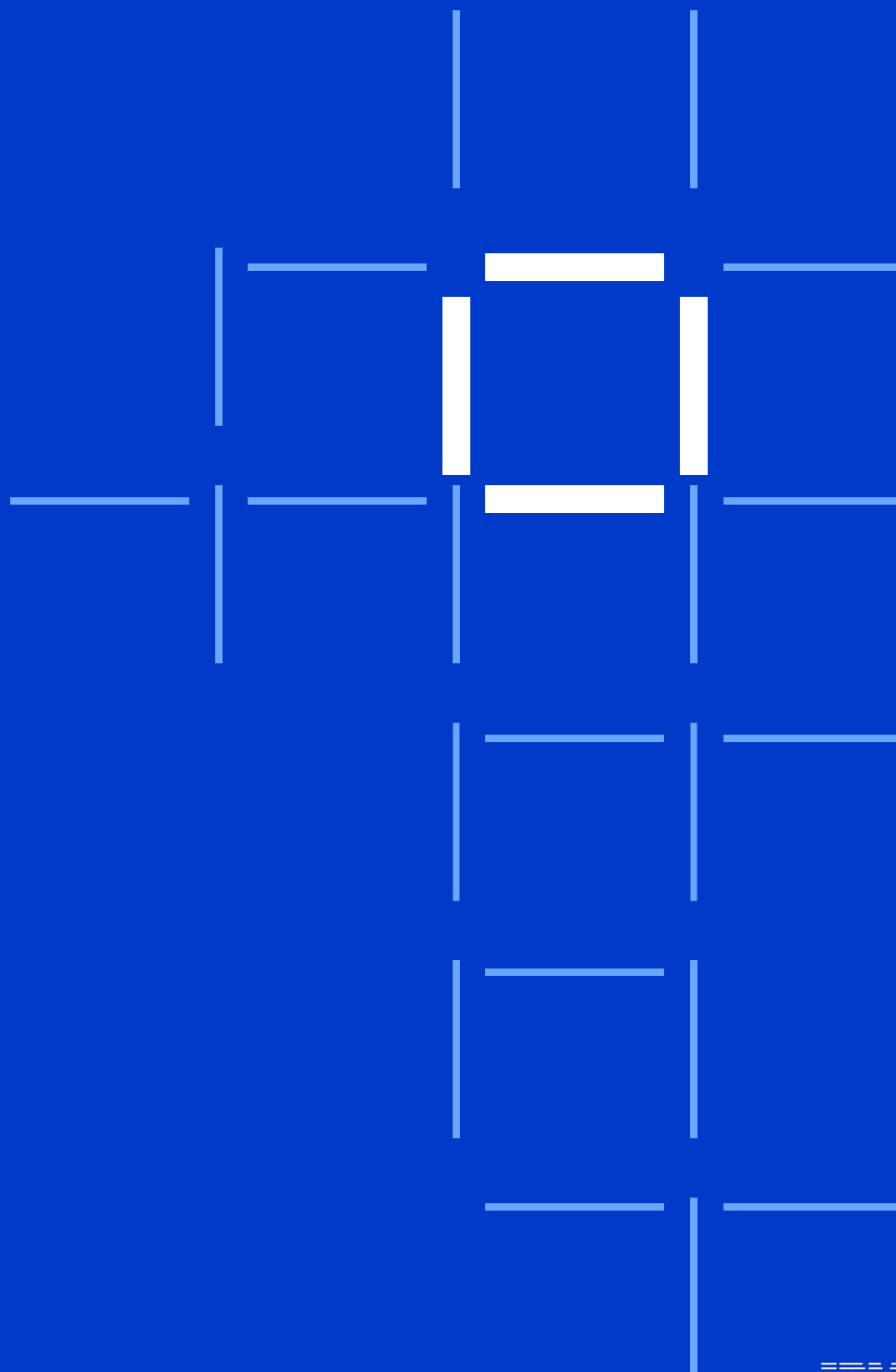


IBM Blockchain Platform

Technical Overview

Updated November 2018



Introduction

This paper provides an overview of the capabilities of the IBM Blockchain Platform built on the Linux Foundation's Hyperledger Fabric. The IBM Blockchain Platform provides a managed, full stack blockchain-as-a-service (BaaS) offering delivered in an environment of your choice, including the IBM Cloud, on-premises, and third-party clouds, such as Amazon Web Services (AWS). It allows members to develop and operate a network with the performance and security necessary for even the most demanding use cases in regulated industries.

