Lesson 40: Electronic Trading and Orders

Module 4: Traditional Digital Finance

Digital Finance Course

2025

Learning Objectives

- Understand electronic order types and routing mechanisms
- Analyze order book dynamics and matching algorithms
- Examine price-time priority and market structure
- Evaluate dark pools and alternative trading venues
- Assess regulatory frameworks for electronic trading

Evolution of Trading Technology

Historical Progression:

- **Open Outcry (pre-1990s):** Physical trading floors
- **Screen-Based (1990s):** SETS, XETRA introduction
- **Direct Market Access (2000s):** Broker bypass
- **Algorithmic Trading (2010s):** Automated execution
- **Low Latency (2020s):** Microsecond competition

Technology Drivers:

- Electronic communication networks (ECNs)
- FIX protocol standardization (1992)
- Co-location and proximity hosting
- FPGA and custom hardware acceleration
- Market fragmentation across venues

Key Milestone: NASDAQ becomes fully electronic in 1994, NYSE follows with Hybrid Market in 2006

Understanding history helps predict future developments in the technology.

Electronic Trading System Architecture

Core Components:

- **Order Management System (OMS):** Portfolio-level order creation
- **Execution Management System (EMS):** Routing and execution
- **Smart Order Router (SOR):** Venue selection logic
- **Market Data Handler:** Real-time price feeds
- **Risk Manager:** Pre-trade compliance

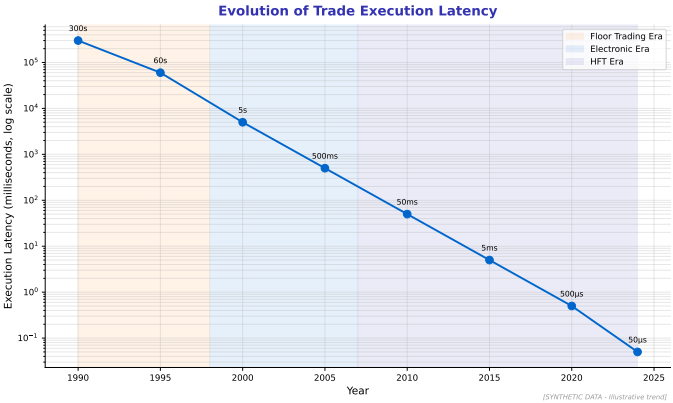
Modern systems process millions of orders per second with 99.999% availability

Latency Benchmarks:

- Order entry to exchange: 100-500 microseconds
- Matching engine processing: 10-50 microseconds
- Market data dissemination: 50-200 microseconds
- Round-trip execution: 200-1000 microseconds
- Co-located vs remote: 10x latency difference

Electronic trading has transformed market structure and efficiency.

Trading Latency Benchmarks



Latency optimization is critical for competitive advantage in electronic markets.

Basic Order Types

Market Orders:

- Execute immediately at best available price
- Guarantee execution, not price
- Consume liquidity (aggressive)
- Pay taker fee (typically 0.003-0.005%)
- Risk: slippage in volatile markets

Limit Orders:

- Execute only at specified price or better
- Provide liquidity (passive)
- Receive maker rebate (0.001-0.002%)
- Risk: non-execution

Stop Orders:

- Become market/limit order when trigger hit
- Stop-loss: sell below current price
- Stop-buy: buy above current price
- Used for risk management and breakout strategies

Execution Example:

- Stock trading at $100.00
- Limit buy at $99.50: waits for price drop
- Stop-loss at $98.00: sells if price falls
- Market sell: executes immediately at best bid

Key concepts from this slide inform practical applications in finance.

Advanced Order Types

Time-in-Force Instructions:

- **GTC (Good Till Cancelled):** Active until filled or cancelled
- **DAY:** Expires at market close
- **IOC (Immediate or Cancel):** Execute available, cancel rest
- **FOK (Fill or Kill):** Complete fill or cancel entire order
- **GTD (Good Till Date):** Active until specified date

Conditional Orders:

- **Iceberg/Hidden:** Display portion, hide balance
- **Pegged:** Price tracks market (mid-point peg)
- **Discretionary:** Price improvement range
- **All-or-None:** Execute full size or nothing
- **Minimum Quantity:** Require minimum fill size

Iceberg orders typically display 10-20% of total size to minimize market impact

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Algorithmic Order Types

VWAP (Volume-Weighted Average Price):

- Target: match daily volume profile
- Slices order across trading day
- Benchmark: VWAP $= \sum(P_i \times V_i) / \sum V_i$
- Typical duration: full trading session
- Use case: large passive orders

TWAP (Time-Weighted Average Price):

