

Week 1

What is Stellar?

Stellar Technical Academy



Session 1: Agenda

1. Primitives on Stellar
2. The Stellar Stack
3. The Power of Stellar
4. Stellar Accounts & Ledgers
5. Conclusion



Session 1: Objectives

In the first week of the Stellar Technical Academy, you will:

- ✓ Learn about the fundamentals of Stellar
- ✓ You will get acquainted with the Stellar Stack and its components
- ✓ Learn about the power of Stellar. More specifically, you will start by getting a glimpse into how Stellar works on a high level
- ✓ Discover how accounts and ledgers work on Stellar



1. Primitives on Stellar

Primitives on Stellar

What is Stellar?

- Stellar is an **open-source, layer-1** blockchain for currencies and payments, specifically designed to make traditional forms of money more useful and accessible, so all the world's financial systems can work together on a single network.
- Stellar's main purpose is to provide an open, interoperable, borderless payment and currency system.
- With Stellar, you can **create**, **send** and **trade** digital representations of all forms of money, aiming to enhance rather than undermine or replace the existing financial system, while making it cryptocurrency-adjacent (Stellar does not privilege any particular currency).
- As a **layer-1 blockchain**, which refers to the underlying infrastructure of the blockchain, Stellar can validate and finalize transactions without the need for another network.
- Stellar has no owner; it is a decentralized system that facilitates trading any kind of money in a transparent and efficient way. It relies on **blockchain**, but it is faster, cheaper and more energy-efficient than typical blockchain-based systems.
- **Stellar Lumens** (XLM) is Stellar blockchain's native digital currency, and XLM is required in small amounts for initializing accounts and making transactions.

Primitives on Stellar

Stellar Development Foundation (SDF)

- The ongoing development of the basic Stellar technology is guided and supported by the Stellar Development Foundation, a non-profit organization based in the U.S.
- The Foundation helps maintain Stellar's codebase, supports the engineering and business communities around Stellar, and is a speaking partner to regulators and institutions.
- It has no shareholders, so it can be purely dedicated to the success of Stellar as a neutral, equitable and public network.
- Since **transparency** is a dominant principle and a tenet in Stellar's network, its code is open-source and available for anyone to audit or contribute.

Primitives on Stellar

Who can build on Stellar?

- Anyone can access Stellar and benefit from it.
- For **end-users**, Stellar is a fast, efficient network for trading, saving and spending digital money.
- For **builders**, Stellar is an open financial infrastructure.
- Their respective issuers handle **deposits**, **redemptions** and **compliance**, so builders can focus on the end-user experience.
- For **businesses**, any financial institution can issue new digital tokens to fill a market need.

Primitives on Stellar

How does Stellar work at a high level?

- At a high level, Stellar is a system for tracking ownership and, just **like accountants**, it uses a ledger to do so. But, Stellar's innovation lies in the fact that instead of an actual accountant, there is a network of computers each checking and rechecking the work of others.
- Stellar is a system without a central authority. This means that no one can stop the **network** or secretly adjust the numbers to their liking.
- Every token on Stellar is **exchangeable** with any other token on the network and the Stellar protocol itself connects buyers and sellers.
- No middleman arranges settlement and no entity acts as an intermediate custodian.
- For every account holder, Stellar's ledger stores two important things: what the holder **owns** (e.g. "100 Pesos tokens") and what is the **purpose** of the holder (e.g. "sell 50 Pesos tokens for 10 Lumens").

Primitives on Stellar

How does Stellar work on high level?

- Among the top blockchains, Stellar not only tracks balances (as Bitcoin or Ethereum do) but also tracks and settles trade balances in a decentralized, ownerless way.
- The computers that run the core Stellar software and therefore publish and check the ledger are called **nodes**. So, when you send someone a Euro token on an app built on Stellar, the nodes check that the correct balances were debited and credited, and each node makes sure every other node sees and agrees to the transaction.
- The current Stellar network is verified by hundreds of nodes across the **globe**; the nodes and how they communicate is public information and anyone can install the Stellar software and join the consensus process.
- You can also watch [this video](#) (Stellar Core: A Crash Course, 19mins runtime).

