HYPERLEDGER

Hyperledger (or the **Hyperledger project**) is an [umbrella project](#) of [open source](#) [blockchains](#) and related tools,[1] started in December 2015 by the [Linux Foundation](#),[2] and supported by big industry players like [IBM](#), [Intel](#) and [SAP Ariba](#), to support the collaborative development of [blockchain](#)-based [distributed ledgers](#).

CONTENTS

HISTORY AND AIMS

In December 2015, the Linux Foundation announced the creation of the Hyperledger Project. The founding members of the project were announced in February 2016 and ten further members and the makeup of the governing board were announced March 29.[3] On May 19, [Brian Behlendorf](#) was appointed executive director of the project.[4]

The objective of the project is to advance cross-industry collaboration by developing blockchains and distributed ledgers, with a particular focus on improving the performance and reliability of these systems (as compared to comparable [cryptocurrency](#) designs) so that they are capable of supporting global business transactions by major technological, financial and supply chain companies.[5] The project will integrate independent open protocols and standards by means of a framework for use-specific modules, including blockchains with their own [consensus](#) and storage routines, as well as services for identity, access control and smart contracts. Early on there was some confusion that Hyperledger would develop its own bitcoin-type cryptocurrency, but Behlendorf has unreservedly stated that the Hyperledger Project itself will never build its own cryptocurrency.[6]

In early 2016, the project began accepting proposals for incubation of codebases and other technologies as core elements. One of the first proposals was for a codebase combining previous work by [Digital Asset](#), [Blockstream](#)'s libconsensus and [IBM](#)'s OpenBlockchain.[7] This was later named Fabric.[8] In May, Intel's distributed ledger, named Sawtooth,[9] was incubated.[10]

On 12 July 2017 the project announced its production-ready Hyperledger Fabric 1.0 and it started to gain popularity in the [Initial coin offering](#) market.[11] In July 2017, [London Stock Exchange Group](#) in a partnership with IBM announced that it will create a blockchain platform designed for digitally issuing shares of Italian companies with Hyperledger Fabric as the basis of the platform.[12] In August 2017, [Oracle](#) joined the Hyperledger consortium and announced its Blockchain Cloud Service offering.[13][14] In September 2017 the [Royal Bank of Canada](#) (RBC) started using Hyperledger for its US - Canada interbank settlements.[15]

MEMBERS AND GOVERNANCE

Early members of the initiative included blockchain ISVs, (Blockchain, [ConsenSys](#), [Digital Asset](#), [R3](#), Onchain), well-known technology platform companies ([Cisco](#), [Fujitsu](#), [Hitachi](#), [IBM](#), [Intel](#), [NEC](#), [NTT DATA](#), [Red Hat](#), [VMware](#)), financial services firms ([ABN AMRO](#), [ANZ Bank](#), [BNY Mellon](#), [CLS Group](#), [CME Group](#), the [Depository Trust & Clearing Corporation](#) (DTCC), [Deutsche Börse Group](#), [J.P. Morgan](#), [State Street](#), [SWIFT](#), [Wells Fargo](#), [Sberbank](#)), business software companies like [SAP](#), academic institutions (Cambridge Centre for Alternative Finance, Blockchain at Columbia, UCLA Blockchain Lab), systems integrators and others ([Accenture](#), Calastone, [Wipro](#), Credits, [Guardtime](#), IntellectEU, [Nxt Foundation](#), [Symbiont](#), Smart Block Laboratory)[16].

The governing board of the Hyperledger Project consists of twenty members chaired by Robert Palatnick, (managing director and chief technology architect for DTCC), and a twelve-member Technical Steering Committee chaired by Dan Middleton, Principal Engineer at Intel.

HYPERLEDGER FRAMEWORKS

Hyperledger Burrow

Burrow[17] is a blockchain client including a built-to-specification [Ethereum](#) Virtual Machine. Contributed by [Monax](#)[18] and sponsored by Monax and [Intel](#).[19]

Hyperledger Fabric

Hyperledger Fabric is a permissioned blockchain infrastructure, originally contributed by [IBM](#)[20] and Digital Asset, providing a modular architecture with a delineation of roles between the nodes in the infrastructure, execution of [Smart Contracts](#) (called "chaincode" in Fabric) and configurable consensus and membership services. A Fabric Network comprises "Peer nodes", which execute chaincode, access ledger data, endorse transactions and interface with applications. "Orderer nodes" which ensure the consistency of the blockchain and deliver the endorsed transactions to the peers of the network, and MSP services, generally implemented as a Certificate Authority, managing [X.509](#) certificates which are used to authenticate member identity and roles.[21]

Fabric is primarily aimed at integration projects, in which a Distributed Ledger Technology (DLT) is required, offering no user facing services other than an SDK for [Node.js](#), [Java](#) and [Go](#).

Fabric supports chaincode in Go and [JavaScript](#) (via [Hyperledger Composer](#), or natively since v1.1) out-of-the-box, and other languages such as Java by installing appropriate modules. It is therefore potentially more flexible than competitors that only support a closed Smart Contract language.

Hyperledger Iroha

Hyperledger Iroha was written from scratch in C++, with an emphasis on supporting mobile applications. It was contributed by Soramitsu[22], a Japanese blockchain fintech company, in 2016[23].

