Decentralized Finance

Derivatives

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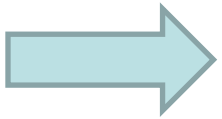
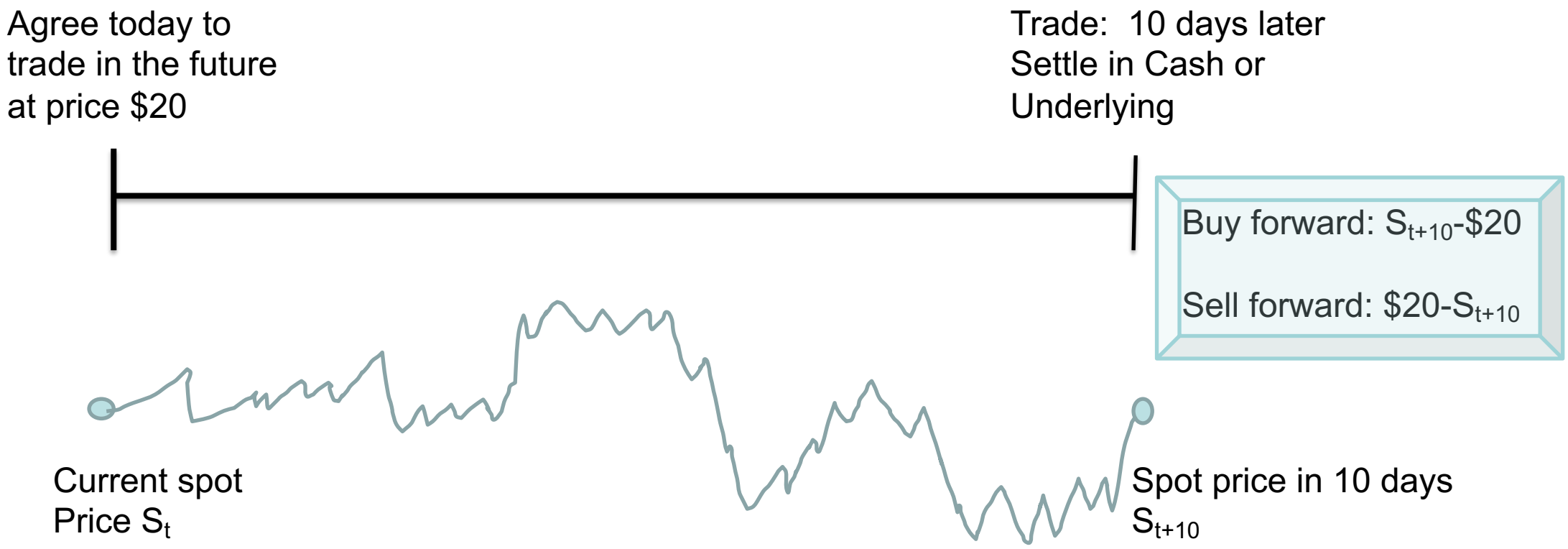
Traditional Derivatives

- Derivatives are paid conditional on the outcome (usually price) of another asset some time in the future.
  - E.g., Futures and Forwards, Options

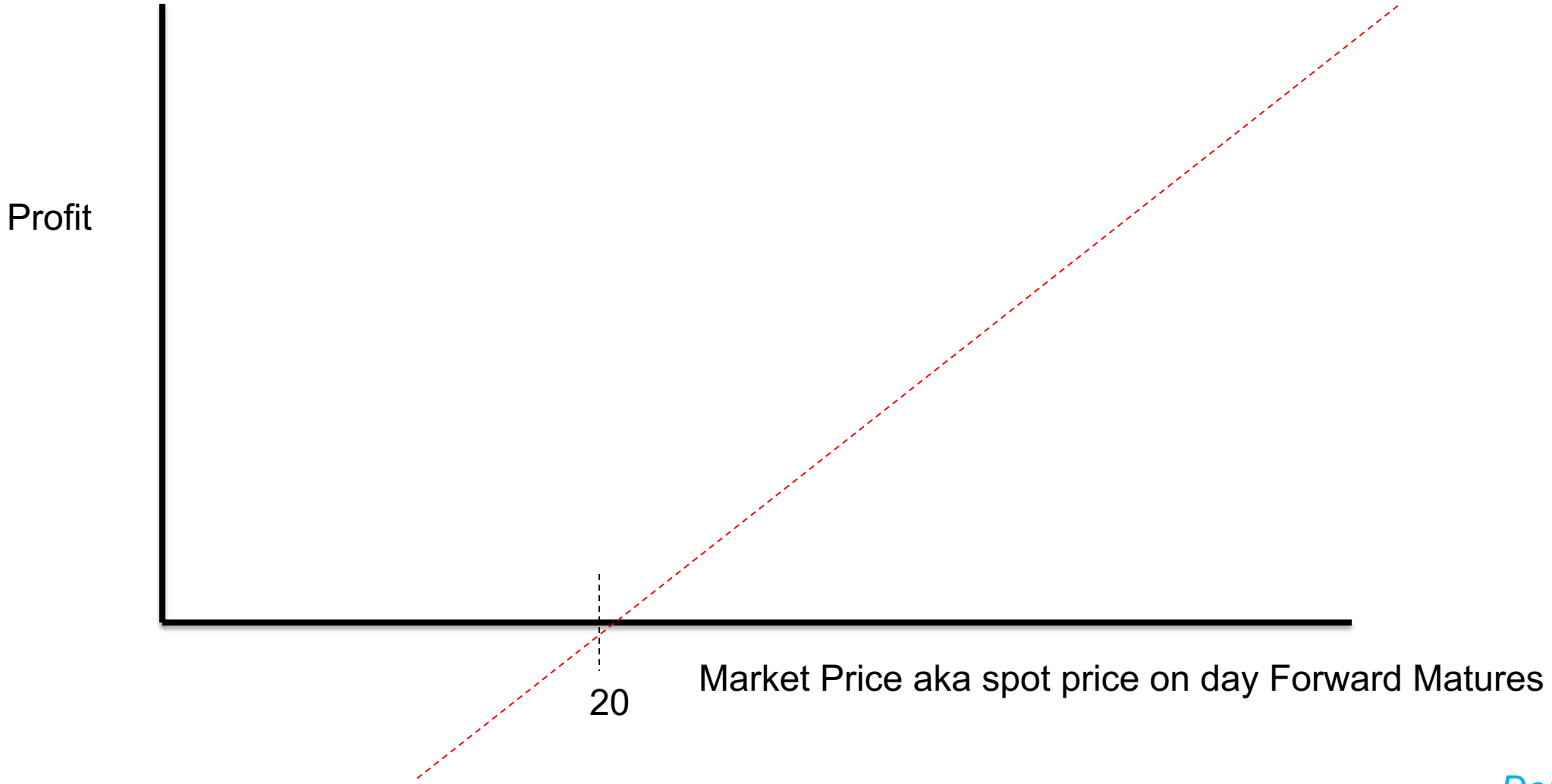
1. How/why are they designed the way they are?
   - Who will trade the contract?
   - Does the contract admit leverage?
2. Payouts happen in the future  counterparty risk.

   How is this risk managed?

Buy Now, Pay later: Futures and Forwards



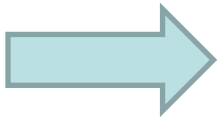
Profit to a long (buy) Forward contract at $20



Futures vs Forwards

- A forward contract is a commitment to purchase at a future date, a given amount of a commodity or an asset, at a price agreed on today.
  - Custom or “bespoke” and traded over the Counter (OTC).
  - No money changes hands until maturity
  - Large counter-party risk.
- A futures contract is a standardized forward contract that is marked to market.
  - All contracts ``against the house'' and so no counterparty risk.

Margin and Marking to Market prevents default

- **Initial Margin** set by the exchange and depends on the asset volatility.
- **Variance or maintenance margin**: if the dollar value in the account is too low  margin call.

- **Marking to market**: each day the profits and losses from the new futures price reflected in the account.
- This ensures that there is a ``common'' futures price.

Long 1 contract for Silver on CME (contract for 5,000 oz)

Day	Futures price	Profit (Loss)	
0	5.10		Post Margin
1	5.20	0.10 x 5,000 = 500	500
2	5.25	0.05 x 5,000 = 250	250
3	5.18	-0.07 x 5,000 = (350)	-350
4	5.18	0	
5	5.21	0.03 x 5,000= 150	150

On day 5 when the contract matures, buy 5,000 oz of silver for 5.21 an ounce.

