ITU – NBTC Training
On

“Building Distributed Ledger Technologies (Blockchain) Projects”

5 – 8 November 2019,
Bangkok, Thailand

ITU – NBTC Training – Session 1

Global overview of DLT (including Blockchain) Ecosystem and Technologies

Objective: To provide an overview of DLT Ecosystem and technologies.

5 November 2019,
Bangkok, Thailand

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A brief introduction:

Skylar Hurwitz, ITU Expert on DLT

- **Editor of 4 reports for the ITU's Focus Group on Applications of Distributed Ledger Technology**
- **Capacity building consultant focused on bridging the knowledge gap between SMEs and DLT developers**

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Overview of this 75-minute session:

- **Basics of blockchain and DLT:** 10 minutes
  - Problems they solve – the double spend issue
  - How they work
- **Introduction to the ITU's work on DLT:** 5 minutes
- **Types blockchains and DLTs:** 10 minutes
- **Consensus algorithms and hardware for securing DLTs:** 5 minutes
- **Key characteristics, ecosystem, and components:** 10 minutes
- **Ongoing challenges for blockchain and DLT adoption:** 10 minutes
- **Reviewing key terms and topics:** 10 minutes
- **Question and answer:** 15 minutes

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Part 1. Basics of blockchain and DLT

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Part 1. Basics of blockchain and DLT

Why do we need blockchain?

The digital double spend issue

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Part 1. Basics of blockchain and DLT

How do we mitigate
against double spending?

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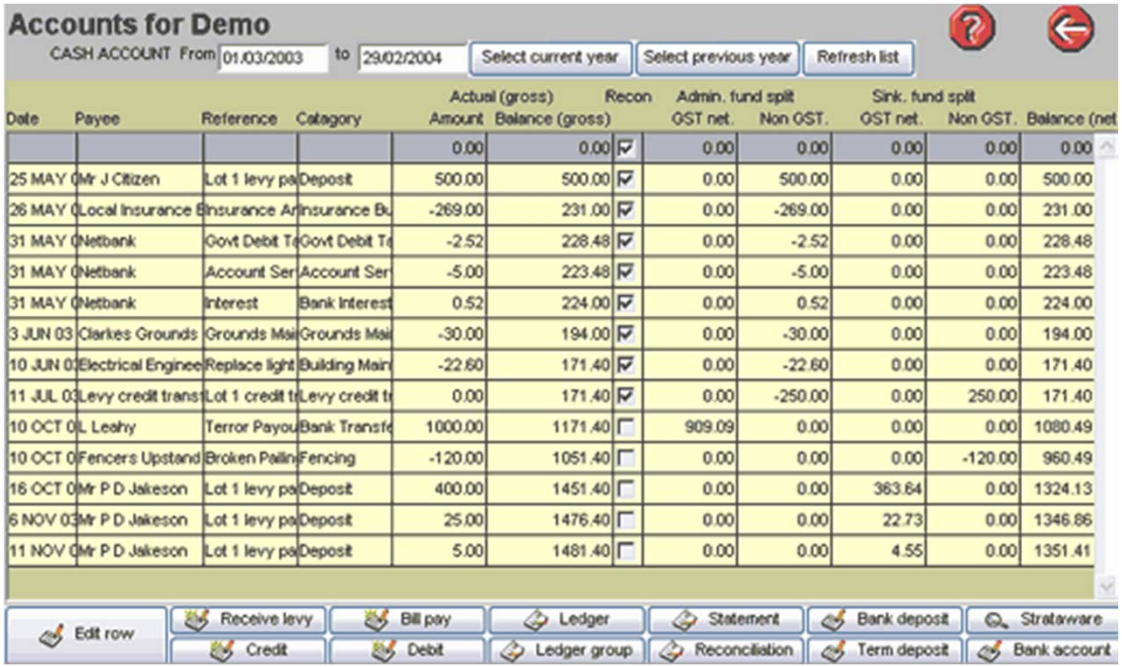
Part 1. Basics of blockchain and DLT

How do we mitigate against double spending?

