CS251 Fall 2022

(cs251.stanford.edu)

Stablecoins

Dan Boneh

Recap: Solidity

Everything is a contract:

- Contracts manage state variables
- Contracts have functions that can be called externally
- Can inherit code from other contracts (`contract A is B,C`)
- Types of contracts: contract, interface, abstract, library

Global objects: `block`, `msg`, `tx`

An example: ERC20 tokens

- https://github.com/ethereum/EIPs/blob/master/EIPS/eip-20.md

- A standard API for fungible tokens. (ERC-721 for non-fungible tokens)

- An ERC20 token is itself a smart contract that maintains all user balances:

  mapping(address => uint256) internal _**balances**;

- A standard interface allows other contracts to interact with every ERC20 token. No need for special logic for each token.

ERC20 token interface

```
function transfer(address _to,   uint256 _value) external returns (bool);

function transferFrom(address _from,   address _to,   uint256 _value) external returns (bool);

function approve(address _spender,  uint256 _value) external returns (bool);


function totalSupply() external view returns (uint256);

function balanceOf(address _owner) external view returns (uint256);

function allowance(address _owner, address _spender) external view returns (uint256);
```

How are ERC20 tokens transferred?

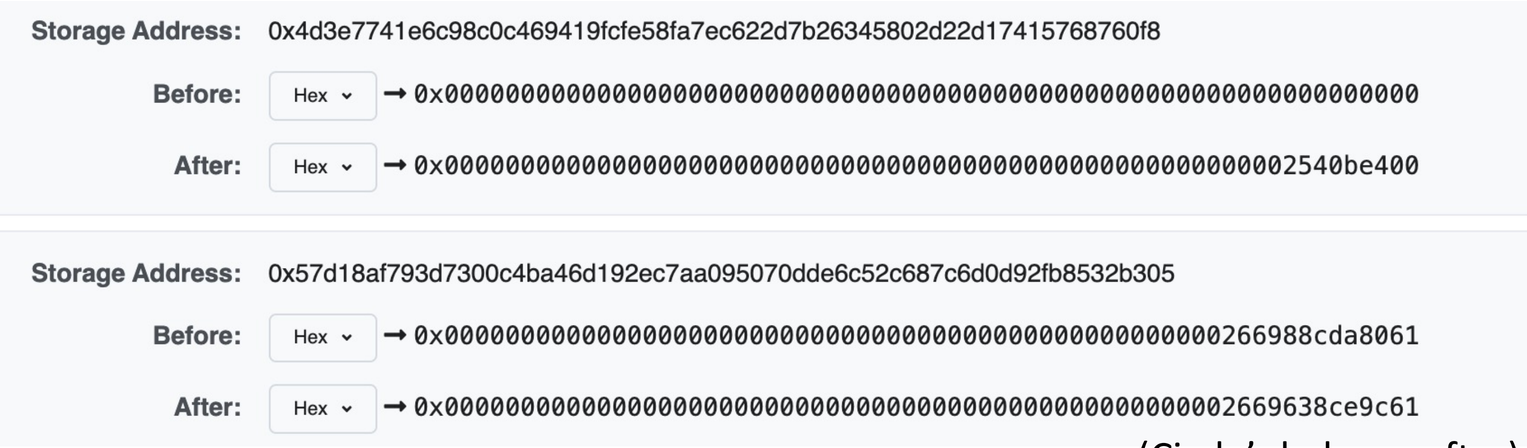
```
contract ERC20 is IERC20  {
  mapping (address => uint256) internal _balances;

  function transfer(address  _to,  uint256  _value)  external returns (bool)  {
     require(_balances[msg.sender] >= _value,  "ERC20_INSUFFICIENT_FUNDS");
     _balances[msg.sender]  -=  _value;
     _balances[_to]  +=  _value;
     emit Transfer(msg.sender, _to, _value);     //  write log message
     return true;
  }}
```

Tokens can be minted by a function **mint(address _to, uint256 _value) onlyOwner;**

Anyone can read ERC20 _balances[]

Transaction Hash: 0x6b85ca95e484d94503d1276456bfc32cc55f6fdb8bb231ff83....

Tells the USDC contract to transfer 10,010.00 USDC
from Circle's account to 0x7656159E42209A95b77aD374d...



```
Storage Address: 0x4d3e7741e6c98c0c469419fcfe58fa7ec622d7b26345802d22d17415768760f8
         Before: Hex ⌄ → 0x0000000000000000000000000000000000000000000000000000000000000000
          After: Hex ⌄ → 0x00000000000000000000000000000000000000000000000000000002540be400

Storage Address: 0x57d18af793d7300c4ba46d192ec7aa095070dde6c52c687c6d0d92fb8532b305
         Before: Hex ⌄ → 0x000000000000000000000000000000000000000000000000000266988cda8061
          After: Hex ⌄ → 0x0000000000000000000000000000000000000000000000000002669638ce9c61
```

recipient's entry

Circle's entry

(Circle's balance after)

(etherscan.io)

Calling other contracts

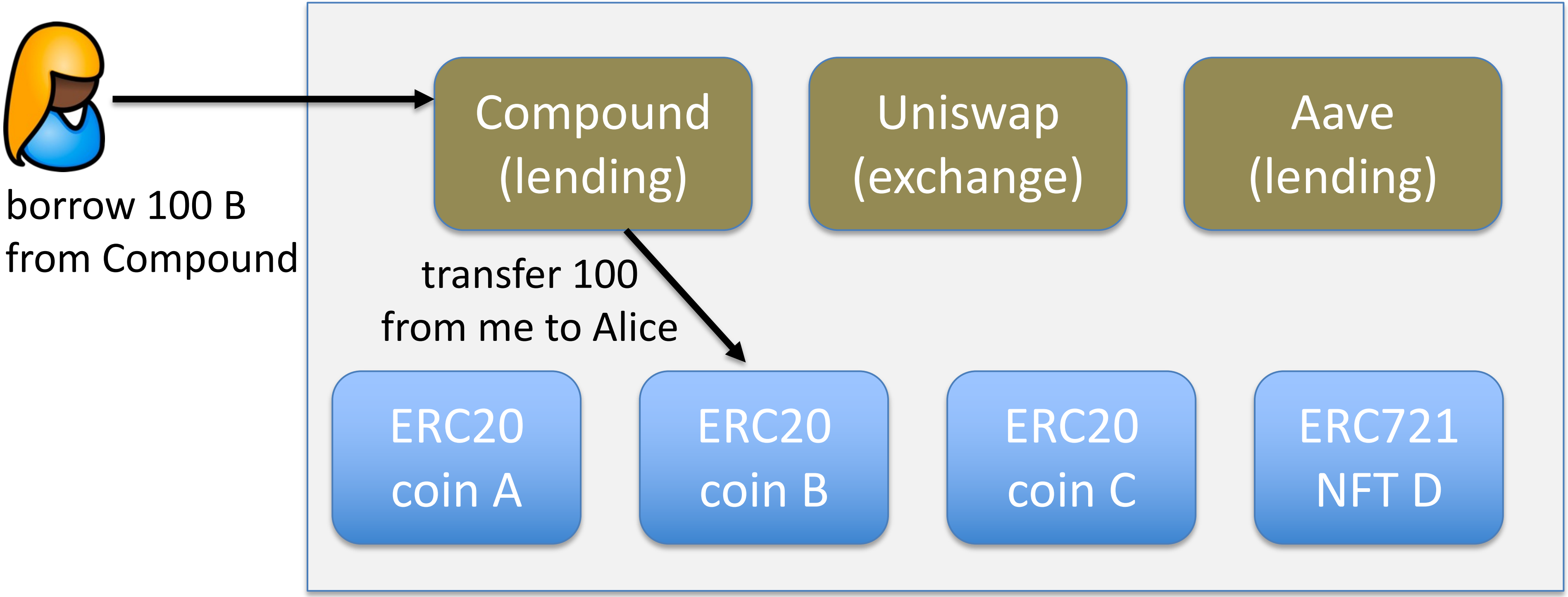
Addresses can be cast to contract types.

```
address  _token;
ERC20Token  tokenContract = ERC20Token(_token);
```