Why are futures contracts/trading designed like this?

1. Fills a missing economic function:
   - Risk sharing between producers and speculators.
   - Producers can lock in price today which makes planning easier.
2. Maximizes Market Liquidity:
   - Contract size (dollar value) chosen so most potential participants will find it attractive.
   - Exchange takes care of collateral management so traders don't have to expend time and effort to find a safe counterparty.
   - Common price due to marking to market makes it easier to trade.

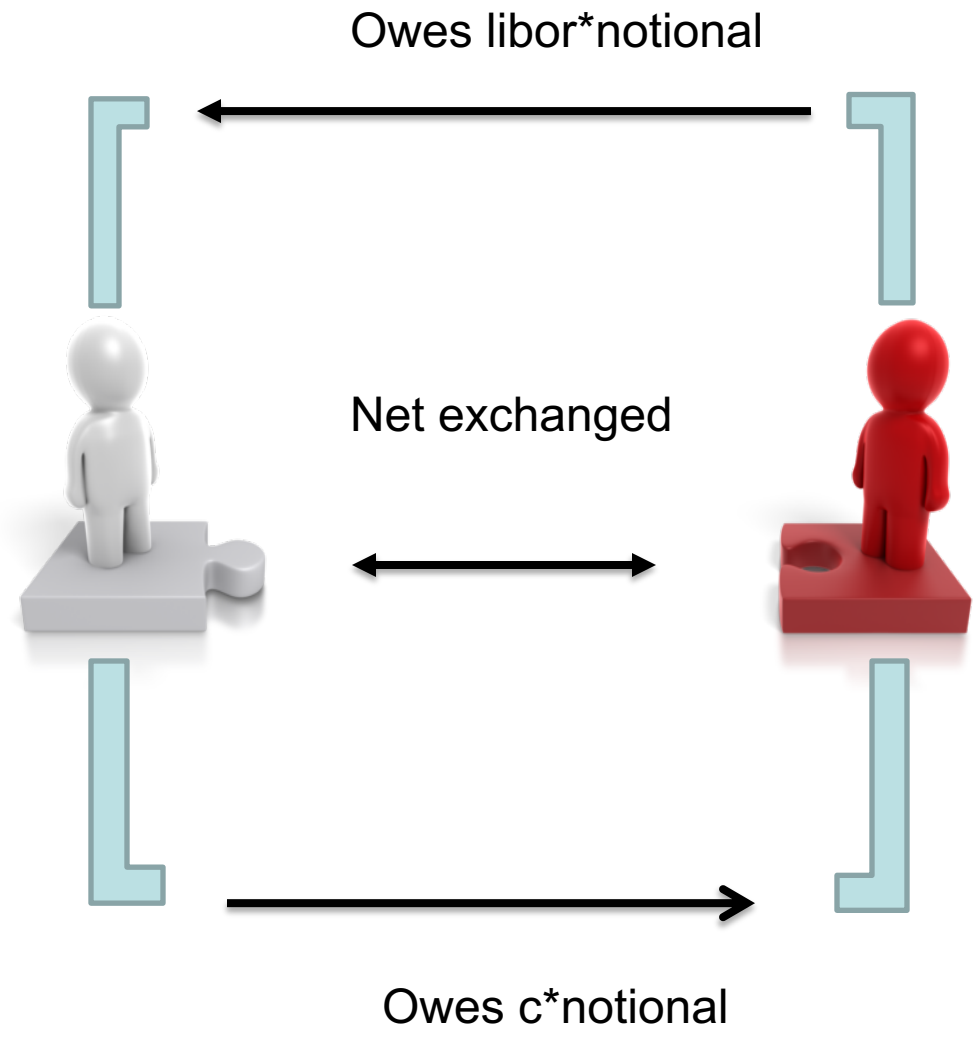
Bilateral Derivatives: Swaps

- Massive Market with industry body International Swap Dealers Assocation (ISDA)
- Large institutions sign master ISDA agreement.

1. Currency
2. Fixed Income: Fixed rate for floating rate
3. Credit Default Swaps
4. Equity Return Swaps

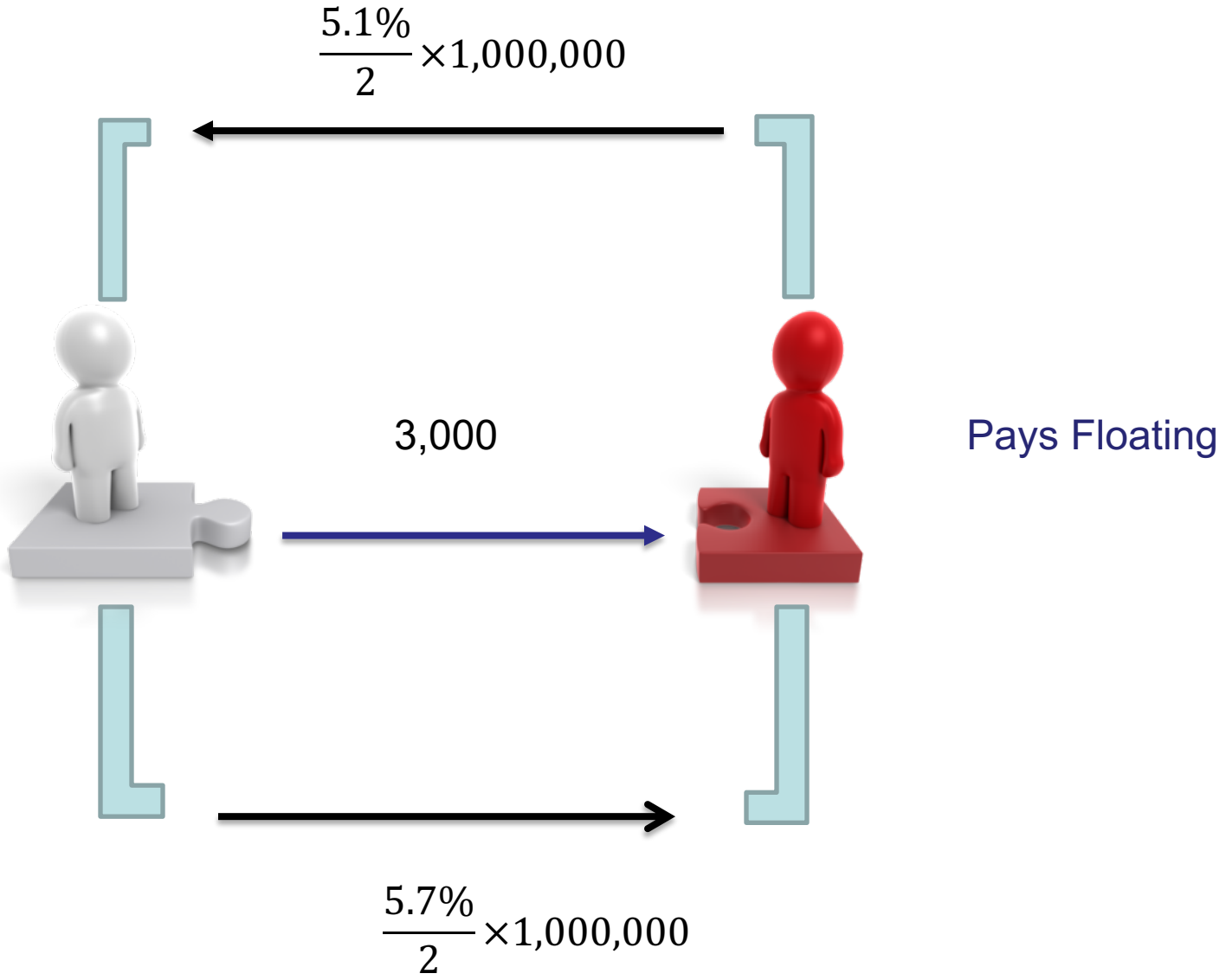
Fixed for Floating Swap

- Periodic cash flows are calculated on a **notional** amount.
- Only the net cash flows are exchanged
- The notional amount is not exchanged.