- Ledgers!
- Dual entry & approvals



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Part 1. Basics of blockchain and DLT

Who owns a particular ledger and how can you trust its historical data?

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Part 1. Basics of blockchain and DLT

Who owns a particular ledger and how can you trust its historical data?

- **Outsider threat** - centralized database can be hacked
- **Insider threat** - centralized entity or an employee could intentionally tamper historical data for a specific purpose

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Part 1. Basics of blockchain and DLT

Blockchain and distributed ledger technology (DLT)

- Satoshi Nakamoto made the first Bitcoin transaction, which solved the double spend issue with a public consensus algorithm, proof of work, in January 2009.

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Part 1. Basics of blockchain and DLT

The blockchain – First type of distributed ledger technology

- Ledger is stored across many different computers
- New transactions are packaged into a block
- Each new block of transactions is sent to the network in chronological order, where all participants begin competing to be the first to validate these transactions
- Once confirmed, each new block gets a unique hash identifier and is added to the chain with a reference to the cryptographic hash of the block that immediately precedes it
- The process begins again.
- **Data is now immutable** - since each new block cryptographically references the block before it, any attempt to change historical data results in a break in the chain.

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Part 1. Basics of blockchain and DLT

Key terms – Definitions from FG-DLT D1.1

- **Distributed ledger** – a type of ledger that is shared, replicated, and synchronized in a distributed and decentralized manner.
- **Blockchain** - a type of distributed ledger which is composed of digitally recorded data arranged as a successively growing chain of blocks with each block cryptographically linked and hardened against tampering and revision.
- **Public key cryptography** – cryptography in which a public key and a corresponding private key are used for encryption and decryption, where public key is disseminated, and private key is known only to the key owner.
- **Public address** - identifier for entity(ies) performing transactions or other actions in a blockchain or distributed ledger network.
- **Private key** – unique passphrase for signing transactions corresponding to your public address in a DLT system.
- **Wallet** - software and/or hardware used to generate, manage and store both private and public keys and addresses, which enable DLT users to transact. Some wallets may interact with smart contracts and allow single and/or multi-signature.

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Part 1. Basics of blockchain and DLT

Key terms - Definitions from FG-DLT D1.1

- **Node** - computer or device that participates in a DLT
- **Block** – individual data unit of a blockchain, usually composed of transactions and a block header
- **Block header** – data structure that includes a cryptographic link to the previous block
- **Hash function** – a function that maps a bit string of arbitrary length to a fixed-length bit string. Approved hash functions are one-way and collision resistant.
- **Wallet** - software and/or hardware used to generate, manage and store both private and public keys and addresses, which enable DLT users to transact. Some wallets may interact with smart contracts and allow single and/or multi-signature.