- Equal-sized slices over time
- Ignores volume patterns
- Simpler, more predictable
- Risk: adverse selection if volume spikes

Implementation Shortfall:

- Minimize difference vs decision price
- Balances market impact and timing risk
- Aggressive when price favorable
- Passive when price adverse

Participation Rate (POV):

- Target: fixed % of market volume
- Typical range: 5-20% participation
- Adapts to volume fluctuations
- Risk: extended execution in low volume

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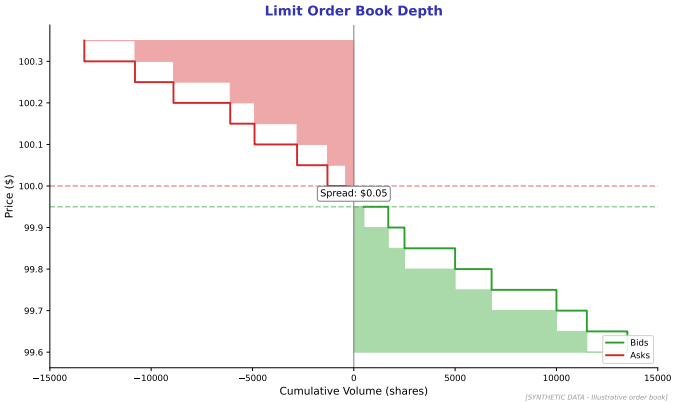
Order Book Visualization



Order book depth reveals supply and demand dynamics at each price level.

Electronic Order Book Structure

Order Book Components:

- **Bid Side:** Buy orders ranked by price (descending)
- **Ask Side:** Sell orders ranked by price (ascending)
- **Spread:** Difference between best bid and ask
- **Depth:** Quantity at each price level
- **Mid-Price:** (Best Bid + Best Ask) / 2

Example Order Book:

Bids		Asks	
Size	Price	Price	Size
500	99.98	100.02	300
800	99.97	100.03	600
1200	99.96	100.04	400

Spread = \$0.04 (4 cents or 4 bps)

Order Book Metrics:

- **Quoted Spread:** Ask - Bid
- **Effective Spread:** $2 \times$ —Trade Price - Mid—
- **Realized Spread:** Effective spread minus adverse selection
- **Order Book Imbalance:** (Bid Vol - Ask Vol) / Total
- **Depth Imbalance:** Predictive signal for price movement

Liquidity Indicators:

- Volume at top 5 levels
- Average quoted spread (daily)
- Order arrival/cancellation rates

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Price-Time Priority Matching

Matching Algorithm:

1. **Price Priority:** Best prices matched first
2. **Time Priority:** Within price level, oldest order first
3. **Display Priority:** Visible orders before hidden (some venues)
4. **Size Priority:** Rare, used in some Asian markets

Example Execution:

- Time 09:00:00 - Limit buy 500 at $100.00
- Time 09:00:05 - Limit buy 300 at $100.00
- Time 09:00:10 - Market sell 400
- *Result:* First 400 from 09:00:00 order filled, 100 remains

Alternative Mechanisms:

- **Pro-Rata:** Size-proportional allocation (Eurex)
- **FIFO with LMM:** Lead market maker priority (some options)
- **Random Selection:** Anti-latency mechanism (IEX D-Peg)
- **Batch Auction:** Periodic clearing (opening/closing)

Queue Position Value:

- Early position in queue = higher fill probability
- Incentivizes speed competition
- Queue jumping via price improvement
- Drives investment in low-latency infrastructure

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Order Book Dynamics and Toxicity

Order Flow Toxicity:

- **Informed Trading:** Orders contain price-relevant information
- **Adverse Selection:** Market makers lose to informed traders
- **VPIN (Volume-Synchronized PIN):** Toxicity measure
- **Order Imbalance:** Predictive of short-term price moves

VPIN Calculation:

$$\text{VPIN} = \frac{|\sum \text{Buy Volume} - \sum \text{Sell Volume}|}{\text{Total Volume}}$$

High VPIN (¿0.8) signals elevated informed trading risk

Market Maker Response:

- Widen spreads when toxicity increases
- Reduce quoted depth
- Increase order cancellation rates
- Temporarily withdraw liquidity

Resilience Metrics:

- Order-to-trade ratio: 20:1 to 100:1 typical
- Cancellation rate: 95-98% of orders cancelled
- Book depth recovery time: seconds to minutes
- Flash crash (2010): VPIN spiked to 0.98

Key concepts from this slide inform practical applications in finance.

