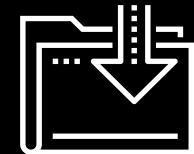


Blockchain Transactions and Web3.py

FinTech

Lesson 19.1



Class Objectives

By the end of this lesson, you will be able to:

-  Articulate how nodes and the mempool play roles in adding transactions to the Ethereum blockchain.
-  Explain how gas fees help determine which transactions are selected for addition to the Ethereum blockchain.
-  Describe the six steps required to add a transaction to the Ethereum blockchain.
-  Compare and contrast low-, medium-, and high-gas strategies.
-  Utilize Web3.py as a provider to access account addresses and balances, and convert ether into different denominations.
-  Use Web3.py to define the parameters required for an Ethereum transaction, including the sender, receiver, gas, and ether.
-  Explain the role of a testnet in the Ethereum ecosystem.



WELCOME



Let's begin by recapping the
previous unit and lessons.

Recap

In the last unit, you:

01

Built a local blockchain and a decentralized network using a Python library called Streamlit.

02

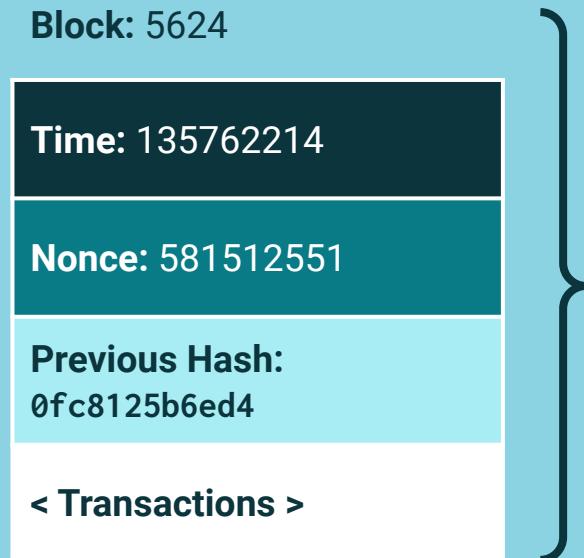
Constructed a complete PyChain blockchain ledger instance.

03

Designed this ledger to record financial transactions among multiple parties.

The Ethereum Blockchain

On the Ethereum blockchain, instead of a record attribute, each block has an attribute named **Transactions** that stores data.



This week, you will learn about **Web3.py** and how to use it to send transactions on the Ethereum blockchain.

The Ethereum Blockchain

Having the ability to send transactions on a blockchain is an important skill, especially if you plan on working in an industry that uses blockchain.

Here are some examples:

Automotive

Healthcare and life sciences

Retail and consumer goods

Supply chain

Banking and financial services

Insurance

Telecommunications

Oil and gas

Government

Media and entertainment

Travel and transportation

Manufacturing

The Ethereum Blockchain

Let's say you work for a company that wants to make a million or even billion dollar transactions.

Banks will charge a percentage as a fee to send an amount of money this large.

- The ability to send cryptocurrency to facilitate purchases saves thousands of dollars in transaction fees.
- In addition, the transactions will be stored on the blockchain.



The Ethereum Blockchain

Ethereum is another blockchain with its own cryptocurrency: **ether**.



It is the second-largest cryptocurrency in terms of market capitalization.



It is the second-most valuable cryptocurrency.



The Ethereum blockchain is the most actively used blockchain.



It is special because it has capabilities that other blockchains do not, such as storing entire contracts that automate transactions.



The Ethereum Blockchain

These contracts can be as simple as an IOU between two parties. Or, they could involve transfers of ownership of cryptocurrency, other financial assets, or even copyrights to intellectual property.



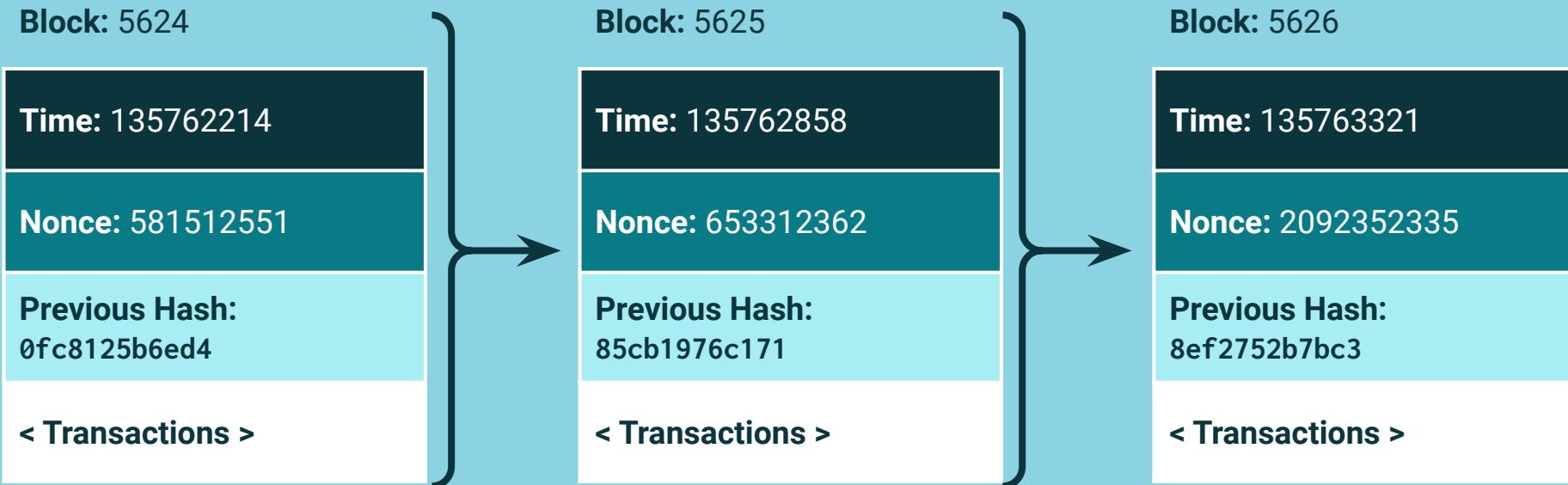
Adding Transactions to the Blockchain



Similar to Bitcoin, Ethereum has a blockchain that stores data in blocks. Ethereum blocks store data such as transactions and smart contracts. The part of the block that stores the transactions is an attribute known as the **transactions attribute**. On the Bitcoin blockchain, this attribute is called a **record attribute**.

Adding Transactions to the Blockchain

A member of the blockchain network, or a blockchain participant, creates a transaction that will store data or transfer assets over the blockchain.

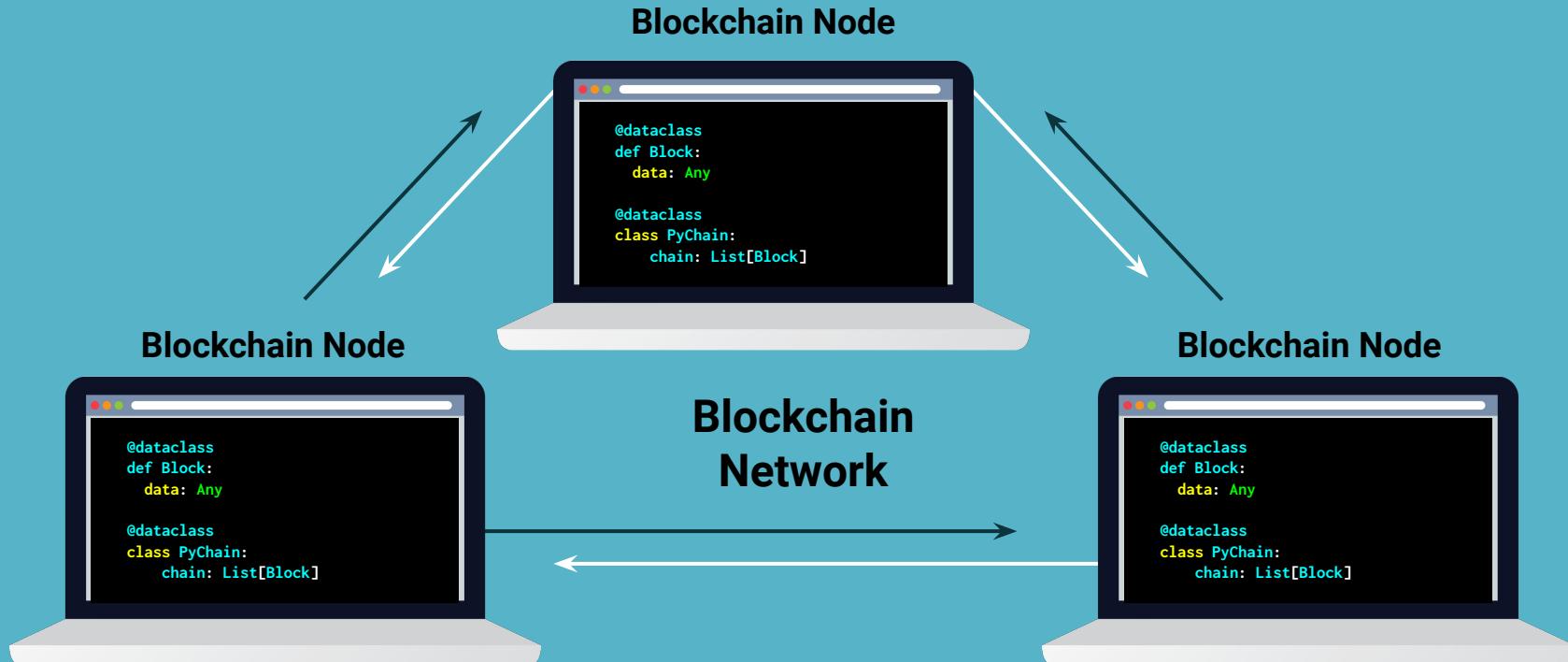




What happens after the transaction
is created?

Adding Transactions to the Blockchain

The participant sends the transaction to the blockchain network.





A **mempool** is where all new transactions wait to be confirmed by the blockchain network, added to a block, and included in the chain.



Why would a transaction be
in a mempool?

What would keep it from
being processed?



