Georgia Tech

On the Feasibility of Automating Stock Market Manipulation (LASER Workshop)

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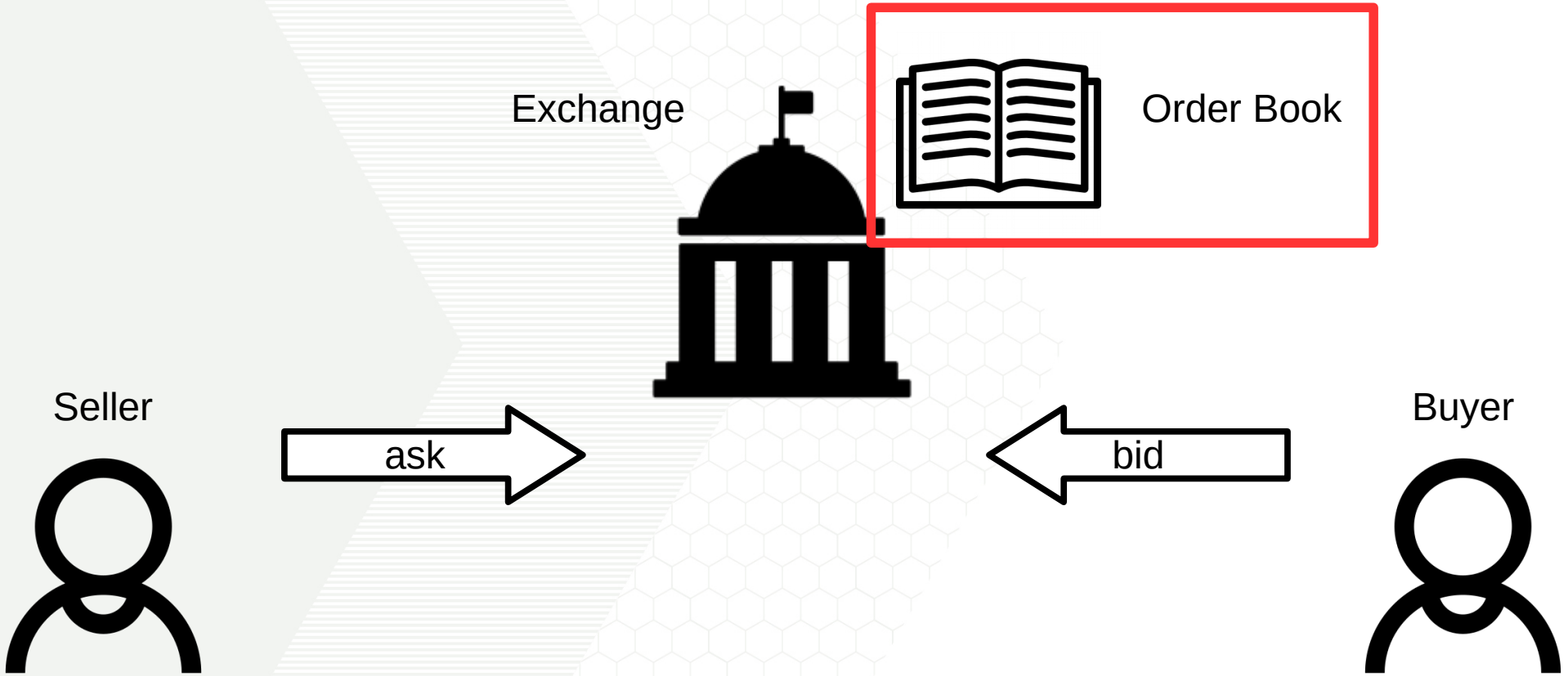
CREATING THE NEXT®