To call the “transfer” function of contract at address _token:

```
tokenContract.transfer(_to,  _value);
```

The world of DeFi

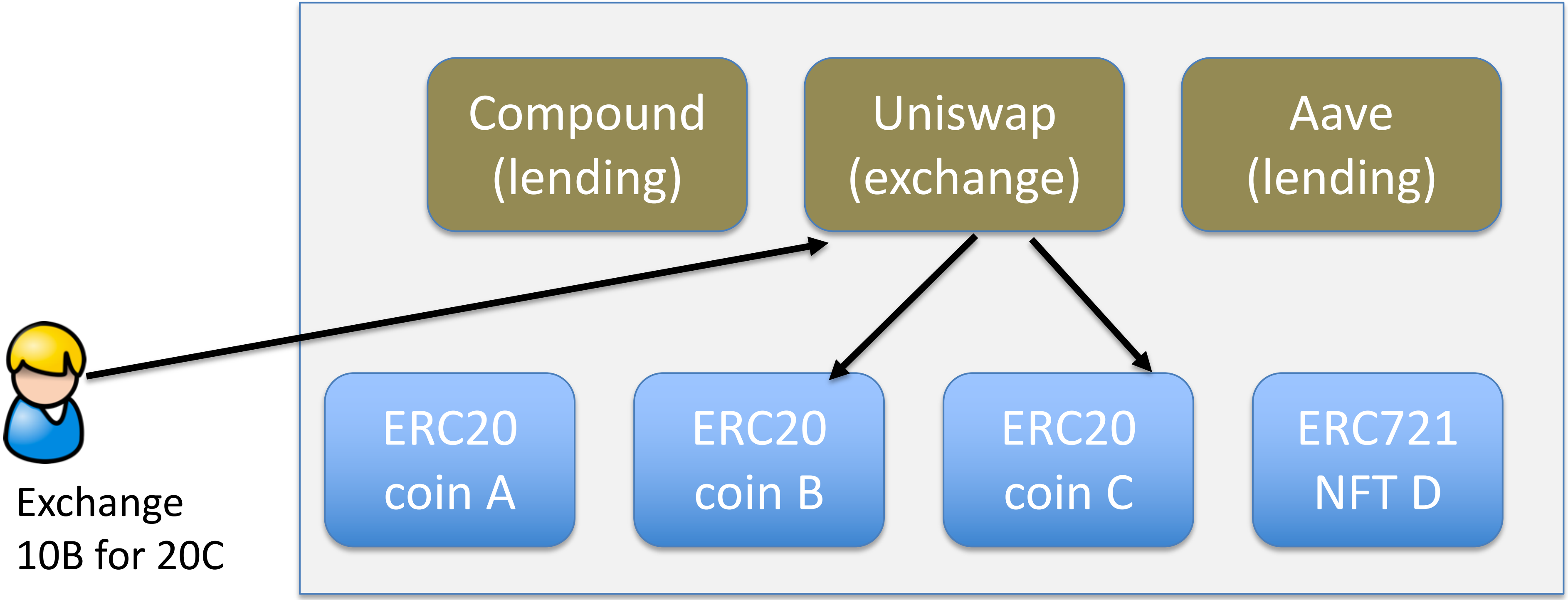


borrow 100 B
from Compound

transfer 100
from me to Alice

on-chain contracts

The world of DeFi



Compound (lending)

Uniswap (exchange)

Aave (lending)

ERC20 coin A

ERC20 coin B

ERC20 coin C

ERC721 NFT D

Exchange
10B for 20C

on-chain contracts

Stable Coins

Stable Coins

A cryptocurrency designed to trade at a fixed price

- Examples: **1 coin = 1 USD**, 1 coin = 1 EUR, 1 coin = 1 USDX

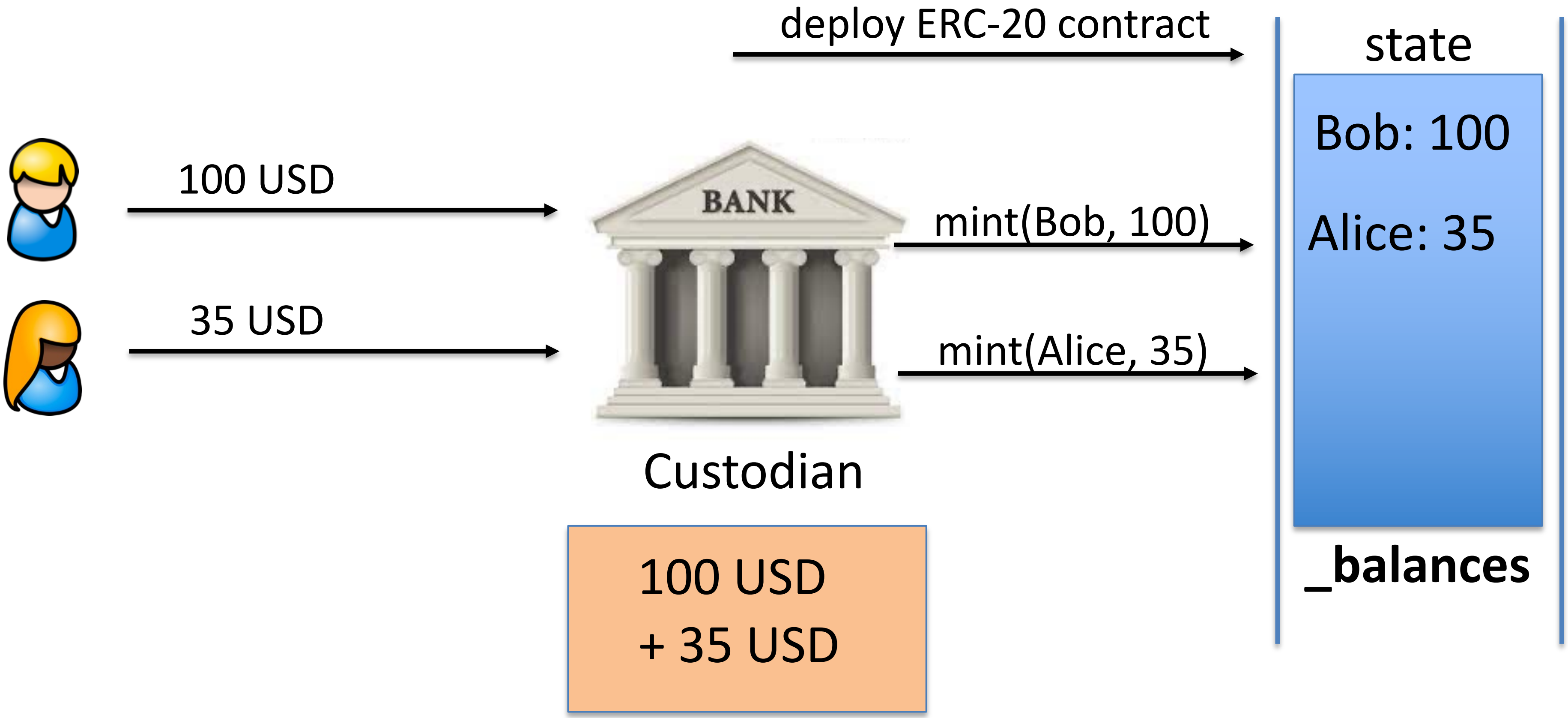
Goals:

- Integrate real-world currencies into on-chain applications
- Enable people without easy access to USD,
  to hold and trade a USD-equivalent asset

Types of stable coins

	centralized	**algorithmic**
collateralized	custodial stablecoins (USD Coin)	synthetics (DAI)
Un(der)collateralized	central bank (digital) currency	Undercollateralized stablecoins

Custodial stablecoins



deploy ERC-20 contract

100 USD

35 USD

mint(Bob, 100)

mint(Alice, 35)

Custodian

100 USD
+ 35 USD

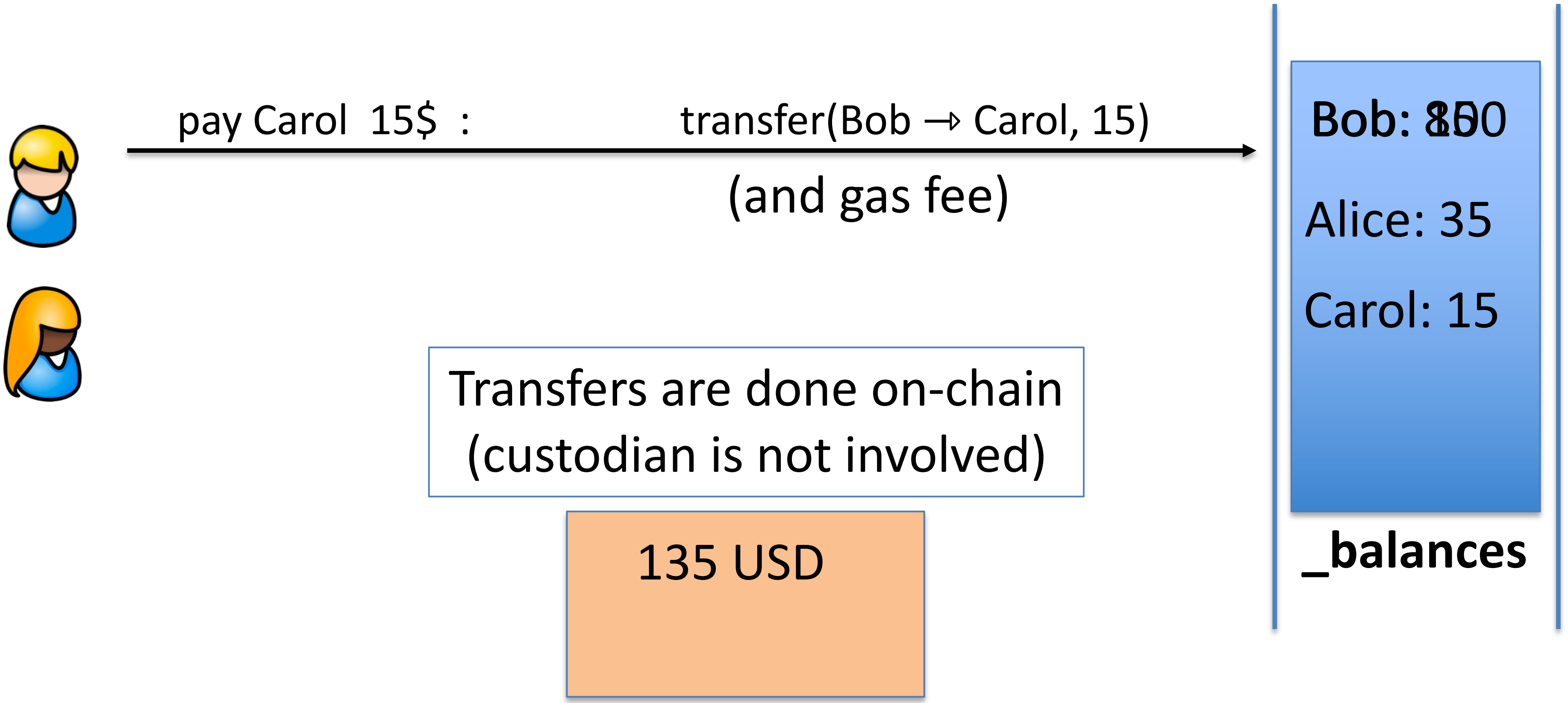
state

Bob: 100

Alice: 35

_balances

Custodial stablecoins



pay Carol 15$:

transfer(Bob → Carol, 15)

(and gas fee)

Bob: 100 85

Alice: 35

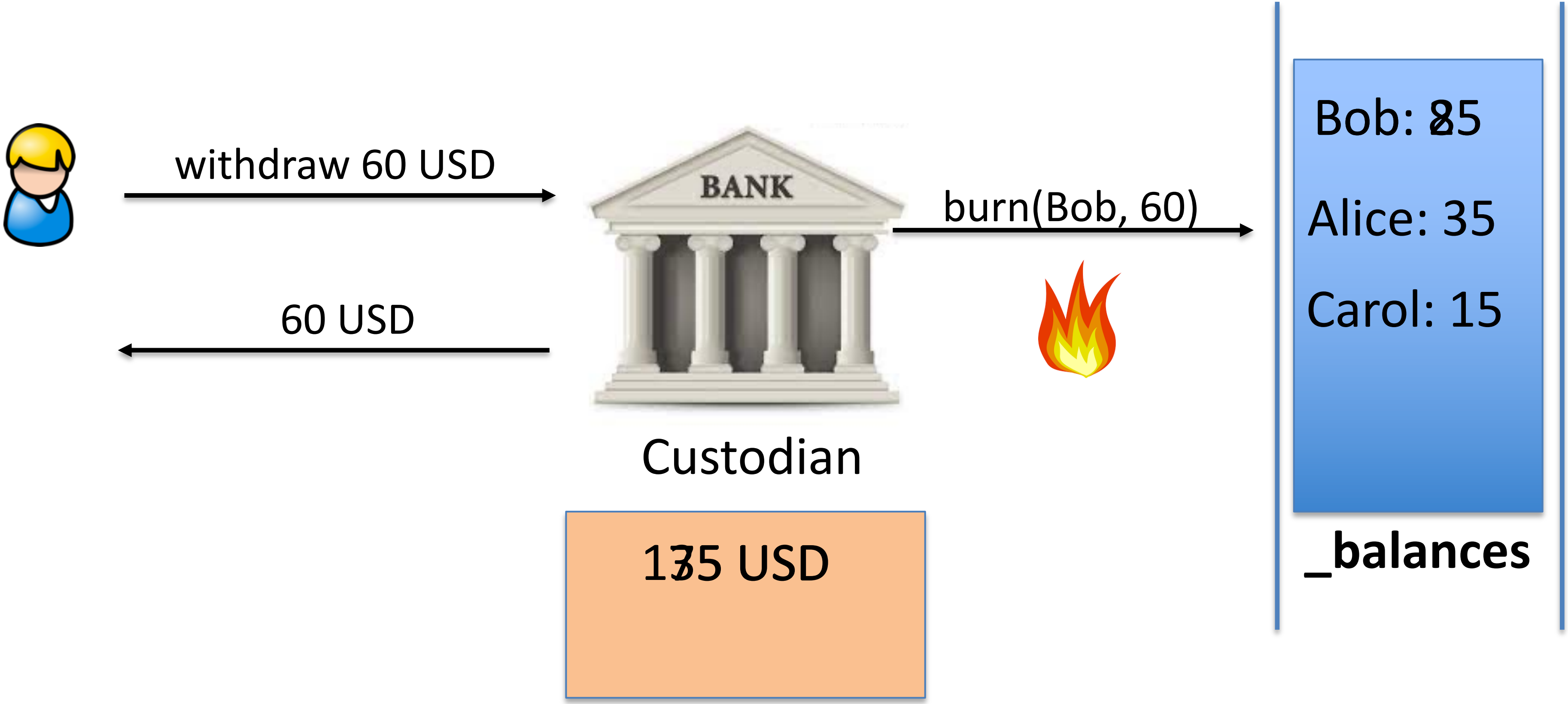
Carol: 15

_balances

Transfers are done on-chain
(custodian is not involved)