Primitives on Stellar

Stellar Lumens (XLM)

- Although Stellar is made to support digital representations of any currency, it also has its very own native token, the lumen.
- The lumen is created in order to fulfil a special role in the network; it is essential, by design, that each Stellar account holds a minimum amount of lumens at all times, in order to get and stay activated.
- Stellar has its own **built-in token**, called the ***lumen***, created to fill a special role in the network. By design, Stellar requires that each account hold a small number of lumens at all times.
- Without some nominal barrier or cost, the ledger could become filled with spam or nonsense, or used as a kind of arbitrary database system.
- Stellar lumens are needed to introduce just the slightest bit of friction to deter bad or frivolous actors. Imposing a **minimum balance** on each account and a very small per-transaction fee were chosen as these deterrent costs.
- The minimum balance is 1 lumen and the minimum per-transaction fee is 0.00001 lumen.
- **But, why doesn't Stellar allow people to pay these costs in Dollars, Pesos, Yuan or anything else?** Stellar didn't want the network to 'prefer' any particular national currency—if Stellar used dollars, say, then network prices would stay fixed for Americans but float for everyone else, now it is **independent** of economic and political factors.

2. The Stellar Stack

The Stellar Stack

Introduction

- In essence, the Stellar network is a set of Stellar Core nodes.
- These nodes are computers that keep a common ledger of accounts and balances, take incoming transactions and agree, through the Stellar Consensus Protocol, to apply a valid set of those transactions to update the ledger.
- As any other blockchain network, each transaction comes along with a small fee, which is necessary to prevent malicious actors from spamming the network.
- Normally, every ledger on Stellar is updated every 3-5 seconds.
- Although Stellar provides a friendly user interface, most developers don't use directly the Stellar Core node.
- Instead, they choose to program using a Software Development Kit (SDK). Then, those SDKs interact with the Stellar network API, Horizon.
- This *three-tiered stack* makes the Stellar Stack.
- Basically, the Stellar Stack divides the responsibilities, so each piece of software can focus on a specific task.
- For example, Stellar Core is responsible for the transaction submission and the consensus, while the Horizon API is responsible for handling queries and converting network data into a user-friendly format.