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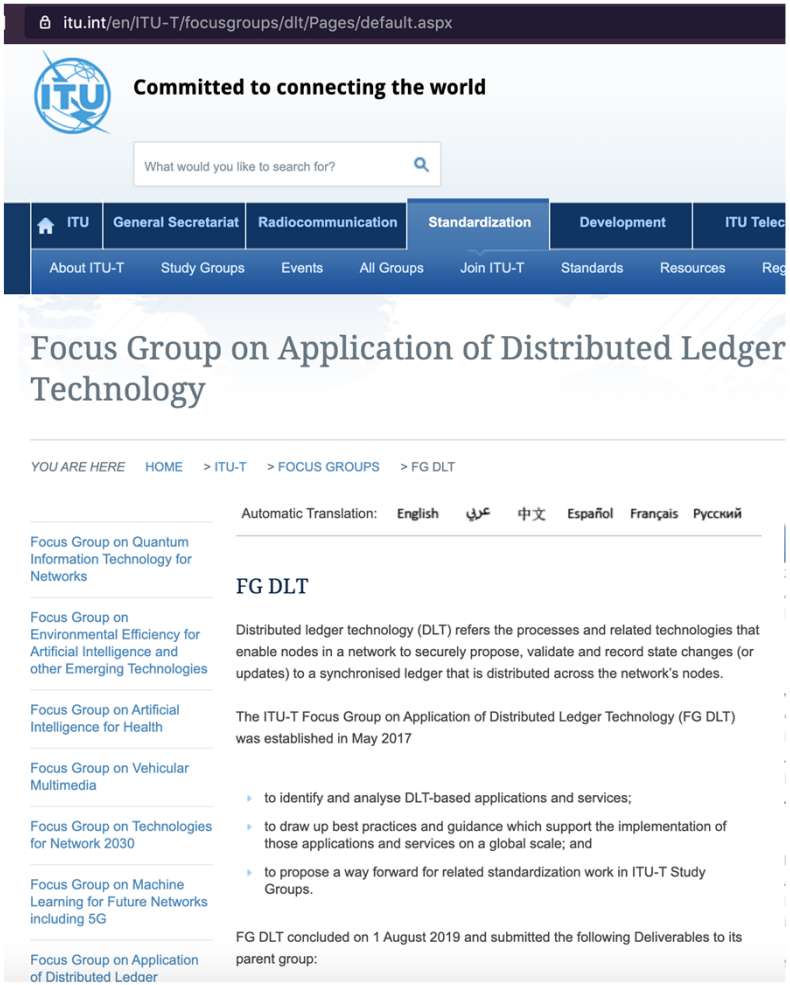
Part 2. Introduction to the ITU's work on DLT

- **Focus Group on Application of Distributed Ledger Technology (FG-DLT)**
  - **May 2017 through August 2019**

- Focus Group on Digital Currency including Digital Fiat Currency (FG-DFC)
  - May 2017 through June 2019



https://www.itu.int/en/ITU-T/focusgroups/dlt/Pages/default.aspx

Reports of FG-DLT

Type	Number	Title	Download
Technical Specification	FG DLT D1.1	**DLT terms and definitions**	PDF
Technical Report	FG DLT D1.2	**DLT overview, concepts, ecosystem**	PDF
Technical Report	FG DLT D1.3	**DLT standardization landscape**	PDF
Technical Report	FG DLT D2.1	**DLT use cases**	PDF (Report only) ZIP (Report and use cases)
Technical Specification	FG DLT D3.1	**DLT reference architecture**	PDF (Specification only) ZIP (Specification and platform mapping)
Technical Specification	FG DLT D3.3	**Assessment criteria for DLT platforms**	PDF
Technical Report	FG DLT D4.1	**DLT regulatory framework**	PDF
Technical Report	FG DLT D5.1	**Outlook on DLTs**	PDF

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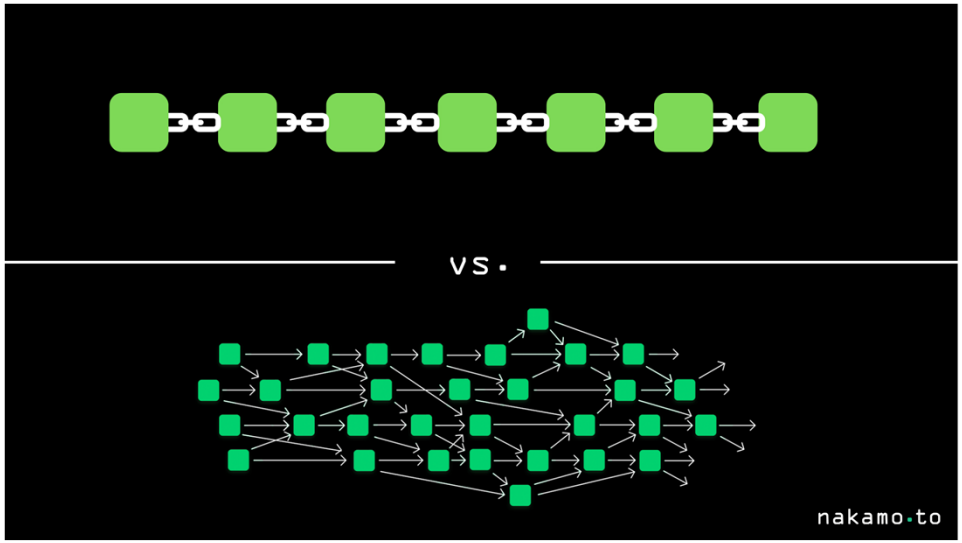
Part 3. Types of blockchains and DLTs

