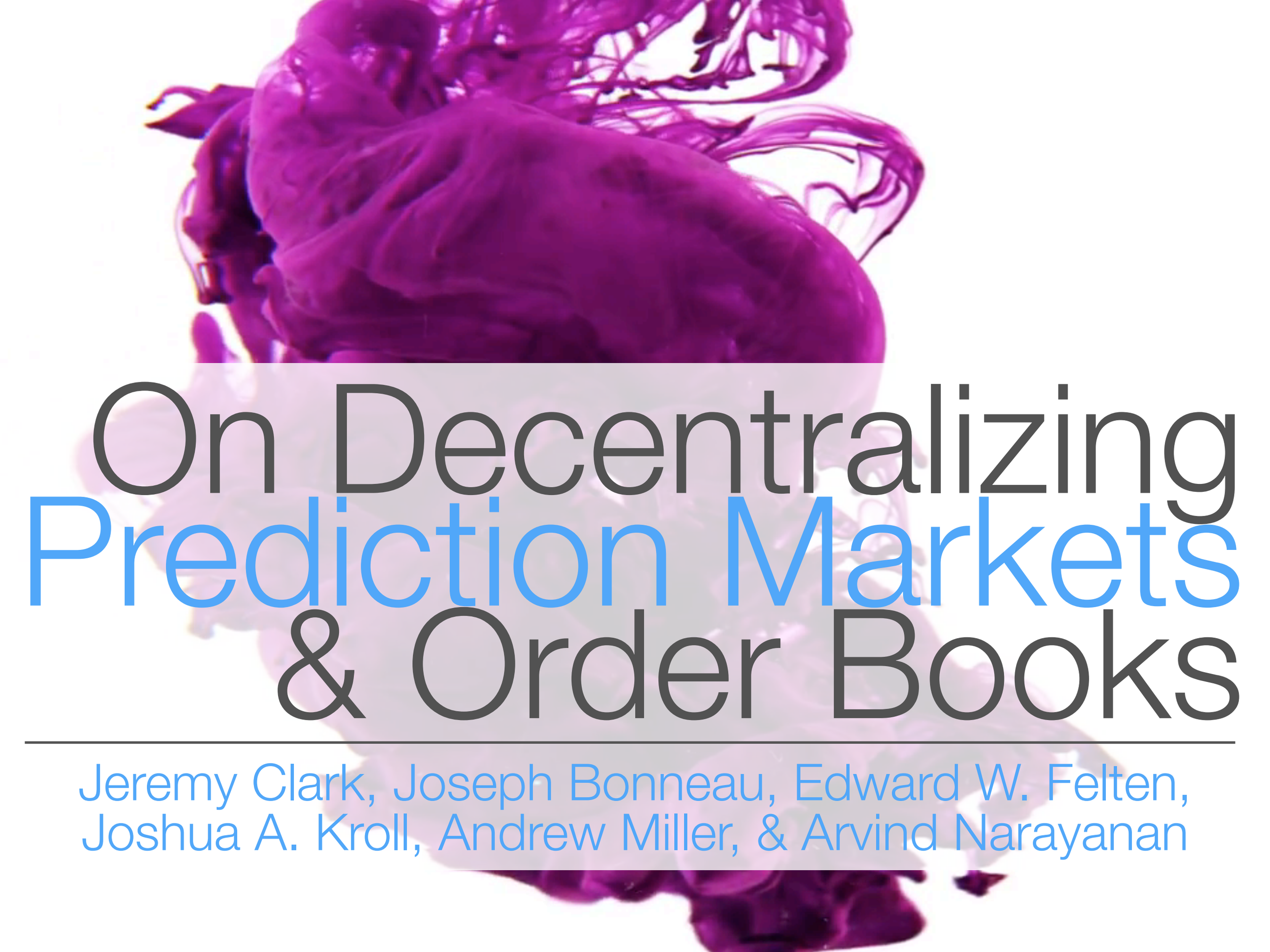


On Decentralizing Prediction Markets & Order Books

Jeremy Clark, Joseph Bonneau, Edward W. Felten,
Joshua A. Kroll, Andrew Miller, & Arvind Narayanan