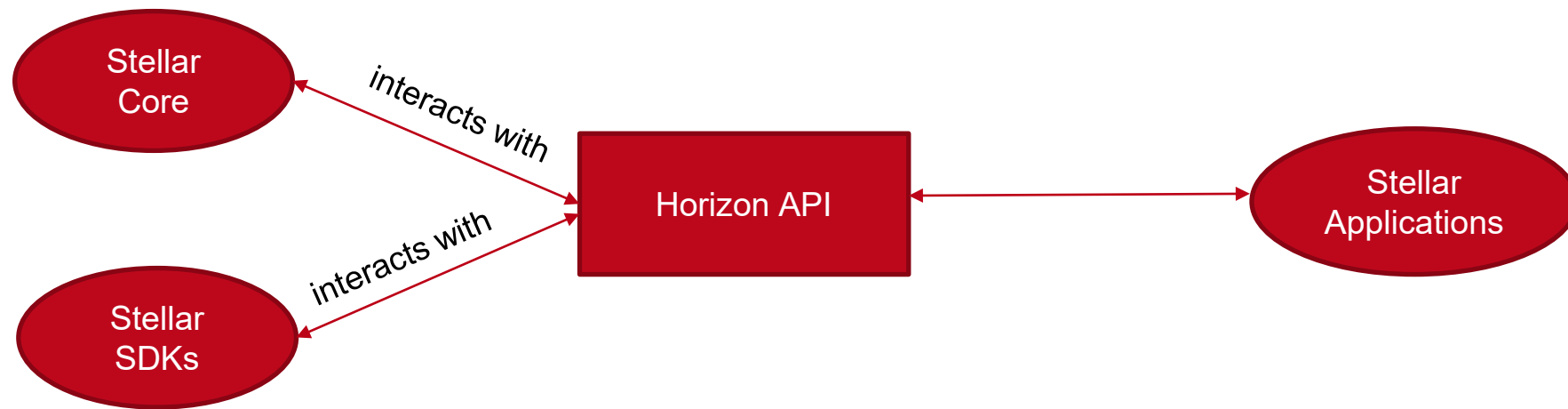
The Stellar Stack

Stellar SDKs

- SDKs are extremely useful because they abstract away complexity and offer convenient access in a variety of programming languages.
- SDKs are designed to make it easy for developers to code and handle network queries and transaction submissions.
- A wide variety of programming languages is available to choose from, making it possible for every developer to interact with the network.
- Each SDK is robust, having its very own source code and documentation showing how to request data, and create and submit transactions.
- More specifically, a developer can use Stellar's SDK in JavaScript, Java, Go, Python, C# .NET, Ruby, iOS, Scala, Qt/C++ and Flutter.
- The Stellar Development Foundation (SDF) maintains SDKs written in JavaScript, Java and Go, while the rest are maintained by community developers.
- Of course, they all are open-source and anyone interested can contribute to them.

The Stellar Stack

Stellar SDKs



The Stellar Stack

Horizon API

- The Horizon API serves as a link between the Stellar-built apps and the Stellar Core.
- Projects like wallets, decentralized exchanges, and asset issuers use the Horizon API to submit transactions, query an account balance or stream events (e.g., transactions to an account).
- Horizon uses a RESTful HTTP API that provides a straightforward way to achieve all the aforementioned tasks.
- Since it's HTTP, it makes it easy to communicate with Horizon using SDKs. However, one can use the web browser or simple command line tools instead.
- The Stellar Development Foundation runs two instances of Horizon; one for the public network and one for the test network.

The Stellar Stack

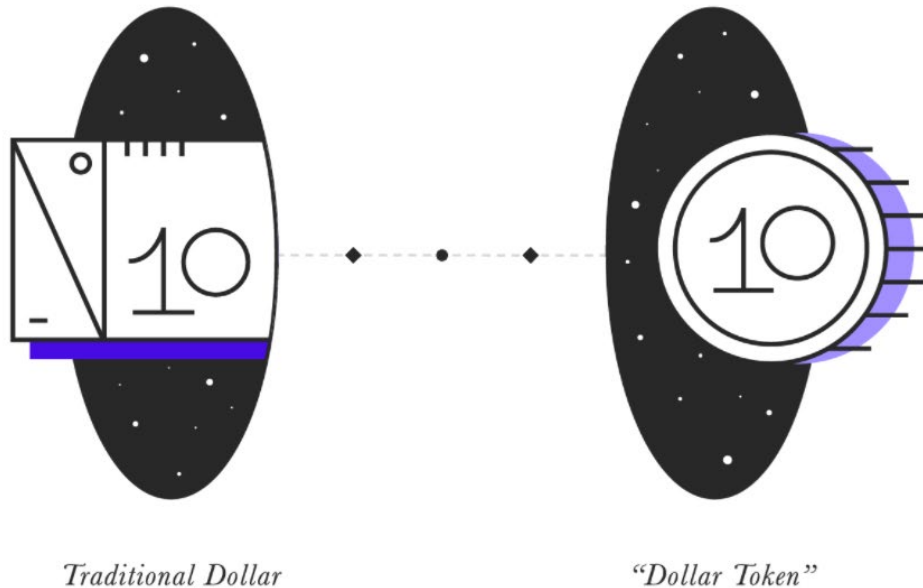
Stellar Core, the Network Backbone

- Stellar Core's work is crucial. It interacts with the Stellar Consensus Protocol (SCP) – which we will dive into later - in order to validate and agree with other instances of Core on the status of every transaction.
- Running a node is extremely important if one wants to ensure constant access or contribute to the health and decentralization of the network.
- The total of the Stellar Core nodes actually make up the entire network. However, most developers don't work directly with the Stellar Core.
- All the messages passed between computers running Stellar Core, ledgers, transactions, results and history are encoded using Extended Data Representation (XDR), which is sufficient but not human readable.
- Stellar provides extended documentation on how one can run its very own Core Node.