Smart Order Router (SOR) Architecture

SOR Decision Factors:

- **Displayed Liquidity:** Visible order book depth
- **Fill Probability:** Historical fill rates by venue
- **Latency:** Network and execution speed
- **Fees/Rebates:** Maker/taker economics
- **Price Improvement:** Mid-point or better execution
- **Market Impact:** Venue size and anonymity

Routing Strategies:

- **Top-of-Book:** Route to best displayed price
- **Sweep:** Send to multiple venues simultaneously
- **Sequential:** Try venues in priority order
- **Hidden Liquidity Seeking:** Ping dark pools first
- **Smart Posting:** Become passive liquidity provider

Typical SOR evaluates 20-50 venues in under 100 microseconds, routing to top 3-5 destinations

Key concepts from this slide inform practical applications in finance.

Venue Fragmentation and Best Execution

US Equity Market Structure (2024):

- 16 public exchanges (Nasdaq, NYSE, CBOE BZX, etc.)
- 30+ dark pools (40-50% of volume)
- Wholesalers (Citadel, Virtu): 40-45% retail flow
- Market share: Nasdaq 15%, NYSE 12%, off-exchange 50%

European Market (MiFID II):

- Dark pool volume cap: 8% per venue, 4% instrument-level
- Systematic Internalizers (SIs) disclosure
- Consolidated tape still fragmented (no official CTP)

Best Execution Criteria:

- **Price:** Most important for large institutions
- **Cost:** Total explicit and implicit costs
- **Speed:** Critical for time-sensitive strategies
- **Likelihood of Execution:** Fill rate priority
- **Settlement:** Certainty and timing

Regulatory Requirements:

- Reg NMS (US): National best bid/offer protection
- MiFID II (EU): Best execution reporting
- Quarterly 606 reports: routing practices disclosure

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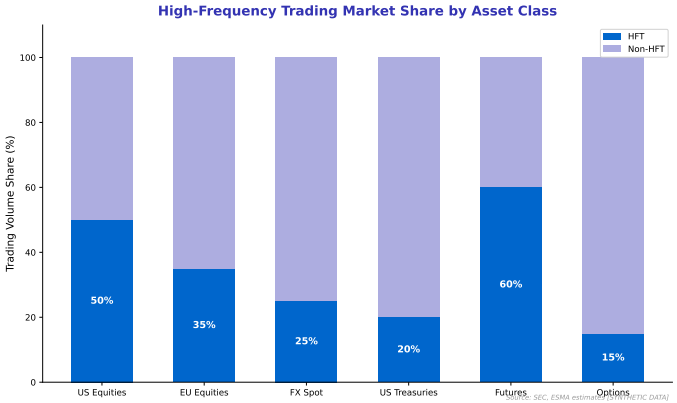
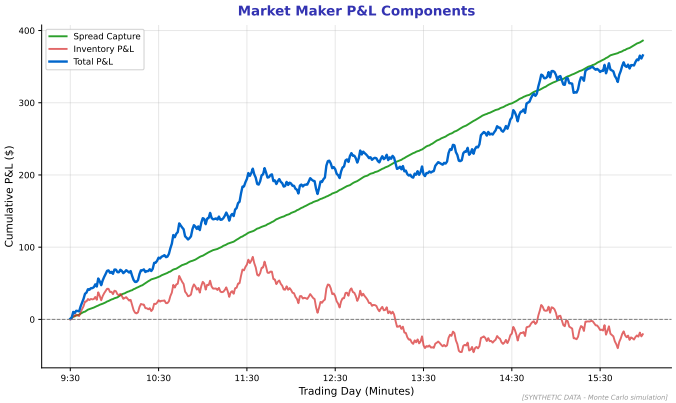
HFT Market Share Evolution



HFT now represents a significant portion of market activity in major venues.

Market Maker Economics



Market makers provide continuous liquidity through bid-ask quotes and rebates.

Dark Pool Types and Mechanics

Dark Pool Categories:

- **Broker-Dealer Owned:** UBS ATS, MS Pool, GS Sigma X
- **Agency Broker:** ITG POSIT, Liquidnet (block focus)
- **Exchange-Owned:** NYSE Midpoint, Nasdaq TRF
- **Electronic Market Makers:** Citadel Connect, Virtu

Execution Mechanisms:

- **Mid-Point Peg:** Execute at NBBO mid-point
- **Periodic Auction:** Batch matching (IEX, Cboe LIS)
- **Conditional Orders:** Minimum size, IOC only
- **No Pre-Trade Transparency:** Orders invisible

Advantages:

- Reduced market impact for large orders
- Price improvement (mid-point execution)
- Information leakage protection
- Lower adverse selection vs lit markets

Disadvantages:

- Lower fill rates (10-30% typical)
- Information asymmetry concerns
- Potential for predatory strategies
- Regulatory scrutiny (MiFID II caps)