Hint:

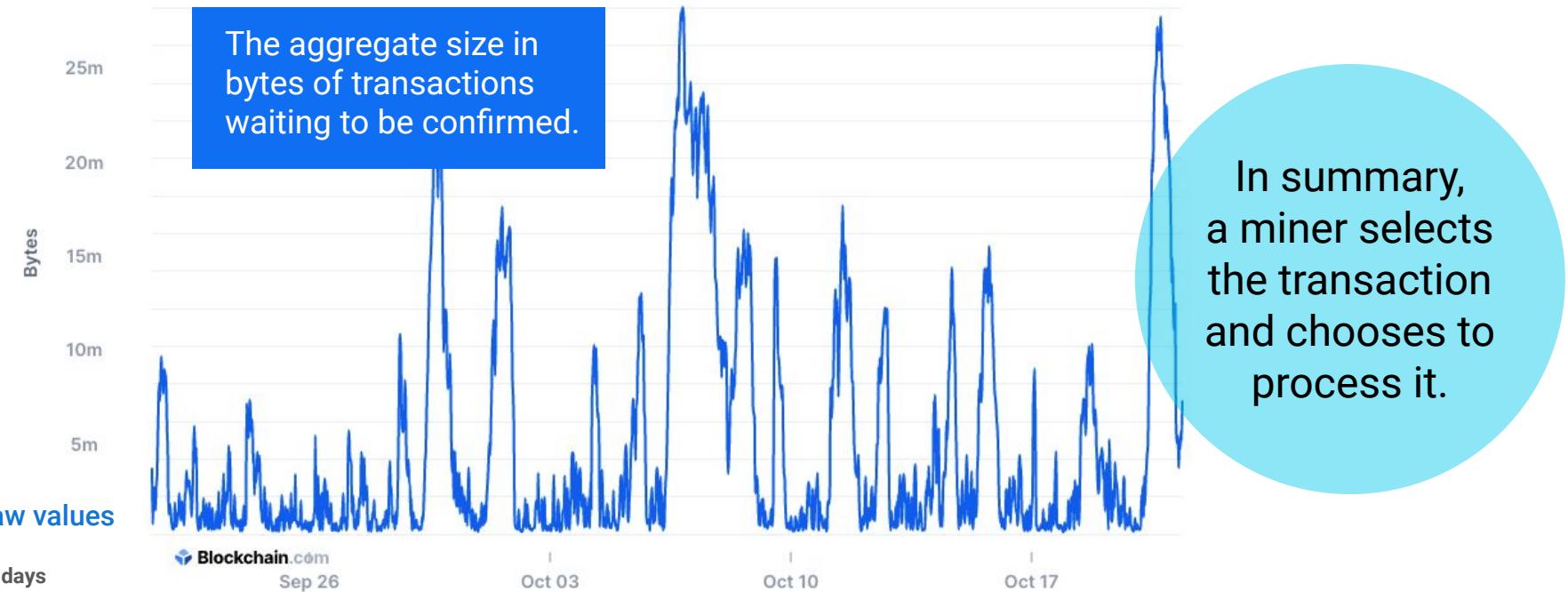
Each computer or server that maintains a copy of the blockchain ledger and validates new transactions—in other words, each participant on the blockchain network—is called a node.



Each node on the network has a local mempool. When a new transaction is sent to the network, nodes add the new transaction to their local mempools.

Mempools

The size of a mempool can vary depending upon the network traffic, or the number of transactions that network participants are generating at any given time.



Blocknative Mempool Explorer

Build real-time data feeds for monitoring in-flight Blockchain transactions

See the introductory blog post →

See documentation →

Polygon (MATIC)



Watch Quickswap Router
transactions on Polygon

[Watch now](#)

Binance (BSC)



Monitor Pancakeswap v1 and
v2 transactions on Binance
Smart Chain

[Watch now](#)

Simulation Platform

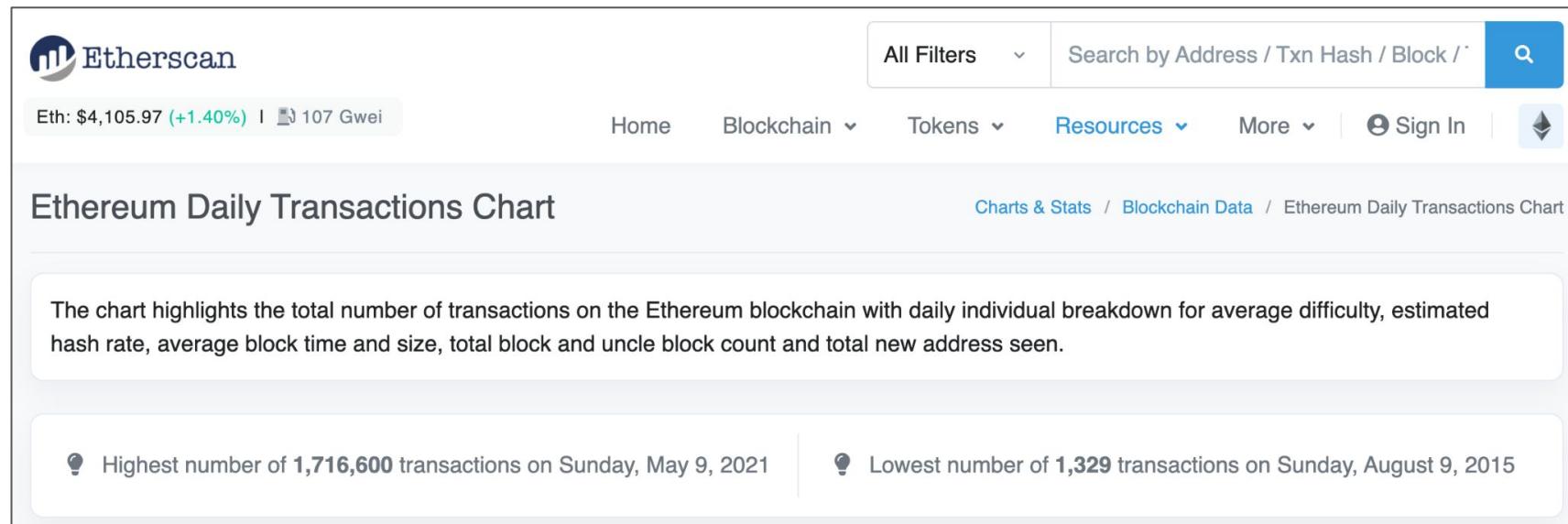


Peer into the future - view
simulated transactions on
Uniswap now.

[Watch now](#)

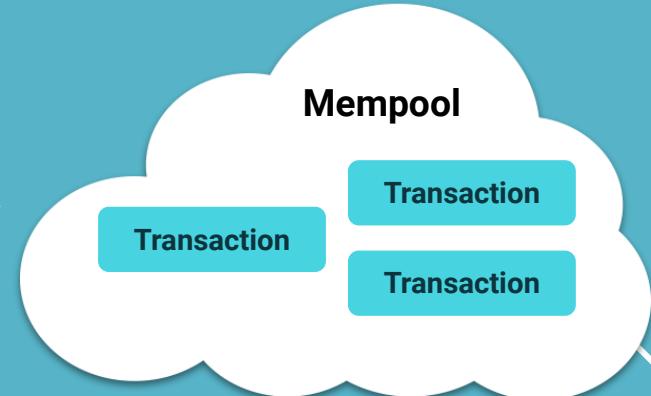
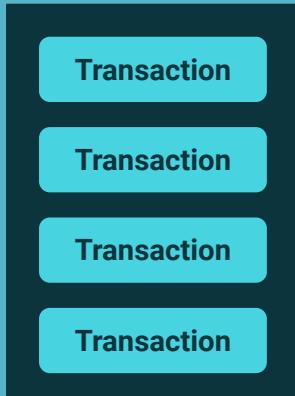
The Ethereum Blockchain

An Ethereum block currently averages around 500 transactions, and about 2 megabytes of data, per block. However, the number of transactions included in any given Ethereum block is dependent on the size and complexity of the transactions.