Semi-annual fixed for floating swap

- Notional Value of 1 million
- Fixed Leg pays 5.7%
- Floating Pays Libor
  (assume relevant is 5.1%)

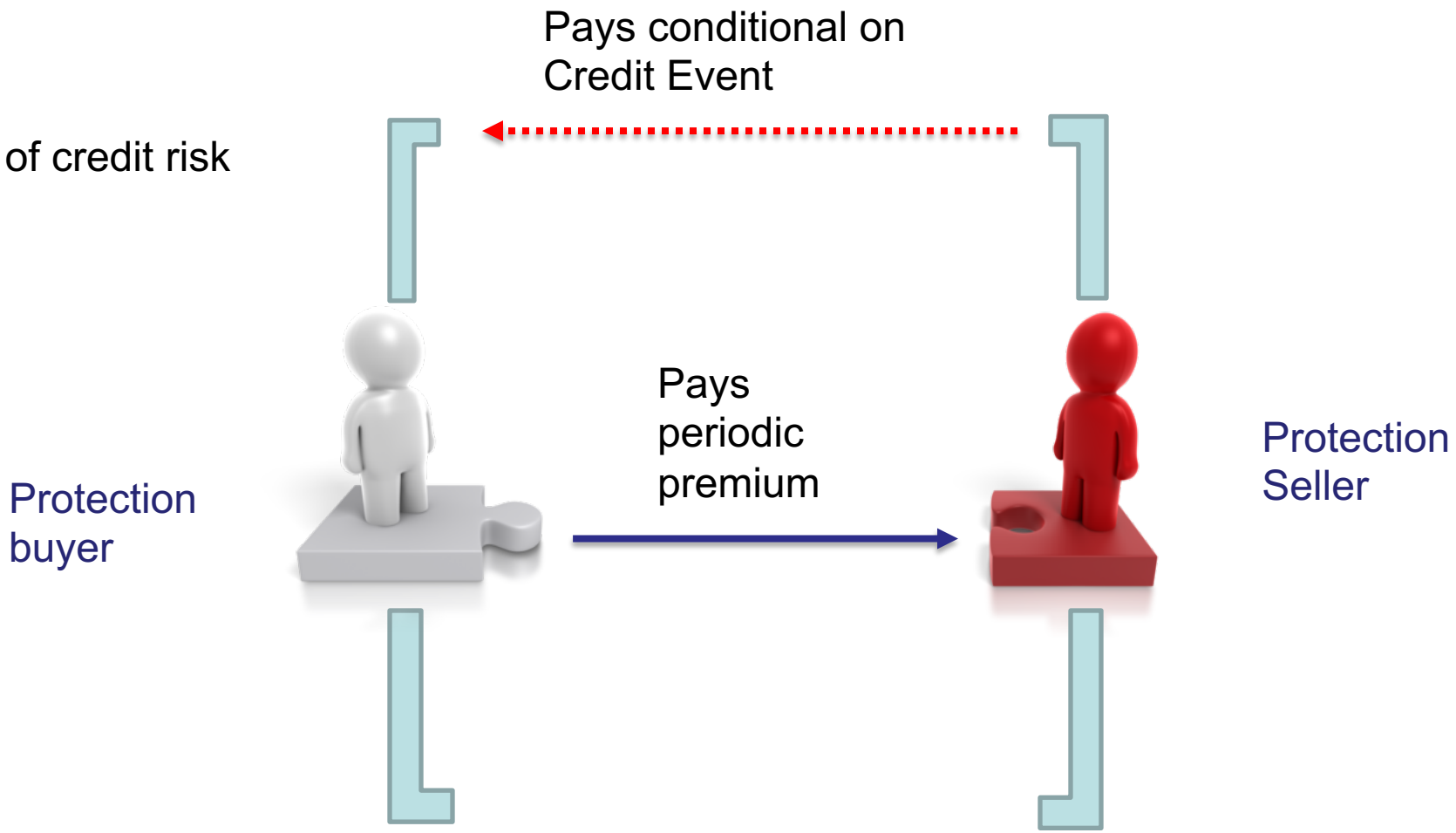


Sidebar: ``Oracle Attack''

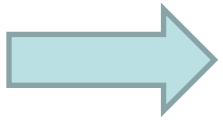
- Valuation and trading of swaps is contingent on an easy to observe and trustworthy benchmark.
- One of the floating rates used is the London Interbank Offer Rate (LIBOR)
- Massive scandal in 2012 on the manipulation of the rate by traders.
- Revised formula, and current administered by ICE (owned by NYSE)

Credit Default Swap

- Pure trading of credit risk



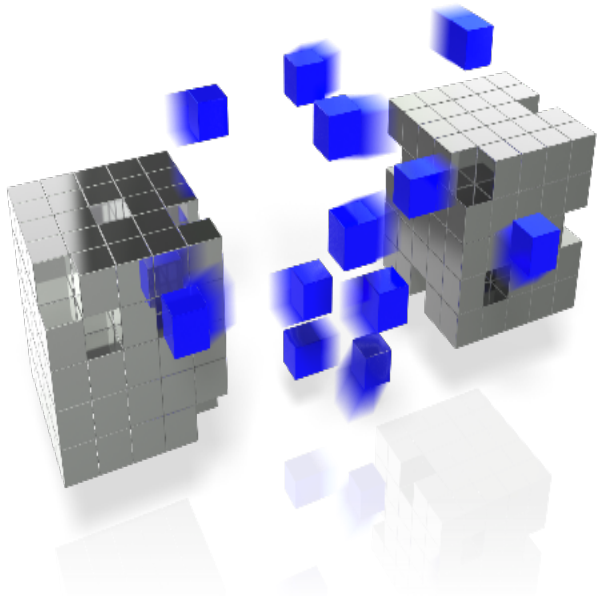
Why are swaps designed this way?

- Want a specific economic exposure but too expensive to sell + buy underlying.
- Cash flows only exchanged on the notional value  lower counterparty risk.

- Flexible way to construct synthetic securities, i.e.,

  credit default swap + treasury = corporate bond

Central Clearing

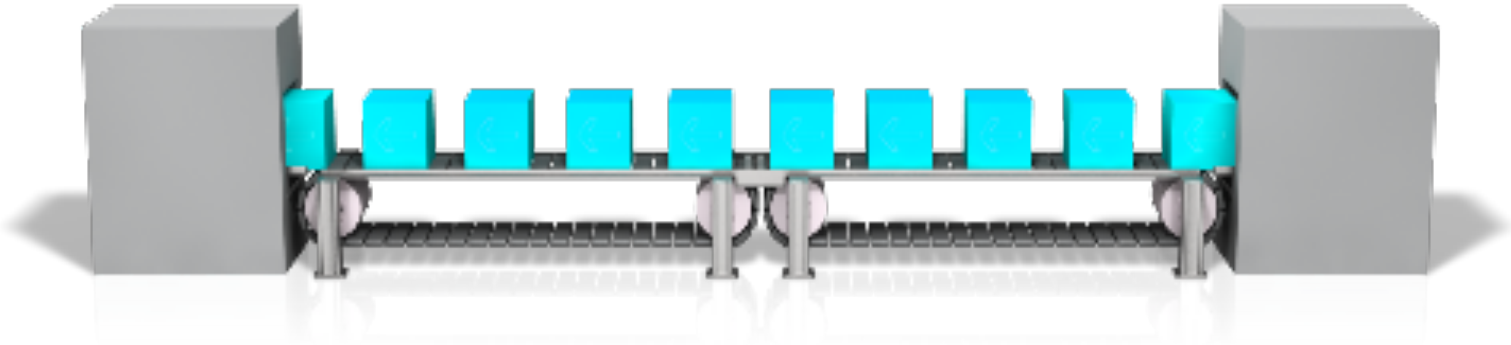


- Nets trades
- Sequences of bilateral netting can be inefficient

- Assumes credit risk
- All Trades are against the ``house''
- Members pay margins


Defi Synthetic Assets
https://defi-learning.org

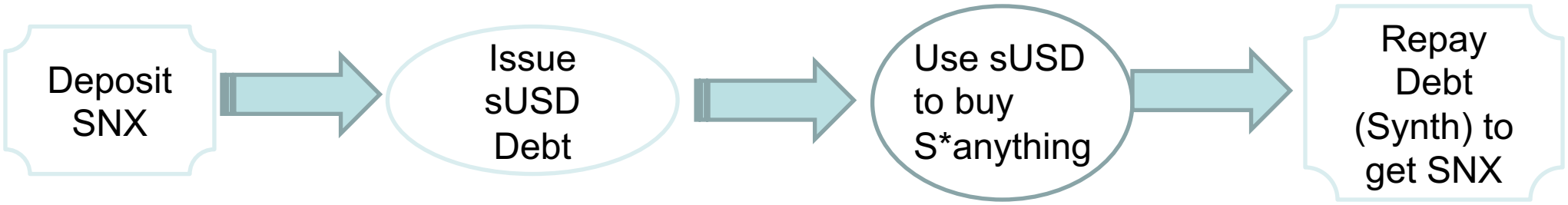
Designing/Manufacturing Synthetic Assets/Derivatives



1. Identify the economic/financial risk to be exposed to.
2. Robust way to measure/agree on changes in risk (oracle)
3. If no one owns the underlying, how to ensure payouts
4. How to make the new assets easy to trade (market liquidity)

Example: Synthetix

- Liquid synthetic derivatives called `synths'
- These track any asset or position typically using Chainlink's oracles.
- System has a collateral asset called SNX.