The IBM Blockchain Platform enables you to create a blockchain network with a few clicks and provides an easy-to-use interface for managing networks, channels, and chaincode (smart contracts). When you are ready to grow your network, the IBM Blockchain Platform makes it easy to invite new members, create channels, customize governance policies, manage the identity credentials of network participants, and much more. Leveraging Hyperledger Fabric, the IBM Blockchain Platform enables a new kind of distributed business network founded on the principles of finality, trust, and privacy.

1. Data finality matters

When transactions are committed to the ledger they should not be removed or altered. Because Hyperledger Fabric does not fork, information appended to the blockchain will not change. The only way the ledger can be updated is via a new transaction. Since data finality is important, the system leverages a checks and balances protocol that ensures transactions are valid, accurate, and verified. For example, a transaction process includes: initiation by an authorized client, verification and signing by endorers, inspection and validation of endorser responses, then validation of the transaction by all peers on the network. All of this must perform successfully before a new block can be appended to the blockchain. For enterprise use, distributed ledger technology must be capable of ensuring data is secure, transparent and final.

2. Trust through transparency, not through anonymity

Unlike permission-less networks, the IBM Blockchain Platform is not based on trust through anonymity. Participants to business networks must be known to the network, enabling distributed trust amongst a known business network. Regulatory requirements often dictate certain information on participants and transactions in a network be known. It is also important to note that working in an onymous nature removes the need for mining, and inherently makes transaction processing speeds much faster.