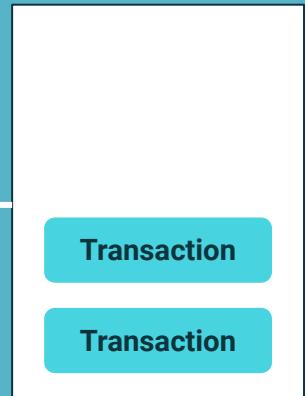




Blockchain



Miner bundles
transactions



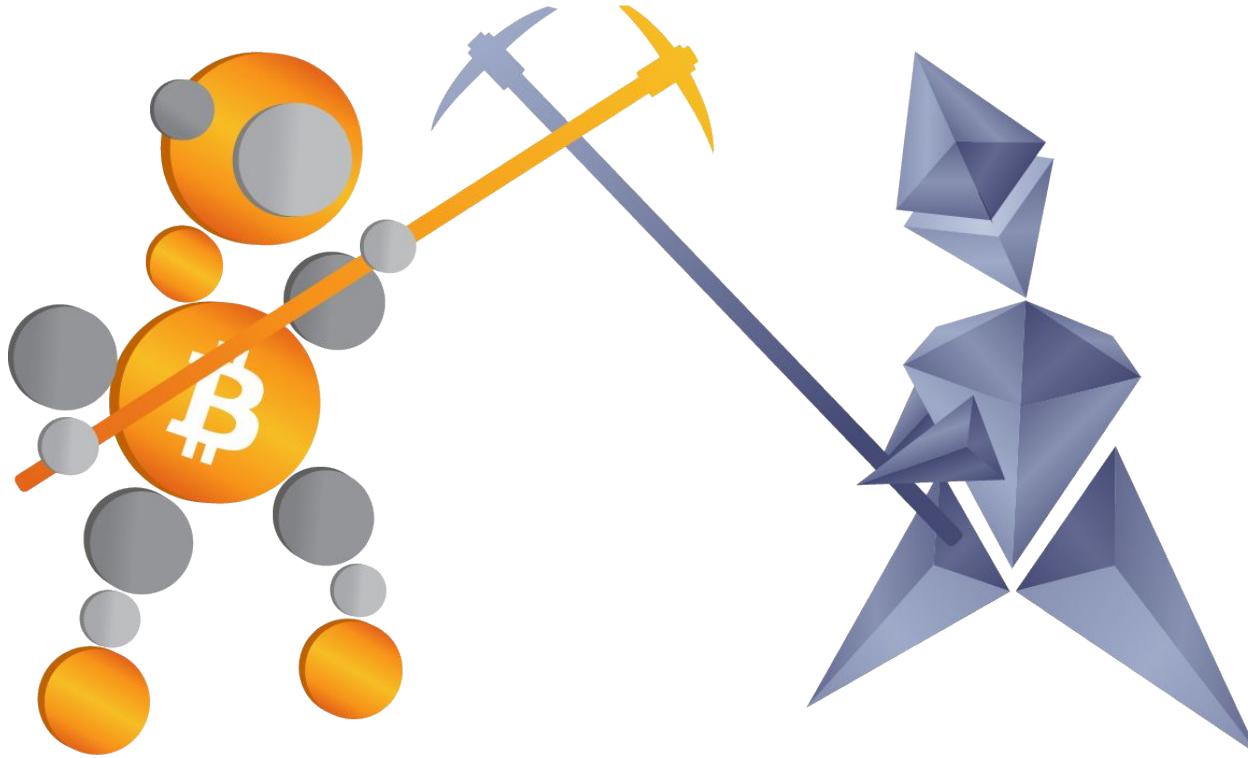


Instructor Demonstration

Blockchain Transaction Fees

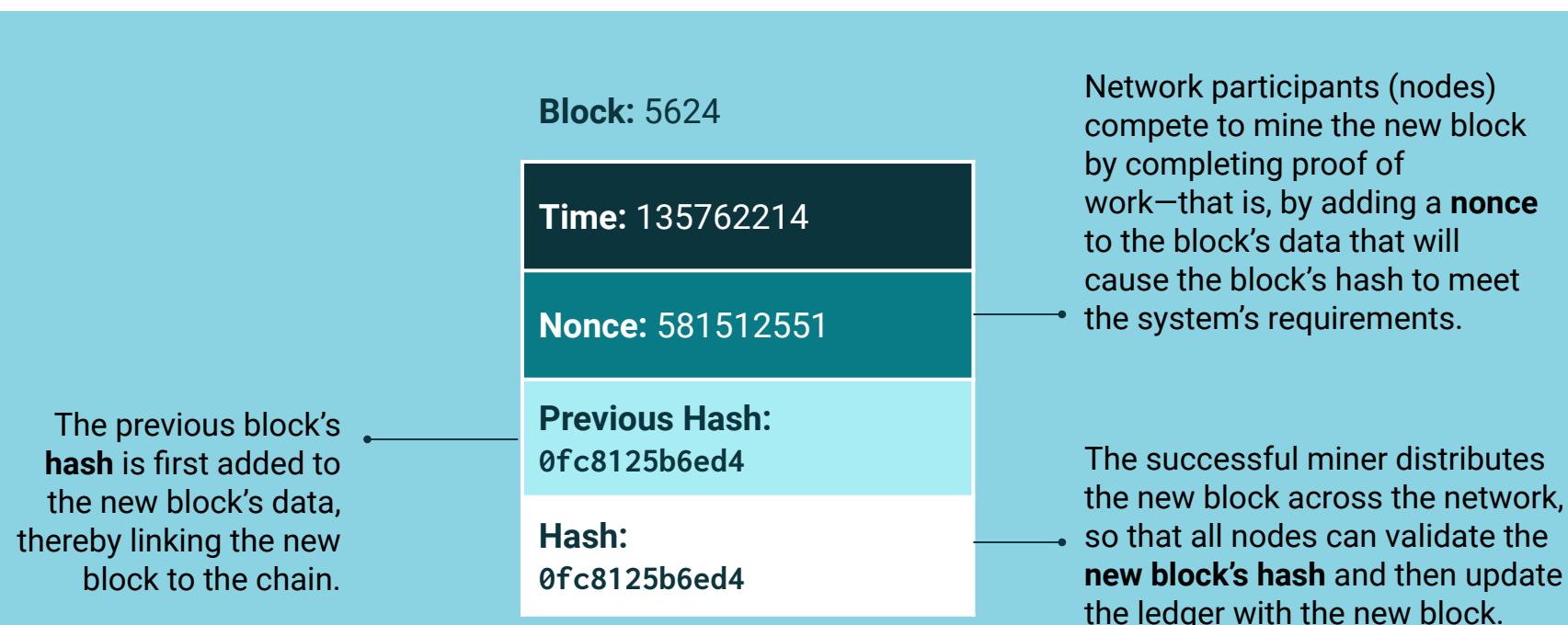
Blockchain Transaction Fees

Miners of Ethereum have a different strategy than those mining Bitcoin because of fees.



Blockchain Transaction Fees

Recall that when mining Bitcoin...



Blockchain Transaction Fees

Ethereum miners do not view all transactions in the mempool as having equal priority. The reward for mining each transaction is different.



Blockchain Transaction Fees

A transaction fee on any blockchain is an incentive given to people or miners to run the blockchain on their machines; otherwise, miners would have high energy costs and no return.

This is why many blockchain networks charge a transaction fee every time a participant records a new transaction onto the chain.



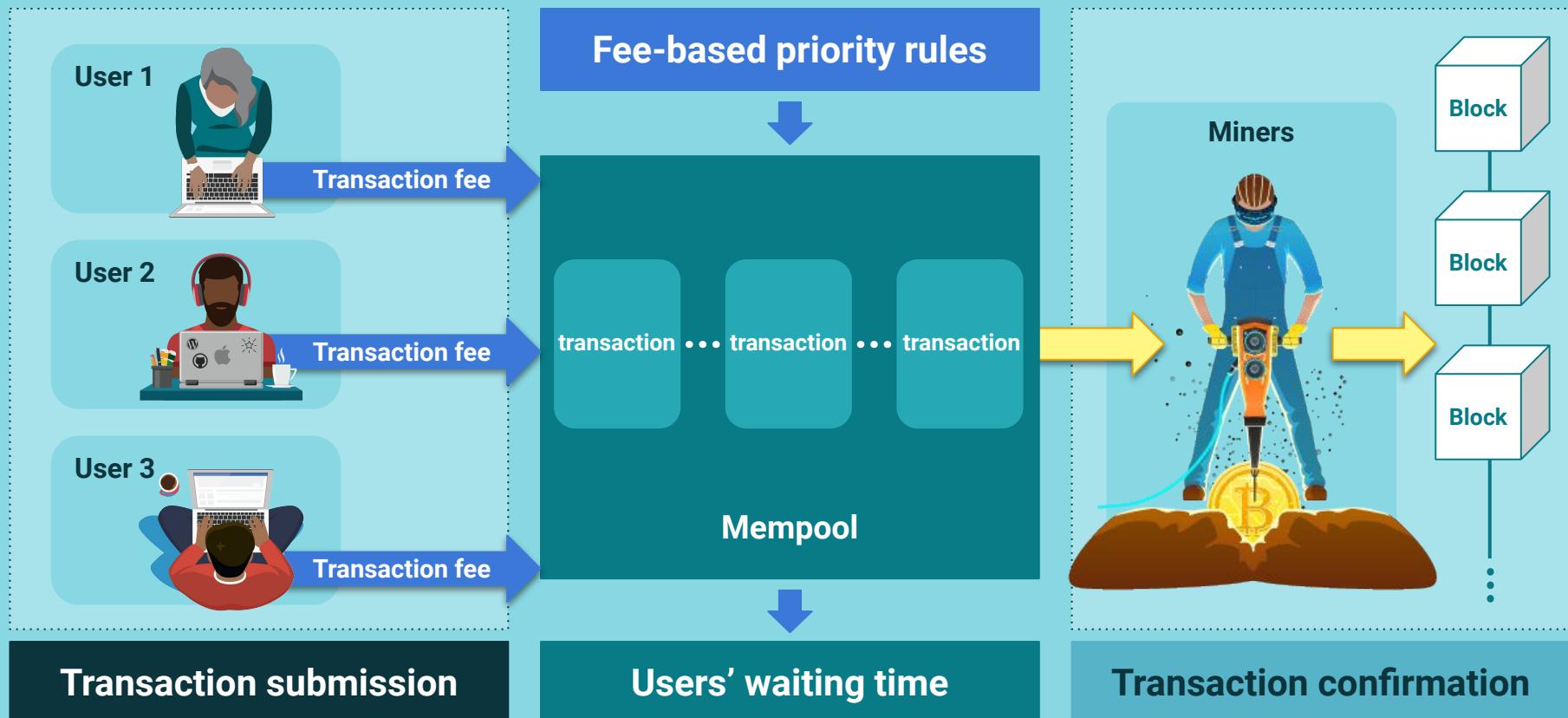
Wiring money through a bank generally has transaction fees.



Blockchain transaction fees are structured a bit differently.

Each blockchain network has its own rules for calculating these fees, and pricing can vary even within one network. Often, transaction fees increase or decrease

Blockchain Transaction Fees



Blockchain Transaction Fees

-  On the Ethereum network, transactions wait in the network mempools before a miner picks them up and adds them to the chain.
-  Miners don't necessarily add transactions to blocks on a first-come-first-serve basis.
-  Computational power on the Ethereum network and space within each block are both limited, and demand for them fluctuates.
-  During periods of high demand, the number of transactions sitting in an Ethereum node's mempool may exceed the number of transactions that can fit into a single block.
-  The node's miner will decide which transactions to put in a new block and which to leave in the mempool until later.
-  During periods of high traffic, when lots of users are sending transactions, miners will prioritize transactions that pay higher fees.
-  On Ethereum, the participant who completes proof of work first and mines a new block receives the transaction fees for all the transactions contained within that block.
-  In other words, in the Ethereum ecosystem, the transaction fees are included in the block reward.

General Rules for Adding Blocks to Blockchains



A block reward allocates funds to the participant who spent the energy to mine a block.



It incentivizes a blockchain network's participants to spend energy completing proof of work and mining new blocks.



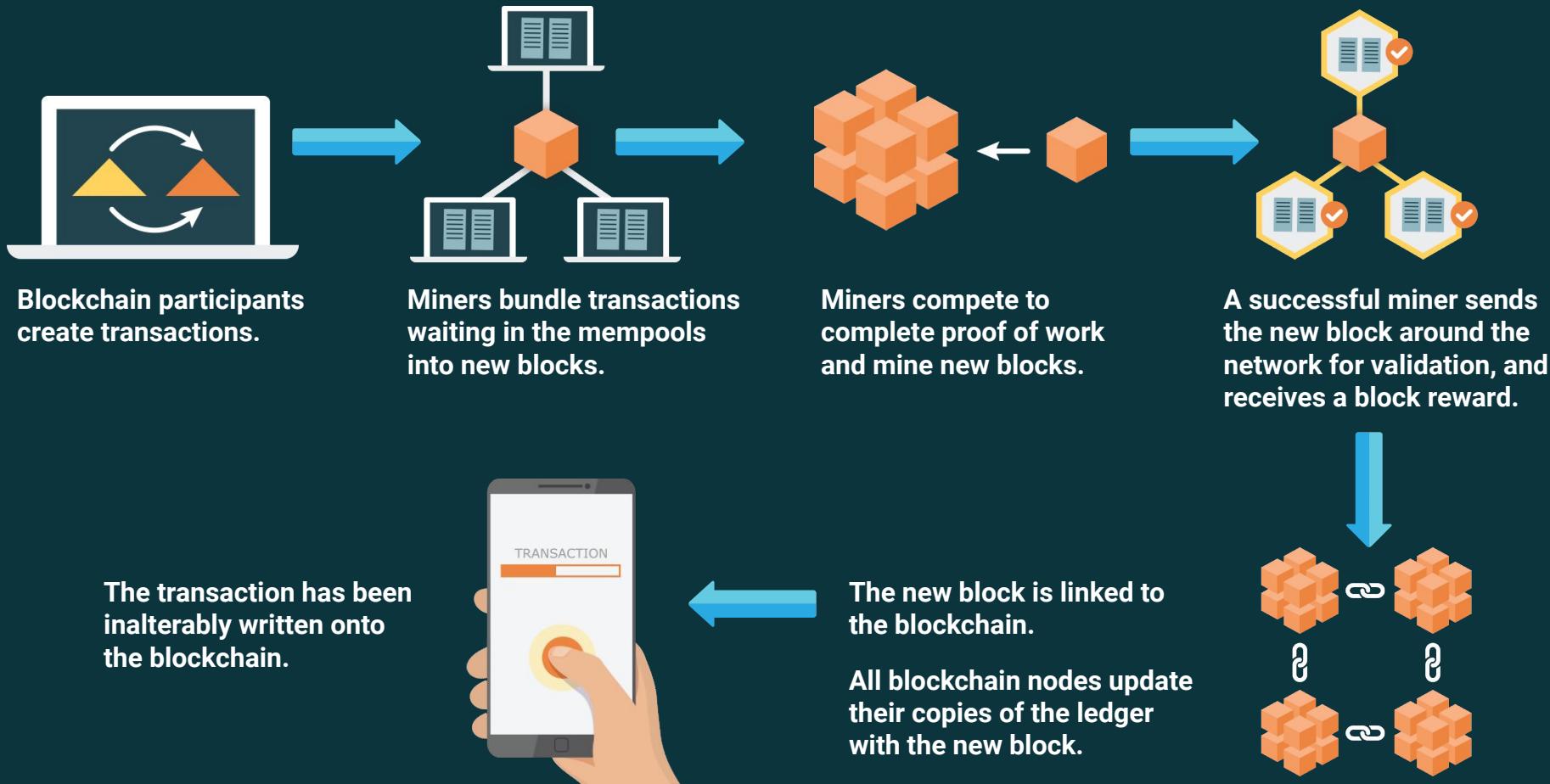
After a block is mined and validated, it is written to all of the nodes' ledgers, which effectively executes the block's transactions across the network.