- **Distributed ledger** – a type of ledger that is shared, replicated, and synchronized in a distributed and decentralized manner.
- **Blockchain** - a type of distributed ledger which is composed of digitally recorded data arranged as a successively growing chain of blocks with each block cryptographically linked and hardened against tampering and revision (i.e. Bitcoin).
- **Directed Acyclic Graph (DAG)** - a DAG is a network of individual transactions linked to multiple other transactions where individual transactions provide validation for one another (i.e. Byteball and IOTA).
- **Byzantine fault tolerance (BFT)** - property that enables a system to continue operating properly even if some of its components fail or existence of intentional bad actors (i.e. Hyperledger).



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Part 3. Types of blockchains and DLTs

- End-users
  - Public
  - Private
- Network infrastructure
  - Permissioned
  - Permissionless
  - Hybrid

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Part 3. Types of blockchains and DLTs

Definitions from FG-DLT 1.1 and examples from FG-DLT D3.1

- End-users
  - **Public** - a distributed ledger system which is accessible to the public for use (i.e. Bitcoin, Ethereum, Libra*)
  - **Private** - distributed ledger system which is accessible for use only to a limited group of DLT users (i.e. Hyperledger, Quorum, Corda).

* Note that Libra has not yet officially launched, though source code is available.

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Part 3. Types of blockchains and DLTs

Definitions from FG-DLT 1.1 and examples from FG-DLT D3.1

- Network infrastructure
  - **Permissioned DLT** - distributed ledger system in which permissions are required to maintain and operate a node (Hyperledger, Quorum, Libra*).
  - **Permissionless DLT** - distributed ledger system where permissions are not required to maintain and operate a node (Bitcoin, Ethereum).
  - **Hybrid permissions** - a combination of permissionless and permissioned accessibility (Ardor).

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Part 4. Consensus algorithms and hardware

Definitions and examples from FG-DLT D1.1, D1.2, D3.1

- Proof of work (POW)
- Proof of stake (POS)
- Byzantine fault tolerant (BFT)
- Delegated proof of stake (dPOS)

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Part 4. Consensus algorithms and hardware

Definitions and examples from FG-DLT D1.1, D1.2

- **Proof of work (PoW) - consensus process to solve a difficult (costly, time-consuming) problem that produces a result that is easy for others to correctly verify (i.e.Bitcoin, Ethereum).**
  - In a proof of work (PoW) system, a node validates the next block by being the first to solve a computationally intensive puzzle. The solution to this puzzle is the "proof" that they have performed the work. The probability of validating a new block depends on the instantaneous computational power devoted to the task. As a reward for validating a block, the node (miner) will receive a certain amount of crypto assets or transaction fees.
  - Pro: new users can join and compete to validate transactions at any time as long as they have the necessary equipment.
  - Con: extremely energy intensive.
    - Bitcoin uses as much electricity per year as Austria, as of 29/10/19 (source: Cambridge, DigiConomist)
    - Ethereum consumed as much electricity per year as Angola (source: DigiConomist)