Remove uncertainty about unknown events

Politics

Sports

Weather

Market Share

Geo-politics

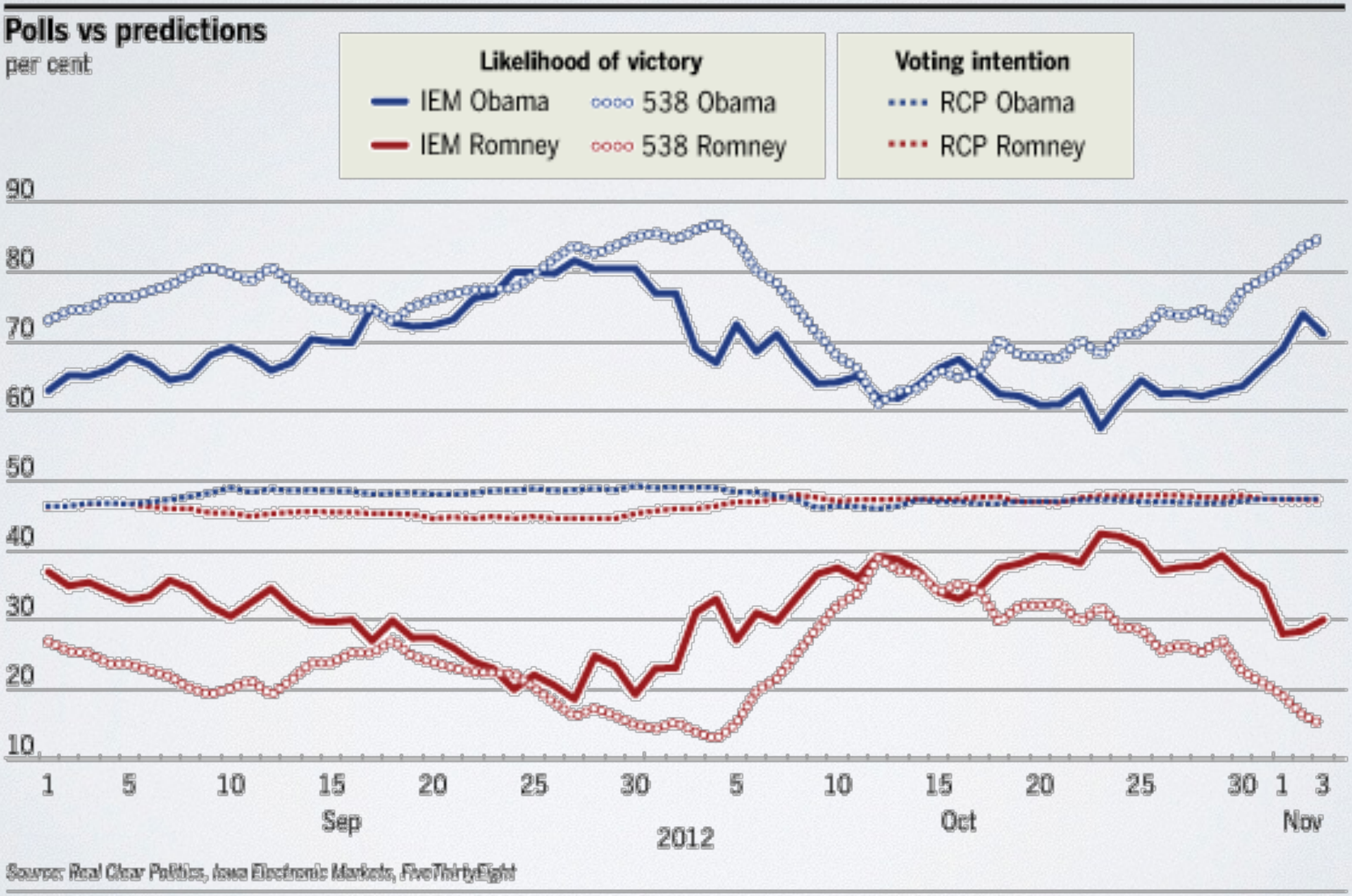
Product Completion

Scientific Discoveries

Sales

Awards

Prediction Markets



Prediction Markets

Obama
Romney
Johnson
Other

Winner: $10
Losers: $0

Prediction Markets

Obama	$6.10	61%		
Romney	$3.80	38%	Winner:	$10
Johnson	$0.09	0.9%	Losers:	$0
Other	$0.01	0.1%		