3. The Power of Stellar

The Power of Stellar

The 1:1 relationship



Source: <https://www.stellar.org/learn/intro-to-stellar>

- On Stellar you can create a digital representation of a U.S. Dollar or a “**Dollar token**” and you can tell the world that whenever someone deposits a traditional Dollar with you, you will issue them one of your tokens.
- When someone brings that ‘Dollar token back to you, you promise to **redeem** it in turn for one of the regular Dollars in that deposit account.
- This process sets up a **1:1** (one-to-one) **relationship** between the digital token and the traditional Dollar. Every one of the tokens out in the world is **backed** by an equivalent deposit, making digital tokens exchangeable for traditional money.

The Power of Stellar

The 1:1 relationship

- No matter how a token moves through the economy, the underlying Dollars never leave that bank account in the U.S.
- Let us say that someone loans their tokens to someone else, who then uses them to buy a car. No bank has to settle the purchase or approve the loan. Furthermore, it doesn't matter wherever the seller of the car lives in the world. They can still own the tokens and trade them however they please, making money **borderless**.



The Power of Stellar

You can issue you own assets

- Stellar allows a user to create a redeemable, tradable, highly configurable representation of any asset and this is one of Stellar's most powerful features.
- Such representations are called tokens. Tokens are most useful when tied to currencies (representing Dollars or Yuan or Euros digitally makes payments borderless and instant) but in theory, on Stellar, you could issue a token for corn bushels or gold, or shares of a REIT or an hour of your time as a consultant.
- By default, Stellar tokens can be seen, held, and traded by any user.
- This functionality is built in at the protocol level; tokenization is a fundamental part of the network, so the supporting code is tested and fast.

The Power of Stellar

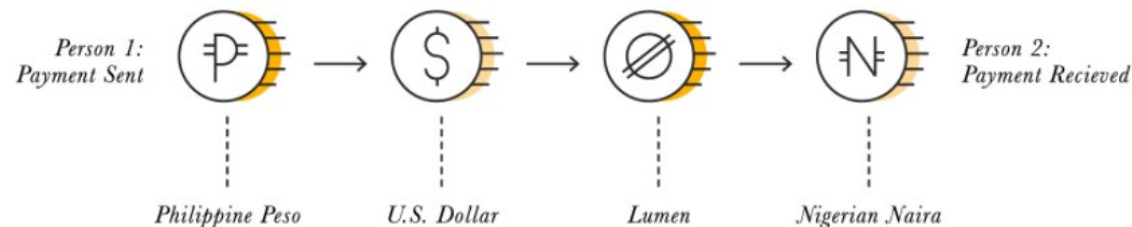
You can trade tokens peer-to-peer

- Every token on Stellar is exchangeable with any other token on the network, and the Stellar protocol itself connects buyers and sellers.
- Users can submit their bids or asks to the public network via a single, simple operation, and every few seconds compatible trades will automatically resolve. No middleman arranges settlement and no entity acts as an intermediate custodian.
- As mentioned above, there is a decentralized exchange (a.k.a. a DEX) built into Stellar's ledger system. Among the top blockchains, Stellar is unique in this regard. The base Stellar protocol not only tracks balances (as Bitcoin and Ethereum do) but also tracks and settles trades between balances in a decentralized, ownerless way.

The Power of Stellar

You can transform currency as you send it

- Like any payments system, Stellar allows one user to send currency to another. But, it also allows a user to send one currency and have the recipient receive another.
- Essentially, you can send and exchange money in a single atomic transaction and neither side has to manually convert; Stellar automatically finds the best conversion rate. This is called a path payment.
- For example, an American company can pay an invoice in Mexico by spending Dollar tokens, while the vendor receives Peso tokens. Neither side incurs exchange risk or delays. Both sides get only the currency they want.