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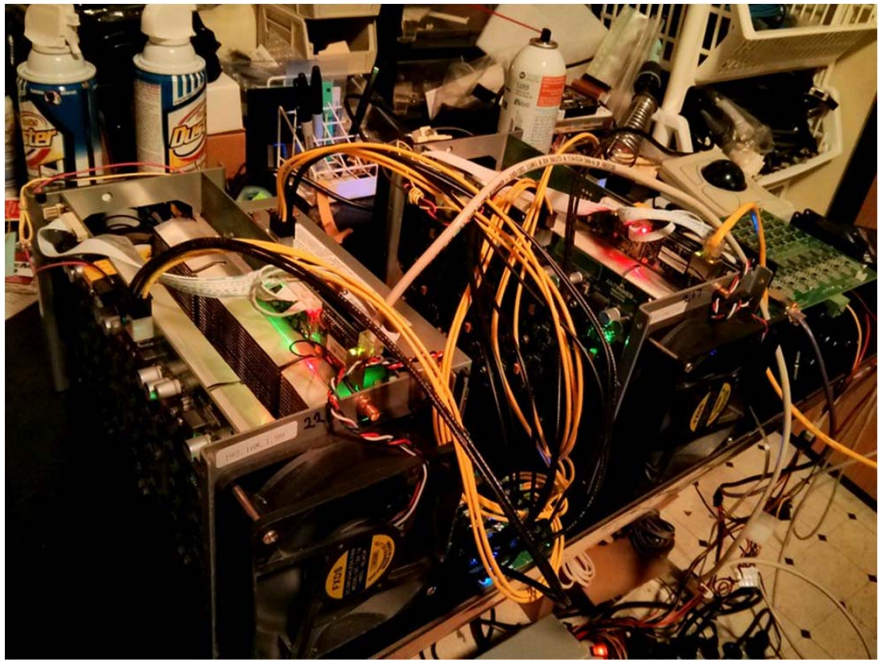
Part 4. Consensus algorithms and hardware

PoW mining:



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Part 4. Consensus algorithms and hardware

Definitions and examples from FG-DLT D1.1, D1.2

- **Proof of Stake (PoS) – consensus process, where an existing stake in the distributed ledger system (e.g., the amount of that currency that you hold) is used to reach consensus (i.e. Peercoin, Nxt).**
  - Proof of stake (PoS) is a consensus process where an existing stake in a particular distributed ledger system (e.g., the amount of stored value held) is used to reach consensus instead of energy intensive computations. Proof of stake (PoS) is based on the idea that, since users must invest directly into a particular system to participate in consensus, they are more likely to want that system to succeed and less likely that they will want to subvert it. For example, stake is often an amount of crypto asset that the DLT network user has invested into the system. Nodes participating in the PoS consensus mechanism are rewarded by receiving the transaction fees included in each block they are the first to successfully validate.
  - Pro: faster transactions and 99% more energy efficient
  - Con: the more tokens you hold, the higher the odds that you will receive fees

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Part 4. Consensus algorithms and hardware

PoS staking / forging:

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Part 4. Consensus algorithms and hardware

Definitions and examples from FG-DLT D1.1, D1.2

- **Byzantine Fault Tolerant (BFT) – property that enables a system to continue operating properly even if some of its components fail or existence of intentional bad actors (Hyperledger, Quorum).**
  - In DLT systems, Byzantine faults may occur when some nodes in the network behave abnormally. The BFT-based consensus algorithm has been designed and implemented to solve this problem by ensuring that the distributed ledger system functions normally even with abnormal nodes involved in the network. In BFT-based consensus, all nodes in the network need to participate in the consensus process which involves performing multiple rounds of voting and communication to reach consensus on a block. It is therefore more compatible with small systems, which have a limited number of nodes. Additionally, since BFT requires that all participants agree on the list of participants in the network, the protocol is normally only used in permissioned distributed ledger systems.
  - Pro: faster transactions, energy efficient, and customized permissions
  - Con: all nodes must vote so if a node is offline or down for some reason, the network comes to a hault

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Part 4. Consensus algorithms and hardware

Definitions and examples from FG-DLT D1.1, D1.2

- **Delegated proof of stake (dPOS) – another approach to Proof of Stake where a set number of nodes are elected or selected to function as the block-producing full validating nodes for the network (EOS, Lisk).**
  - Pro: faster transaction speeds than PoS, energy efficient, and block producers receive substantive fees so they are incentivized to operate with integrity.
  - Con: the network is more susceptible to cartels and collusion between this small, yet powerful, group of individuals who control the validation of new transactions.

