Unit IV: - Hyperledger Blockchain Platform

Hyperledger is an open-source project and collaborative effort aimed at advancing cross-industry blockchain technologies. It was initially launched by the Linux Foundation in December 2015 and has since grown into a consortium of organizations and individuals working on various blockchain-related projects. Hyperledger provides a framework for developing and implementing blockchain-based applications and solutions with a focus on privacy, security, and scalability.

Key characteristics and components of Hyperledger include:

Modularity: Hyperledger offers a modular architecture, allowing developers to choose the specific components and tools that best suit their needs. This modularity enables flexibility in designing and implementing blockchain solutions.

Permissioned Blockchains: While some blockchain platforms, like Bitcoin and Ethereum, are public and permissionless, Hyperledger primarily focuses on permissioned blockchains. This means that participants in a Hyperledger network are known and authorized, making it suitable for enterprise and business use cases.

Variety of Projects: Hyperledger hosts several individual blockchain-related projects, each with its own goals and features. Some of the most notable projects include Hyperledger Fabric, Hyperledger Sawtooth, Hyperledger Besu, Hyperledger Indy, and Hyperledger Iroha.

Hyperledger Fabric: Fabric is one of the most widely adopted Hyperledger projects. It offers a flexible and modular architecture, making it suitable for various business applications, especially those requiring privacy and permissioning.

Hyperledger Sawtooth: Sawtooth is designed for applications that need a simple, pluggable consensus mechanism. It focuses on scalability and ease of development.

Hyperledger Besu: Besu is an Ethereum client for private and public networks. It enables enterprises to build applications compatible with the Ethereum ecosystem.

Hyperledger Indy: Indy is specifically designed for decentralized identity management, which is critical for identity verification and authentication in various industries.

Hyperledger Iroha: Iroha is suitable for mobile and web applications due to its simple architecture and emphasis on ease of use.

Collaborative Ecosystem: Hyperledger is a collaborative effort that involves contributions from a wide range of organizations, including technology companies, financial institutions, supply chain companies, and more. This collaborative approach fosters innovation and knowledge sharing within the blockchain community.

Governance and Standards: Hyperledger projects adhere to certain governance and development standards, ensuring a degree of stability, security, and compatibility across different implementations.

Hyperledger aims to accelerate the development of blockchain-based solutions for various industries, including finance, supply chain management, healthcare, and more. It provides tools, libraries, and frameworks that simplify the process of building and deploying enterprise-grade blockchain applications while addressing the unique requirements of business use cases.

Hyperledger blockchains, such as Hyperledger Fabric, Hyperledger Sawtooth, and others, offer several key features that make them well-suited for enterprise and business use cases. Here are some of the prominent features of a Hyperledger blockchain:

Permissioned Network: Hyperledger blockchains are typically permissioned, meaning that participants in the network are known and authorized. This feature enhances security and privacy, making Hyperledger suitable for enterprise applications where controlled access is critical.

Modularity: Hyperledger frameworks are designed with modularity in mind. This allows developers to select and customize the components they need for their specific use cases. Modularity makes it flexible for organizations to design and implement blockchain networks that meet their requirements.

Pluggable Consensus Mechanisms: Hyperledger offers pluggable consensus mechanisms, allowing organizations to choose the consensus algorithm that best suits their use case. This flexibility is vital because different applications may have varying requirements for consensus, such as Byzantine fault tolerance (BFT) or Practical Byzantine Fault Tolerance (PBFT).

Smart Contracts: Hyperledger supports the execution of smart contracts, also known as chaincode in Hyperledger Fabric. These are self-executing contracts with predefined rules and logic that automate processes on the blockchain. Smart contracts enable automation and enforce business rules within the network.

Privacy and Confidentiality: Hyperledger frameworks prioritize privacy and confidentiality features. They offer options for private channels (Hyperledger Fabric) or private transactions (Hyperledger Besu) to restrict access to specific information within the blockchain network, making it suitable for confidential business processes.