Prediction Markets

Obama	$6.10
Romney	$3.80
Johnson	$0.09
Other	$0.01

Prediction Markets

Obama	$6.10
Romney	$3.80
Johnson	$0.09
Other	$0.01

Obama -$6.10

Prediction Markets

Obama	$6.10	$7.30
Romney	$3.80	$2.65
Johnson	$0.09	$0.04
Other	$0.01	$0.01

Obama -$6.10

Prediction Markets

Obama	$6.10	$7.30
Romney	$3.80	$2.65
Johnson	$0.09	$0.04
Other	$0.01	$0.01

Obama -$6.10 +$7.30

Prediction Markets

Obama	$6.10	$7.30
Romney	$3.80	$2.65
Johnson	$0.09	$0.04
Other	$0.01	$0.01

Obama

-$6.10 +$7.30 = $1.20

Prediction Markets

Obama	$6.10	$7.30
Romney	$3.80	$2.65
Johnson	$0.09	$0.04
Other	$0.01	$0.01

Obama

-$6.10 +$7.30 = $1.20

Immediately Realized

Prediction Markets

Obama	$6.10	$7.30
Romney	$3.80	$2.65
Johnson	$0.09	$0.04
Other	$0.01	$0.01

Romney | Johnson | Other

-$2.70 = $2.65 + $0.04 + $0.01

Prediction Markets

Obama	$6.10	$7.30	$6.40
Romney	$3.80	$2.65	$3.53
Johnson	$0.09	$0.04	$0.06
Other	$0.01	$0.01	$0.01

Romney | Johnson | Other

-$2.70

Prediction Markets

Obama	$6.10	$7.30	$6.40
Romney	$3.80	$2.65	$3.53
Johnson	$0.09	$0.04	$0.06
Other	$0.01	$0.01	$0.01

Romney | Johnson | Other

-$2.70 +$3.60 = $0.90

Prediction Markets

Obama	$6.10	$7.30	$6.40
Romney	$3.80	$2.65	$3.53
Johnson	$0.09	$0.04	$0.06
Other	$0.01	$0.01	$0.01

Romney | Johnson | Other

-$2.70

Prediction Markets

Obama	$6.10	$7.30	$6.40
Romney	$3.80	$2.65	$3.53
Johnson	$0.09	$0.04	$0.06
Other	$0.01	$0.01	$0.01

Romney | Johnson | Other | Obama

-$2.70 -$6.40

Prediction Markets

Obama	$6.10	$7.30	$6.40
Romney	$3.80	$2.65	$3.53
Johnson	$0.09	$0.04	$0.06
Other	$0.01	$0.01	$0.01

Romney | Johnson | Other | Obama

-$2.70 -$6.40 +$10.00 = $0.90

Decentralization

Decentralization

Centralized Market:

- Money escrowed
- Shares escrowed
- Proprietary markets
- Match orders
- Vendor lock-in
- Adjudicate outcome
- Go offline
- Potentially transparent
- High fees

Decentralized Market:

- Hold your own money
- Hold your own shares
- Choose any market
- Open order matching
- Use any exchange
- Trust agility
- Fault tolerant
- Transparent by design
- Low fees

Decentralization

Centralized Market:

- Money escrowed
- Shares escrowed
- Popular markets
- Match orders
- Exchange lock-in
- Adjudicate outcome
- Easily disrupted
- Transparent by choice
- High fees

Decentralized Market:

- Hold your own money
- Hold your own shares
- Choose any market
- Open order matching
- Use any exchange
- Trust agility
- Fault tolerant
- Transparent by design
- Low fees