On the Ethereum blockchain, this entire process usually takes between 15 seconds and 5 minutes depending on network traffic.



The complete process of adding a transaction to the Ethereum blockchain



Blockchain Transaction Fees

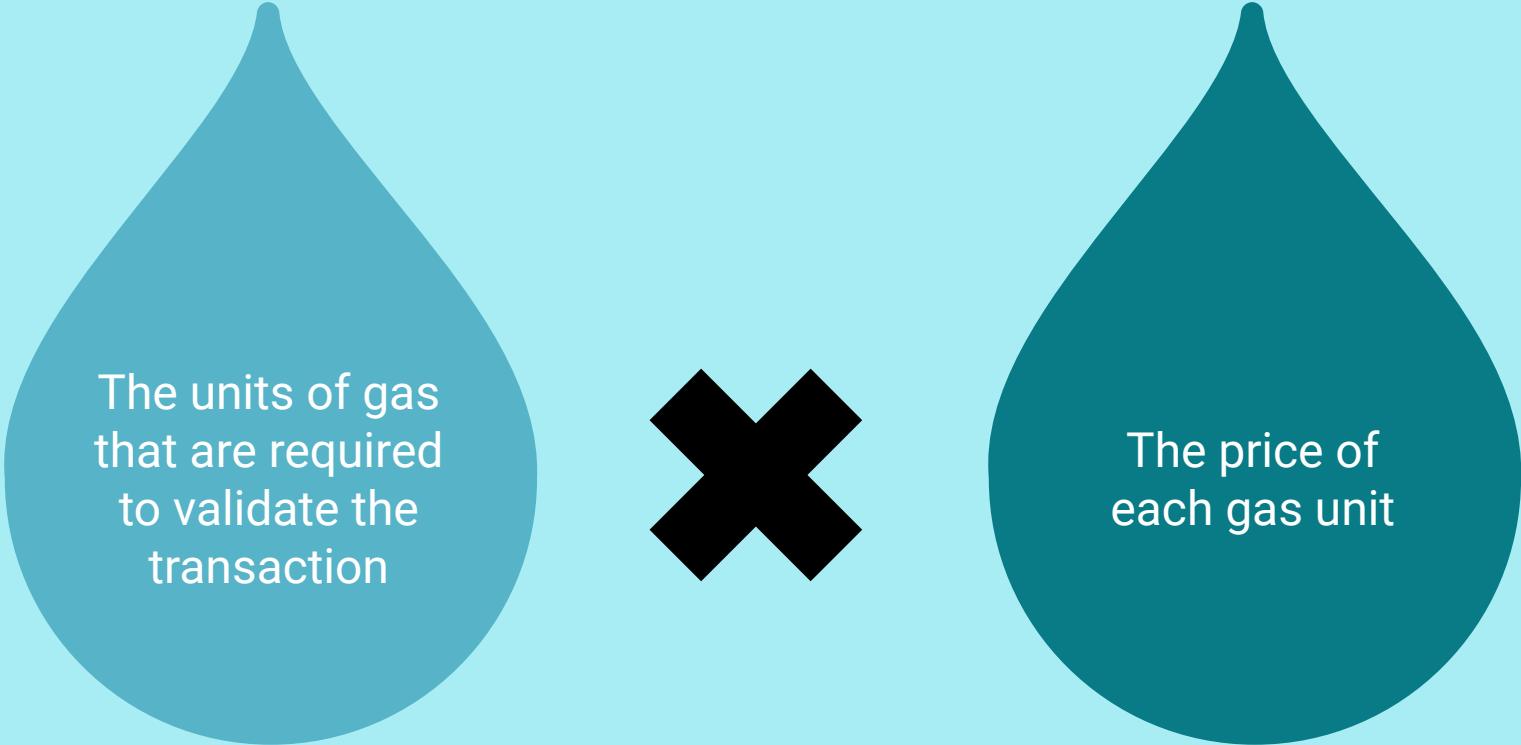
We are about to review the actual cost and fee structure for sending a transaction to Ethereum.

- Ethereum's transaction fee does not depend on the value of the transaction being processed.
- The transaction fee depends on factors such as the amount of computational power, or gas, that is required to validate the transaction and add it to a block.
- For this reason, Ethereum's transaction fee is known as a **gas fee**.



Blockchain Transaction Fees

The calculation of the gas fee for a given transaction is:

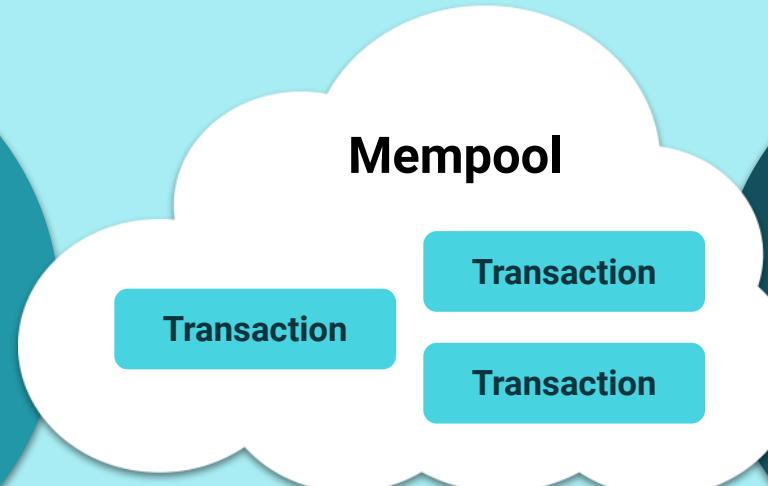


The units of gas
that are required
to validate the
transaction

The price of
each gas unit

Blockchain Transaction Fees

The price of gas fluctuates based on network traffic, i.e., how many transactions are waiting in the mempool to be picked up by miners.



During periods of high demand, when many transactions compete to be mined at the same time, the gas price increases.

Mempool

Transaction

Transaction

At times when more participants want to add transactions to the chain, the cost of adding a particular transaction to the chain goes up.

You can find additional information about Ethereum gas in the Decentralized Finance (DeFi) article “Ethereum Gas Explained.”

The screenshot shows a white page with a decorative background of vertical bars in light blue, orange, and purple. At the top left is the defiprime.com logo. To its right are navigation links: a magnifying glass icon for search, a flame icon for DeFi Blog, Projects, Community, DeFi Rates, DeFi Tokens, Events, and About. The main title 'Ethereum Gas Explained' is centered in large, bold, dark blue letters. Below it, the author 'William M. Peaster' and the date 'on 22 Sep 2020' are displayed. The article summary begins below.

Ethereum is an open-source network designed to reliably power decentralized applications. A crucial element of the network is “gas,” which, if we understand Ethereum as a world computer, serves as the fuel for this computer’s applications and transactions. Accordingly, gas is one of the most salient UX aspects of Ethereum.

Benefits of Using Ethereum for Financial Transactions

Benefits of Ethereum Blockchain

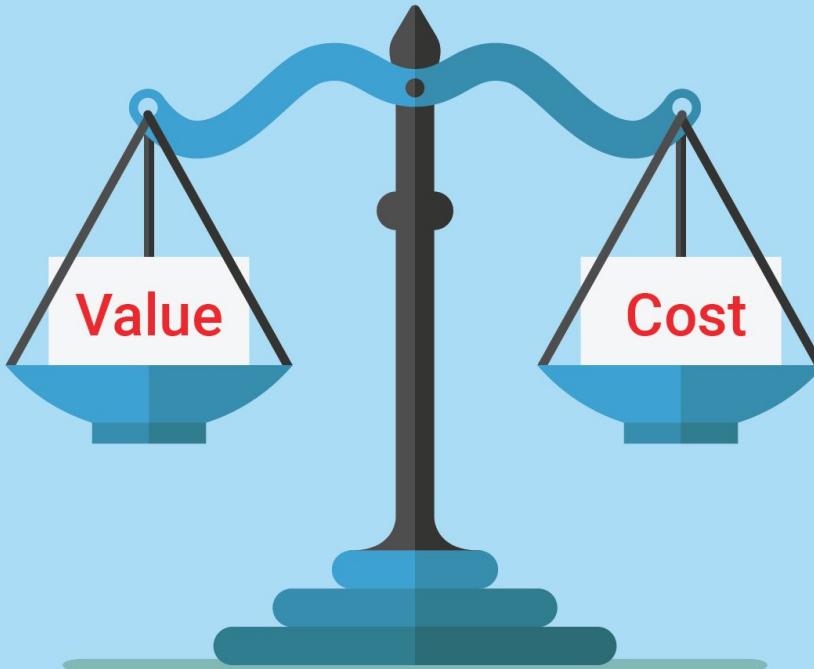
Ethereum nodes are globally distributed. When someone across the globe sends you money, you can access it almost instantly.

This means that you don't have to wait for your bank to open in order to withdraw your new funds or pay fees for currency exchange.



Benefits of Ethereum Blockchain

Ethereum's dynamic, supply-and-demand-based fee structure offers another unique benefit for financial transactions: the cost of the transaction is not related to the value of the transaction.



Benefits of Ethereum Blockchain

Processing a cryptocurrency transaction that transfers 100 ether from one participant to another might require the same amount (i.e., the same number of units) of gas that processing a transaction of 1,000 ether, or 100,000 ether, does.