Identity Management: Hyperledger projects often include identity management solutions. For example, Hyperledger Indy is dedicated to decentralized identity management, providing tools for secure and verifiable identity verification on the blockchain.

Scalability: Hyperledger blockchains are designed with scalability in mind. Solutions like Hyperledger Sawtooth aim to address scalability challenges by using a unique architecture that separates transaction validation from block creation, allowing for greater scalability as more participants join the network.

Interoperability: Hyperledger projects emphasize interoperability with other systems and networks. This means they are designed to work seamlessly with existing enterprise systems, databases, and other blockchain networks.

Permissioned Data Sharing: Hyperledger Fabric, in particular, supports permissioned data sharing among participants in a network. This feature allows organizations to share specific data with select participants while keeping the rest of the data private.

Consensus Flexibility: Hyperledger blockchains offer flexibility in choosing and configuring consensus algorithms, including practical Byzantine fault tolerance (PBFT), crash fault tolerance (CFT), and others, depending on the network's needs.

Governance and Standards: Hyperledger projects follow governance models and standards that help ensure the stability and sustainability of the technology. This governance helps manage contributions, updates, and long-term support.

Analytics and Monitoring: Many Hyperledger frameworks provide tools and APIs for analytics, monitoring, and reporting, allowing organizations to gain insights into their blockchain network's performance and activity.

These features collectively make Hyperledger blockchains a robust choice for building and deploying secure, scalable, and customizable blockchain solutions tailored to specific enterprise and business needs.

Hyperledger Fabric in Blockchain

- Hyperledger Fabric is an open-source platform for building distributed ledger solutions, with a modular architecture that delivers high degrees of confidentiality, flexibility, resiliency, and scalability. This enables solutions developed with fabric to be adapted for any industry. This is a private and confidential blockchain framework managed by the Linux Foundation. The article focuses on discussing Hyperledger Fabric in Blockchain. The following topics will be discussed here:
  1. What is Hyperledger Fabric ?
  2. How does Hyperledger Fabric Work ?
  3. Hyperledger Fabric Consensus Algorithm.
  4. Industry Use Cases For Hyperledger Fabric.
  5. Benefits Of Hyperledger Fabric.
  6. Limitation of Hyperledger Fabric.

What is Hyperledger Fabric ?

Hyperledger Fabric is designed for use in enterprise-level applications, and it is characterized by its modular architecture, permissioned network, and smart contract functionality, known as “chaincode”.

- The platform provides a high degree of security, privacy, and scalability, and it supports the development of custom blockchain solutions for various use cases across industries such as finance, supply chain, and healthcare.
- Hyperledger Fabric operates as a network of nodes, where each node performs a specific function, such as validating transactions, maintaining the ledger, and executing chaincode.
- Transactions are validated and ordered by a consensus mechanism, which ensures the integrity and consistency of the ledger.

How does Hyperledger Fabric Work?

Components:

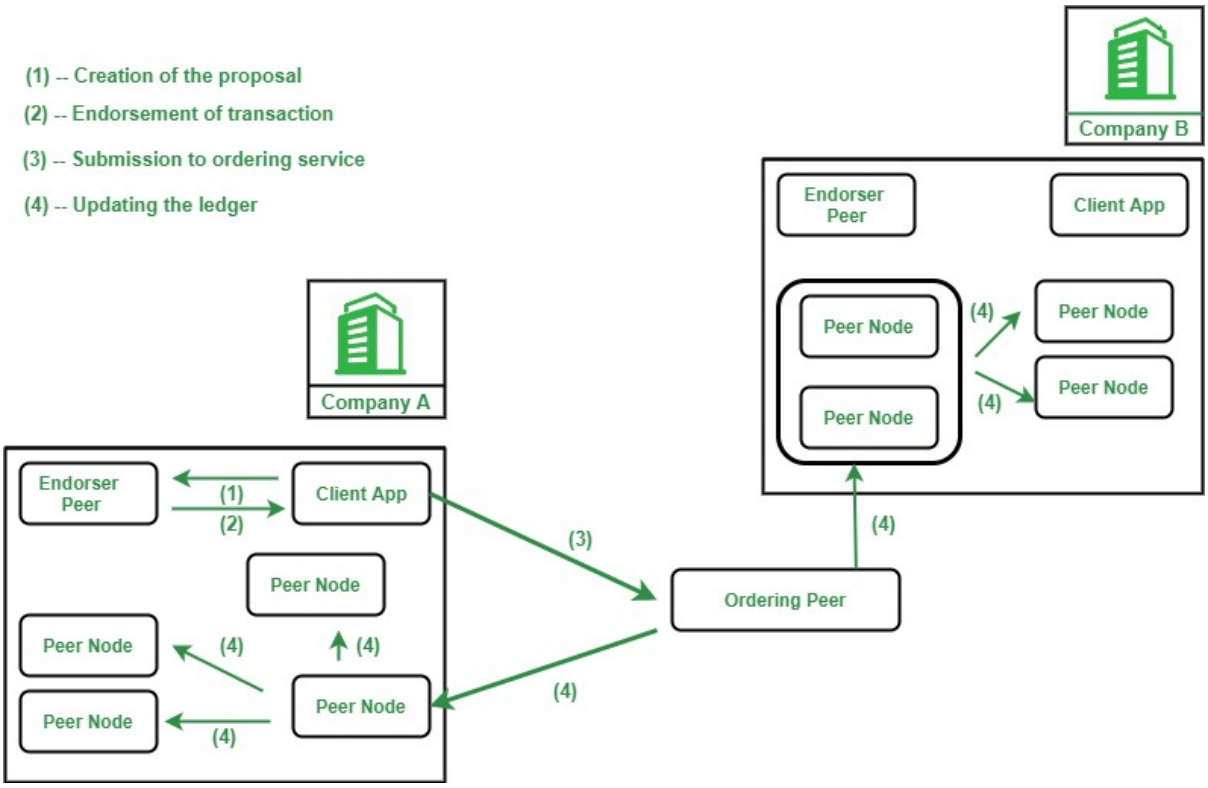
- Hyperledger fabric is an enterprise-level permission blockchain network. It is made up of various unique organizations or members that interact with each other to serve a specific purpose. For example, these organizations can be a bank, financial institution, or a supply chain network. Each organization is identified and they have a fabric certificate authority. These organizations are called members.
- Each member of the fabric can set up one or more authorized peers to participate in the network using the fabric certificate authority. All of these peers must be authorized properly.
- There is a client-side application connected to the network written with the software development kit (SDK) of any particular programming language.

Workflow:

For each and every transaction in the fabric, the following steps are followed-

1. **Creation of the proposal:** Imagine a deal between a smartphone manufacturer company and a smartphone dealership. The transaction begins when a member organization proposes or invokes a transaction request with the help of the client application or portal. Then the client application sends the proposal to peers in each organization for endorsement.
2. **Endorsement of the transaction:** After the proposal reaches the endorser peers (peers in each organization for endorsement of a proposal) the peer checks the fabric certificate authority of the requesting member and other details that are needed to authenticate the transaction. Then it executes the chain code (a piece of code that is written in one of the supported languages such as Go or Java) and returns a response. This response indicates the approval or rejection of the following transaction. The response is carried out to the client.
3. **Submission to ordering service:** After receiving the endorsement output, the approved transactions are sent to the ordering service by the client-side application. The peer responsible for the ordering service includes the transaction into a specific block and sends it to the peer nodes of different members of the network.

4. **Updating the ledger:** After receiving this block the peer nodes of such organizations update their local ledger with this block. Hence the new transactions are now committed.



Hyperledger Fabric Consensus Algorithm

Hyperledger Fabric uses a consensus algorithm to achieve agreement among the participants in a network on the contents of the shared ledger. The consensus algorithm in Hyperledger Fabric is pluggable, which means that it can be replaced with a different algorithm as needed.