Decentralization

Bitcoin

Bitcoin

K_A K_B

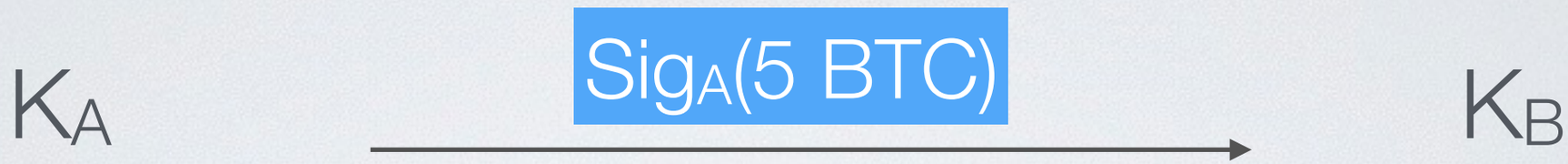
Bitcoin

K_A K_B

From	*To*	*Amount*
K	K	10 BTC
K	K	5 BTC
K	K	18 BTC

Ledger

Bitcoin

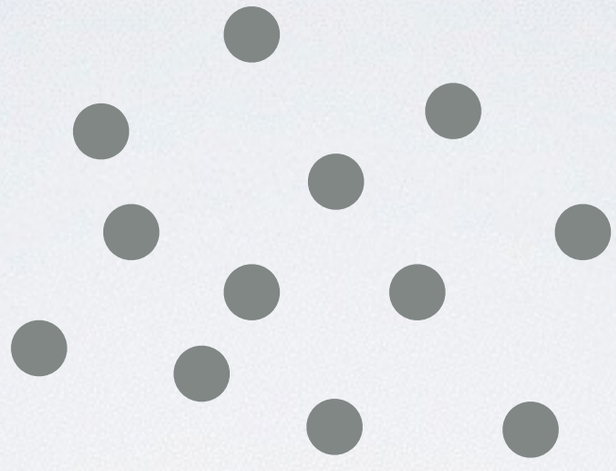


From	*To*	*Amount*
K	K	10 BTC
K	K	5 BTC
K	K	18 BTC
K	K	5 BTC

Ledger

K_A → T-9833

K_B



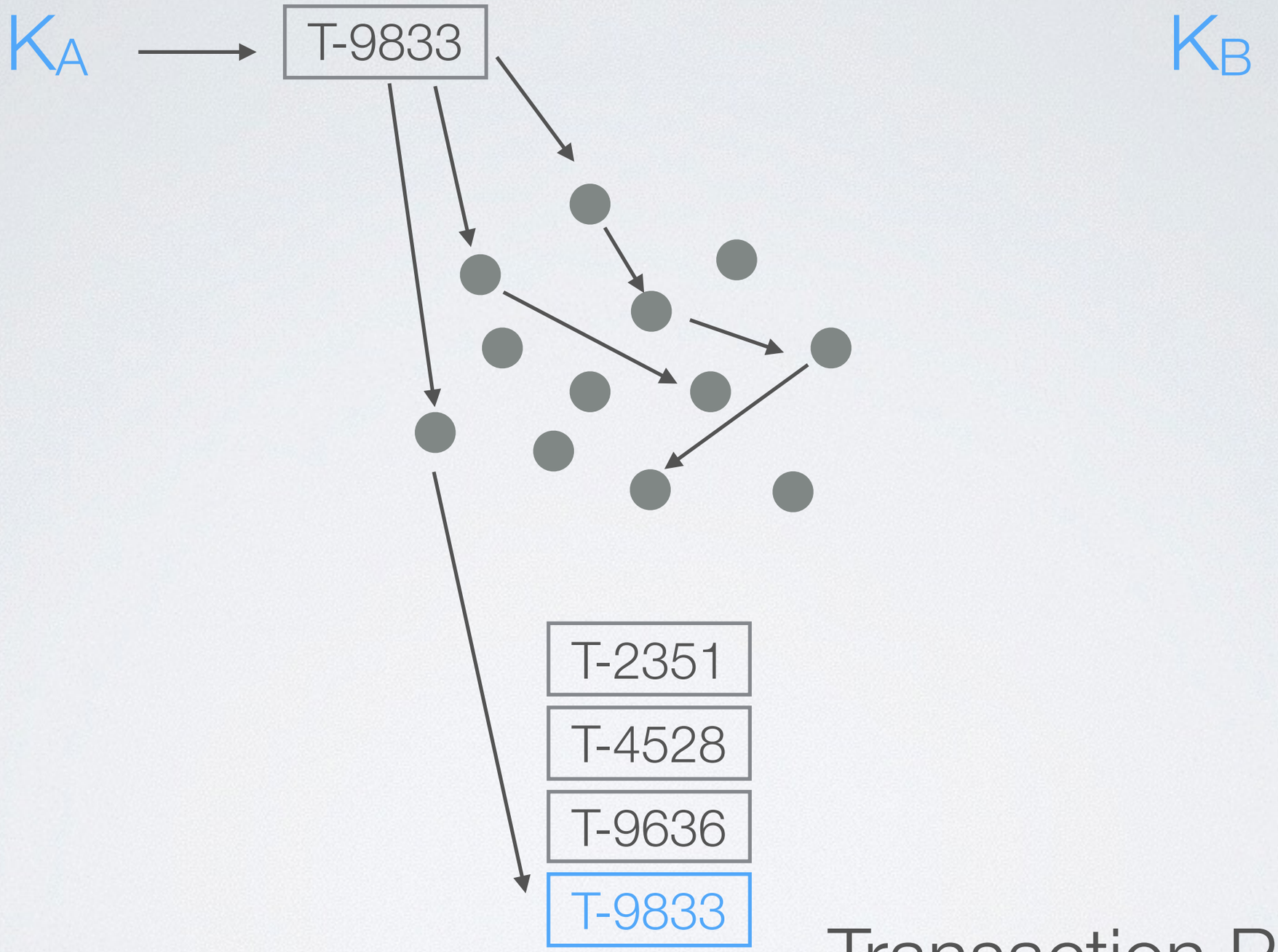
Miners

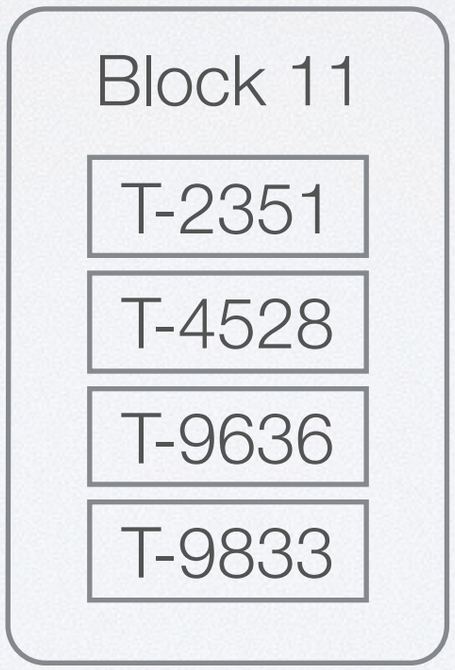
T-2351

T-4528

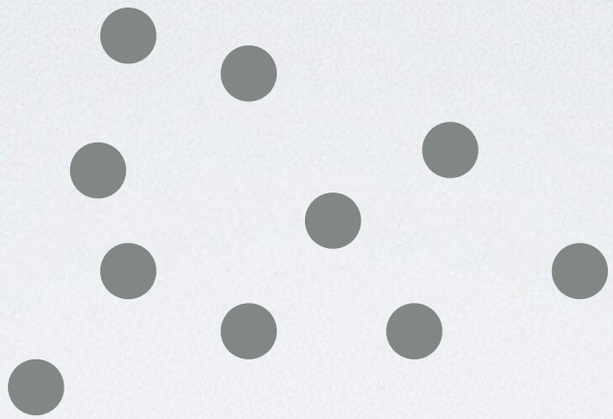
T-9636

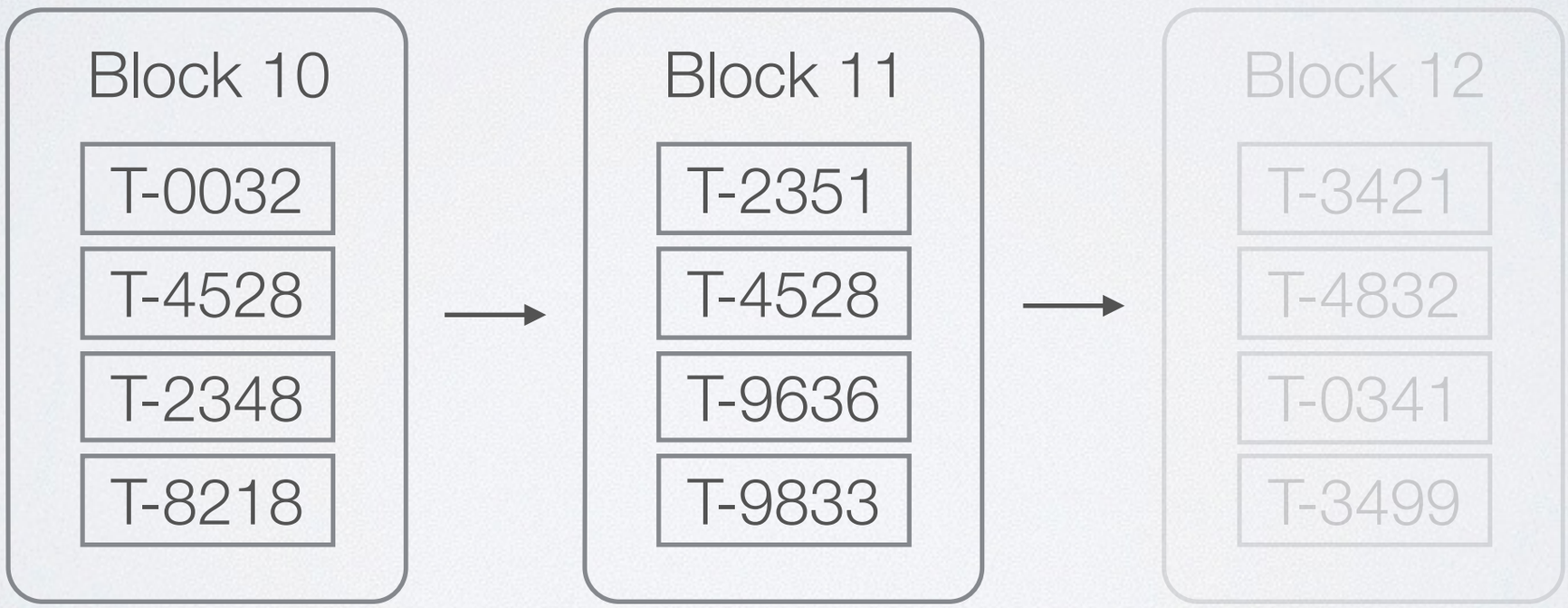
T-9833


K_A
T-9833
K_B
T-2351
T-4528
T-9636
T-9833
Transaction Pool



Ledger




Block 10
T-0032
T-4528