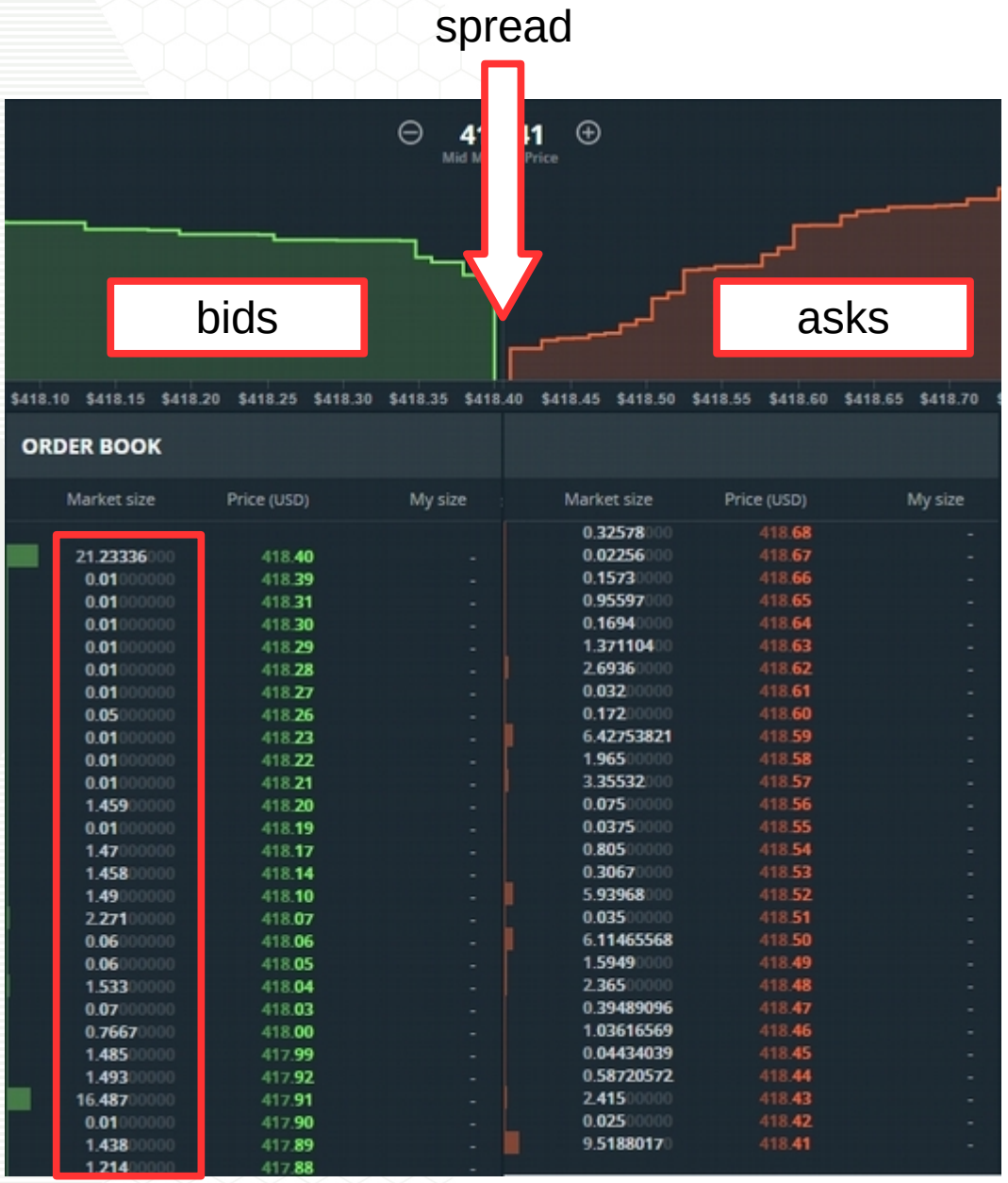
Unknowns of Automated Market Manipulation

- What can bots automate?
- How can they automate, communicate?
- Who will they compromise?
- How will they evade detection?