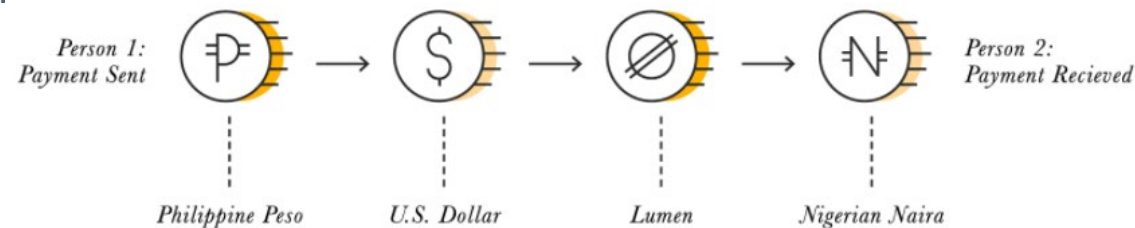


Source: <https://www.stellar.org/learn/the-power-of-stellar>

The Power of Stellar

You can transform currency as you send it

- Here's how it works:
- The sender in the U.S. holds Dollar tokens and signals to the network they want to send Peso tokens to the vendor.
- The network searches through the decentralized exchange described above and finds the **best price** for the sender.
- The network **locks** in the prices and amounts.
- The sender **confirms** the transaction, and the Dollar tokens leave their account.
- The transaction executes and the recipient gets the Peso tokens. The payment is **atomic** and submitted to the network as a **single transaction**. Neither side can get “caught in the middle” and hold tokens they don't want.



Source: <https://www.stellar.org/learn/the-power-of-stellar>

The Power of Stellar

Overall

- Stellar provides a solid foundation for the empowerment of the next generation of FinTech apps and beyond.
- Through the coming weeks, we will dive deeper into how Stellar is actively enhancing the FinTech scene and examine some of its use cases.



4. Stellar Accounts and Ledgers

Stellar Accounts & Ledgers

Accounts on Stellar

- Accounts are the main data structure in Stellar.
- They are responsible for:
 - Holding balances
 - Signing transactions and
 - Issuing assets
- Generally, all entries that persist in the ledger are owned by a particular account.
- In addition to generating a valid keypair, an account needs to be funded with a minimum of 1 (one) XLM to meet the minimum criteria to activate and maintain the address on the network.

Stellar Accounts & Ledgers

Accounts on Stellar - Keypair

- Stellar relies on the simple concept of public key cryptography, in order to ensure that transactions are secure.
- In public key cryptography, there is a keypair which consists of two keys; a *public* key and a *private* key.
- The public key is visible on the ledger, anyone can have access to it and it is what others use to send payments to the account, identify the issuer of an asset and verify that a given transaction is authorized.
- Whereas the secret (aka private) key, as its name suggests, it is something that an account holder should safeguard since it determines account access/ownership.
- It is like the password for an email account; once someone has access to that password, they can send and receive any email they want.
- Respectively, anyone who has access to the secret key also has access to the account and can sign transactions, send funds and so on.
- That's why it is of vital importance that you never share your private key with anyone.
- On Stellar, you can easily generate your own valid keypair through any Stellar wallet or SDK.

Stellar Accounts & Ledgers

Accounts on Stellar – Account Creation

- While creating a keypair is a big step towards creating a Stellar account, it is not all it takes.
- Before an account exists on the ledger, it needs an XLM – Stellar's native token - balance, sufficient enough to meet the minimum network reserve.
- The minimum reserve, which is determined by a validator vote, is intended to disincentivize the creation of numerous unused accounts in order to prevent ledger spam and maintain the efficiency and scalability of the network.
- There is a specific operation, named 'Create Account', which we are going to explore in the laboratory, and it is used to make a payment to a valid public key that does not exist on the ledger, thereby creating the account.