The most commonly used consensus algorithms in Hyperledger Fabric are:

- **Practical Byzantine Fault Tolerance (PBFT):** PBFT is a consensus algorithm that provides fault tolerance and reliability in a network. It is well-suited for networks with a limited number of participants who are trusted and well-known.
- **RAFT**: RAFT is a consensus algorithm that is used to maintain a consistent state across multiple nodes. It is well-suited for networks where the participants are unknown and potentially untrusted.
- **Solo**: Solo is a consensus algorithm that is used for testing purposes in a single-node network. It is not suitable for production use.

Industry Use Cases For Hyperledger Fabric

1. Supply Chain: Supply chains are global or regional webs of suppliers, manufacturers, and retailers of a particular product. Hyperledger Fabric networks can improve the transaction processes of the supply chain by increasing the clarity and traceability of transactions within the fabric. On a Fabric network, enterprises having authentication to access the ledger can view the data of the previous transactions. This fact increases accountability and reduces the risk of counterfeiting of the transactions. Real-time production and shipping updates can be updated to the ledger. Which can help us to track the product condition in a much faster, simpler, and efficient way.
2. Trading and Asset Transfer: Trading and asset transfer requires many organizations or members like importers, exporters, banks, brokers. They work with one another. And even in the era of digitalization a lot of paperwork is going on in this sector. But using Hyperledger they can transact and interact with each other in a paperless way. The Hyperledger fabric can add the same layer of trust as the document signed by a trusted authority. This also increases the performance of the system.
Another benefit of Hyperledger fabric is that assets can be dematerialized on the blockchain network with the help of Hyperledger fabric. Due to this traders or stakeholders will be able to have direct access to their financial securities and they can trade it anytime.
3. Insurance: The insurance industry spends billions to avoid insurance frauds or falsified claims. With the help of Hyperledger fabric, the Insurance company can refer to the transaction data that is stored inside the ledger. Hyperledger Fabric can also make the processing of claims faster using the chain code and automate the payment. This process will be also helpful for multi-party subrogation claims processing. Where it can automate repayment from the fault party back to the insurance company. Verification of identity or KYC process will be easy using this private blockchain.

Benefits Of Hyperledger Fabric

1. Open Source: Hyperledger fabric is an open-source blockchain framework hosted by the Linux foundation. It has an active community of developers The code is designed to be publicly accessible. Anyone in the community can see, modify, and distribute the code as they see fit. People across the world can come and help to develop the source code.
2. Private and Confidential: In a public blockchain network each and every node in the network is receiving a copy of the whole ledger. Thus keeping privacy becomes a much bigger concern as everything is open to everyone. In addition to this one, the identities of all the participating members are not known and authenticated. Anyone can participate as it is a public blockchain. But in the case of Hyperledger fabric, the identities of all participating members are authenticated. And the ledger is only exposed to the authenticated members. This benefit is the most useful in industry-level cases, like banking, insurance, etc where customer data should be kept private.
3. Access Control: In the Hyperledger fabric, there is a virtual blockchain network on top of the physical blockchain network. It has its own access rules. It employs its own

mechanism for transaction ordering and provides an additional layer of access control. It is especially useful when members want to limit the exposure of data and make it private. Such that it can be viewed by the related parties only. As an example when two competitors are on the same network. The fabric also offers private data collection and accessibility, where one competitor can control the access to its own data such that the data do not get exposed to the other competitor.

4. Chaincode Functionality: It includes a container technology to host smart contracts called *chain code* that defines the business rules of the system. And it's designed to support various pluggable components and to accommodate the complexity that exists across the entire economy. This is useful for some of the specific types of transactions like asset ownership change.

5. Performance: As the Hyperledger fabric is a private blockchain network, There is no need to validate the transactions on this network so the transaction speed is faster, resulting in a better performance.