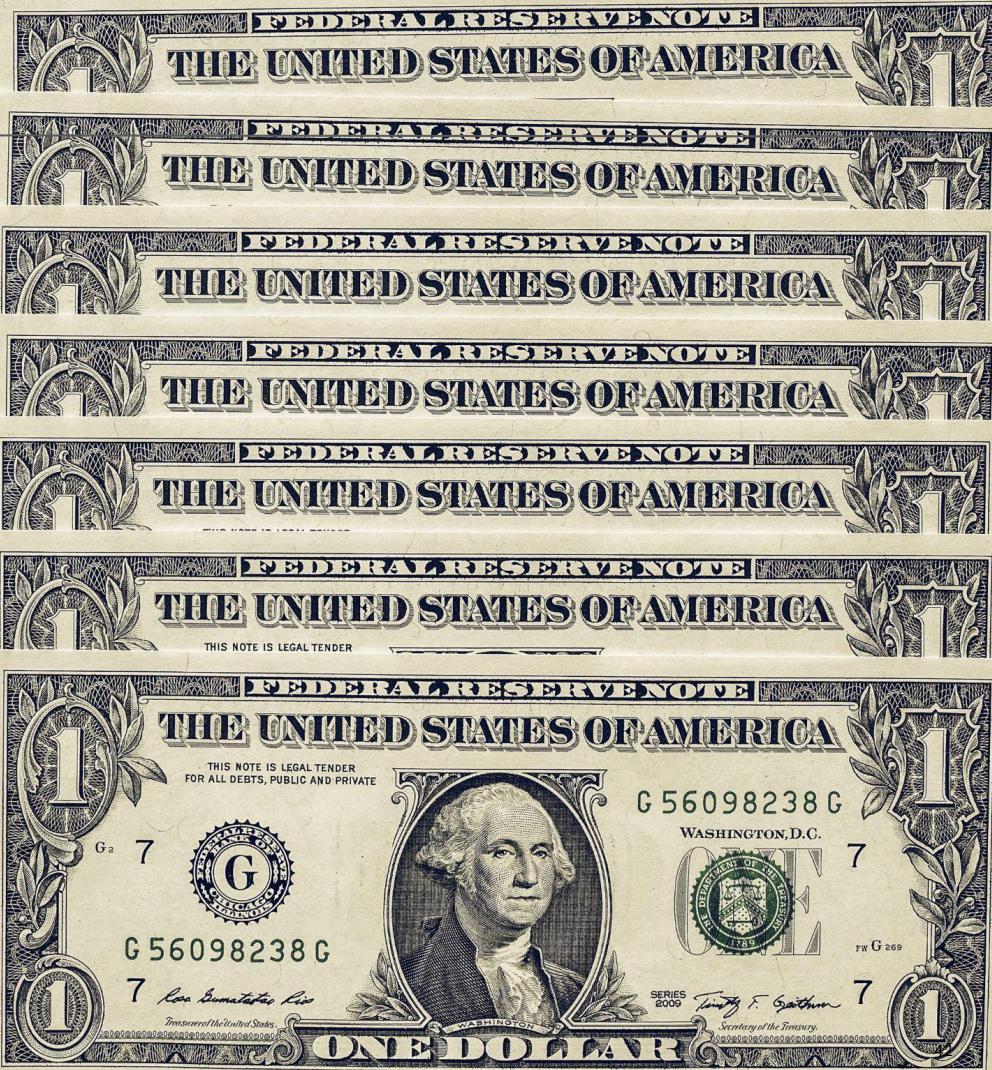
Compare this with traditional money transfer systems, which charge increasingly high fees to send larger amounts of money.



Blockchain Benefits

In 2018, cryptocurrency exchange Binace demonstrated the real-world usefulness of a blockchain transaction-fee system by transferring \$600 million worth of Bitcoin for a transaction fee of just \$7!

A comparable transaction through traditional financial institutions such as banks, or even through digital payment platforms like PayPal, could have cost millions of dollars in fees.

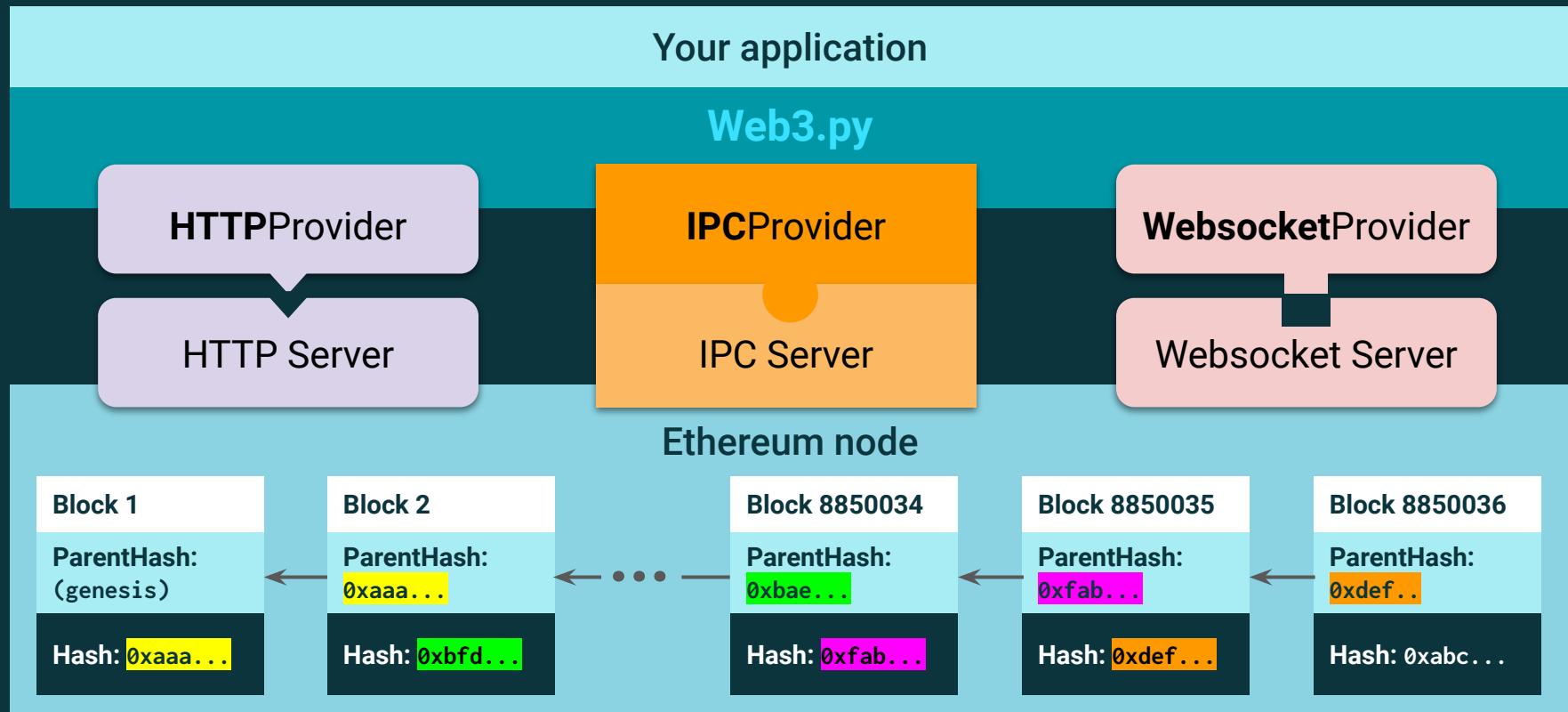


Questions?



Introduction to Web3.py

Introduction to Web3.py



Benefits of Web3.py



Web3.py is a library that allows us to talk to Ethereum nodes in Python.



Web3.py is a software development kit (SDK) like any other SDK you've used to talk to other APIs. But, this time, the API originates from an Ethereum node.



Web3.py can help you read block data, sign and send transactions, and deploy and interact with contracts.



Web3.py allows you to communicate with the blockchain and serves as a window to reading the ledger.



Search projects



Help

Sponsors

Log in

Register

web3 5.22.0

pip install web3



Latest version

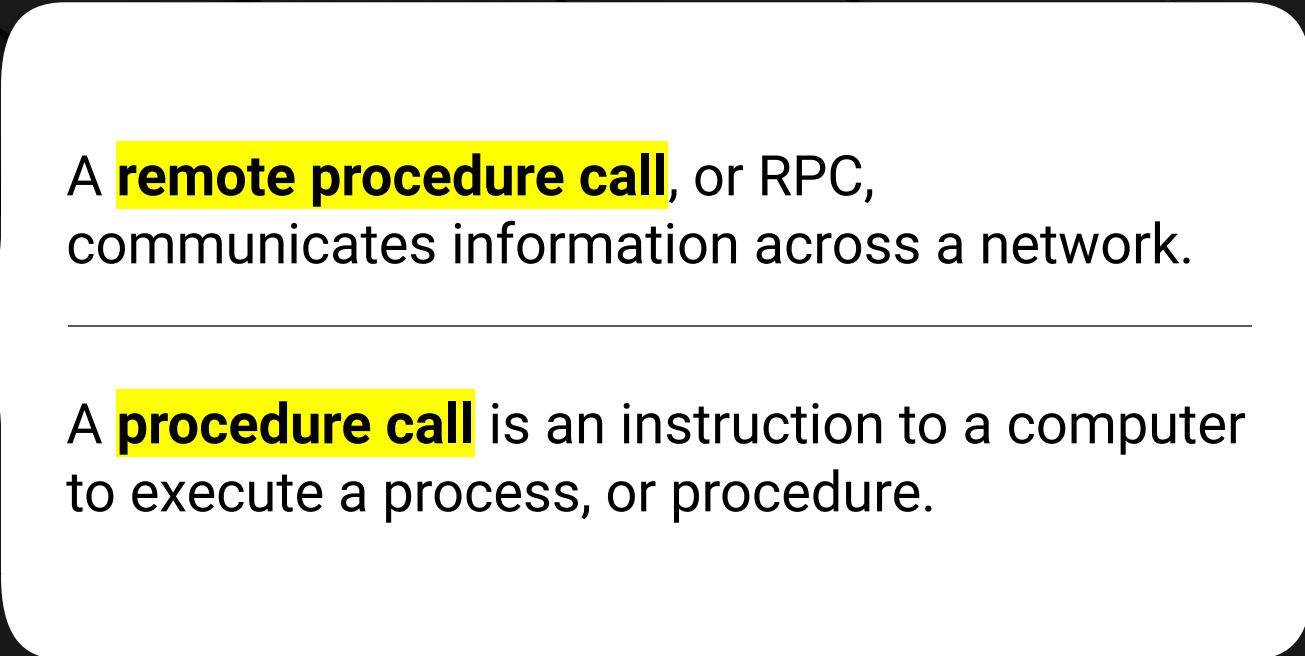
Released: Aug 2, 2021

Remote Procedure Call (RPC)

Computers in the blockchain network share information with one another by using protocols as we learned last week.

Specifically, they use **consensus protocols**, but this is not the only kind of protocol.