135 USD

Custodial stablecoins



withdraw 60 USD

60 USD

burn(Bob, 60)

Custodian

135 USD

Bob: 85

Alice: 35

Carol: 15

_balances

Two Examples

	Coins issued	24h volume
USDC	43.93 B	2.56 B
USDT	68.45 B	31.98 B

Some issues

Custodian keeps treasury in a traditional bank

- Must be audited to ensure treasury is available
- What happens if a hack steals treasury?

Custodian has strong powers:

- Can censor customers / refuse withdrawal requests
- Custodian can remove funds from user balances

Synthetics

Synthetics

The challenge: can we build a non-custodial stable coin?

- Collateral has to be a crypto currency like ETH
- The problem: ETH is not stable vs. USD

[preferably not using USDC … re-introduce custodian]

MakerDAO: building a stablecoin from an unstable asset

Goal: 1 DAI = 1 USD

The MakerDAO system

Two types of tokens:

- DAI: the stable coin (price the last year: 0.99 - 1.01 USD)
- MKR: anyone can buy MKR and earn interest.
  used for governance and to stabilize DAI in an emergency

Amount of DAI minted:	6.2 B	(Oct. 2022)
Amount of MKR:	1 B	

MakerDAO: minting DAI

Alice wants to pay Bob in DAI (stable), but she has 1 ETH (unstable)

⇒ She creates a vault on the MakerDAO contract. She has:

- a **wallet**: for funds that she controls
- a **vault**: for locked funds

Alice's Wallet		
Token	**Balance**	**USD value**
ETH	1	$3000
DAI	0	$0

Alice's Vault		
Token	**Balance**	**USD value**
ETH	0	$0
DAI	0	$0

MakerDAO: minting

Alice locks up 1 ETH in her MakerDAO vault

Alice’s Wallet		
Token	**Balance**	**USD value**
ETH	0	$0
DAI	0	$0

→

Alice’s Vault		
Token	**Balance**	**USD value**
ETH	1	$3000
DAI	0	$0

MakerDAO: minting

She can use her locked ETH as collateral to borrow DAI into her wallet

Alice’s Wallet		
Token	**Balance**	**USD value**
ETH	0	$0
DAI	2000	$2000

Alice’s Vault		
Token	**Balance**	**USD value**
ETH	1	$3000
DAI	-2000	-$2000

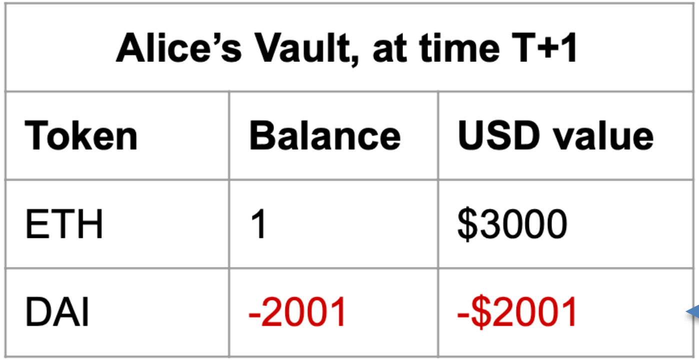
130% collateralization ⇒ she can mint (borrow) up to 2300 DAI

- Alice can now pay Bob in DAI from her wallet
- she can repay her debt at any time at get her 1 ETH back

MakerDAO: stabilization

Alice pays interest on her borrowed DAI: ***stability fee***

- Most of the fee goes to DAI holders (via DAI savings rate: ***DSR***)
- Some of the fee is paid as interest to MKR holders



Alice's Vault, at time T+1		
Token	**Balance**	**USD value**
ETH	1	$3000
DAI	-2001	-$2001

debt increases over time

The DAI Savings Rate (DSR)

Anyone holding DAI can lock it up in the MakerDAO DSR contract

- **DSR**: the interest rate on DAI locked in the DSR contract
- Users can withdraw DAI from the DSR contract at any time

Why DSR? Encourages institutions to hold their idle assets in DAI

Stability mechanism

DAI trading below 1$ ⇒ ***stability fee*** and ***DSR*** are raised

⇒ minters are encouraged to repay their loan

⇒ reduces the liquid supply of DAI

⇒ DAI price goes up

DAI trading above 1$ ⇒ ***stability fee*** and ***DSR*** are lowered

⇒ minters are encouraged to mint more DAI

⇒ increases the liquid supply of DAI

⇒ DAI price goes down

Liquidation

Why collateral? Ensures Bob pays back his DAI debt.

- stability fee goes up ⇒ Bob wants to repay DAI to get his collateral

What if Vault debt exceeds 130% collateral ?

Bob's vault at time $T + 100$		
Token	**Balanace**	**USD value**
ETH	1	\$3000
DAI	-2400	$-\$2400$

liquidation →

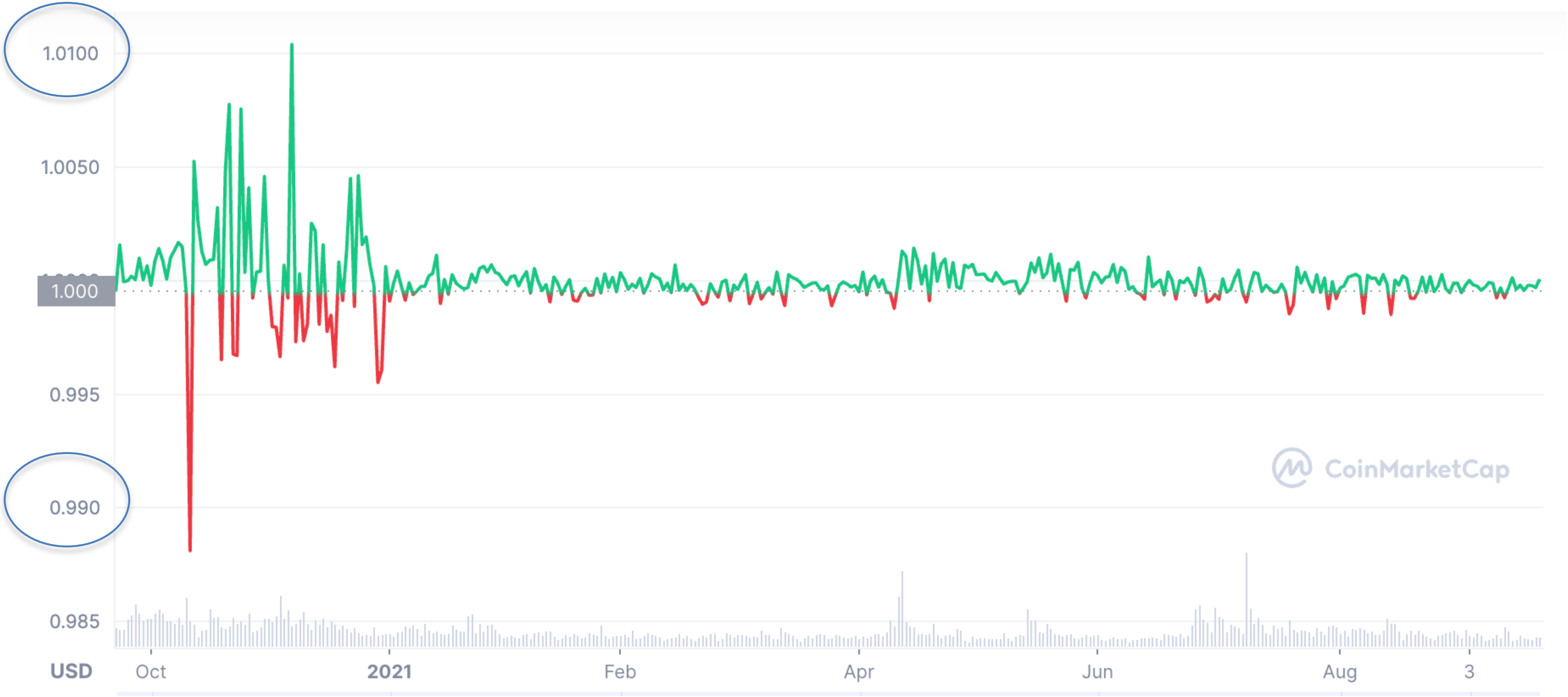
Bob's vault at time $T + 101$		
Token	**Balanace**	**USD value**
ETH	0.7	\$2100
DAI	-1600	$-\$1600$