T-2348
T-8218
Block 11
T-2351
T-4528
T-9636
T-9833
Block 12
T-3421
T-4832
T-0341
T-3499

Ledger

Design Decisions

Underlying digital currency & block chain

- Extend Bitcoin
- Altcoin (XFT)
- Colored Coins

Design Decisions

How to Declare a Winner:

- Machine-readable feed
- Trusted (human) arbiter
- Miners vote
- Users vote

Design Decisions

How to Declare a Winner:

- Machine-readable feed
- Trusted (human) arbiter
- Miners vote
- Users vote

Threats:

- Wrong decision -> profitable
- No decision -> DoS

Design Decisions

How to Declare a Winner:

- Machine-readable feed
- Trusted (human) arbiter
- Miners vote
- Users vote

Arbiters:

- Choose who you trust (agility)
- Low barrier to entry
- History & external reputation
- Trustworthiness built into price

Design

New Operations (Simplified)

- OpenMarket( ) Description & Arbiter, signed by arbiter
- CloseMarket( ) Outcome, signed by arbiter

Design

New Operations (Simplified)

- OpenMarket( ) Description & Arbiter, signed by arbiter
- CloseMarket( ) Outcome, signed by arbiter

- BuyPortfolio( ) Convert 1 XFT into complete set of shares, signed by currency holder
- SellPortfolio( ) Convert complete set for 1 XFT, signed by share holder