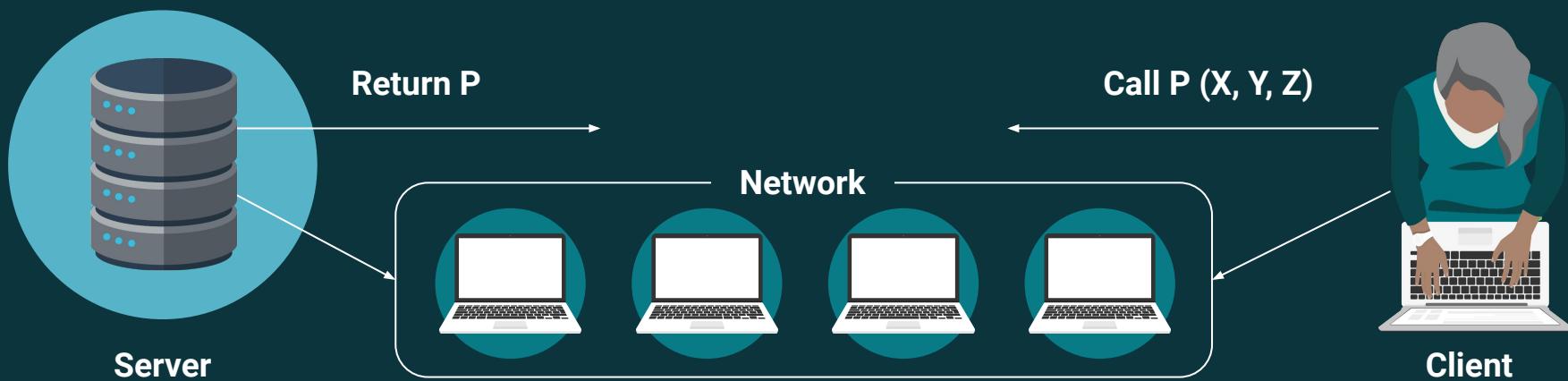


A **remote procedure call**, or RPC, communicates information across a network.

A **procedure call** is an instruction to a computer to execute a process, or procedure.

Remote Procedure Calls (RPCs)

A **remote procedure call** is when a computer program's request causes a procedure to execute on a computer or shared network at a remote location. The computer or network then completes the request made by the initial computer that made the request.



Remote Procedure Calls (RPCs)

Here's how RPCs are helpful to the blockchain:



When a program is executed by using the RPC model, it doesn't matter whether the requesting computer or network is in a different location than the executing computer or network.



Web3.py makes this possible by an RPC provider commonly referred to as a provider. This provider facilitates the connection and communication between our computers and the Ethereum blockchain network. Web3.py comes bundled with several default providers.



The EthereumTesterProvider allows us to simulate interactions with an Ethereum blockchain.



This means that we don't have to run our own blockchain or blockchain nodes in order to test code that interacts with the Ethereum blockchain.



Instead, we will interact with a mock blockchain that the ethereum-tester library and the EthereumTesterProvider makes available to developers for testing purposes.



Instructor Demonstration

Introduction to Web3.py



Activity: Ethereum Through Web3.py

In this activity, you will use Web3.py to connect to a local mock development blockchain. Then, you'll check the account balance of one of the accounts that is available on the mock blockchain.

Suggested Time:

30 minutes



Time's Up! Let's Review.

Questions?



Break



Transactions with Web3.py



Once we are connected to a Web3 mock blockchain instance, we can use several Web3.py methods to create and send ether-based transactions from one account to another.

Transactions with Web3.py

from:

The 42-character Ethereum account address from which the transaction is sent.

to:

The 42-character Ethereum account address to which the transaction is sent.

gas:

An integer representing the maximum units of gas to be used in mining the transaction. A standard ether transfer requires at least 21,000 units of gas. Any unused gas is returned to the sender.

value:

An integer representing the amount of money, in wei, that this transaction will transfer from the sender to the recipient.

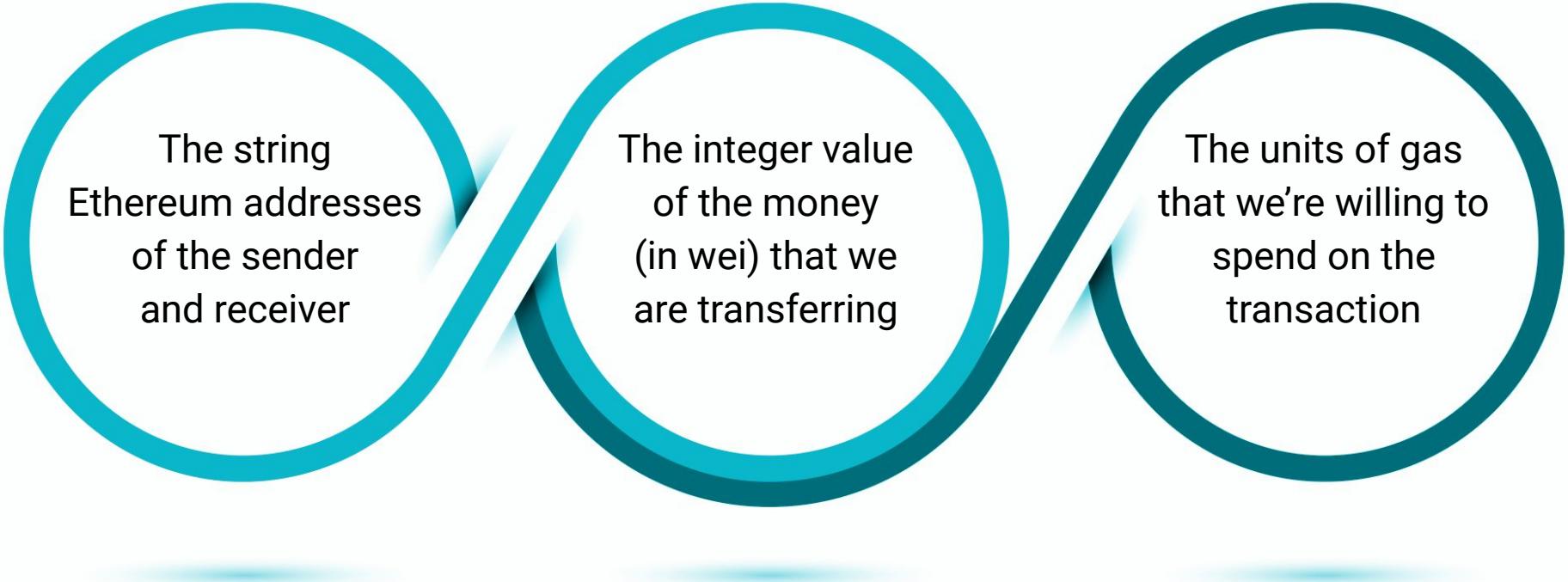
Ether Denominations

You learned about a new cryptocurrency **ether** and the denominations of it.

Unit Name	Wei Value	Number of Wei
Wei (wei)	1 wei	1
Kwei (babbage)	1e3 wei	1,000
Mwei (lovelace)	1e6 wei	1,000,000
Gwei (shannon)	1e9 wei	1,000,000,000
Twei (szabo)	1e12 wei	1,000,000,000,000
Pwei (finney)	1e15 wei	1,000,000,000,000,000
Ether (buterin)	1e18 wei	1,000,000,000,000,000,000

Transactions with Web3.py

In order, to send our transaction, we'll need:



The string Ethereum addresses of the sender and receiver

The integer value of the money (in wei) that we are transferring

The units of gas that we're willing to spend on the transaction



Instructor Demonstration

Transactions with Web3.py



Activity: Transactions with Web3.py

In this activity, you will create a transaction between Ethereum accounts. You will use Web3.py to connect to a local mock development blockchain. Then, you will create, send, and review a financial transaction by using several Web3.py methods.

Suggested Time:

30 minutes



Time's Up! Let's Review.

Questions?





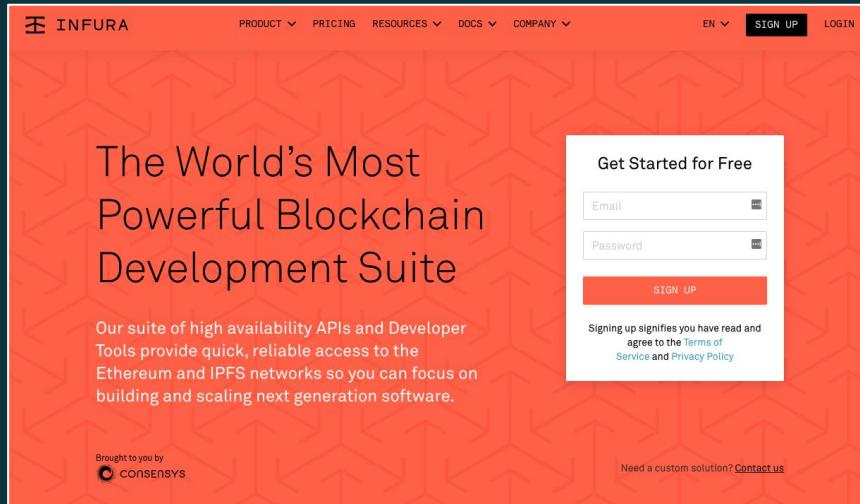
Review Web3.py/Fundamental Concepts

Suggested Time:

20 minutes

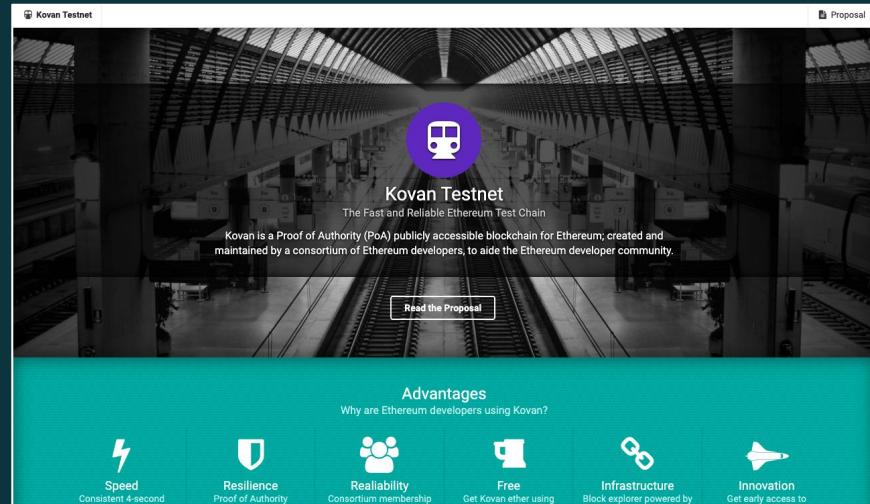
Review Web3.py/Fundamental Concepts

Now we will discuss Infura and testnets, tools that help you develop transactions for Web3.



The Infura homepage features a prominent orange header with the Infura logo and navigation links for PRODUCT, PRICING, RESOURCES, DOCS, and COMPANY. A "SIGN UP" button is located in the top right corner. The main visual is a large orange background with a geometric arrow pattern. On the left, the text "The World's Most Powerful Blockchain Development Suite" is displayed. In the center, there is a "Get Started for Free" sign-up form with fields for Email and Password, and a "SIGN UP" button. Below the form, a note states: "Signing up signifies you have read and agree to the [Terms of Service](#) and [Privacy Policy](#)". At the bottom, there is a link to "Contact us". The footer includes the text "Brought to you by CONSENSYS" and the ConsenSys logo.