insufficient collateral (>130%)

Bob's ETH collateral is auctioned off

(returns – fees) are used to pay off Bob's debt until 130% is achieved

In practice


1.0100
1.0050
1.000
0.995
0.990
0.985
USD
Oct
2021
Feb
Apr
Jun
Aug
3
CoinMarketCap

The World of NFTs

Griffin Dunaif

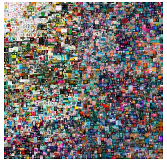
The 4 Questions

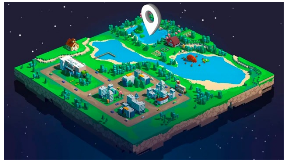
1. What are NFTs?
2. Why are NFTs important?
3. What can be built on top of NFTs?
4. Where does this all go?

What are NFTs?

Token ownership of a digital asset

- Digital artwork, video game spaceship, virtual plot of land





No two NFTs are the same: they aren't mutually exchangeable

NFTs are defined by their:

- History, utility, appearance, cultural importance, etc.

Ownership of Digital Assets

What does owning a digital asset even mean?

- NFTs function identically to legal deeds

What is a deed?

- Legal contract that transfers "title" from one party to another
- Title is the legal status of owning property
- Title grants you certain legal rights:
  - Right to reside, renovate, accrue capital gains, etc.

NFTs as Deeds

Owning an NFT grants you title to digital property

- Owners of Bored Apes get access to a social network, verification on twitter, certain IP rights, etc.
- Axie holders get access to a game and earnings

A deed has tangible benefits and utility

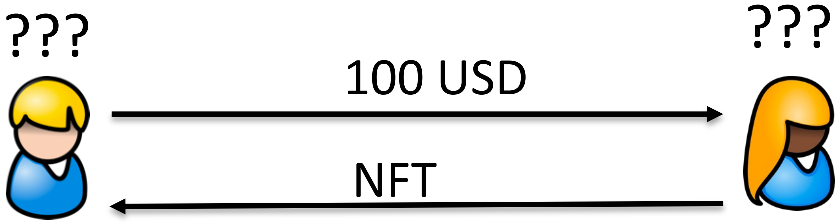
- You are not buying a picture
- You are buying title, granting NFT-specific rights

How Do You Get an NFT?

Two methods:

1. Find the owner and barter
2. Go to a marketplace and bid

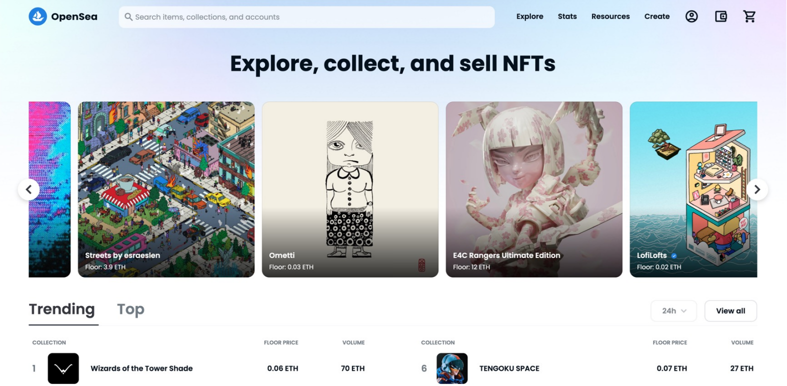
Purchase NFT from owner: Who sends first? Asset or money?



NFT Marketplaces

NFT marketplaces built as a collection of smart contracts

- OpenSea, Rarible, Axie, etc.



Explore, collect, and sell NFTs

COLLECTION	FLOOR PRICE	VOLUME	COLLECTION	FLOOR PRICE	VOLUME
1 Wizards of the Tower Shade	0.06 ETH	70 ETH	6 TENGOKU SPACE	0.07 ETH	27 ETH

Why smart contract marketplace?

- Trustless: Don't need to give 3rd party custody of your asset
- Permissionless: Anyone with wallet can purchase or list
- Atomic: Payment for asset and delivery of asset done in one Tx

What Do We Have So Far?

A system of **property and exchange** for digital assets

- Facilitating efficient and verifiable property transactions
- This enables businesses to be built on top of NFTs
- Thereby driving the economic growth of the ecosystem

Digital Property? Why?

In the real world our economy rests upon a system of **property and exchange**

Without it:

- How would you mortgage your house?
- How would you buy or sell shares in a company?

National scale businesses rely on clear ownership and low-cost verifiability

- Banks, insurance companies, brokerages would look very, very different without such guarantees

Why NFTs?

They bring true **ownership** to the internet:

- You can resell an NFT
- You can accrue capital gains
- Emergent peer-to-peer activity

Enables a digital **commerce** layer:

- No confusion and conflicting claims (chain is source of truth)
- No platform risk (can't rewrite history or revoke ownership)
- Low-cost (can verify provenance with simple query)
- Composable (can use NFTs and services as Lego pieces)

The Service Layer

Gaming Guilds

One of the first inter-game financial institutions (Yield Guild Games)

The idea:

Source capital from LPs (by issuing a token)