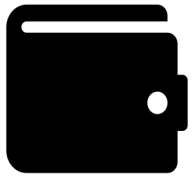


Collateralization Ratio: 400% on L1
750% on L2

Many different Synths are offered.

- Fiat Synths
  - sUSD, sEUR, sKRW.
- Commodity Synths
  - synthetic gold and synthetic silver, both measured per ounce;
- Cryptocurrencies
  - sBTC, sETH.
- Also offer inverse Synths e.g. iBTC.
  - If the price of the underlying does down, these go up in value
  - Same payoffs as a **short** position in TradFi
- Also Synths that track indexes (similar to ETF)

Benefit: Infinite Liquidity
``Buying'' sBTC with sUSD



- Charge a fee
- Remove (burn) sUSD.
- Add sBTC at a rate determined by the oracle

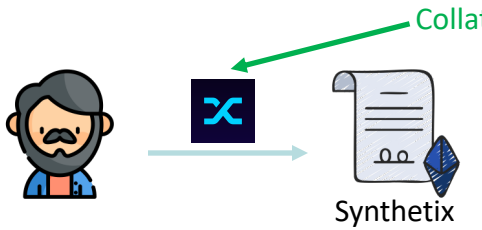
Adjust sUSD supply
Adjust sBTC supply

- System converts the debt from one Synth to another.
- No counterparty needed
- Infinite liquidity
- No Debt change is required as Synth pool increases and decreases by the same amount

Synthetix

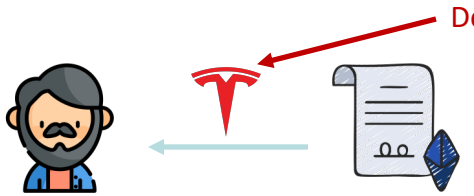
Mint a derivative asset

Step 1



SNX deposited to mint derivative
600% collateral mints 100% derivative

Step 2

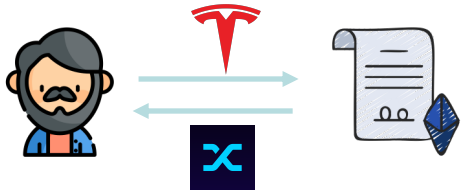


Draw derivative
(e.g. sTSLA share)

Report prices external
to the blockchain

Price Oracle

Step 3



Pay back sTSLA to unlock SNX

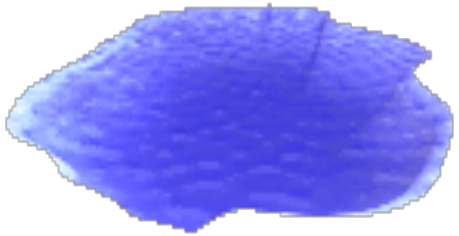
Ensuring Price Pegs

1. If the price of a synth is too low, stakers can profit from buying sUSD back below par and burning it to reduce their debt
2. sETH liquidity pool on Uniswap: a portion of SNX added to the total supply (due to inflationary policy) is distributed as a reward to sETH/ETH liquidity providers
3. SNX auction: partnering with dFusion protocol, discount SNXs are sold for ETH, which is then used to purchase synthetic assets below peg.

Risk Sharing: using sUSD to trade BTC

Alice has 50K
worth of sBTC
50% of Pool

Bob has 50K
worth of iBTC
50% of Pool



Debt pool is
Worth 100K

BTC
Increases
By
50%

Alice has 75K
worth of sBTC
50% of Pool

Bob has 25K
worth of iBTC
50% of Pool

Debt pool is
Worth 100K

Alice has a
NET position of
+25K

Bob has a
NET position of
-25K

Risk Sharing: using sUSD to trade BTC

Alice has 50K
worth of sBTC
50% of Pool

BTC
Increases
By
50%

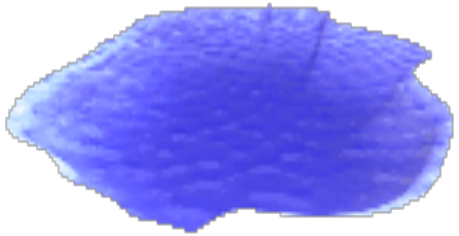
Alice has 75K
worth of sBTC
50% of Pool

Alice has a
NET position of
+12.5K

Bob has 50K
worth of sUSD
50% of Pool

Bob has 50K
worth of sUSD
50% of Pool

Bob has a
NET position of
-12.5K



Debt pool is
Worth 100K

Debt pool is
Worth 125K

Collectivizing Gains and Losses

- Protocol payoffs are transfers between participants.
- Payoffs to positions relative to what others are trading

Total Return = Fundamental + Relative Return

- If there are enough people in the protocol

relative return = market return

Other Protocols

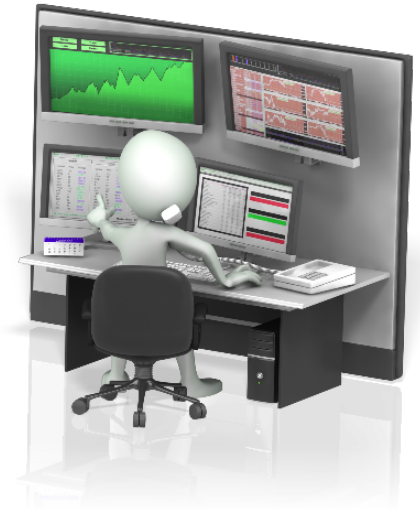
Provides the creation of complex financial derivatives with templates and oracle services

Provides creation and trading of synthetic assets on an unlimited liquidity market

Mirror Protocol; Provides creation of synthetic assets with automated market maker and liquidity provider mechanisms

Mirror Protocol Roles

Minter: Generates mAssets as CDPs

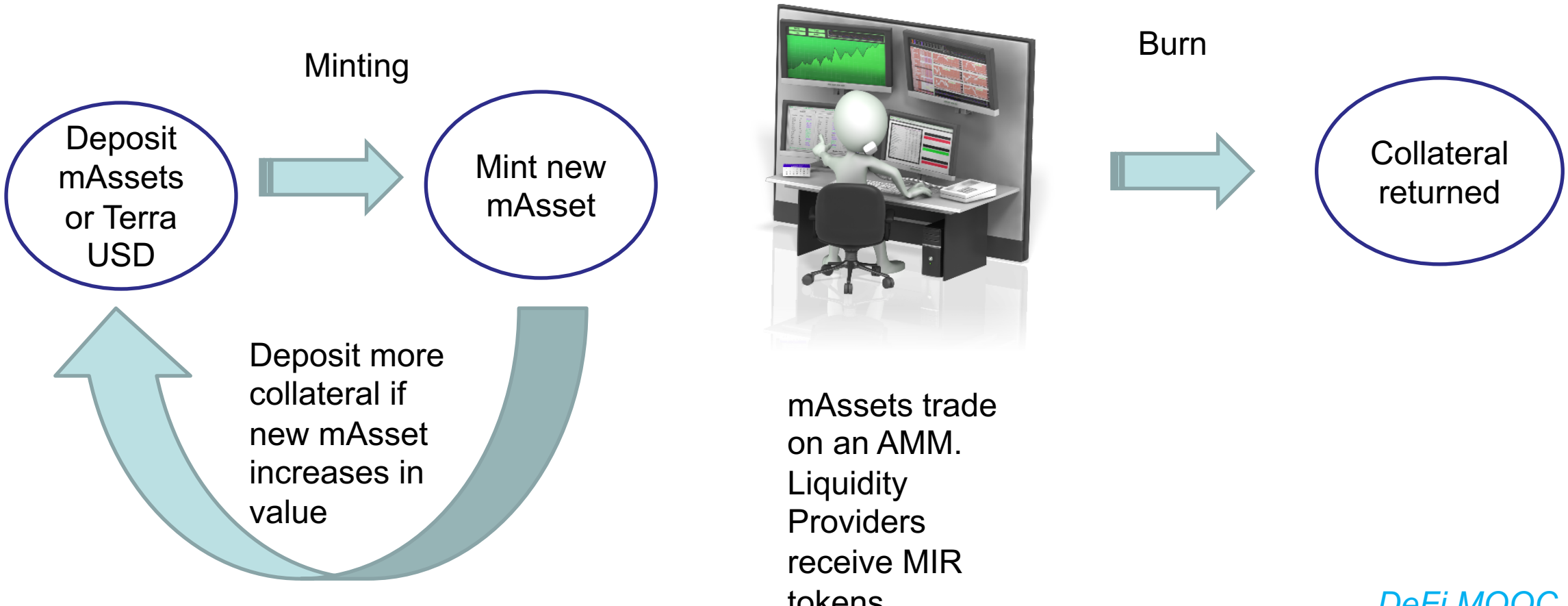


Trader: buys and sells mAssets

Staker: stakes Liquidity or governance Tokens (MIR)

Liquidity Provider: Provides mAsset And TerraUSD to a TerraSwap pool

- Mirror is built on the Terra blockchain, but interoperable with Ethereum and Binance Smart Chain.