<https://infura.io/>



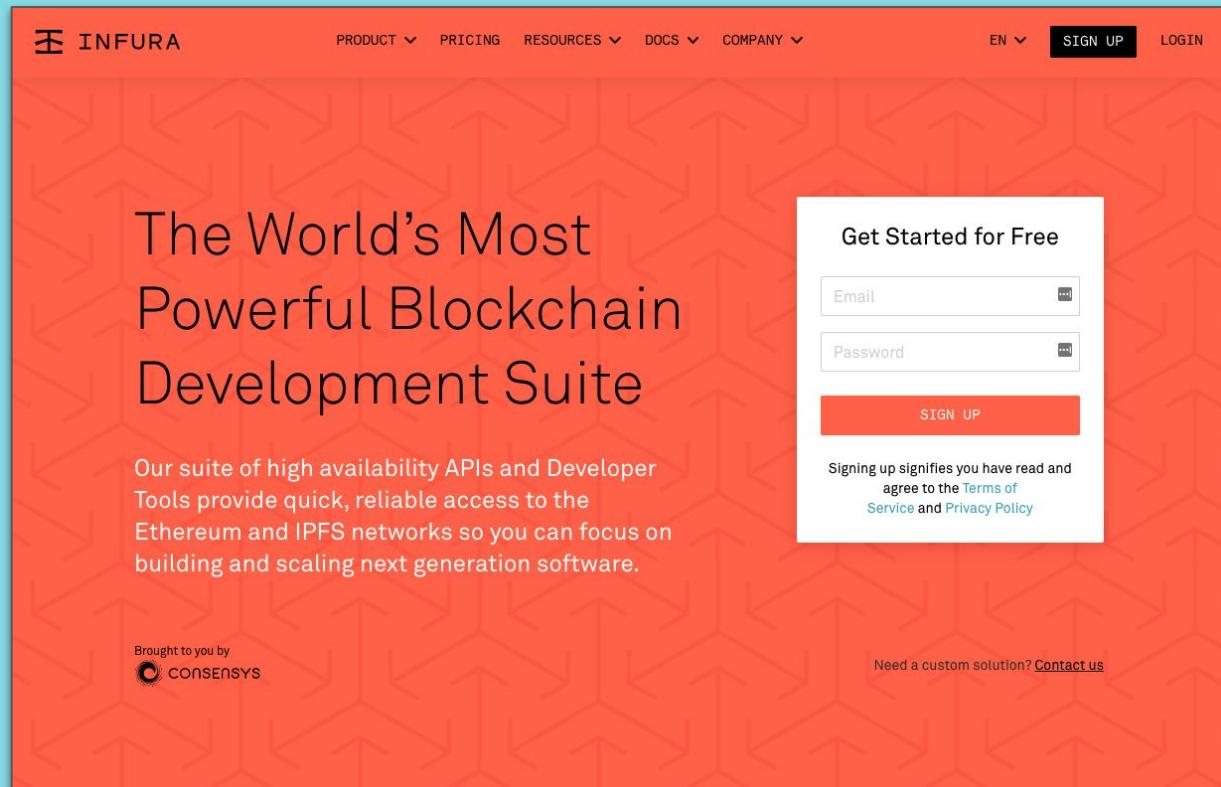
The Kovan Testnet homepage has a dark background featuring a blurred image of a modern train station or subway platform. At the top, the text "Kovan Testnet" is displayed next to a small icon. Below the image, there is a purple circular icon containing a white bus-like symbol. The text "Kovan Testnet" is repeated, followed by the subtitle "The Fast and Reliable Ethereum Test Chain". A note below states: "Kovan is a Proof of Authority (PoA) publicly accessible blockchain for Ethereum; created and maintained by a consortium of Ethereum developers, to aide the Ethereum developer community." A "Read the Proposal" button is located in the center. The bottom section is a teal-colored box titled "Advantages" with the subtext "Why are Ethereum developers using Kovan?". It lists six advantages with corresponding icons: Speed (lightning bolt), Resilience (shield), Reliability (people icon), Free (coffee cup), Infrastructure (chain links), and Innovation (airplane). Each advantage has a brief description below it.

<https://kovan.etherscan.io/>

Infura

The Infura API connects applications to the Ethereum and IPFS networks, providing access over HTTPS and WebSockets.

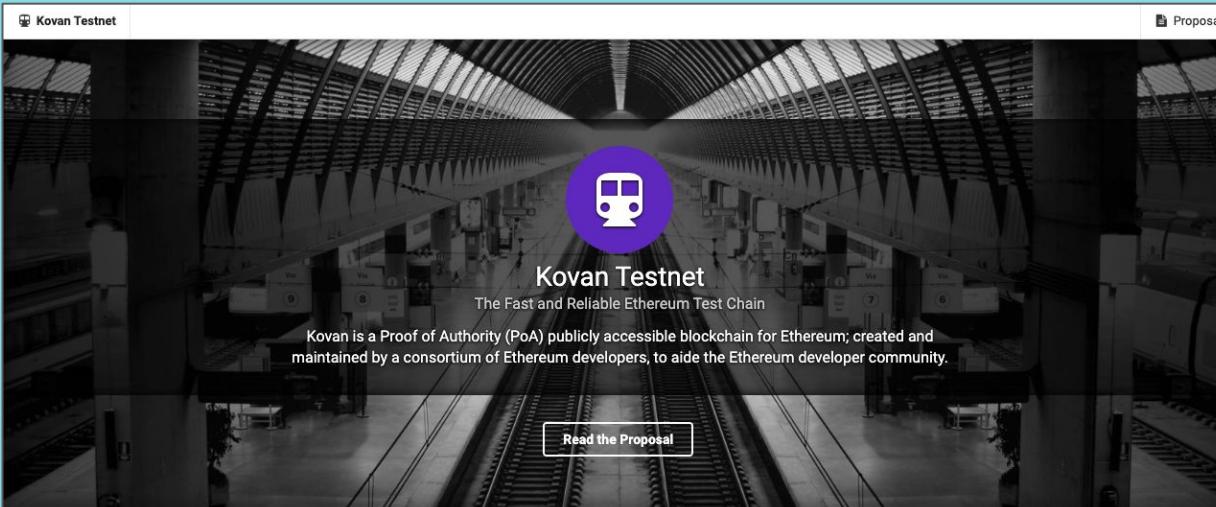
This creates infrastructure for decentralized applications to run on the blockchain.



The screenshot shows the Infura homepage with a red background featuring a repeating geometric pattern of arrows pointing upwards. At the top, there is a navigation bar with the Infura logo, language selection (EN), a "SIGN UP" button, and a "LOGIN" link. The main headline reads "The World's Most Powerful Blockchain Development Suite". Below the headline, a paragraph explains the service: "Our suite of high availability APIs and Developer Tools provide quick, reliable access to the Ethereum and IPFS networks so you can focus on building and scaling next generation software." To the right, a white call-to-action box contains the text "Get Started for Free", two input fields for "Email" and "Password", a large red "SIGN UP" button, and a smaller text note about agreeing to the Terms of Service and Privacy Policy. At the bottom left, it says "Brought to you by" with the ConsenSys logo, and at the bottom right, there is a link to "Contact us".

Kovan

Kovan tests our transactions by giving us ether that has no value (KETH).



The screenshot shows the Kovan Testnet landing page. At the top, there's a purple circular icon containing a white train icon. Below it, the text "Kovan Testnet" and "The Fast and Reliable Ethereum Test Chain". A subtext explains: "Kovan is a Proof of Authority (PoA) publicly accessible blockchain for Ethereum; created and maintained by a consortium of Ethereum developers, to aide the Ethereum developer community." A "Read the Proposal" button is visible. The background is a grayscale image of a modern subway station platform.

Advantages
Why are Ethereum developers using Kovan?

Speed Consistent 4-second blocktimes for a superior developer experience	Resilience Proof of Authority prevents attacks from hindering development	Realibility Consortium membership enforced by smart contract logic	Free Get Kovan ether using multiple faucet services	Infrastructure Block explorer powered by Etherscan and RPC nodes from Infura	Innovation Get early access to experimental protocol upgrades
--	---	--	---	--	---

Review Web3.py/Fundamental Concepts

When programming, we usually follow a pattern after coding a finished product.

When things go smoothly, we test and deploy.

Otherwise, we test, test, test, test, and some day, deploy.

Deploying a transaction that is not ready for deployment can cost us a lot in assets or crypto.





How will we test a transaction
without using real money or ether?
How will testnets help us?

By giving us
“fake” ether to use!



Testnet

Before launching anything on the Ethereum blockchain or making changes to the blockchain itself, a version of it is deployed to the Ethereum test network.



Testnet

Kovan is one of these testnets, but there are others such as **Ropsten** or **Rinkeby** as well. We use **testnets** to work out any issues that we may have before sending real assets. These testnets can provide ether tokens that carry no real-world value and can be requested from the testnet.

The screenshot shows the Etherscan Ropsten Testnet Explorer interface. At the top, there are navigation links for Home, Blockchain, Tokens, Misc, and Ropsten (which is highlighted). Below the header, there's a search bar and a button to "Advertise your brand here!". The main area is divided into two sections: "Latest Blocks" and "Latest Transactions".

Latest Blocks:

- Bk 11275848 Miner Oxc27c09cd615629... 2 Eth 14 secs ago
- Bk 11275847 Miner Oxc27c09cd615629... 2.00544 Eth 27 secs ago
- Bk 11275846 Miner 0xf2d0aad1d5577d... 2.00419 Eth 36 secs ago
- Bk 11275845 Miner Oxc27c09cd615629... 2.02488 Eth 41 secs ago

Latest Transactions:

- Tx 0x20c28... From 0x5709fab0715f1b... 0 Eth 27 secs ago To 0xce66b4b15cbccf...
- Tx 0xb7407... From 0x5709fab0715f1b... 0 Eth 27 secs ago To 0xce66b4b15cbccf...
- Tx 0xd2631... From 0x1ffc28c14e4d1e4... 0.0001 Eth 27 secs ago To 0x65030a55d45a2...
- Tx 0x124dd... From 0x689e694742c4... 0 Eth 41 secs ago

