#12 Derivatives: Perpetual Futures

Lecture Notes for CS190N: Blockchain Technologies and Security November 10, 2025

This lecture explores perpetual futures, the dominant financial instrument in cryptocurrency derivatives. We will demystify the core mechanisms that make them work, including the funding rate that anchors them to reality and the leverage that makes them both powerful and risky. We will focus on the essential concepts, using analogies and diagrams to build a clear mental model, and conclude with a look at how these instruments are implemented in a decentralized context through the GMX case study.

1 THE PROBLEM: TRADING AN ECHO

1.1 Why Derivatives Exist

Imagine trying to build a financial system where the value of your measuring tape, the dollar, stretches and shrinks unpredictably every day. This is the challenge of building with volatile assets like Bitcoin (BTC) and Ether (ETH). Stablecoins were the first solution, creating a fixed, reliable unit of account. They are the solid ground in the volatile world of crypto.

However, stability is only half the story. A mature financial market also needs tools to manage, and speculate on, the volatility itself. This is where derivatives come in. Instead of trading the asset, you trade a contract that **derives** its value from the asset. You're not trading the object itself, but its echo. This allows for complex strategies like hedging (protecting your holdings from price drops) and leveraged speculation.

1.2 Spot vs. Futures vs. Perpetuals

To understand what makes perpetual futures special, let's quickly compare the three main ways to trade.

- **Spot Trading:** The simplest form. You buy 1 BTC, you own 1 BTC. It's a direct exchange of assets for immediate ownership.
- **Traditional Futures:** A contract to buy or sell an asset at a set price on a future date. Think of it as pre-ordering a new phone. You agree on the price today, but the transaction happens later. The fixed expiration date is crucial, as it forces the contract's price to converge with the asset's actual price on that day.
- **Perpetual Futures (Perps):** The innovation that took over crypto. A perpetual is a futures contract with a superpower: **it never expires**. You can hold a position indefinitely. This creates a seamless trading experience but introduces a new, critical problem: if there's no expiration date to force the price to converge, what stops the contract's price from drifting away from the real asset's price forever?

Table 1. Comparison of Trading Models

Feature	Spot Trading	Traditional Futures	Perpetual Futures
Expiration Date	None	Fixed Date	**None**
Leverage	Low/None	Yes	High
Asset Ownership	Direct	Contract Only	Contract Only
Price Anchor	Market Price	Expiration Date	**Funding Rate**

2 THE CORE MECHANISM: THE FUNDING RATE

2.1 The Problem: Keeping the Echo in Sync

The lack of an expiration date is the perpetual's greatest strength and its greatest engineering challenge. Without a future settlement date to act as an anchor, the price of a BTC perpetual contract (P_{perp}) could drift miles away from the actual spot price of BTC (P_{spot}). The contract would become a meaningless echo, completely disconnected from the asset it's supposed to represent.

The solution to this is an elegant mechanism called the **funding rate**.

2.2 The Solution: A Financial Tug-of-War

The funding rate is a periodic payment exchanged directly between traders holding long positions and those holding short positions. The exchange doesn't take a cut; it just facilitates the transfer. Its sole purpose is to create a financial incentive that pulls the perpetual price back towards the spot price.

Think of it as a constant tug-of-war, where the funding rate is the force that keeps the rope centered over the spot price.

- **When $P_{\text{perp}} > P_{\text{spot}}$ (Perp is expensive):** The market is bullish, and there are more longs than shorts. The funding rate becomes **positive**. To rebalance, longs must pay shorts. This makes it expensive to be long and profitable to be short, encouraging traders to sell the perpetual, pushing its price down towards the spot price.
- **When $P_{\text{perp}} < P_{\text{spot}}$ (Perp is cheap):** The market is bearish, with more shorts than longs. The funding rate becomes **negative**. To rebalance, shorts must pay longs. This punishes short positions and rewards long positions, encouraging traders to buy the perpetual, pushing its price up towards the spot price.