Risk Sharing and Liquidity

- Minters are bearing the risk of price changes.
  - They are providing insurance against market moves to the mAsset traders.
- Liquidity is provided by liquidity providers on the AMM
- Protocol separates trading and risk bearing

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- Institutional Borrowing is done through REPURCHASE agreements.
- Repos are over-collateralized loans.

- Market is large…12 trillion USD
- The money comes from Money Market funds, asset managers
- Borrowers are banks, hedge funds

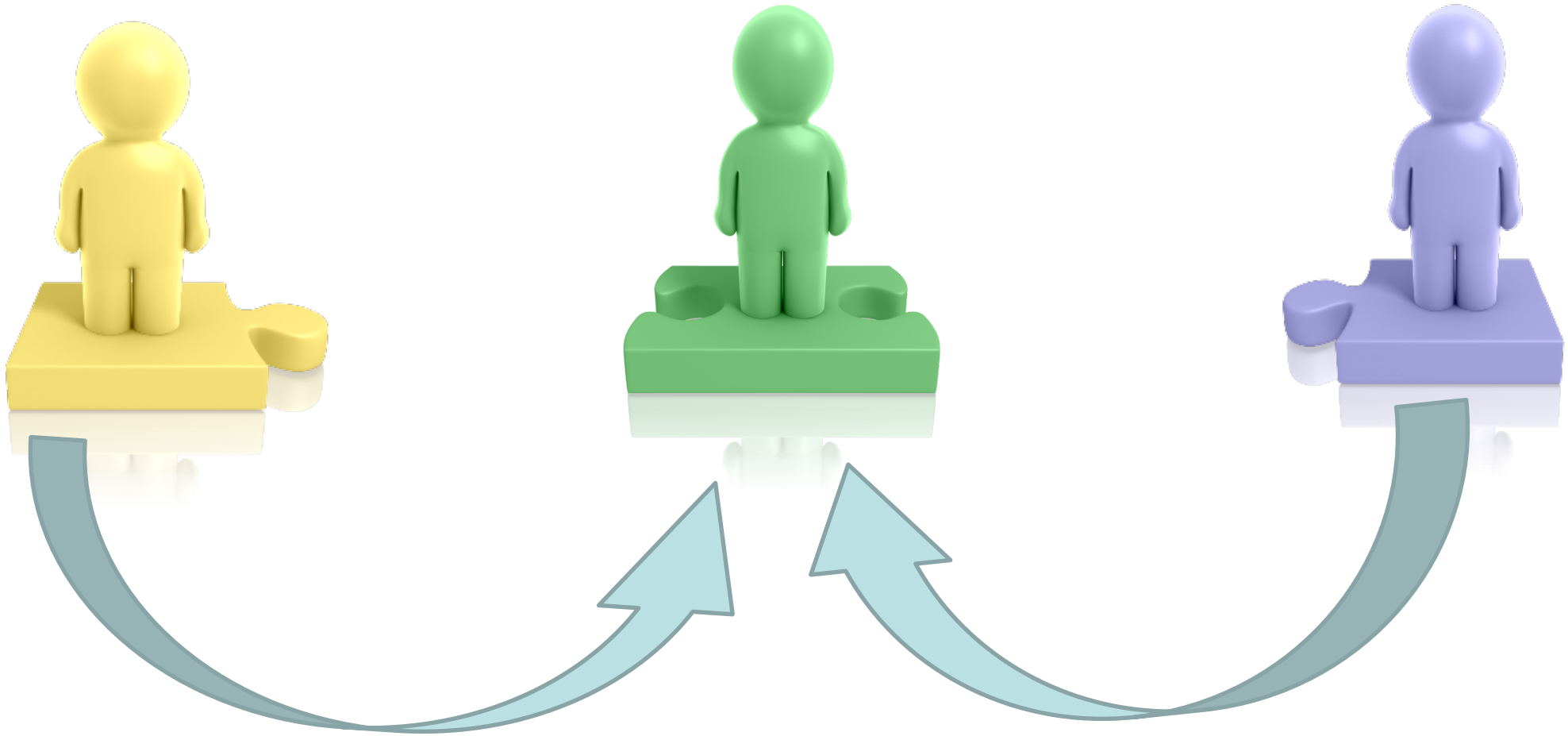
Repurchase agreements

Collateral + promise to
Repurchase at a fixed price

Cash

- Repo agreements can be used to borrow cash or borrow securities

Triparty Repo



- Triparty system makes efficient use of collateral/netting of positions
- Systemic Risk: everyone is exposed to the custodian bank

Leverage using Repos

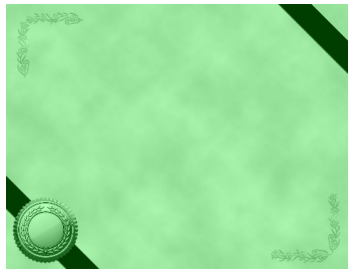
Security
Worth $100

Repo for
$100- h_1

Use $ to buy
Another security

Repo for
$100-$h_1$-$h_2$

Use $ to
buy
Another
security



- Repos are overcollateralized so amount borrowed is a ``haircut'' less than the market value of the collateral.
- If haircuts are zero….infinite leverage!

Many financial instruments have built in leverage

- Options contracts:
  - Options that are ``out of the money'' cost less than the underlying.
- Futures Contracts:
  - The initial and maintenance margins are less than the future purchase price (the futures price).
- Individual ``margin'' loans

Restrictions on Borrowing

- After the Great Depression, Federal Reserve put in regulations to prevent borrowing to buy.
- Regulation T: restricts the amount that brokers can lend to investors in order to buy securities to 50%. (i.e., have to put down 50% of the price of the security.
- Does not restrict other debt that consumers have.

Defi Leveraged Derivatives

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dydx

- Partially decentralized exchange/financial services.
- One of the earliest suppliers of flash loans.
- Offers **decentralized** leveraged trading
  - Margin
  - Perpetuals
  - Spot

dy/dx margin trading protocol for Token B

Loan offer
Buy order for
Token B

Dydx smart contract

Sell Token B

Margin
amount

Position Closed
With smart order
To sell token B

Sale Proceeds
Token A

Perpetuals

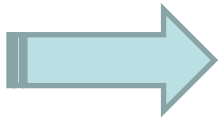
- Synthetic assets that track commonly traded DeFi pairs
- Different Initial Margin Fraction Leverage

BTC	25X
ETH	25X
Others	10X

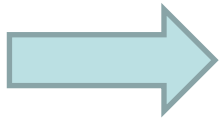
- Maintenance Margin triggers liquidation
- Each perpetual has its own tick size, minimum order size etc.