Limitation of Hyperledger Fabric

Hyperledger Fabric is a robust and flexible platform for developing blockchain applications, but like any technology, it has certain limitations:

1. **Scalability:** Hyperledger Fabric is designed for permissioned networks, where the participants are known and trusted, which can limit its scalability for large-scale public networks.
2. **Performance:** The performance of Hyperledger Fabric can be impacted by factors such as network size, network configuration, and the complexity of chaincode, which can limit its ability to handle high volumes of transactions.
3. **Complexity:** Setting up and configuring a Hyperledger Fabric network can be complex, requiring a deep understanding of the technology and its components.
4. **Compatibility:** Hyperledger Fabric is designed to be used with specific programming languages, such as Go and JavaScript, which can limit its compatibility with other technologies and programming languages.
5. **Cost:** Running a Hyperledger Fabric network requires infrastructure and resources, which can add costs to the deployment and operation of blockchain applications.
6. **Interoperability:** Hyperledger Fabric is designed to be used within a single network, and its interoperability with other blockchain platforms is limited.

Ethereum and Hyperledger are both blockchain platforms, but they serve different purposes and have distinct characteristics. Here are some of the key differences between Ethereum and Hyperledger:

Use Case and Target Audience:

Ethereum: Ethereum is a public, permissionless blockchain platform primarily designed for decentralized applications (DApps) and smart contracts. It aims to provide a global, open, and trustless platform for anyone to build and deploy decentralized applications.

Hyperledger: Hyperledger is a collection of private, permissioned blockchain frameworks and tools designed for enterprise use cases. It focuses on providing solutions for businesses and organizations to build and deploy blockchain applications tailored to their specific needs.

Permissioning:

Ethereum: Ethereum is permissionless, meaning anyone can participate in the network as a node, create smart contracts, and interact with DApps without needing explicit permission. It relies on a consensus mechanism known as Proof of Stake (PoS) as it transitions from Proof of Work (PoW).

Hyperledger: Hyperledger blockchains are typically permissioned, which means participants are known and authorized. This makes it suitable for enterprise scenarios where controlled access and privacy are essential.

Consensus Mechanism:

Ethereum: Ethereum has traditionally used a Proof of Work (PoW) consensus mechanism, which requires miners to solve complex mathematical puzzles to validate transactions. It is transitioning to Proof of Stake (PoS) to improve scalability and energy efficiency.

Hyperledger: Hyperledger offers pluggable consensus mechanisms, including Practical Byzantine Fault Tolerance (PBFT) and others, depending on the specific framework used. These consensus mechanisms are designed for greater security and scalability.

Smart Contracts and Chaincode:

Ethereum: Ethereum supports the execution of smart contracts, which are self-executing agreements with predefined rules. These contracts are written in Solidity or other Ethereum-compatible languages.

Hyperledger: Hyperledger supports smart contracts as well, referred to as "chaincode" in some of its frameworks, like Hyperledger Fabric. Chaincode can be written in various programming languages like Go, Node.js, and Java.

Privacy and Confidentiality:

Ethereum: Ethereum is a public blockchain, and all transactions and data are visible to all participants. While it is possible to build private DApps on Ethereum, it requires additional layers or solutions.

Hyperledger: Hyperledger emphasizes privacy and confidentiality, offering features like private channels (Hyperledger Fabric) and private transactions (Hyperledger Besu) to restrict data access to authorized participants.

Interoperability:

Ethereum: Ethereum's focus has been on its own ecosystem, and while it is possible to create bridges to other blockchains, it may not be as straightforward as in Hyperledger.

Hyperledger: Hyperledger projects are designed to be interoperable with existing systems and other blockchains, making it easier to integrate with various enterprise technologies.

Governance:

Ethereum: Ethereum's governance has evolved over time and can be influenced by stakeholders and developers within the Ethereum community.

Hyperledger: Hyperledger projects follow a more structured governance model under the Linux Foundation, which provides a framework for collaboration and decision-making involving member organizations.

In summary, Ethereum is geared towards open, public, and permissionless blockchain applications, while Hyperledger is tailored for private, permissioned, and enterprise-centric use cases. The choice between Ethereum and Hyperledger depends on the specific requirements and goals of the blockchain project.