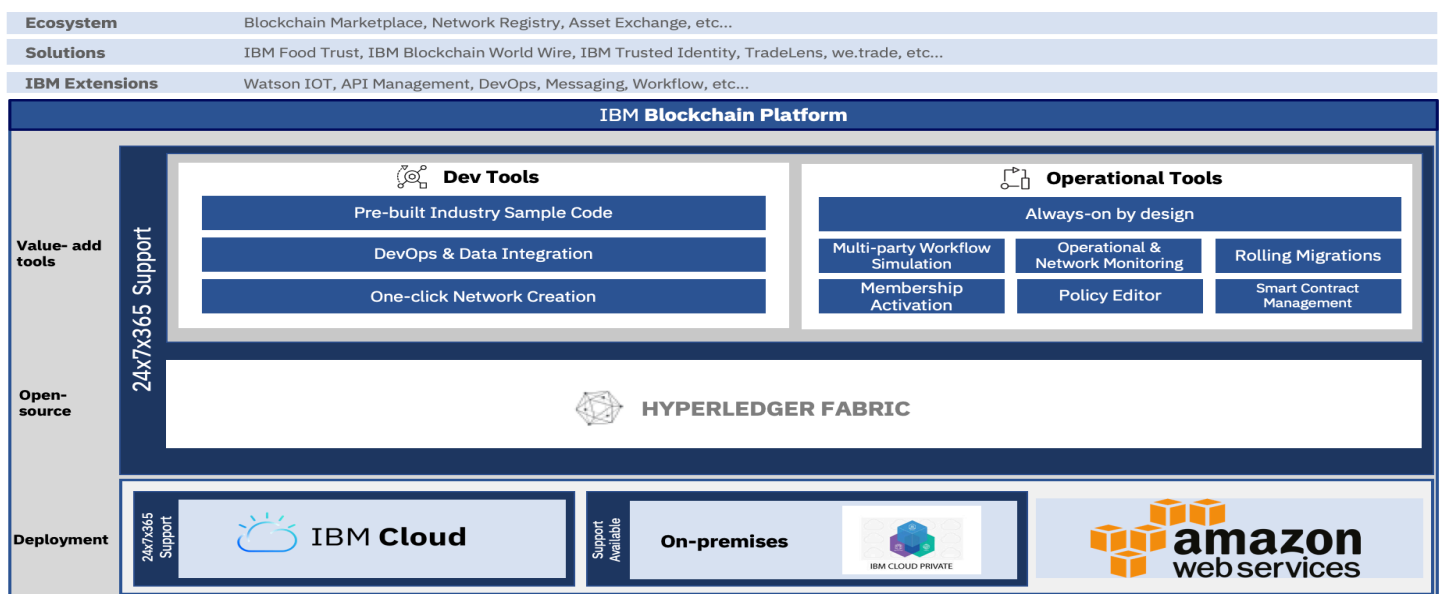
3. Privacy on the network

Businesses require full confidence that both their transaction data and the transactions themselves are confidential. The IBM Blockchain Platform enables privacy via three key mechanisms (one in production, two coming soon): channels (in production), private data database, and zero-knowledge proof technologies. Channels are used when information is not desired to be shared with the entire network. The private data database is operated alongside the ledger to store private data that may be referenced, ensuring private information remains private. Lastly, zero-knowledge proof technologies enable a party who possesses private information to prove to another party that the information satisfies a certain set of properties without revealing the information.

Architecture overview

The IBM Blockchain Platform builds on top of key open-source and openly-governed technologies resulting in no vendor lock-in. Utilizing the modularity, performance, privacy and scalability of Hyperledger Fabric, the IBM Blockchain Platform provides the necessary components for developing and operating enterprise blockchain solutions. Figure 1 outlines the end to end architecture of the IBM Blockchain Platform. This captures the experience from hundreds of client engagements to provide a production-ready platform for enterprise blockchain networks.

Figure 1: IBM Blockchain Platform Overview



Hyperledger Fabric

The core open source component of the IBM Blockchain Platform is Hyperledger Fabric. Hyperledger announced the production-ready version of Hyperledger Fabric 1.0 in July of 2017. Hyperledger Fabric v1.0 benefited from the contribution of 159 developers from 28 organizations – built by the enterprise community, for the enterprise community. Hyperledger’s Technical Steering Committee drove community involvement and contribution in line with the needs of enterprise adoption, enabling modularity, scalability, and consensus for production networks. As of August 2018, Hyperledger now consists of over 250 contributing organizations that continue to advance the capabilities of Fabric, which is currently in version 1.3.0.

Hyperledger Fabric provides core features to address specific needs of a permissioned blockchain network with organizational membership from businesses large and small. Hyperledger Fabric is built with modularity throughout the architecture to allow a variety of implementations on cryptography, identity, consensus protocols, smart contract languages and other aspects to be easily interchangeable based on the needs of the consortium. Hyperledger Fabric provides a strong foundation for building decentralized business networks without having to integrate disparate solutions.

Modularity

Blockchain networks must be able to incorporate a wide range of new and existing “pluggable” features depending on the enterprise and industry. As a result, Hyperledger Fabric was developed to be modular in order to support networks as new features emerge.

Modularity in Hyperledger Fabric allows the IBM Blockchain Platform to leverage industry leading security practices to serve production-ready networks, including GDPR and HIPAA best practices.

Scalability

Organizations across sectors demand solutions that scale as they move past initial explorations and proof-of-concepts. Hyperledger Fabric was built to support growing business networks which need to dynamically add participants and support increasing transaction processing.

Many aspects of scalability depend on network configuration of consensus, membership, and security. The IBM Blockchain Platform leverages Hyperledger Fabric to provide a modular platform that supports the ability to configure a network to support needed throughput numbers and network growth.