  Design features to maximize liquidity

Perpetuals

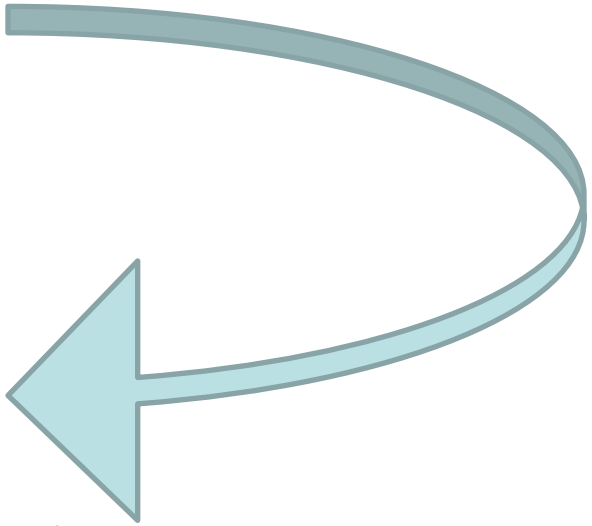


USDC is the collateral asset



Off Chain Order Book/matching engine

Non-custodial on-chain settlement



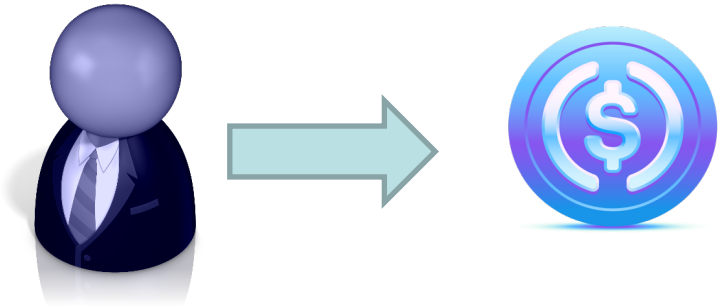
- Funding Payments incurred every hour.

Size x Oracle Price x Funding rate

If the perpetual is too high, the longs pay the shorts.

Liquidation

- Assume an initial margin requirement of 10% and a **maintenance margin requirement of 7.5%**.



Uses 1,000 USDC to short 1 XYZ @2,000

Account
1,000 USDC Deposit
2,000 USDC Short
-1 XYZ

Initial Margin=$\frac{3{,}000-2{,}000}{2{,}000}=50\%$

- The price of XYZ increases, and the index price hits 2795 USDC
- Margin=$\frac{3{,}000-2{,}795}{2{,}795}=7.3\%$

- Triggers automatic liquidation.
  - Liquidator seizes net equity (3,000-2,795) and closes the position.
  - Residual after fees goes into an insurance fund.

Contract Loss Backstops

- If underlying has high volatility, some accounts may fall to zero net equity before liquidation.
- **Insurance fund**: Takes the loss on underwater accounts.
- **Deleveraging**: If the insurance fund is depleted, loss absorbed by accounts that are profitable and leverage.


Active Portfolio Management
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Hiring Someone to Invest for you

- Hedge Funds
- Commodity Trading Advisors/Pool: (Only invest in futures)
- Private Equity
- Venture Capital

Benefits	Costs
Have access to markets/investments/leverage	Opaque
Have specialized knowledge/Information	Risky
Have specialized trading skill	Expensive

Hedge Funds

- Holds securities, does not raise money by public offering and does not register under the Securities Act or Investment Company Act
- Dodd-Frank increased disclosure requirements.

- Often highly levered
- Only sell to ``sophisticated'' investors: high net worth.
- Tax Optimized

Hedge Fund Strategies

1. Fixed Income arbitrage: statistical or actual arbitrage.
2. Convertible arbitrage: typically long convertible bonds and short stock.
3. Short Bias: net shorts
4. Emerging Markets: frequently long only.
5. Equity market neutral: long/short hedges
6. Event Driven: mergers acquisitions, bankruptcy etc.
7. Global Macro: sector bets
8. Long/short Equity hedges: not necessarily market neutral, but long/short bets
9. Managed Futures

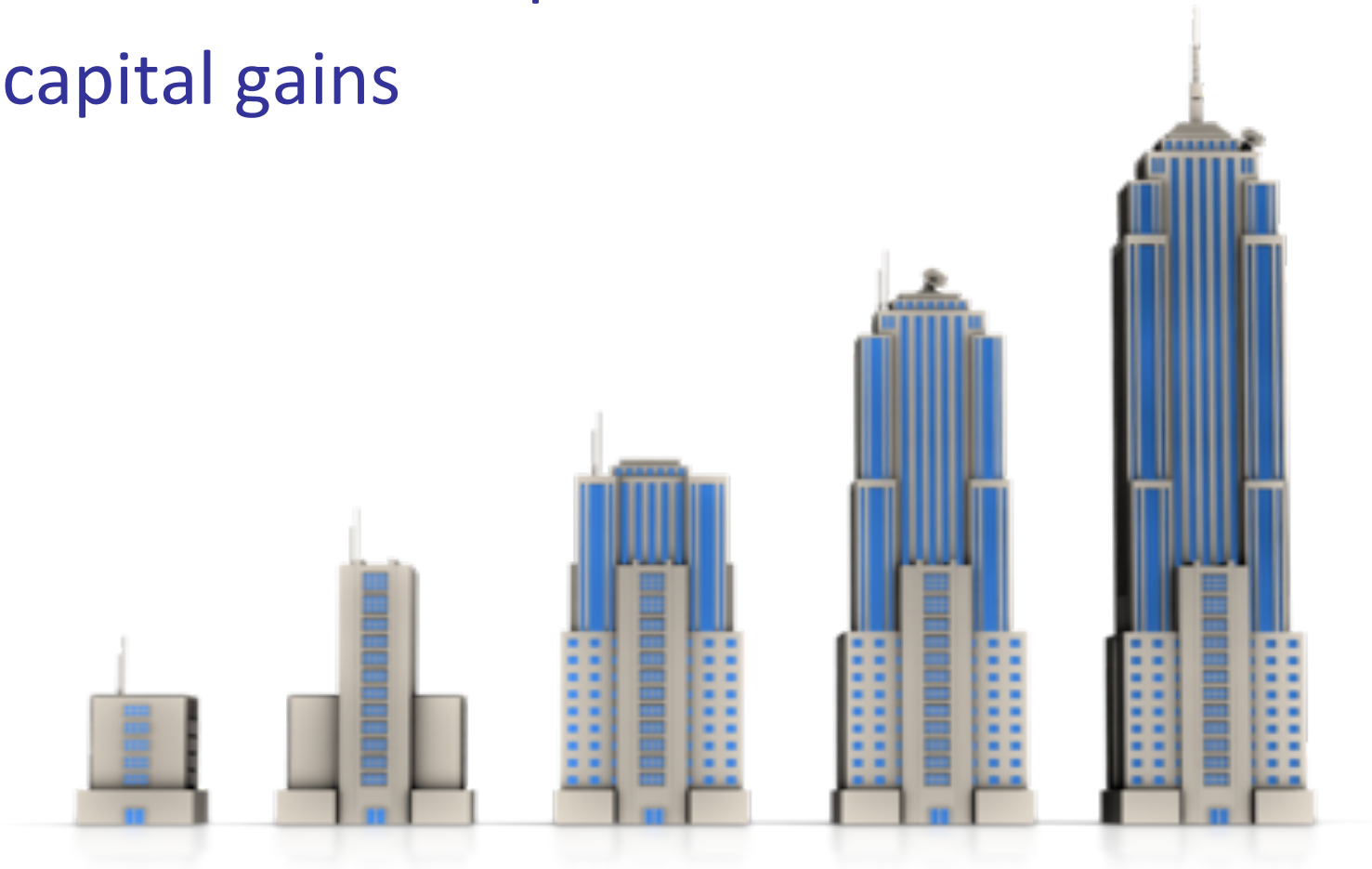
Private Equity

- Limited partners commit capital.
- Only Drawn down if projects are found.

- Funds usually have a fixed horizon.
- Usually highly leveraged
- Illiquid Investments

Returns to Hedge Fund Investors

- 2% fee on committed capital or assets under management (AUM)
- 20% on capital gains



Risks

1. Manager Risk: What a manager says he does and what he does are two different things. (Ponzi Schemes)
2. Measurement of Alpha might be incorrect.
3. Liquidity Risk: Beware of Cash Flow problems
   - Lockups: restrictions on when/how much you can withdraw
   - Gates: withdrawal fees
4. What looks like diversification might not be.

Calculating Leverage/Risk

1. Total market long/total investment capital.
2. (Total market long+ total market short)/investment capital

- A has $100 long position and no shorts.
- B has $100 long and $100 short.
- If each fund has the same initial $10 investment:
- What is the leverage of each fund under each definition?
- Which is riskier?

Is the manager adding value?

1. What is the risk of the portfolio
   - May be difficult to assess if the strategy is ``secret''
2. What return would the `next best' portfolio with the same risk give me?
3. Adjust for fees and possible lockup risk.