<https://infura.io/>



<https://www.rinkeby.io/#stats>

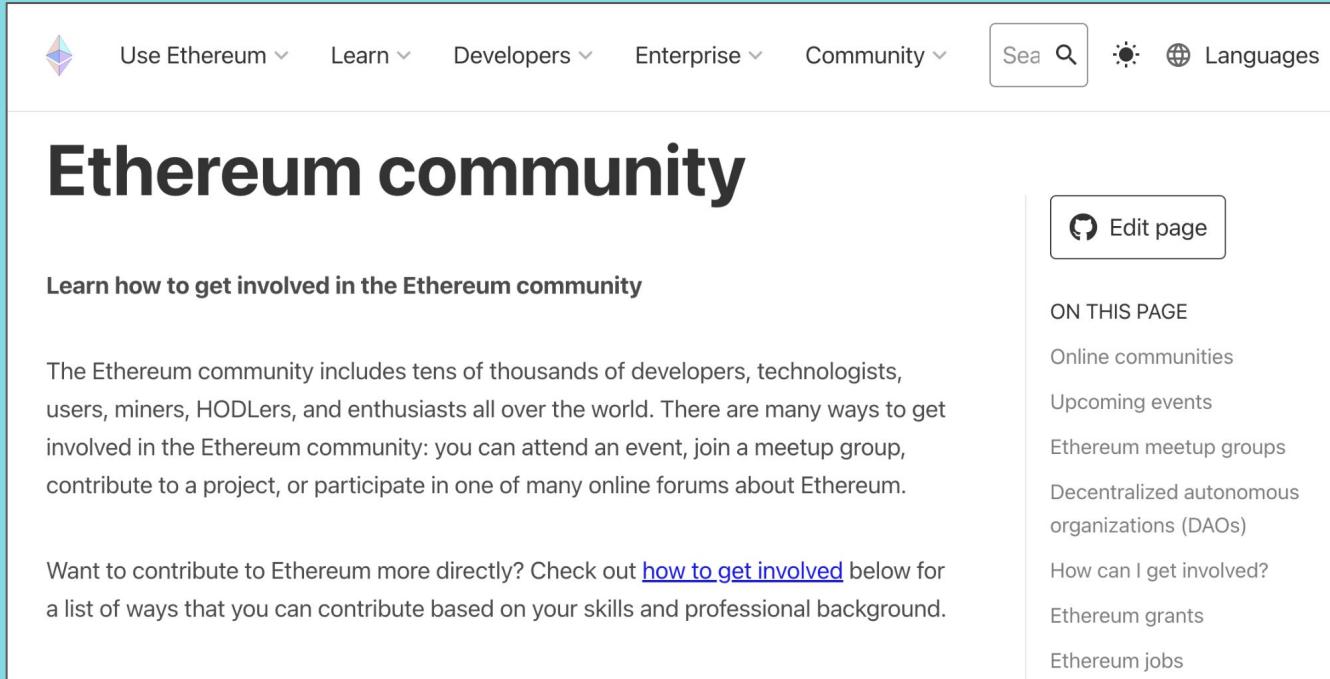
Kovan's Own Definition:

The Fast and Reliable Ethereum Test Chain

“Kovan is a Proof of Authority (PoA) publicly accessible blockchain for Ethereum; created and maintained by a consortium of Ethereum developers, to aid the Ethereum developer community.”

Ethereum Community

The proof-of-authority aspect of the Ethereum blockchain gives access to a node by the community, allowing us to use test ether.

A screenshot of the Ethereum community page. The top navigation bar includes links for "Use Ethereum", "Learn", "Developers", "Enterprise", "Community", a search bar, and language selection. The main title "Ethereum community" is prominently displayed. Below the title, a section titled "Learn how to get involved in the Ethereum community" contains text about the diverse ways to engage with the community. A sidebar on the right lists various community-related topics such as online communities, events, and DAOs.

Ethereum community

Learn how to get involved in the Ethereum community

The Ethereum community includes tens of thousands of developers, technologists, users, miners, HODLers, and enthusiasts all over the world. There are many ways to get involved in the Ethereum community: you can attend an event, join a meetup group, contribute to a project, or participate in one of many online forums about Ethereum.

Want to contribute to Ethereum more directly? Check out [how to get involved](#) below for a list of ways that you can contribute based on your skills and professional background.

ON THIS PAGE

- Online communities
- Upcoming events
- Ethereum meetup groups
- Decentralized autonomous organizations (DAOs)
- How can I get involved?
- Ethereum grants
- Ethereum jobs

Infura's Own Definition:

“A means to provide the tools and infrastructure that allow developers to easily take their blockchain application from testing to scaled deployment—with simple, reliable access to Ethereum and IPFS.”

IPFS

The InterPlanetary File System is a protocol and peer-to-peer network for storing and sharing data in a distributed file system.

The file storage on the blockchain!



Infura Features

Infura is a development suite that provides API access to the Ethereum blockchain network.

01

Infura is what Ethereum calls a hosted node, as it hosts all of the services required to interact with the Ethereum blockchain network.

02

Infura requires that a developer get an API key that allows them to monitor who is using services to read from and write to the blockchain.

03

Infura allows the developer to determine what Ethereum blockchain they want to connect with—either the mainnet (the live blockchain) or a testnet like Kovan or Ropsten.

Hosted Node

The primary negative aspect of a **hosted node** is that you are centralizing an aspect of your project's infrastructure.



If the primary use case for blockchain is decentralization, using a hosted node might not make sense.



INFURA

Set Up Your Account

Questions?





RECAP

Recap

Today, you were able to:



Connect to a blockchain



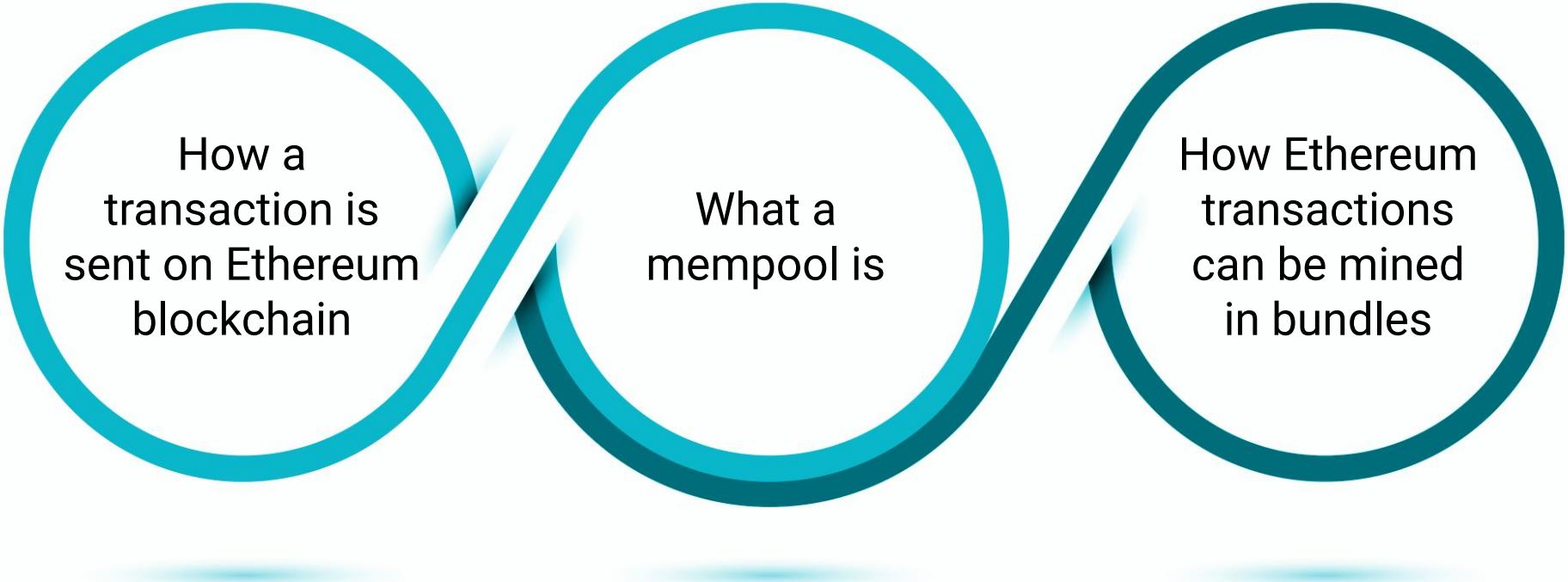
Read transactions



Send transactions

Recap

You've learned about:



How a transaction is sent on Ethereum blockchain

What a mempool is

How Ethereum transactions can be mined in bundles

Recap

You learned how miners mine Ethereum in bundles of transactions and how these transactions get prioritized, with the payment being higher or lower based on the amount of gas a sender is willing to send.



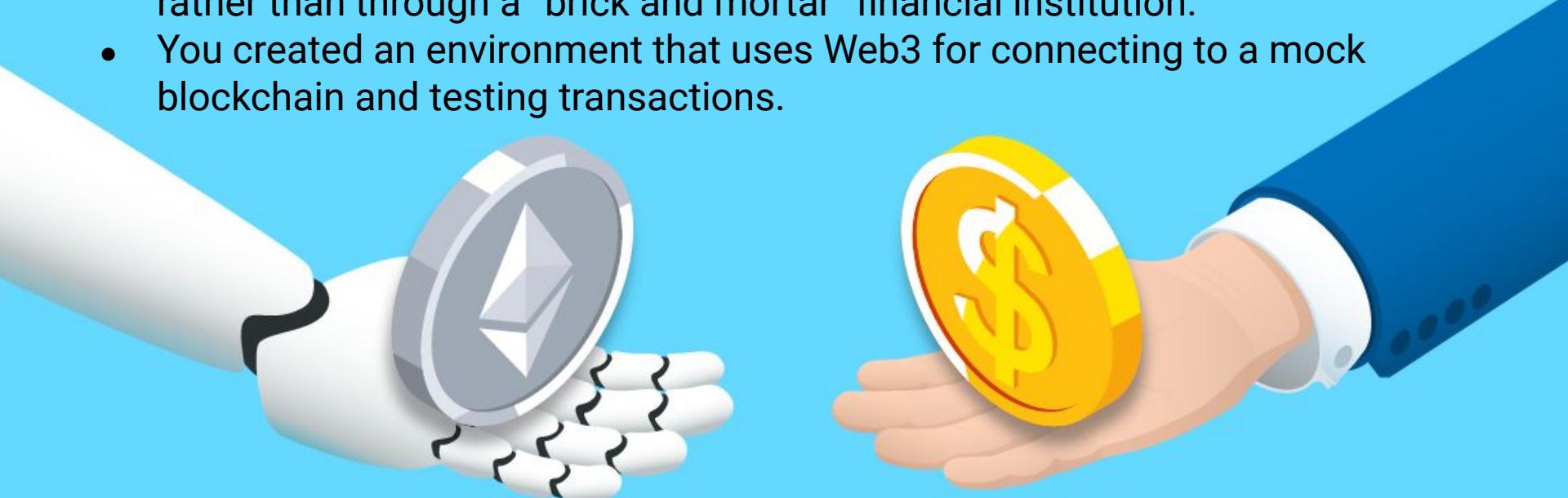
Recap

You learned about a new cryptocurrency, ether, and its denominations.

Unit Name	Wei Value	Number of Wei
Wei (wei)	1 wei	1
Kwei (babbage)	1e3 wei	1,000
Mwei (lovelace)	1e6 wei	1,000,000
Gwei (shannon)	1e9 wei	1,000,000,000
Twei (szabo)	1e12 wei	1,000,000,000,000
Pwei (finney)	1e15 wei	1,000,000,000,000,000
Ether (buterin)	1e18 wei	1,000,000,000,000,000,000

Recap

- You addressed some of the benefits to sending transactions on a blockchain rather than through a “brick and mortar” financial institution.
- You created an environment that uses Web3 for connecting to a mock blockchain and testing transactions.



Questions?



*The
End*