=> Buy up swathes of virtual land, avatars, in-game items

=> Generate revenue by **leasing** assets to players

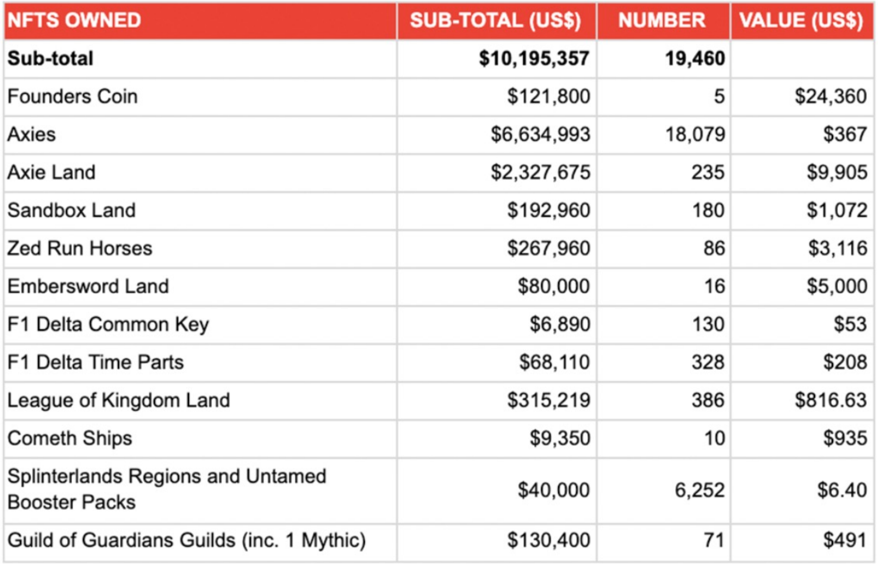
=> Pay LPs dividends

=> Take % spread

=> Accrue capital gains on the underlying assets

Gaming Guilds

YGG's NFT holdings as of July, 2021



NFTS OWNED	SUB-TOTAL (US$)	NUMBER	VALUE (US$)
Sub-total	**$10,195,357**	**19,460**	
Founders Coin	$121,800	5	$24,360
Axies	$6,634,993	18,079	$367
Axie Land	$2,327,675	235	$9,905
Sandbox Land	$192,960	180	$1,072
Zed Run Horses	$267,960	86	$3,116
Embersword Land	$80,000	16	$5,000
F1 Delta Common Key	$6,890	130	$53
F1 Delta Time Parts	$68,110	328	$208
League of Kingdom Land	$315,219	386	$816.63
Cometh Ships	$9,350	10	$935
Splinterlands Regions and Untamed Booster Packs	$40,000	6,252	$6.40
Guild of Guardians Guilds (inc. 1 Mythic)	$130,400	71	$491

Gaming Guilds

Guilds are a form of internet-native **holding company**

Guilds were one of the first institutions to popularize **digital asset leases**

Virtual Real Estate Developers

Everyrealm: An internet-native **REIT** (real estate investment trust)

EVERYREALM

The idea:

Raise money from LPs

=> Buy up virtual land

=> Develop structures and experiences people will pay for

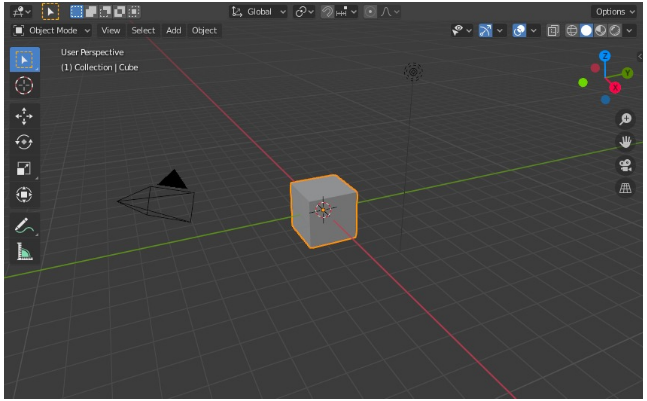
=> Distribute payments to LPs and take % of spread

=> In future, sell developed property for capital gains

Develop Virtual Land?

What does this even mean? That can't require nearly as much funding as a real property development, right?

Challenge for everyone: turn a cube into a digital city.



=>

Cost of Games Going Up

Recent AAA title development costs:

- Cyberpunk 2077: $174M
- Battlefield 4: $100M
- Shadow of the Tomb Raider: $75M

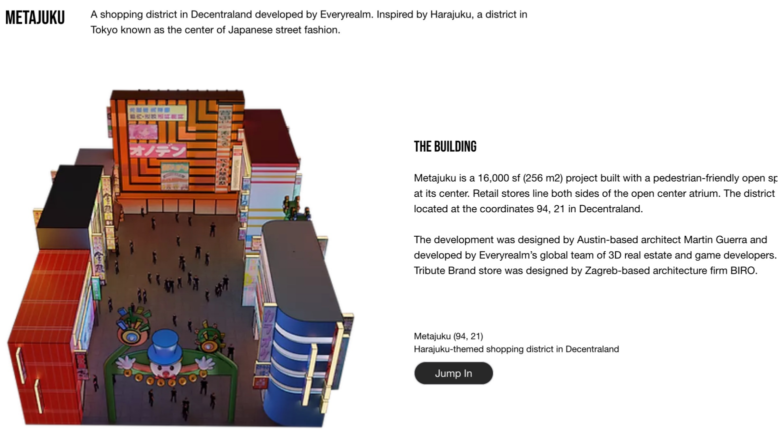
Shadow of the Tomb Raider

Why?

- Graphical fidelity increasing -> development difficulty not decreasing
- Users want massively multiplayer and/or more immersive simulations

Virtual Land Development

A few of Everyrealm's developments



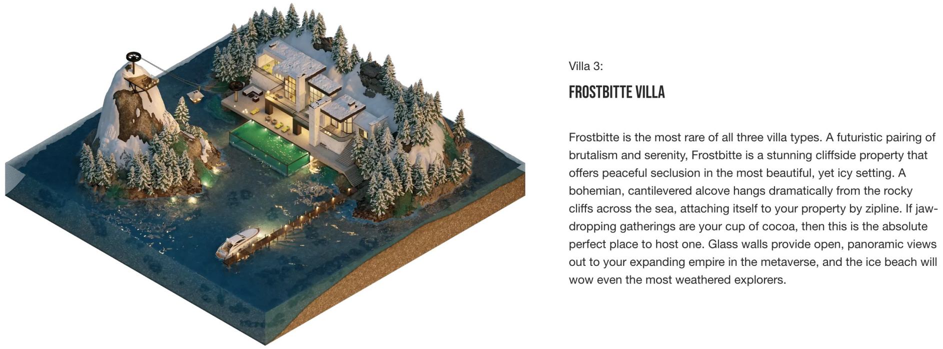
METAJUKU A shopping district in Decentraland developed by Everyrealm. Inspired by Harajuku, a district in Tokyo known as the center of Japanese street fashion.

THE BUILDING

Metajuku is a 16,000 sf (256 m2) project built with a pedestrian-friendly open sp at its center. Retail stores line both sides of the open center atrium. The district located at the coordinates 94, 21 in Decentraland.

The development was designed by Austin-based architect Martin Guerra and developed by Everyrealm's global team of 3D real estate and game developers. Tribute Brand store was designed by Zagreb-based architecture firm BIRO.

Metajuku (94, 21)
Harajuku-themed shopping district in Decentraland



Villa 3:

FROSTBITTE VILLA

Frostbitte is the most rare of all three villa types. A futuristic pairing of brutalism and serenity, Frostbitte is a stunning cliffside property that offers peaceful seclusion in the most beautiful, yet icy setting. A bohemian, cantilevered alcove hangs dramatically from the rocky cliffs across the sea, attaching itself to your property by zipline. If jaw-dropping gatherings are your cup of cocoa, then this is the absolute perfect place to host one. Glass walls provide open, panoramic views out to your expanding empire in the metaverse, and the ice beach will wow even the most weathered explorers.