On-Chain Portfolio Management
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ETF

- An exchange traded fund (ETF) is a type of security that tracks an index, sector, commodity, or other asset, but which can be purchased or sold on a stock exchange the same way a regular stock can.
  - E.g., SPDR S&P 500 ETF (SPY), which tracks the S&P 500 Index
- Advantages
  - Convenience for diversification
  - Enables targeted sectors and investment thesis
  - Low management fee
  - Only taxed when selling ETF; no tax whiling holding it

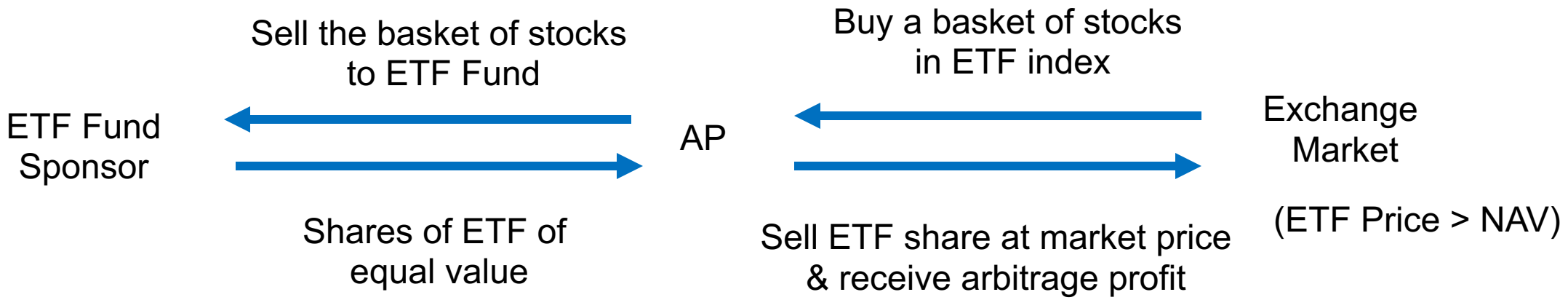
ETF Operations

- ETF buy/sell on exchange: price per share determined via trading
- NAV (Net Asset Value): an accounting mechanism that determines the overall value of the assets or stocks in an ETF
- Premium/discount: difference btw ETF price vs. NAV

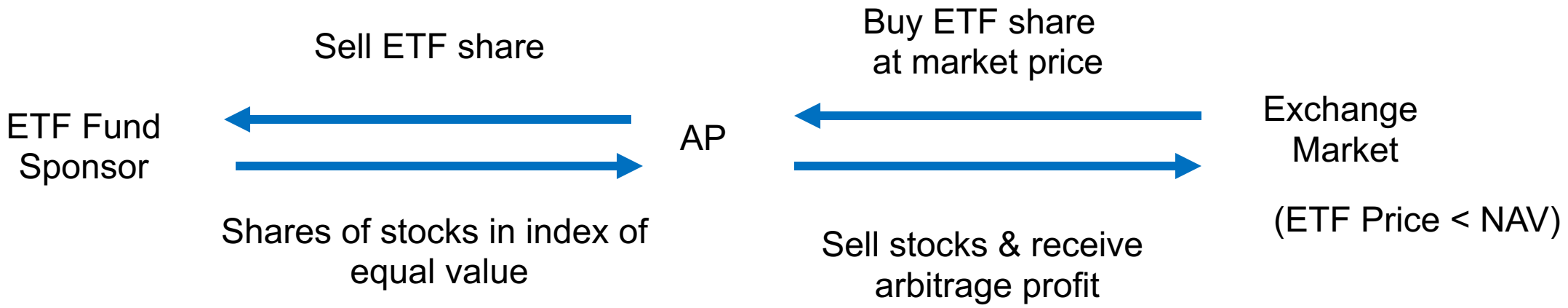
ETF Operations

- The supply of ETF shares is regulated through a mechanism known as creation and redemption, which involves large specialized investors called authorized participants (APs)
- Traditionally, authorized participants are large banks, such as Bank of America (BAC), JPMorgan Chase (JPM), Goldman Sachs (GS), and Morgan Stanley (MS).

ETF Share Creation/Issuance



ETF Redemption



Issues in Traditional ETF

- Inefficiency
  - Intermediary: AP, taking arbitrage profit
- Closed system, no open access
  - Only certain regulated entities can create new ETF funds
- Trust third-party for custodial of assets

On-chain Portfolio Mangement

- Smart contract handles index token creation and redemption, instead of a centralized fund sponsor
  - Remove AP
  - Anyone can interact directly with smart contract for creation & redemption
  - Anyone can create a new smart contract for a new index fund
  - Smart contract holds collateral assets
- Composable nature of DeFi:
  - Utilizing Oracle, DEX, etc.
- Example: SET protocol (https://docs.tokensets.com/)

Set Protocol (Token Sets): Overview

- Combines Assets into tokens called Sets, Sets are **100% collateralised** ERC20 tokens.
- Sets can simply be a portfolio of tokens or a trading strategy e.g., a portfolio that shifts between ETH and USD based on triggers.
- Prices and returns are calculated with oracle, and users are charged fees (front-end, management) etc.

Set (Index) Creation

- Token Selection
  - Choose the tokens as collateral to be included in the set and adjust their allocations. The allocation table can be changed later.
- Metadata Configuration
  - Name, Symbol, start price (arbitrary number)
- Publish the Set
  - Deploy the Set to the Ethereum mainnet or Polygon. Once published, the set can issue collateralized ERC20 tokens.

Allocation Table

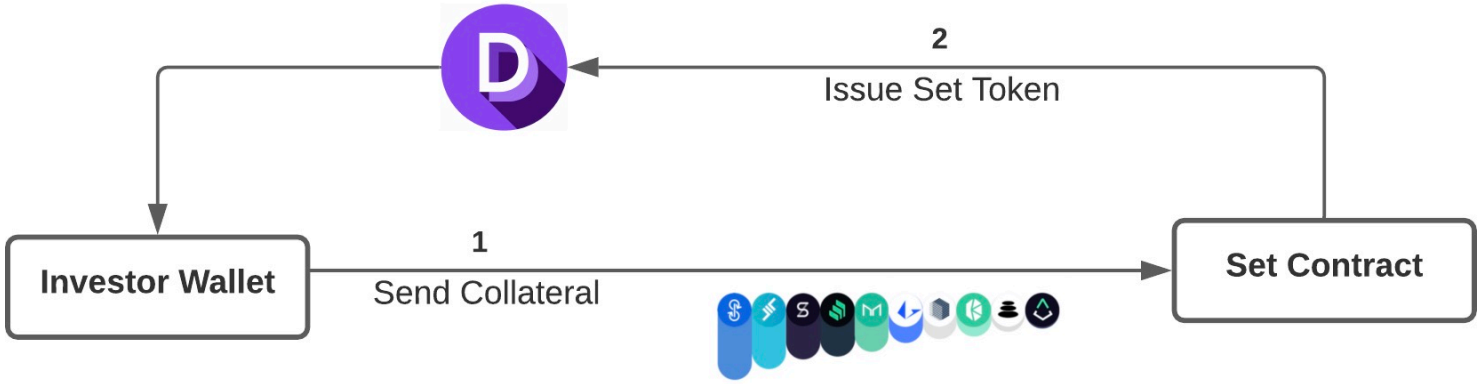
Token	Quantity per Set	Token Price	Current Price Allocation	Percent Change	Total Price per Set
DeFi Pulse Index				-15.62%	$335.56
Underlying Tokens					
Uniswap	3.309854 UNI	$25.69	25.34%	7.44%	$85.03
Aave Token	0.210857 AAVE	$306.99	19.29%	-8.68%	$64.73
Maker	0.014409 MKR	$2477.63	10.64%	-20.37%	$35.70
Sushi	3.082058 SUSHI	$10.54	9.68%	-5.65%	$32.48
Compound	0.094183 COMP	$313.01	8.79%	-22.29%	$29.48
Synthetix Network Token	2.796481 SNX	$10.10	8.42%	-4.64%	$28.24
Yearn	0.000571 YFI	$32001.61	5.44%	-9.27%	$18.26
REN	14.086704 REN	$1.11	4.66%	62.56%	$15.64
Loopring	19.919256 LRC	$0.39	2.32%	-5.76%	$7.79
Kyber Network v2	3.115434 KNC	$1.69	1.57%	-3.89%	$5.27
Balancer	0.172654 BAL	$22.41	1.15%	-14.25%	$3.87
Badger DAO	0.154363 BADGER	$23.45	1.08%	19.34%	$3.62
Cream	0.012254 CREAM	$143.62	0.52%	-13.7%	$1.76
Harvest Finance	0.009796 FARM	$175.58	0.51%	-15.86%	$1.72
Instadapp	0.262895 INST	$4.22	0.33%	5.29%	$1.11
Vesper Finance	0.082945 VSP	$6.63	0.16%	-51.21%	$0.55