Consensus

An important feature to the security, scalability, and maturity of any blockchain framework is a clearly-defined and implemented consensus protocol. Selecting the appropriate consensus protocol is vital to enabling distributed trust within a decentralized business network.

As mentioned above, consensus in Hyperledger Fabric is designed to be pluggable and fit specific enterprise use-cases. Therefore, Fabric allows you to choose the best consensus protocol to fit your specific business networks’ needs.

Hyperledger Fabric’s success to date is driven by the massive amount of community support it has received through Hyperledger. Open governance of the code base with a clear purpose has allowed it to emerge as the industry leading protocol and framework for enterprise production networks.

IBM Blockchain Platform builds on Fabric

Hyperledger Fabric is the premier blockchain framework for enterprise use. There are many benefits, as mentioned above, to working with Fabric; however, Fabric combined with the IBM Blockchain Platform brings the capabilities and value necessary for enterprises to innovate with the security, speed, and scale required in industry today. The IBM Blockchain Platform builds on Fabric by providing a fully managed and supported, full stack blockchain- as-a-service (BaaS) offering delivered with flexible deployment options to meet your business requirements.

The IBM Blockchain Platform, built on Hyperledger Fabric, offers an array of capabilities that expand and enhance the value of Fabric. It allows members to model, create and operate networks with the performance and security necessary for a multitude of use cases in regulated industries. Check out some of the key features below.

- Built on Hyperledger Fabric (Open-source)
- Development and operational dashboards and toolsets
- One-click network creations
- Add new members/participants in seconds not minutes
- Create secure, private channels with a couple clicks
- Multi-industry use case sample code
- Support for multiple smart contract languages, including: Node.js, Go, Java, Solidity and more
- Rolling migrations of updates with zero network downtime
- Multi-cloud deployment models: IBM Cloud, AWS, on-premises and more
- Thriving blockchain marketplace including existing IBM and third-party blockchain solutions
- 24x7x365 support
- \$500 credit when you get started today
- And much, much more

Development

The first step in recognizing the value of transactional business networks is enabling developers to materialize innovative business ideas. The IBM Blockchain Platform allows developers to leverage core tools and common languages to model, build, test, and deploy business applications to a distributed business network.

The platform enables developers to

- Ensure alignment across business and technical requirements to significantly reduce blockchain application develop time.
- Quickly build blockchain skills by leveraging popular tools and languages such as Node.js, Go, Java, REST, Docker, Yeoman, and more.
- Flexibly learn and develop in preferred environments with an open and modern toolset, including VS Code integration.

The IBM Blockchain Platform continues to build on top of Fabric, by providing core development tools and services that provides developers with capabilities to model business use cases using common programming languages and quickly deploy to Fabric.

IBM Blockchain Platform: Develop

IBM Blockchain Platform: Develop, using core development tools and an easy to use Web Playground, is the framework for building blockchain based applications that reflect the core structures of business networks. This framework enables developers to:

- Model business networks
- Expose blockchain data and smart contracts (chaincode or business logic) via auto-generated REST APIs
- Create blockchain ready applications

IBM Blockchain Platform: Develop includes a powerful object-oriented domain specific language, used to specify a business model, including the structure of assets, participants and transactions. The domain model is used across the platform for code generation, type validation, and API generation – amongst other things.

IBM Blockchain Platform: Develop contains a series of code libraries, data models and runtimes, developer tools, and a web-based developer environment designed to expedite learning and adoption. All of these capabilities bring speed and efficiency while reducing risk during the application development process.

IBM Blockchain Platform: Develop is designed around a collection of artifacts that is a high-level abstraction over the functional primitives of Hyperledger Fabric, including models

for defining the assets and relationships, JavaScript-based functions for smart contracts, and declarative expressions of access control rules over the domain models. The IBM Blockchain Platform builds on Hyperledger Fabric, allowing developers to easily go from building to deploying applications onto live decentralized business networks in a secure and repeatable fashion.

