writes in its internal ledger one block in each turn.

•Network storage scaling.

•The negative impact on consensus latency is minimized by adding new signatory nodes, as these can be distributed among the different networks of the cluster.

THE BUSINESS ROADMAP

In spite of the importance of Blockchain and its increased number of implementations, this technology is not applicable everywhere every time. In a nutshell, Blockchains are a good fit for ecosystems but not necessarily for single entities. Scriber [2] presented a framework for determining blockchain applicability. In this work, ten architecture or blockchains' characteristics are assessed and weighted through an evaluation matrix to determine blockchain`s level of fit. These characteristics are: Immutability, Transparency, Trust, Identity, Distribution, Workflow, Transactions, Historical record, Ecosystem and Inefficiency. However, this framework is intended to be adopted by software architects and, in our experience, business factors also must be considered in the assessment of blockchain applicability. Another recent effort to evaluate the need of a blockchain in smart factories is presented in [7]. In this case, authors present a flow diagram assessing several business and technological aspects. However, the applicability of the proposal outside smart factories environments is limited.

Following an action research approach [2], authors present a set of assumptions that lead to a rapid and business-oriented DLT applicability assessment. In order to define which environments are suitable for DLT, seven different aspects must collide in the project:

I.There are different and independent entities involved in the use case

II.These entities need to share parts of information in order to participate in the system

III.Information exchanges must be regulated by formal procedures

IV. Information exchange traceability must be certified

V. Transparency is required among actors

VI. Process automation is key for the system

VII. Information fragments shared among players must be valuable

This simplified set of questions could lead to a first and swift decision to pursue a Blockchain project. In our experience, some C suite workers blinded by the blockchain supernova, push CIOs or CTOs towards DLTs solutions without a previous evaluation of the applicability of the technology. These seven questions could be the tool for software practitioners and their technical managers to tackle the hype problem many professionals are facing in their jobs.

THE TESTING

When needed, blockchain has been applied to ensure data integrity while transferring sensible data [8]. However, as the demand of computing power rose because of the use of Blockchain-based solutions, challenges on performance and operability began to appear. In scenarios in which computing power is limited e.g. Internet of things (IoT), these challenges are more tangible.

In this section, we present results of a case study on the adoption of NDL in an IoT environment.

As a proof of concept, NDL nodes were embedded within electric vehicle charging devices implemented over Raspberry Pi III Model B nodes. Initial tests installing some commercial blockchain nodes in such devices reported high temperatures and loss of performance and operability. The testing setup includes a Retis network with complete physical nodes implemented on virtual machines (10 nodes) and a Retis network with experimental nodes specifically designed for Raspberry Pi III devices. Both networks were interconnected with a 3-node NDL Integra Network implemented on virtual machines in an environment independent of the other two networks.

In order to validate the applicability of NDL, we tested three of these devices during three weeks measuring device temperature and CPU usage (%). This setup was tested with different latencies, namely 10, 5, 1 and 0.2 seconds. The three devices were encapsulated in solid cases without ventilation, in a cool and dry environment with an ambient temperature of 21ºC. Software installed in the three devices is a NDL node and connector developed in J2SE. Connectors worked as follows:

```
THREAD1
While True
    Calculate sending data
    Apply RSA 512 on data
    Select 10 nodes in the network with less latency
    For each Node
        Throw a new thread
        Encrypt the data with the peer public key
        If Connection
            Send data to peer
            Obtain answer
            Calculate peer new latency
            Update peers file (new latency)
            Close connection
        Else
            Update peer (maximum latency)
        End
    End
    Hold 10000ms
End

THREAD2
While True
  Select 10 nodes in the network with less lag
  For each Node
    Throw a new thread
    If Connection
      Send request to peer of its known peers
      Obtain answer
      Calculate peer new latency
      Update peers file (new latency)
      Add new nodes (zero latency)
      Close connection
    Else
      Update peer (maximum latency)
    End
  End
  Hold 30000ms
End
```

Results presented in Figure 1, show the averages of temperature and CPU usage (%) in the four scenarios (10, 5, 1 and 0.2 seconds latencies) measured in 24 periods of 12 hours. Temperature is pictured in the primary axis (vertical left). In the secondary axis (vertical right), CPU usage is coded.