Stellar Accounts & Ledgers

Accounts on Stellar – Account Fields

- A Stellar account has the following fields:
 - Account ID
 - Sequence Number
 - Number of subentries
 - Number of sponsored subentries
 - Number of entries sponsored by this account
 - Thresholds
 - Home domain
 - Flags
 - Balances
 - Liabilities
 - Signers

Stellar Accounts & Ledgers

Accounts on Stellar – Account Creation

Sequence Number

Sequence Number starts equal to the ledger number at which the account was created and increments as the account signs transactions. Each transaction of the account has its unique sequence number.

Number of Entries

Number of Entries field represents the number of entries that the account owns. This number is used to calculate the account's minimum balance. Each subentry increases an account's reserve by 0.5 XLM. Subentries include Trustlines', offers, signers and data entries. (Since protocol version 11, an account cannot increase the number of subentries above 1000).

Account ID

Account ID is represented by the aforementioned public key that was used to create the account. Even if you replace the signer with a different key, the original account ID will always be used as the account identifier.

Stellar Accounts & Ledgers

Accounts on Stellar – Account Creation

Number of Sponsored Subentries

Number of Sponsored Subentries is the number of subentries the account owns that are sponsored by another account. These kind of subentries do not incur any reserve requirement on the account that owns them.

Number of Entries Sponsored by this Account

Number of Entries Sponsored by this Account, unlike the sponsored subentries, do incur a reserve requirement.

Home Domain

Home Domain is a fully qualified domain name, such as example.com, which is linked to the account. It is required of asset issuers, who use it to publish meta-information for Stellar wallets and potential token holders, and for organizations running validators, who use it to self-identify their nodes.

Thresholds

Thresholds is a field that specifies thresholds for low, medium and high-access levels on operations, as well as the weight of the master key.

Stellar Accounts & Ledgers

Accounts on Stellar – Account Creation

Flags

Flags field are set by asset issuers at the account level, if they want to control access to the assets they issue. There are four kinds of flags: Authorization required, Authorization revocable, Authorization immutable, Clawback enabled

Liabilities

Each account tracks its **Liabilities**. Buying liabilities equals the total amount of an asset offered to buy aggregated over all offers owned by this account and selling liabilities equals the total amount of an asset offered to sell aggregated over all offers owned by this account.

Balances

The **Balances** field represents the balance that each account has for each token or pool share the account holds, including XLM.

Signers

The **Signers** field lists other public keys and their weights that can be used to authorize transactions, since one can add extra signers to his account.

Stellar Accounts & Ledgers

Stellar Ledger

- A ledger represents the state of the Stellar network at any given time.
- It is a data structure that is shared across all the nodes that make up the network and contains the list of all accounts and balances, all orders on the distributed exchange and any other needed data.
- At every Stellar Consensus Protocol (SCP) round, as we will discover later on, the network reaches a consensus (an agreement) on which transaction set to apply to the last closed ledger.
- Once the new set is applied, a new 'last closed ledger' is defined.
- Each ledger is cryptographically linked to the previous, unique ledger. This way, a historical ledger chain is being created that goes all the way back to the genesis ledger, which is the very first ledger in the history of the network.

Stellar Accounts & Ledgers

Stellar Ledger – Ledger Header

- Every ledger had its ledger header.
- A ledger header contains references to the actual data within the ledger, as well as a reference to the previous ledger.
- These references are presented in the form of cryptographic hashes of the content being referenced.
- The hashes contained in the ledger header behave like pointers in typical data structures but with added security guarantees.
- More specifically, the specific fields of a ledger header are:
 - **Version:** describes the protocol version of the specific ledger.
 - **Previous ledger hash:** describes the hash of the previous ledger and forms a chain of ledgers stretching back to the genesis ledger.