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Part 5. Key characteristics, ecosystem and components

The key characteristics of DLT systems are [b-NIST]:

- **Append only** – An append only ledger is used to provide full transactional history. Unlike traditional databases, transactions and values in a DLT are not overwritten.
- **Immutable** – Distributed ledgers are cryptographically secure and immutable, ensuring that the data contained within the ledger has not been tampered with, and that the data within the ledger is attestable.
- **Shared** – The ledger is shared amongst multiple nodes. Some nodes contain the full state of the ledger while other nodes do not necessarily contain the full state of the ledger. This provides transparency and optimal efficiency across the node participants in the DLT network.
- **Distributed** – The distributed nature of DLT allows for the scaling of nodes in a DLT network. By increasing the number of nodes, the ability for a bad actor to impact the consensus protocol used by the DLT is reduced thus, making it more resilient to attacks by bad actors.

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Part 5. Key characteristics, ecosystem and components

Key components of a DLT ecosystem include

- **Hardware aspect**
- **Business aspect**
- **Software development aspect**
- **Protocol development aspect**

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Part 5. Key characteristics, ecosystem and components

Key components of a DLT ecosystem include:

- **Hardware aspect**
  - The hardware aspect of DLT ecosystems is comprised of a large number of nodes where each node could either be a computer, server, or storage device.
    - **Block producing full validating node -** participates in a consensus process and contains an entire replica of the distributed ledger, including every transaction that has been executed since its inception (miners in POW).
    - **Non-block producing full validating node -** does not participate in a consensus process and contains an entire replica of the distributed ledger, including every transaction that has been executed since its inception.
    - **Partial / light node -** contains only a partial transaction list but must be connected in some way to a full node to make sure that their data is accurate and useful

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Part 5. Key characteristics, ecosystem and components

Key components of a DLT ecosystem include:

- **Business aspect**
  - The business aspect of the DLT ecosystem consists of users, investors, block producers, corporations, and developers working to solve real world use cases.

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Part 5. Key characteristics, ecosystem and components

Key components of a DLT ecosystem include:

- **Software development aspect**
  - DLT leverages various types of software applications. A "software ecosystem" is defined as a set of entities interacting with a shared market for software and services, together with relationships among them.
    - These applications generally fall into three categories: financial, semi-financial, and non-financial applications.
      - The first involves money being used and managed.
      - The second category includes business processes which may involve money but focus on the completion of tasks or execution of contracts.
      - The last category is very open-ended and may include anything from election voting, governance, data record storage, and ID authentication.

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Part 5. Key characteristics, ecosystem and components

Key components of a DLT ecosystem include:

- **Protocol development aspect**
  - DLT leverages various types of software applications. A "software ecosystem" is defined as a set of entities interacting with a shared market for software and services, together with relationships among them.
    - Developers are involved with setting up DLT protocols that serve networks. The protocol layer is concerned mostly with how cryptographic keys interact with the network.
    - There are two kinds of protocols: **open-source and closed-source**.
      - **Open-source development** communities allow for anyone to download, audit and submit changes to the protocol. Accepting changes might be decided by a system of voting or through a responsible disclosure program.
      - **Closed-source DLT networks** are employed by private entities and accessible only to operations of a specific class.