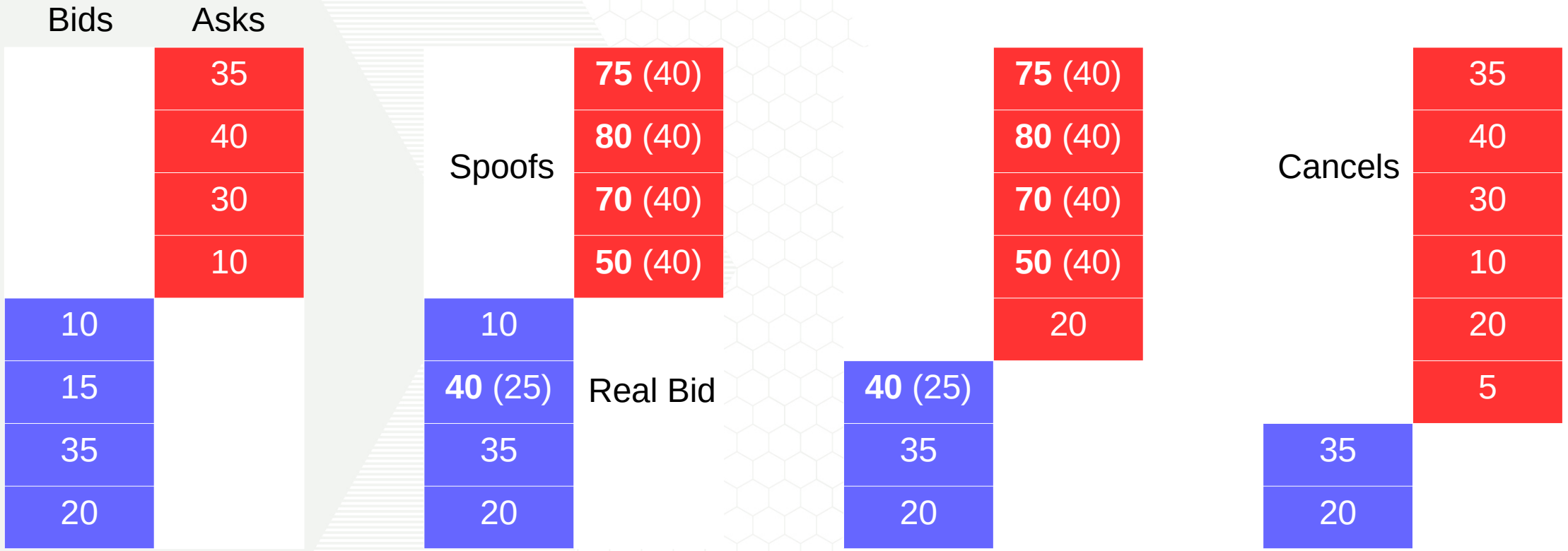
Market Basics (Simplified)