Stellar Accounts & Ledgers

Stellar Ledger – Ledger Header

- SCP value: during consensus, all the validating nodes in the network run the Stellar Consensus Protocol (SCP) and come to an agreement about a particular value, which is a transaction set they will apply to a ledger. This value is stored in the 'SCP value' field and in the
 - 'transaction set hash' field, which is the hash of the transaction set that was applied to the previous ledger
 - 'close time' field, which indicates when the network closed this ledger in the UNIX timestamp format, and
 - 'upgrades' field, a usually empty field that indicates how the network adjusts overall values like the base fee and agrees to network-wide changes like complying with new protocol versions.
- Transaction set result hash: although it is not necessary for validating the results of the transaction set, this field contains a hash of the results of applying the transaction set and it makes it easier for entities to validate the result of a specific transaction without having to apply the transaction set to the previous ledger.
- Bucket list hash: contains a hash that describes all the objects in this ledger. The data structure that contains all the objects is called 'bucket list'.
- Ledger sequence: the sequence number of the specific ledger.
- Total coins: the total number of lumens in existence.

Stellar Accounts & Ledgers

Stellar Ledger – Ledger Header

- **Fee pool:** this field represents the number of lumens that have been paid in fees. Note that even though a transaction's fee is denominated in stroops (1/10,000,000 of a lumen), the 'fee pool' field is denominated in lumens.
- **Inflation sequence:** represents the number of times inflation has been run. Keep in mind that, since inflation ended following a protocol vote on 28/10/2019, this sequence number no longer changes.
- **ID pool:** is the last used global ID. These IDs are used for generating objects.
- **Maximum number of transactions:** the maximum number of operations that validators have agreed on, in order to process in a given ledger. If the **number** of transactions submitted exceeds this number, the network will enter into surge pricing mode, which uses a Vickrey–Clarke–Groves (VCG) auction to decide which transactions to include in a ledger.
- **Base fee:** this field describes the fee that the network charges per operation in a transaction and it is denominated in stroops.
- **Base reserve:** the reserve the network uses when calculating an account's minimum balance.
- **Skip list:** this field contains hashes of ledgers in the past and it allows you to jump back in time in the ledger chain without walking back ledger by ledger.

Stellar Accounts & Ledgers

Stellar Ledger – Ledger Entries

- The ledger per se constitutes a *total* of all entries. Currently, there are four types of ledger entries:
 - **Account entry:** it is an essential entry since it represents an account and in Stellar everything is built around accounts: transactions are performed by accounts and accounts control the access right to balances. Other entries are add-ons, owned by a main account entry and with every new entry attached to the specific account, the minimum balance in XLM goes up for the account.
 - **Trustline entry:** Trustlines are lines of credit the account has given to an Issuer for a specific asset. They define the rules around the use of the currency. These rules can be defined by the user, who sets a maximum balance value to limit risk, or by the issuer, who sets a flag to control access to the asset.
 - **Offer entry:** this field describes the offers that an account creates in an orderbook as entries and they are a way to automate simple trading inside the Stellar network.
 - **Data entry:** they are key-value pairs attached to an account. They allow account controllers to attach arbitrary data to their account and provide an easy way to add application-specific data to the ledger.

5. Conclusion

Conclusion

Key learnings

- Stellar is a decentralized layer 1 blockchain with its native token XLM.
- At a high level, Stellar is a system for tracking ownership, just **like accountants**, but without a centralized authority.
- The network is built for end-users, for developers, for FinTech applications and for financial institutions. Its an all-in-one solution.
- Instead of programming directly with the Stellar Core, Stellar provides an SDK which has an API which interacts via Horizon with the Stellar Core.
- On Stellar, you can create a digital token for every currency in the world, which you can issue and redeem accordingly.
- On Stellar, you can trade tokens peer-to-peer and transform currency while you send it.
- Accounts are the main data structure of Stellar. Each one of them has a unique keypair, which consists of a secret key and a public key.
- A ledger represents the state of the Stellar network at any given time and this information is shared across all the nodes that make up the network.

References

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Questions?

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