Market Share: US dark pool volume: 12-15% (down from 18% pre-2018)

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Alternative Trading Systems (ATS)

ATS Regulatory Framework:

- **SEC Regulation ATS (1998):** Registration and reporting
- **Form ATS:** Operational details disclosure
- **Form ATS-N (2018):** Enhanced transparency
- **Reg SCI:** Systems compliance and integrity
- **CAT (Consolidated Audit Trail):** Order tracking

ATS vs Exchange:

- No self-regulatory organization (SRO) status
- Broker-dealer registration required
- Less stringent listing requirements
- More flexible fee structures

Specialized ATS Models:

- **Block Trading:** Liquidnet (min 10k shares)
- **Retail-Focused:** Off-exchange wholesalers
- **Speed Bumps:** IEX 350-microsecond delay
- **Frequent Batch Auctions:** Anti-HFT design

IEX Innovations (2013):

- Coiled fiber delay (350 microseconds)
- Crumbling quote indicator (prevents stale pricing)
- Discretionary peg (hide spread capture)
- Exchange status granted 2016

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Trading Regulation and Surveillance

Key Regulations:

- **Reg NMS (2005):** Order protection, access, sub-penny rules
- **MiFID II (2018):** Transparency, best execution, algo regulation
- **MAR (2016):** Market abuse detection and reporting
- **Circuit Breakers:** Single-stock (LULD) and market-wide
- **Position Limits:** Derivatives and commodity futures

Surveillance Systems:

- **Pattern Detection:** Layering, spoofing, wash trades
- **Cross-Market:** Equity-derivatives manipulation
- **CAT (Consolidated Audit Trail):** Full order lifecycle
- **Machine Learning:** Anomaly detection algorithms
- **Real-Time Alerts:** Sub-second violation flagging

LULD (Limit Up-Limit Down): Trading halts if price moves exceed % band (5-10% depending on tier and time)

Regulatory frameworks shape adoption patterns and industry structure.

Pre-Trade and Post-Trade Risk Controls

Pre-Trade Risk Checks:

- **Order Price Limits:** % deviation from reference price
- **Order Size Limits:** Max shares/contracts per order
- **Duplicate Orders:** Detect unintended resubmissions
- **Position Limits:** Net and gross exposure caps
- **Notional Limits:** Dollar value thresholds
- **Fat Finger:** Size and price reasonableness checks

Latency Impact: Pre-trade checks add 10-50 microseconds per order

Post-Trade Monitoring:

- **Wash Trade Detection:** Self-matching prevention
- **Marking the Close:** Unusual end-of-day activity
- **Momentum Ignition:** Rapid price manipulation
- **Layering/Spoofing:** Non-bona fide order patterns

Kill Switches:

- Exchange-level: immediate market shutdown
- Broker-level: cancel all active orders
- Client-level: terminate specific trading IDs
- Activation time: under 1 second

Risk management is essential for financial stability and profitability.

Notable Trading Incidents

Flash Crash (May 6, 2010):

- Dow Jones drops 1000 points in minutes
- E-Mini S&P futures selling algorithm trigger
- HFT withdrawal exacerbates liquidity vacuum
- Led to LULD circuit breakers (2012)

Knight Capital (August 1, 2012):

- Software deployment error
- $440 million loss in 45 minutes
- 4 million trades across 154 stocks
- Company near-bankruptcy, acquired by Getco

BATS IPO (March 23, 2012):

- BATS exchange attempts self-listing
- Software bug causes shares to drop from $16 to $0.0002
- IPO withdrawn, exchange embarrassed
- Highlighted exchange technology risks

Lessons Learned:

- Mandatory kill switches (MiFID II/Reg SCI)
- Enhanced testing for algorithm changes
- Circuit breakers at multiple levels
- Real-time position and P&L monitoring

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Summary and Key Takeaways

Core Concepts:

- Electronic trading systems enable microsecond-latency execution
- Order types range from basic (market/limit) to complex (iceberg/algorithmic)
- Price-time priority matching dominates most markets
- Smart order routers optimize across fragmented venues

Market Structure:

- 16 US exchanges + 30+ dark pools
- Dark pools provide 12-15% of equity volume
- Mid-point execution reduces impact for large orders
- Regulatory caps limit dark trading (MiFID II)

Risk and Regulation:

- Pre-trade risk checks prevent erroneous orders
- Circuit breakers halt extreme volatility
- Surveillance systems detect manipulation
- Incidents (Flash Crash, Knight) drive enhanced controls

Technology Trends:

- Latency competition drives infrastructure investment
- Co-location and FPGA acceleration
- Machine learning in routing and surveillance
- Blockchain exploration for settlement (T+0)