The NFT Cost Issue

NFTs are growing in popularity but remain expensive:

- Users who want to own NFTs but don't have the upfront capital are left with two options: save up or rent
- Starting an NFT business is impossible if you don't have cash on hand or access to LPs
- Expanding a business is difficult; the only method of fundraising is getting LPs

Credit Providers

Halliday: An internet-native **credit** provider

The idea:

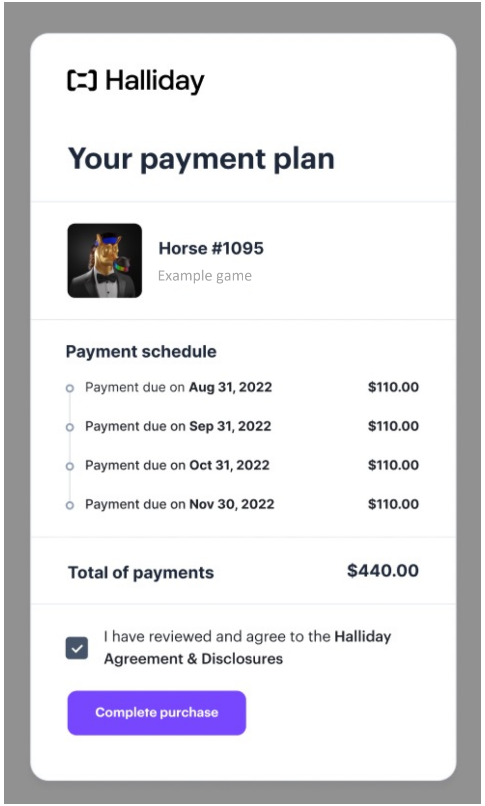
Aggregate capital from LPs

=> Finance game assets over a fixed period

=> Give users immediate access to NFTs

=> Receive payments over time

=> Pass earnings back to LPs and take % cut



Halliday

Your payment plan

Horse #1095

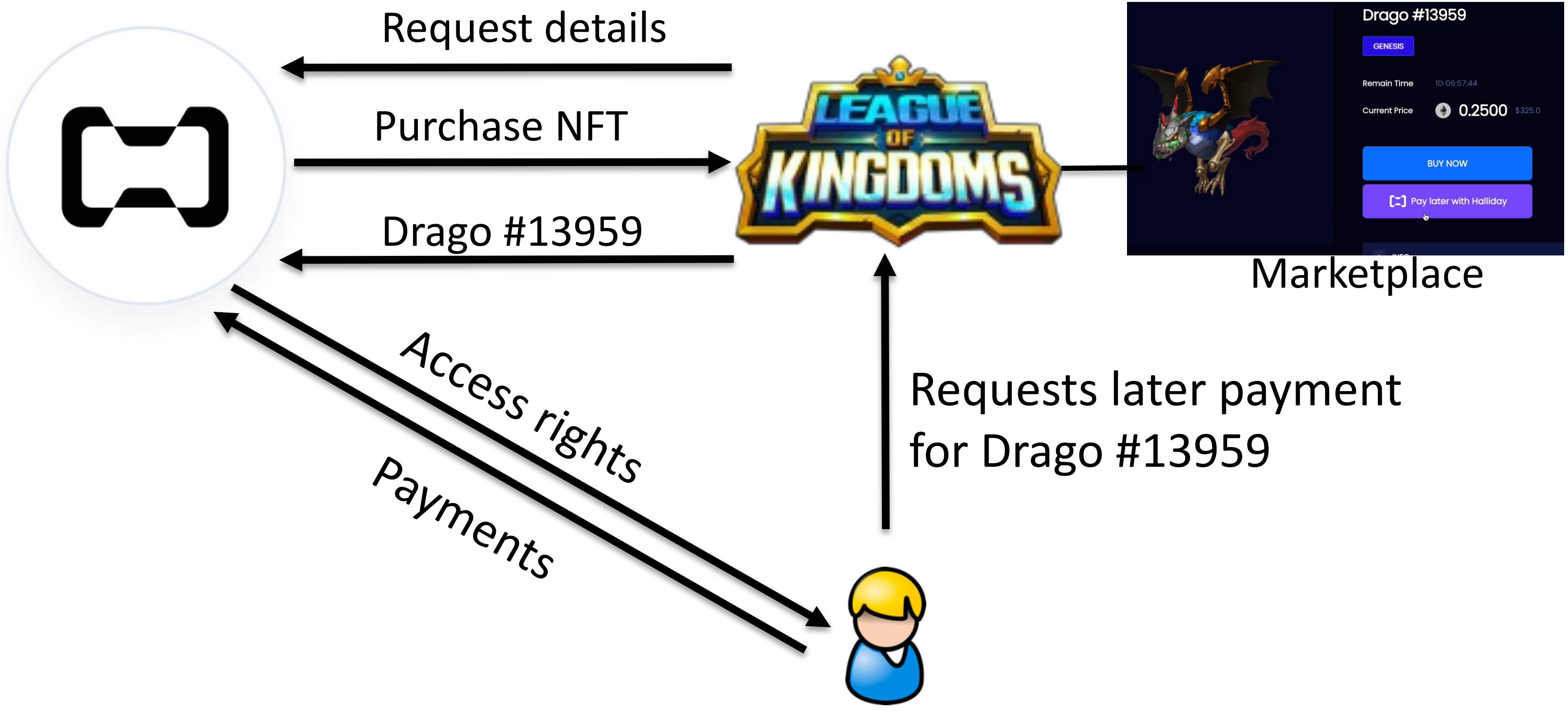
Example game

Payment schedule

Payment due on **Aug 31, 2022**	**$110.00**
Payment due on **Sep 31, 2022**	**$110.00**
Payment due on **Oct 31, 2022**	**$110.00**
Payment due on **Nov 30, 2022**	**$110.00**
Total of payments	**$440.00**