Defi Pulse Index (DPI)

Token	Quantity per Set	Token Price	Current Price Allocation	Percent Change	Total Price per Set
Metaverse Index				13.66%	$127.24
Underlying Tokens					
Illuvium	0.043602 ILV	$622.68	21.34%	34.26%	$27.15
Axie Infinity	0.196441 AXS	$123.75	19.11%	81.19%	$24.31
Enjin Coin	7.835321 ENJ	$1.49	9.17%	-11.34%	$11.67
Decentraland	15.457385 MANA	$0.74	8.96%	-11.36%	$11.40
SAND	14.201465 SAND	$0.71	7.96%	-11.51%	$10.13
Audius	5.159101 AUDIO	$1.93	7.83%	-14.95%	$9.96
WAX Economic Token	0.029589 WAXE	$261.92	6.09%	-6.23%	$7.75
Ethernity Chain	0.420747 ERN	$10.72	3.54%	-16.32%	$4.51
Whale	0.2532 WHALE	$16.82	3.35%	7.16%	$4.26
Rarible	0.20508 RARI	$20.58	3.32%	-4.56%	$4.22
NFTX	0.023411 NFTX	$160.61	2.96%	17.39%	$3.76
Decentral Games	0.013451 DG	$243.85	2.58%	9.54%	$3.28
Terra Virtua Kolect	16.235089 TVK	$0.18	2.34%	-26.33%	$2.98
REVV	14.279437 REVV	$0.13	1.45%	-18.77%	$1.85

Metaverse Index (MVI)

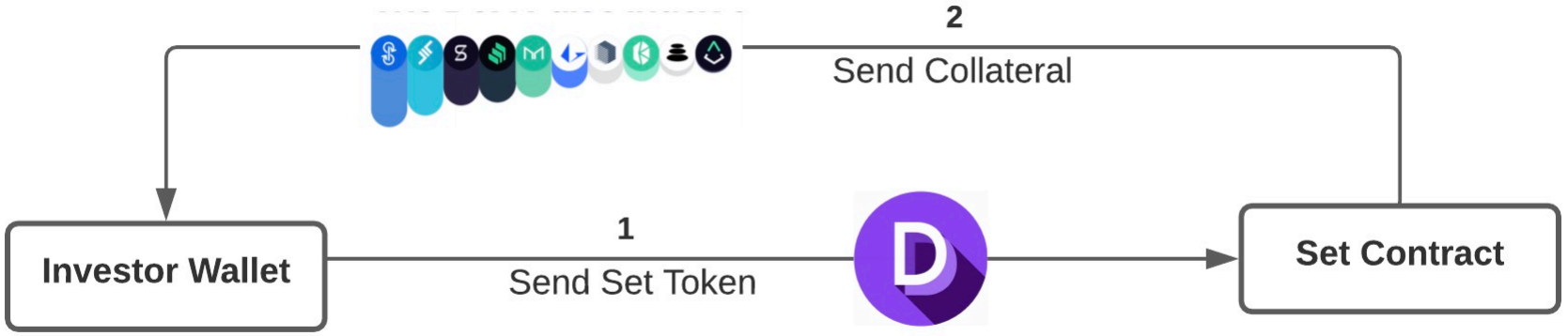
Set Issuance



Example: Bob issues 100 EXAMPLE tokens, comprising of WBTC, WETH & UNI, using his own provided collateral.

- Bob accepts the proposed Issue transaction to convert 1 WBTC, 10 WETH & 100 UNI, that he currently holds within his wallet, into 100 EXAMPLE tokens.
- The required 1 WBTC, 10 WETH & 100 UNI gets sent from Bob's wallet to the Set Contract.
- The Set contract, now holding the underlying assets ensuring 100% collateralisation, issues 100 EXAMPLE tokens and sends them to Bob's connected wallet, completing the Issuance transaction.

Set Redemption



Example: Bob clicks the REDEEM button to burn 100 EXAMPLE tokens and receive the underlying collateral back into his wallet (WBTC, WETH & UNI).

- Bob accepts the proposed redemption transaction to convert 100 EXAMPLE tokens, that he currently holds within his wallet, into 1 WBTC, 10 WETH & 100 UNI.
- The required 100 EXAMPLE tokens get sent from Bob's wallet to the Set Contract.
- The Set contract, now holding the EXAMPLE tokens that represents a portion of the underlying Set collateral, then burns 100 EXAMPLE tokens and sends the representative collateral (1 WBTC, 10 WETH & 100 DPI) back Bob's wallet, completing the Redemption transaction.

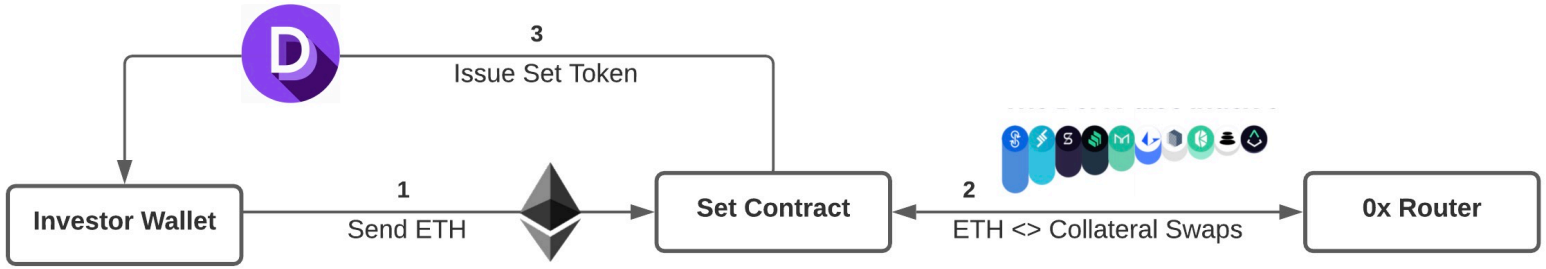
Buy & Sell Sets

- Via Set Protocol

  Step 1: The Set contract creates a series of DEX orders via a 0x API Router to buy all the underlying collateral.

  Step 2: The Set contract issues the Set token using the collateral from Step1.

  Low slipage 😊 , **High gas fees** 😞



- Via DEX

  Sets are fully compliant with the ERC-20 token standard, therefore they can be listed and traded easily on decentralised exchanges if liquidity permits.

  For example, we can use Uniswap to purchase the DeFi Pulse Index (DPI), which has ample liquidity on Uniswap (outside of the Set Protocol).

  Low gas fees 😊 , **Need ample liquidity on DEX** 😞

Set Management

- Managers Portal
  - Issue Set tokens, claim streaming fees, configurations
- Streaming fees
  - The streaming fees are fees that are paid out to Set managers over time based on the entire market cap of the Set (e.g. 2% of market cap over 1 year). This incentivizes managers to increase the value of their Sets over time for their users.
  - The streaming fee is calculated linearly over the lifespan of the Set. For example, if a Set has a 2% streaming fee and 6 months has passed, 1% of streaming fees would have been collected.

Performance Analysis

- AUM: Assets Under Management (market cap of the Set)
- Performance: Price change of the Set token
- Max Drawdown: the largest decline in the history
- Streaming fee
- Set holders

Other Defi Asset Management Protocols

- Enzyme (Previous Melon Protocol): https://enzyme.finance/
  - Similar mechanisms, without issuing collateralized ERC20 tokens.
- PieDAO: https://www.piedao.org/
  - Based on Balancer smart pools.
- DHedge: https://www.dhedge.org/
  - Built on Synthetix, collateral should be Synthetix derivatives.
- Hord: https://hord.app/
  - Social trading with portfolios and ETFs.

Advantages of On-Chain Portfolio Management over Traditional ETF

- Efficiency
  - No intermediary (AP) taking arbitrage profit
- Open ecosystem
  - Anyone can create a new index, trading strategy
    - Be careful that fund manager can front-run investor
- Trustless
  - On-chain custody of assets