Developer tooling

Developers have multiple options for building and testing their applications before deploying to live business networks in production environments. The IBM Blockchain Platform enables developers to quickly and easily align business requirements and accelerate blockchain application development with a cloud sandbox and interactive playground, turning any programmer into a blockchain developer. These tools are designed to turn a business design into code in your preferred environment:

1. Try online or install locally: Leverage the IBM Blockchain Platform web playground, which provides a development environment based on industry standard tools and technologies (Hyperledger Fabric, JavaScript, Docker, Yeoman, and more) that you can use to model and develop a ready-to-deploy use case.
2. Develop on cloud: Developing on the cloud allows for all members of your ecosystem to collaborate, share code and view playbacks of your running blockchain network. This feature utilizes IBM's Container Service, using Kubernetes to quickly stand-up blockchain test networks.

Industry use case sample code

With the IBM Blockchain Platform there is no need for developers to start from scratch. The platform provides developers with a number of simple industry code samples to start their exploration. Additional industry use cases will be added in the future, but at the time of this writing, IBM provides use cases for vehicle manufacture, perishable goods, and asset transfer. A growing base of open source content has also emerged around the IBM Blockchain Platform. Therefore, if you have a sample, we'd be happy to add it if you'd like!

Simple Integration with existing business data (SOR)

Businesses will need to integrate their blockchain solutions with many of their current data sets. To help make this integration easier for application development, IBM provides APIs to aid integration with systems of record. The IBM Blockchain Platform leverages Node-Red to model business flows, as well as LoopBack to assist with routing data flows. The platform also provides a REST server with network APIs, exposed through a Swagger UI.

Governance and Operation

Perhaps the most important feature of decentralized business networks is clear and effective governance definitions, models, and tools. The IBM Blockchain Platform provides key features and dashboards to ensure networks are created with a well-defined model and are governed based on consensus protocols.

Initiating and governing a blockchain network across a group of members once it is operational can take significant amounts of coordination, time and effort. The ability to properly govern a blockchain network is often overlooked and underestimated; however, the IBM Blockchain Platform was built with this in mind, enabling users to easily and seamlessly govern and operate their network.

Proper governance ultimately ensures the network is in compliance, removes uncertainty and risk of your business obligations (embodied within smart contracts), ensures privacy and confidentiality of different classes of transactions (embodied in channels) and affords a vetting process to introduce new members.

Key governance capabilities provided with the IBM Blockchain Platform:

- Democratic management tools allow members of a network to collectively manage the rules and policies governing the decentralized business network
- Dynamic management environment provides the capability to add members to a network as it grows and new smart contracts become available
- Pre-built tools for faster on-boarding customization and activation

The IBM Blockchain Platform introduces a variety of governing and operating capabilities to maintain and optimize their blockchain networks.

Activation Tools

Decentralized business networks constantly change as new participants and transactions are created. Available activation tools allow members to easily invite new members, set up new smart contracts, and create secure channels within a broader business network.

Policy Editor

Core components of a blockchain network such as endorsement policies, membership policy, smart contracts, and transaction channels must be supported in a flexible and democratic manner. The IBM Blockchain Platform allows permissioned members of a decentralized business network to collaboratively update the policies that govern the network.

Multi-party Workflow Simulation

When taking the first steps to creating a blockchain network or understanding what it is like to participate in a blockchain network, it is a good idea to create a test network to simulate how members and organizations will interact. The IBM Blockchain Platform, through Starter Plan, allows you to create as many Members and Organizations necessary to simulate your business network. This will give you visibility and insight into how parties might interact on the network. You may also invite members within your business network to join, making the simulation even more realistic.

Network Operations

The IBM Blockchain Platform enables network members to initiate, invite, and configure a network with a simple user interface.