2.3 The Funding Rate Formula

The funding payment is calculated periodically (e.g., every 8 hours) based on the price difference. A simplified view of the formula is:

$$\text{Funding Payment} = \text{Position Size} \times \text{Funding Rate} \tag{1}$$

Where the funding rate itself is primarily a function of the premium:

$$\text{Funding Rate} \approx \text{Average}(P_{\text{perp}} - P_{\text{spot}}) \tag{2}$$

By averaging the price difference over time (using a TWAP), the system prevents manipulation from single, sudden price spikes.

3 THE DOUBLE-EDGED SWORD: LEVERAGE AND LIQUIDATION

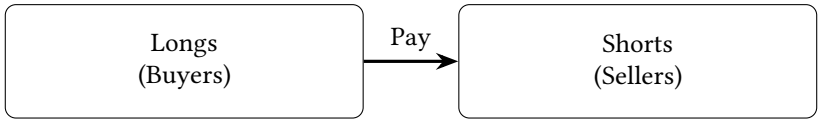
3.1 Leverage: Amplifying Your Bet

The main attraction of perpetuals is **leverage**. It allows you to control a large position with a small amount of capital, known as **margin**. With 10x leverage, $1,000 of your own money can control a $10,000 position. This amplifies both your potential profits and your potential losses. A 5% price increase in the asset results in a 50% profit on your margin. But a 5% price decrease results in a 50% loss.

3.2 Liquidation: The Automated Stop-Loss

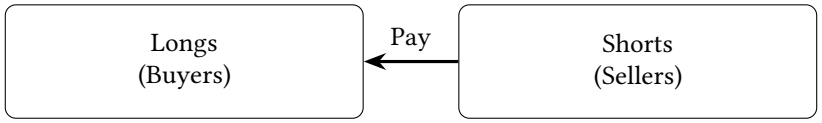
What happens if the market moves against you and your losses start to eat away at your margin? To protect the exchange from your losses exceeding your deposit, there is an automated safety mechanism: **liquidation**.

Scenario 1: Positive Funding Rate ($P_{\text{perp}} > P_{\text{spot}}$)



Result: Discourages buying, encourages selling. P_{perp} is pushed down.

Scenario 2: Negative Funding Rate ($P_{\text{perp}} < P_{\text{spot}}$)



Result: Encourages buying, discourages selling. P_{perp} is pushed up.

Fig. 1. The funding rate mechanism acts as a balancing force. Payments flow from the majority side of the market to the minority side, creating an economic incentive to restore the perpetual price's alignment with the spot price.

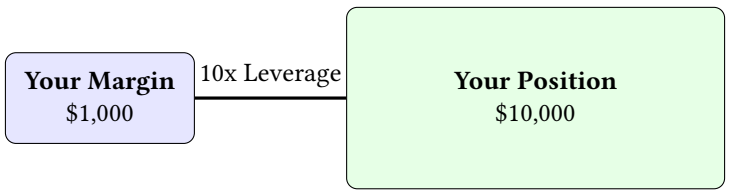


Fig. 2. Leverage allows a smaller amount of initial capital (margin) to control a much larger position size.

When your losses reach a point where your remaining margin falls below a required minimum (the **maintenance margin**), the exchange forcibly closes your position. This price level is called the **liquidation price**. You lose your entire initial margin.

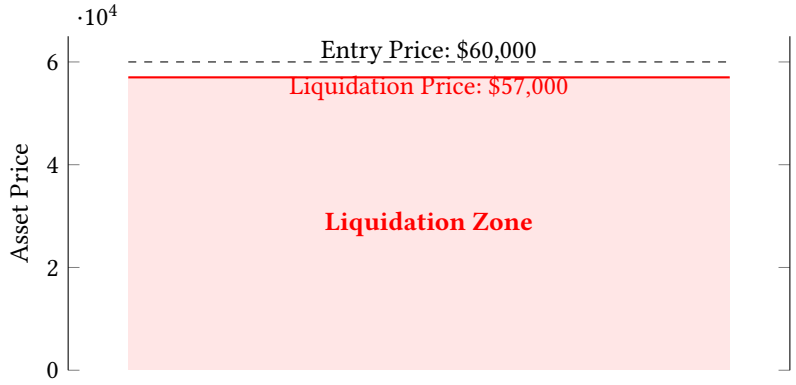


Fig. 3. For a 20x leveraged long position on BTC entered at $60,000, a price drop of just 5% to $57,000 would trigger liquidation, resulting in the loss of the entire initial margin.