☑ I have reviewed and agree to the **Halliday Agreement & Disclosures**

Credit Providers



Request details

Purchase NFT

Drago #13959

Access rights

Payments

Requests later payment for Drago #13959

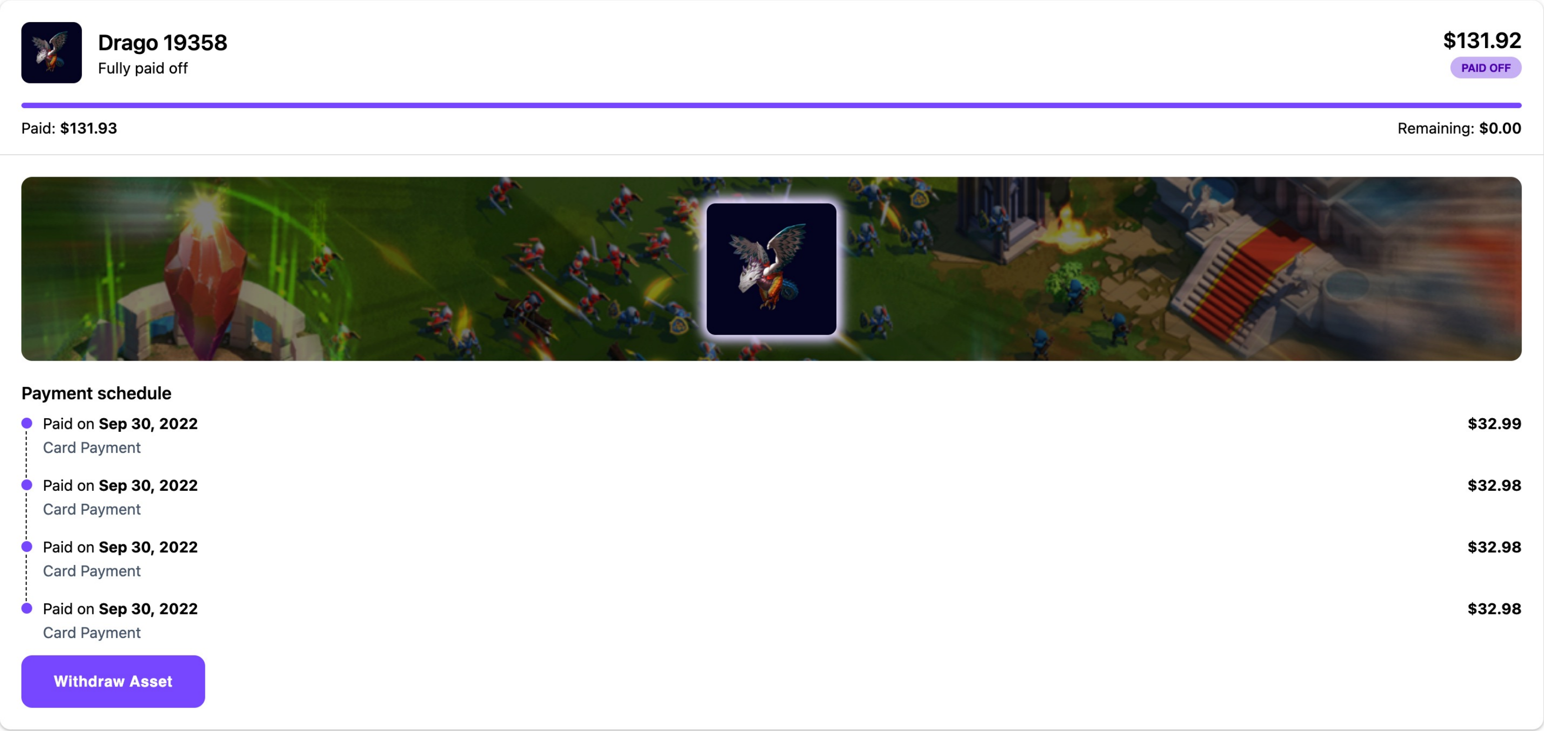
Marketplace

Drago #13959

Remain Time 1D 06:57:44

Current Price 0.2500 $325.0

Credit Providers



Drago 19358

Fully paid off

$131.92

PAID OFF

Paid: $131.93

Remaining: $0.00

Payment schedule

Paid on **Sep 30, 2022** Card Payment	**$32.99**
Paid on **Sep 30, 2022** Card Payment	**$32.98**
Paid on **Sep 30, 2022** Card Payment	**$32.98**
Paid on **Sep 30, 2022** Card Payment	**$32.98**

Credit Providers

Why is credit important?

- Credit puts excess capital to work, fueling growth
- Lowers the economic barrier to ownership
- Allows small businesses to start and expand

Credit is foundational to any modern economy

A Fun Example of Interoperability

Problem: A **REIT** wants to create a digital mega-structure, but they don't have cash on hand to pay for it or enough staff to manage the properties

What can they do?

Collect cash they have for a down payment

=> Mortage the virtual property through a **credit provider**

=> Build the virtual mega-structure

=> Lease out subsections of the development to **guilds** who will sublet to individuals

=> Collect payments from **guilds** and other tenants

=> Use revenue to pay off the cost of the loan

=> Sell the development for capital gains

Where is this going?

This is only the beginning

We've covered only three services enabled by NFTs:

- Virtual holding companies
- Digital REITs
- Blockchain-native credit providers

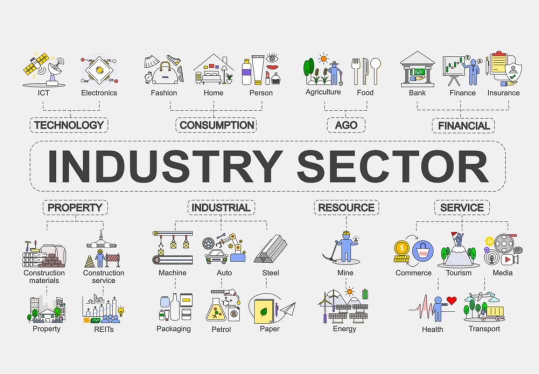
Where is this going?

There is the rest of the stack to build:

- Intergame trade and commerce
- Unified identity protocols
- Virtual world regulatory entities and governing bodies
- Unbundling: Digital construction companies, virtual-only architecture firms, interior design firms, so much more
- Bundling: Game developer and interoperability layer

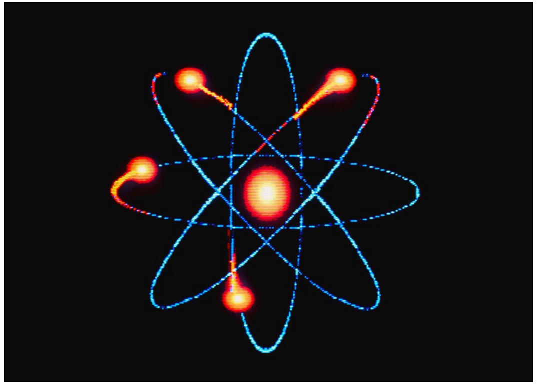
Where is this going?

A thought experiment:



Industry

+

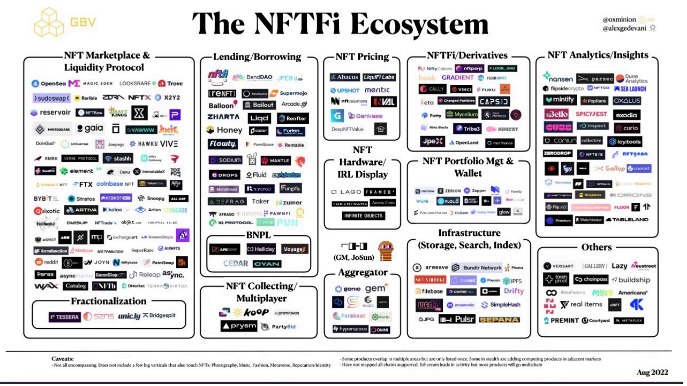


Atoms

=

NYC

Where is this going?

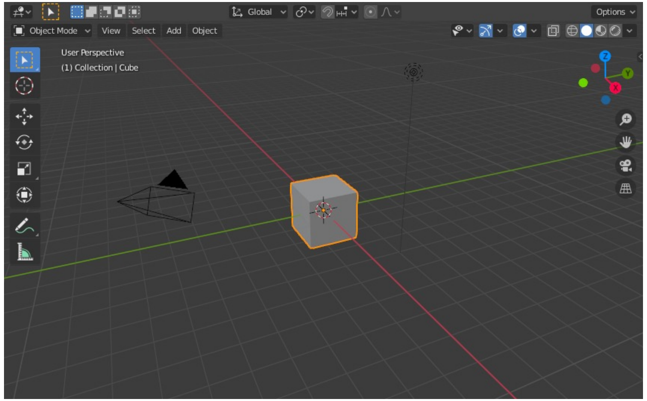


Caveats:
- Not all encompassing. Does not include a few big verticals that also touch NFTs: Photography, Music, Fashion, Metaverse, Reputation/Identity
- Some products overlap in multiple areas but are only listed once. Some in stealth are adding competing products in adjacent markets
- Have not mapped all chains supported. Ethereum leads in activity but most products will go multichain

Aug 2022

Digital Industry

+



Bits

= ???

END OF LECTURE

Next lecture: Decentralized Exchanges (DeX)