Initiating a network with Starter Plan automatically gives you a live blockchain network. Each network comes with an ordering service, Certificate Authorities, two organizations (each with one peer per), and a default channel on which to transact and deploy chaincode. IBM Blockchain Platform handles the creation and configuration of this network. Initiating a network with Enterprise Plan creates three ordering nodes, and two certificate authorities. Both provide the founder with a ready to use foundation for creating their business network. Founders can then invite additional members/participants to the network using any number of peers. Participants will receive email notifications of their invite so that they can easily join the network.

Based on agreement from the network members, the configuration enables members to configure core network components such as identity verification and channel creation. This helps to ensure that only permissioned users access the network, and confidential transactions are enabled via channels.

Business Operations

The IBM Blockchain Platform provides a user interface to support business operations in an active blockchain network. Updates are made with zero network downtime and continuous operations.

Smart contracts represent a core feature of a blockchain network by automating the exchange of information and assets. Users of the IBM Blockchain Platform are easily able to deploy and upgrade smart contracts across the network through a single user interface. Additionally, users are able to edit the policies of a channel which govern consensus. These features ensure business operations are visible, operational, and adaptable for a growing network.

Flexible Deployment

Businesses and business networks require flexibility in deployment models, with options regarding where and how blockchain networks and applications are deployed. In addition to the IBM Cloud (public, dedicated and private), IBM Blockchain Platform can now be deployed on-premises, in a third-party cloud, or multi-cloud.

Network Membership

To participate as a member in a network each member must operate one or more peers which enables them to transact and represents their copy of the distributed ledger. The IBM Blockchain Platform allows members to manage their peers by selecting from a variety of membership options based on the ecosystem's needs for compute performance and isolation:

1. IBM Blockchain Platform Starter Plan (IBM Cloud - SaaS): Monthly charge, Kubernetes-based deployment, with basic service levels, for getting started and testing.
2. IBM Blockchain Platform Enterprise Plan (IBM Cloud - SaaS): Monthly subscription with advanced service levels, ready for production networks. Dedicated compute for performance, isolation and HA.
3. IBM Blockchain Platform for IBM Cloud Private: Take advantage of the full IBM Blockchain Platform solution behind your firewall in your private cloud.
4. IBM Blockchain Platform for Amazon Web Services (AWS): Deploy the IBM Blockchain Platform in an AWS compute environment by using the IBM Blockchain Platform for AWS Quick Start.

IBM Blockchain Platform on the IBM Cloud

As mentioned above, the choice of infrastructure is tied to the service option selected. The IBM Blockchain Platform leverages industry-leading security through Intel and LinuxOne Emperor to ensure that all code and data are encrypted at all times, tampered virtual machines (VM's) will not start, and no admin or privileged access occurs. Code is executed within IBM Secured Services Containers (SSCs) which protect the security of the ledger. SSC's ensure:

- Tenants are isolated from each other
- Protection from insider attacks or compromised credentials by removing privileged access
- Data encryption keys are private and data is inaccessible even to IBM under court order
- Trusted Boot Loading for tamper proof code execution

The IBM Blockchain Platform, deployed on the IBM Cloud, meets the highest FIPS 140-2 Level 4 standard for hardware security modules (HSM).

Additionally, the IBM Blockchain Platform, deployed on the IBM Cloud, is "always-on" by design. It supports network updates while operational and has optimized performance on the world's fastest Linux compute. Each of these features are backed by IBM's deep Hyperledger Fabric expertise and 24x7x365 coverage for technical blockchain support.

Specific tools and capabilities are included in the environment to make network operation easier and more secure. These include:

- Monitoring and management of resources on the network
- Lifecycle management for seamless upgrades of the full code stack without pausing the network
- 24x7x365 technical support integrated into the portal
- Hardened security stack with no privileged access, malware and tamper resistance, 100% disk encryption and HSM key protection

IBM Blockchain Platform for IBM Cloud Private

Many organizations have data residency requirements that require some workloads to run in their datacenters or private clouds, behind their firewall. In many use cases, blockchain deployments will be no exception. Therefore, IBM has introduced IBM Blockchain Platform for IBM Cloud Private, enabling you to deploy in the environment that meets your requirements. The IBM Blockchain Platform for IBM Cloud Private makes it easy to manage costs, security and data sovereignty in ways that work for you.