Iroha is inspired by the Japanese *Kaizen* principle (eliminate excessiveness). Iroha has essential functionality for asset, information or identity management; it is easy to start with Iroha and integrate it using various client libraries[24]. There is no need to create complex smart contracts, as an predefined set of "Commands" and "Queries" suffices for most operations.

Iroha created a new, one-phase asynchronous BFT consensus algorithm called YAC (Yet Another Consensus), which ensures consistency of data state among the nodes and scales linearly.

Hyperledger Iroha is being used in the Kingdom of Cambodia to create a new payment system alongside the National Bank of Cambodia[25], and in various other projects across healthcare, finance and identity management.

Hyperledger Sawtooth

Originally contributed by Intel, Sawtooth includes a dynamic consensus feature enabling hot swapping consensus algorithms in a running network. Among the consensus options is a novel consensus protocol known as "Proof of Elapsed Time," a lottery-design consensus protocol that optionally builds on trusted execution environments provided by Intel's Software Guard Extensions (SGX).[26] Sawtooth supports Ethereum smart contracts via "seth" (a Sawtooth transaction processor integrating the Hyperledger Burrow EVM).[27] In addition to Solidity support, Sawtooth includes SDKs for Python, Go, Javascript, Rust, Java, and C++.[28]

Hyperledger Indy

Indy[29] is a Hyperledger project for supporting independent identity on distributed ledgers. It provides tools, libraries, and reusable components for providing digital identities rooted on blockchains or other distributed ledgers and contributed by the Sovrin Foundation.[30]

Hyperledger Grid

Grid[31] is a framework for building supply chain solutions. It's an ecosystem of technologies, frameworks, and libraries that work together, letting application developers make the choice as to which components are most appropriate for their industry or market model.[32]

HYPERLEDGER TOOLS

Hyperledger Caliper

Hyperledger Caliper is a blockchain benchmark tool and one of the Hyperledger projects hosted by The Linux Foundation. Hyperledger Caliper allows users to measure the performance of a specific blockchain implementation with a set of predefined use cases. Hyperledger Caliper will produce reports containing a number of performance indicators, such as TPS (Transactions Per Second), transaction latency, resource utilisation etc. The intent is for Caliper results to be used by other Hyperledger projects as they build out their frameworks, and as a reference in supporting the choice of a blockchain implementation suitable for a user's specific needs. Hyperledger Caliper was initially contributed by developers from Huawei, Hyperchain, Oracle, Bitwise, Soramitsu, IBM and the Budapest University of Technology and Economics.[33]

Hyperledger Cello

Hyperledger Cello is a blockchain module toolkit and one of the Hyperledger projects hosted by The Linux Foundation. Hyperledger Cello aims to bring the on-demand "as-a-service" deployment model to the blockchain ecosystem to reduce the effort required for creating, managing and terminating blockchains. It provides a multi-

tenant chain service efficiently and automatically on top of various infrastructures, e.g., baremetal, virtual machine, and more container platforms. Hyperledger Cello was initially contributed by IBM, with sponsors from Soramitsu, Huawei and Intel.[34]

Baohua Yang and Haitao Yue from IBM Research are committed part-time to developing and maintaining the project.

Hyperledger Composer

Hyperledger Composer is a set of collaboration tools for building blockchain business networks that make it simple and fast for business owners and developers to create smart contracts and blockchain applications to solve business problems. Built with JavaScript, leveraging modern tools including node.js, npm, CLI and popular editors, Composer offers business-centric abstractions as well as sample apps with easy to test DevOps processes to create robust blockchain solutions that drive alignment across business requirements with technical development.[35]

Blockchain package management tooling contributed by IBM. Composer is a user-facing rapid prototyping tooling, running on top of Hyperledger Fabric, which allows the easy management of Assets (data stored on the blockchain), Participants (identity management, or member services) and Transactions (Chaincode, a.k.a. Smart Contracts, which operate on Assets on the behalf of a Participant). The resulting application can be exported as a package (a BNA file) which may be executed on a Hyperledger Fabric instance, with the support of a Node.js application (based on the Loopback application framework) and provide a REST interface to external applications. Composer provides a GUI user interface "Playground" for the creation of applications, and therefore represents an excellent starting point for Proof of Concept work.

Hyperledger Explorer

Hyperledger Explorer is a blockchain module and one of the Hyperledger projects hosted by The Linux Foundation. Designed to create a user-friendly Web application, Hyperledger Explorer can view, invoke, deploy or query blocks, transactions and associated data, network information (name, status, list of nodes), chain codes and transaction families, as well as any other relevant information stored in the ledger. Hyperledger Explorer was initially contributed by IBM, Intel and DTCC.[36]

Hyperledger Quilt

Hyperledger Quilt is a business blockchain tool and one of the Hyperledger projects hosted by The Linux Foundation. Hyperledger Quilt offers interoperability between ledger systems by implementing the Interledger protocol (also known as ILP), which is primarily a payments protocol and is designed to transfer value across distributed ledgers and non-distributed ledgers. The Interledger protocol provides atomic swaps between ledgers (even non-blockchain or distributed ledgers) and a single account namespace for accounts within each ledger. With the addition of Quilt to Hyperledger, The Linux Foundation now hosts both the Java (Quilt) and JavaScript (Interledger.js) Interledger implementations. Hyperledger Quilt was initially contributed by NTT Data and Ripple.[37]

Hyperledger Ursa

Ursa[38] is a modular, flexible shared cryptography library.[39]