3.3 Cascading Liquidations: The Death Spiral

Liquidation is a risk for individual traders, but it can also become a systemic risk for the entire market. When many traders are highly leveraged in the same direction, their liquidation prices tend to cluster around specific psychological price levels.

If the market price drops into one of these clusters, it triggers a wave of automated liquidations. Each liquidation is a forced market sell order, which pushes the price down further. This price drop then triggers the next cluster of liquidations, creating a self-reinforcing feedback loop. This phenomenon, known as a **cascading liquidation** or a "death spiral," is responsible for the sudden, violent price crashes often seen in crypto markets.

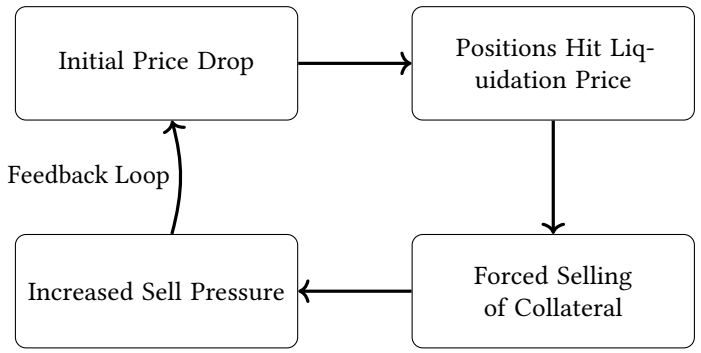


Fig. 4. The feedback loop of a cascading liquidation event, where initial liquidations create further price drops, triggering even more liquidations.

4 CASE STUDY: GMX AND THE GLP MODEL

4.1 A New Model: Trading Against a Pool

While many perpetual exchanges, both centralized and decentralized, use a traditional order book model where traders trade against each other, platforms like GMX pioneered a different approach. Instead of an order book, GMX uses a single, multi-asset liquidity pool called the **GLP pool**.

In this model, traders don't trade against other traders. Instead, they trade directly against the liquidity providers (LPs) who have deposited assets into the GLP pool.

4.2 The GLP Token: Becoming the House

Users who provide liquidity to the pool receive a token called GLP, which represents their share of the pool. By holding GLP, these LPs become the collective counterparty to all trades on the platform. This fundamentally changes the risk dynamic:

- **When traders profit, the GLP pool pays them.** The value of the GLP pool decreases.
- **When traders lose, their losses go into the GLP pool.** The value of the GLP pool increases.

In essence, GLP holders are betting against the aggregate performance of traders on the platform. They become "the house." In return for taking on this risk, they earn a majority (e.g., 70%) of all fees generated by the platform.

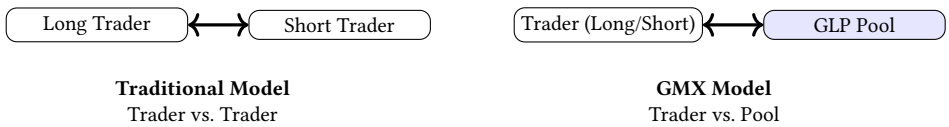


Fig. 5. Comparison of the counterparty risk model in a traditional order book exchange versus GMX's pooled liquidity model.

This model is highly capital-efficient because all assets are in one pool, creating deep liquidity and allowing for large trades with zero slippage. Pricing is determined not by an order book but by reliable external oracles (like Chainlink), which protects the system from the kind of price manipulation seen in AMM-based exchanges.