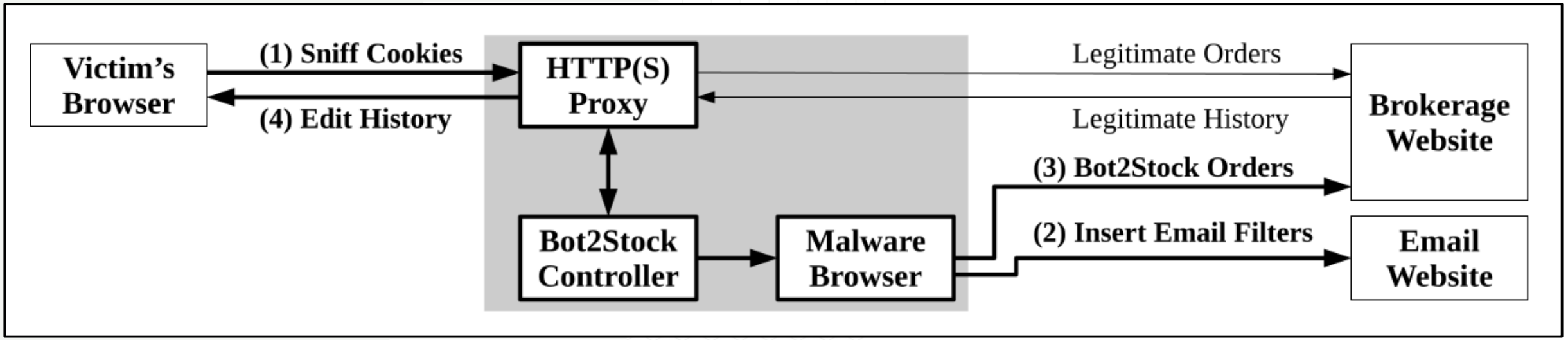
Order Book



Layering



Bot2Stock


Victim's Browser
(1) Sniff Cookies
(4) Edit History
HTTP(S) Proxy
Bot2Stock Controller
Malware Browser
Legitimate Orders
Legitimate History
(3) Bot2Stock Orders
(2) Insert Email Filters
Brokerage Website
Email Website

Evaluation Options

- Real-world attack?
  - Obviously illegal
- Stock-trading game?
  - Uncontrolled variables
  - Still not ethical if other players are human
  - What kind of game?
- “Paper trading” simulation?
  - No slippage