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Part 5. Key characteristics, ecosystem and components

Key components of a DLT ecosystem include

- **Hardware aspect**
- **Business aspect**
- **Software development aspect**
- **Protocol development aspect**

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Part 6. Ongoing challenges for blockchain and DLT adoption

- **Technology Challenges**
  - Scalability
  - Interoperability
  - Decentralization
- **Social Challenges**
  - Lack of knowledge
  - Political and regulatory uncertainty

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Part 6. Ongoing challenges for blockchain and DLT adoption

- **Technology Challenges**
  - Scalability
    - Storage of historical data – (Ethereum is 105 GB and Bitcoin is 256 GB)
    - Throughput / transactions per second
    - Agreement amongst open source cooperatives on updates

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Part 6. Ongoing challenges for blockchain and DLT adoption

- **Technology Challenges**
  - Interoperability
    - Transaction types within individual protocols
    - Exchanging value across different DLT protocols
    - Exchanging data between external systems and DLTs

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Part 6. Ongoing challenges for blockchain and DLT adoption

- **Technology Challenges**
  - Decentralization
    - Private permissioned systems require a level of trust
    - Public mining equipment is expensive
    - Not all data should be public and transparent

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Part 6. Ongoing challenges for blockchain and DLT adoption

- **Social Challenges**
  - Lack of knowledge
    - Unique platform architectures
    - Proprietary coding languages (Solidity, RIDE…)
    - Difficult UIs

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Part 6. Ongoing challenges for blockchain and DLT adoption

- **Social Challenges**
  - Political and regulatory uncertainty
    - EOS only received a small fine for sidestepping regulations during token
    - KIN is in a far larger ongoing court battle
    - Meanwhile, Ethereum is in no trouble at all
  - Which public protocols are acceptable, which aren't?

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Part 7. Reviewing key terms and topics

General terms

- **Distributed ledger technology –** a type of ledger that is shared, replicated, and synchronized in a distributed and decentralized manner.
- **Blockchain** - a type of distributed ledger which is composed of digitally recorded data arranged as a successively growing chain of blocks with each block cryptographically linked and hardened against tampering and revision (i.e. Bitcoin).
- **Node -** device or process that participates in a distributed ledger network.
- **Block -** individual data unit of a blockchain, composed of a collection of transactions and a block header.

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Part 7. Reviewing key terms and topics

Types of consensus

- **Consensus algorithm -** rules and procedures by which consensus is reached.
- **Proof of work -** consensus process to solve a difficult (costly, time-consuming) problem that produces a result that is easy for others to correctly verify.
- **Proof of stake –** consensus process, where an existing stake in the distributed ledger system (e.g., the amount of that currency that you hold) is used to reach consensus.
- **Delegated proof of stake -** another approach to Proof of Stake where a set number of nodes are elected or selected to function as the block-producing full validating nodes for the network.
- **Byzantine fault tolerance (BFT) -** property that enables a system to continue operating properly even if some of its components fail or existence of intentional bad actors.

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Part 7. Reviewing key terms and topics

Types of blockchains

- **Private -** distributed ledger system which is accessible for use only to a limited group of DLT users.
- **Public -** distributed ledger system which is accessible to the public for use.
- **Permissioned DLT -** distributed ledger system in which permissions are required to maintain and operate a node.
- **Permissionless DLT -** distributed ledger system where permissions are not required to maintain and operate a node.
- **Hybrid permissions -** a combination of permissionless and permissioned accessibility

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Part 7. Reviewing key terms and topics

Types of nodes

- **Block producing full validating node -** participates in a consensus process and contains an entire replica of the distributed ledger, including every transaction that has been executed since its inception (miners in POW).
- **Non-block producing full validating node -** does not participate in a consensus process and contains an entire replica of the distributed ledger, including every transaction that has been executed since its inception.
- **Partial / light node -** contains only a partial transaction list but must be connected in some way to a full node to make sure that their data is accurate and useful

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Part 7. Reviewing key terms and topics

Compatibility

- **Fork -** creation of two or more different versions of a distributed ledger.
- **Hard fork –** change to the protocol or rules that result in a fork that is not backward compatible.
- **Soft fork -** change to the protocol or rules that result in a fork that is backward compatible.
- **Intrachain interoperability –** ability of two or more tokens within a distributed ledger platform to operate with one another.
- **Interchain interoperability / atomic swap –** ability of two or more distributed ledger protocols to exchange information and to use information that has been exchanged with one another.

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Part 8: Q&A

Thank You