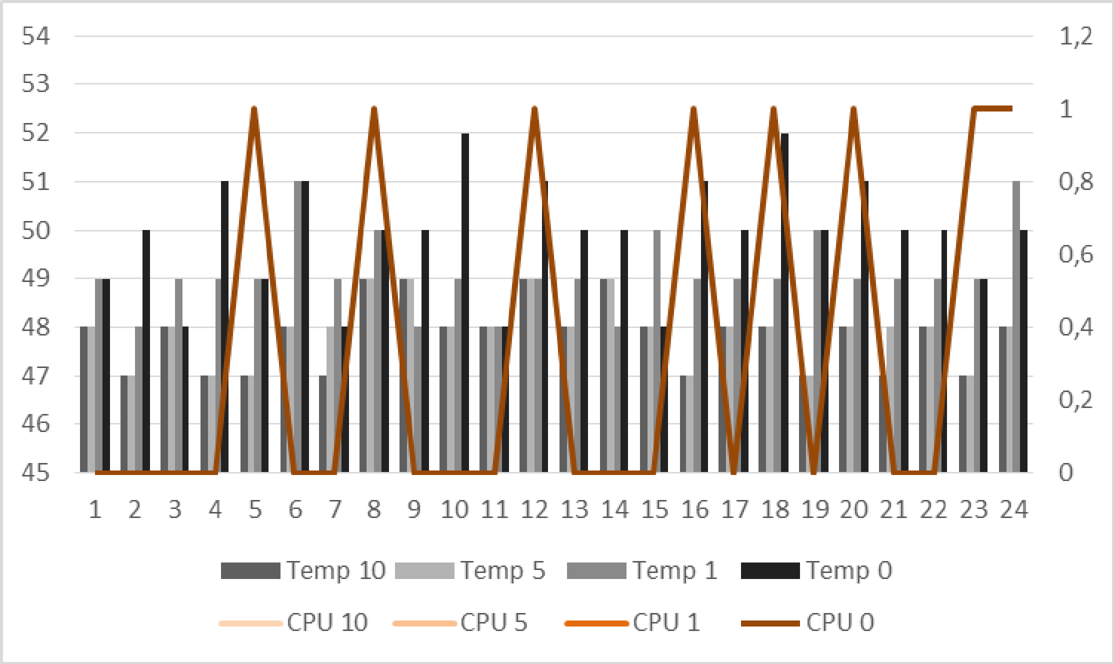

Figure 1. Graph on the measurements of the experiment (Temperature and CPU consumption)

Results show a very low CPU usage reaching to 1% only in few cases, just the ones with lower latency. Regarding temperature, in general, higher temperatures are measured in cases of lower latency too. There is also a light correlation of high temperature with CPU usage. There were no significant differences among the three devices. Moreover, there are not significant differences between the behavior of the three devices with the installed software and the average operating values set by the manufacturer (peak temperatures of 66 Celsius in stress-test settings).

In sum, we can conclude that NDL is capable of working in this environment without compromising performance and operability.

CONCLUSIONS

In this paper authors present NDL, a Blockchain platform that is aimed to tackle some of the known problems of distributed ledgers solutions: interoperability, network speed and storage problems. The presented technology is able to be deployed as a single blockchain network (Retis) but also, by means of configuration, to act as a ledger-of-ledgers in the connection with different blockchain networks (Integra). In sum, this can be considered a third generation blockchain network, being this the main contribution of the work. NDL is currently in the commercialization phase and authors are currently working in the extension of the features of the suite, but also in the creation of customized solutions to different sectors and customers.

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