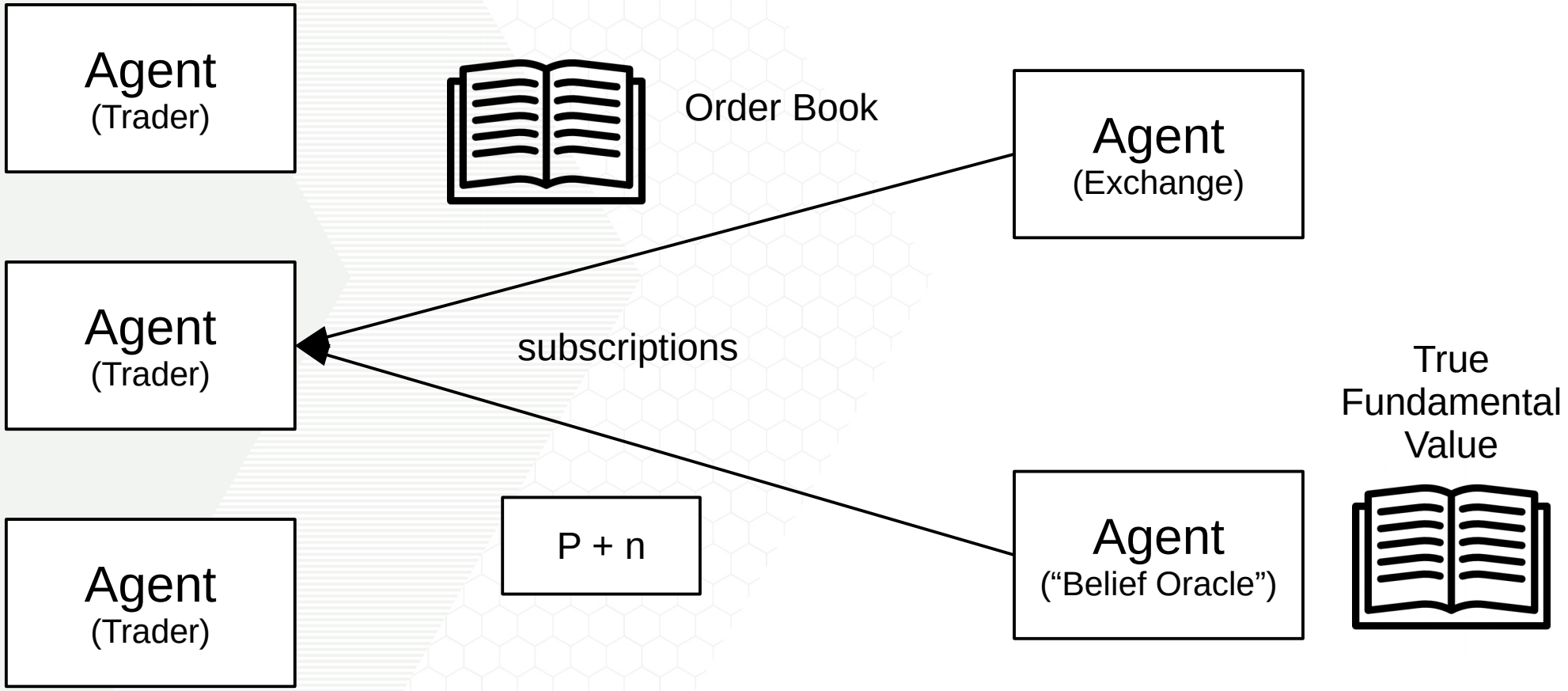
Simulation Plan

- Agent-based simulation
  - Modeling slippage
  - Stock value beliefs
  - Factoring computation, communication

Simulator

- ABIDES: Agent-Based Interactive Discrete Event Simulation environment [Github] [PDF]
  - Developed by Tucker Balch's lab at Georgia Tech
  - Research collaborations with major USA investment banking firm
- **Agent-based:** traders, brokerages, exchanges, dark pools, news websites, belief oracles, etc.
- **Discrete Event Driven:** a kernel delivers messages at discrete time steps, "awakens" agents at predetermined events

Modeling Beliefs



Agent Types

- Oracle
  - Knows the fundamental value of a stock, when asked, returns a noisy reading
- Exchange
  - Maintains order book for 1 stock, receives orders, executes trades, sends subscribers layer info and trade notifications
- Botmaster
  - Buys max shares as attack begins, signals botnet, dumps after fixed time
- Spoofing Agent (Botnet)
  - Maintains an open bid at a price just below the best bid, canceling as needed

Background Traders

- “Spoofing the Limit Order Book: An Agent-Based Model” by Xintong Wang and Michael P. Wellman
- Zero Intelligence Agent (ZI)
  - Randomly buys or sells shares based on current price and fundamental belief
- Heuristic Belief Learning (HBL)
  - Also factors order book: open asks/bids, previously completed transactions

Additional Modeling

- Delay factor: $a + b_{(i, j)} + P(i, j)$
  - i: sender, j: receiver, a: computational delay constant, b: min network latency, P: Poisson distribution (added network latency)

Simulation Timeline

1) Simulation begins
2) Market opens
3) Background traders arrive with Poisson distribution delay
4) Botmaster buys shares
5) Botmaster triggers spoofing agents to begin layering
6) Botmaster sells shares, signals spoofing agents to stop
7) Simulation ends

Experimental Variables

- Ratio bots to background traders
- Network latency of bots vs. background traders

Experimental Design

- Control: background traders, botmaster, no spoofing agents
- Treatment: with spoofing agents
- Trials: 100 control, 100 treatment per configuration
- Configs: 1 to 21 bots, 49 ZI, 16 HBL, 0% to 200% added latency to botnet
- Measurements: Botmaster/spoofing agent cash Δ

Findings

- Attack Duration: < 1 minute
- Network Latency Tolerance: > 200% added (3x)
- Required Trade Volume: 1.5%
- Per-Session ROI: 2.8% ROI
- **Annual ROI: 1022%**

Findings (Cont'd)

- IBM, March 2020: 9,120 shares traded per minute
- 9,120 x 1.5% x Market Price = ~$5,000/session
- 2.8% ROI x 1 session per day x 252 trading days x $100k initial investment
- **Profit: > $1 million**
- **Botnet Loss: Commission Fees**
- **Self-Sustaining**

Discussion

- Factors not modeled
  - Intermediary parties (brokerages, brokers, dark pools)
  - Anomaly detection
  - Background volatility, changing beliefs (e.g., using historical data)
  - Liquidity & designated market makers
- Measuring cash Δ
  - Compare control & treatment *for the same seed*

Resources

- Code: https://github.com/carter-yagemann/bot2stock
- Talk: Thursday, 12 PM EST
- Contact: yagemann@gatech.edu (carteryagemann.com)