IBM Cloud Private is an application platform for developing and managing on-premises, containerized applications. It includes container orchestrator (i.e. Kubernetes), a private image repository, a management console, and monitoring frameworks.

This offering is ideal for network members/participants who:

- Want to keep a copy of the ledger on their own infrastructure for security and/or risk mitigation reasons
- Want to run workloads on their own infrastructure due to preference and/or compliance
- Have data privacy requirements that require them to store data on their own environment

IBM Blockchain Platform for Amazon Web Services (AWS)

The IBM Blockchain Platform provides users a set of capabilities to develop, operate, and govern a network, and now IBM has added a valuable new capability for AWS customers. The newly-launched Quick Start deploys an IBM Blockchain Platform distributed peer on the AWS Cloud, and is for users who want to connect an AWS-hosted peer to an IBM Blockchain Platform Network hosted in IBM Cloud. The offering allows enterprise clients to deploy peers on AWS, satisfying the needs of clients who predominantly use AWS or who want to deploy peers on multiple clouds.

The IBM Blockchain Platform distributed peer for AWS leverages the connection profile, Hyperledger Fabric certificate authorities (CAs), and the ordering service of an existing Enterprise Plan or Starter Plan network on IBM Blockchain Platform to process transactions.

- A highly available architecture that spans two Availability zones
- A VPC configured with public subnets according to AWS best practices. This provides you with your own virtual network on AWS.
- An internet gateway to allow access to the internet. This gateway is used by the bastion hosts to send and receive traffic.
- In the public subnets, an IBM Blockchain Platform for AWS cluster, which includes two peers across two Availability zones (one peer in each subnet).
- In each public subnet, a peer container with either an embedded LevelDB database or a secondary CouchDB container.

Decentralization is a core principle of blockchain technology and it continues to drive blockchain adoption. Combine this with infrastructure preferences becoming more diverse, and we see a clear demand for blockchain platforms that enable network participants to deploy network components in the infrastructure compute environment of their choice. Within the notion that blockchain is a *peer-to-peer network* the IBM Blockchain Platform with flexible deployment options is IBM's first step in this direction.

Conclusion

The past year has seen an incredible amount of blockchain innovation from a diverse range of organizations. This innovation has been fostered by open-source organizations bringing together institutions and developers to make blockchain ready for enterprise.

The IBM Blockchain Platform represents the next step in this innovation by enabling production networks to be developed and operated through an easy to use interface built on an enterprise-ready protocol. It is easy to get started building your use-case, application, or network today using a kick-starter plan. What will we solve together? Let's find out.

For more information: <https://ibm.com/blockchain/platform>

For developers to get started:
<https://www.ibm.com/blockchain/getting-started>

© Copyright IBM Corporation 2018

IBM Corporation Route 100
Somers, NY 10589

Produced in the United States of America
November 2018

IBM, the IBM logo, ibm.com, and Blockchain are trademarks of International Business Machines Corp., registered in many jurisdictions worldwide. Other product and service names might be trademarks of IBM or other companies. A current list of IBM trademarks is available on the Web at "Copyright and trademark information" at <http://www.ibm.com/legal/us/en/copytrade.shtml>

This document is current as of the initial date of publication and may be changed by IBM at any time. Not all offerings are available in every country in which IBM operates.

THE INFORMATION IN THIS DOCUMENT IS PROVIDED "AS IS" WITHOUT ANY WARRANTY, EXPRESS OR IMPLIED, INCLUDING WITHOUT ANY WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE AND ANY WARRANTY OR CONDITION OF NON-INFRINGEMENT. IBM products are warranted according to the terms and conditions of the agreements under which they are provided.