Design

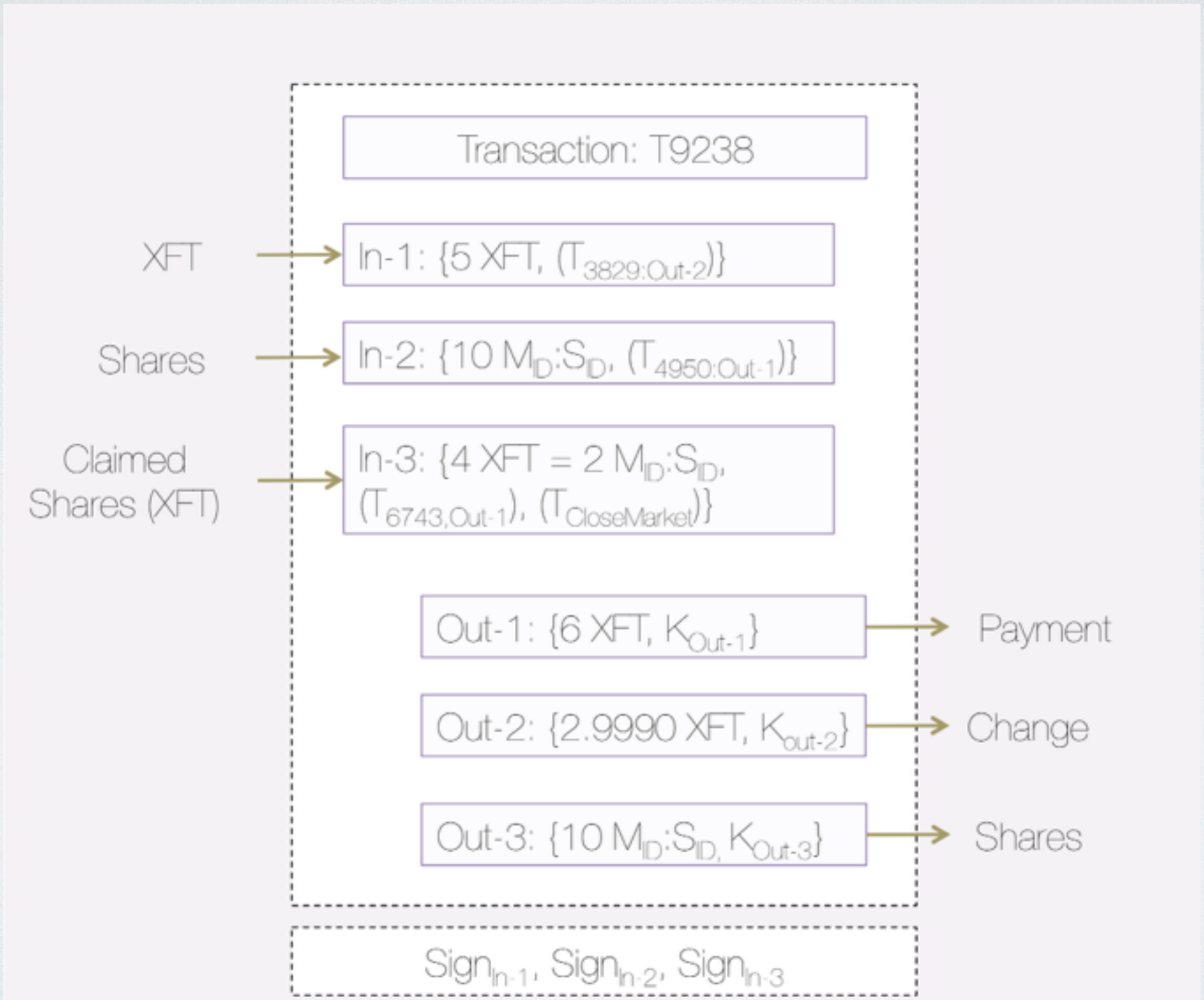
New Operations (Simplified)

- OpenMarket( ) Description & Arbiter, signed by arbiter
- CloseMarket( ) Outcome, signed by arbiter

- BuyPortfolio( ) Convert 1 XFT into complete set of shares, signed by currency holder
- SellPortfolio( ) Convert complete set for 1 XFT, signed by share holder

- Exchange( ) Exchange shares for XFT between two parties, signed by both parties

Design


Transaction: T9238
XFT
In-1: {5 XFT, ($T_{3829:Out-2}$)}
Shares
In-2: {10 M_{ID}:S_{ID}, ($T_{4950:Out-1}$)}
Claimed Shares (XFT)
In-3: {4 XFT = 2 M_{ID}:S_{ID}, ($T_{6743,Out-1}$), ($T_{CloseMarket}$)}
Out-1: {6 XFT, K_{Out-1}}
Payment
Out-2: {2.9990 XFT, K_{out-2}}
Change
Out-3: {10 M_{ID}:$S_{ID,}$ K_{Out-3}}
Shares
$Sign_{In-1}$, $Sign_{In-2}$, $Sign_{In-3}$

Order Book

Most common: continuous, price-time priority

Broadcast orders to Bitcoin-style network:

- Nodes drop competitive orders
- No way to establish time
- Blockchain: updated in batches
- Miners drop competitive orders
- Miners front-run well-priced orders

Order Book

- Nodes drop competitive orders
- No way to establish time
- Blockchain: updated in batches
- Miners drop competitive orders
- Miners front-run well-priced orders

The best we can + support external exchanges

Order Book

- Nodes drop competitive orders
- No way to establish time
- Blockchain: updated in batches
- Miners drop competitive orders
- Miners front-run well-priced orders

Broadcast to all known neighbours

Order Book

- Nodes drop competitive orders
- No way to establish time
- Blockchain: updated in batches
- Miners drop competitive orders
- Miners front-run well-priced orders

Call Market: Market opens, orders pile up, randomly close market, match orders

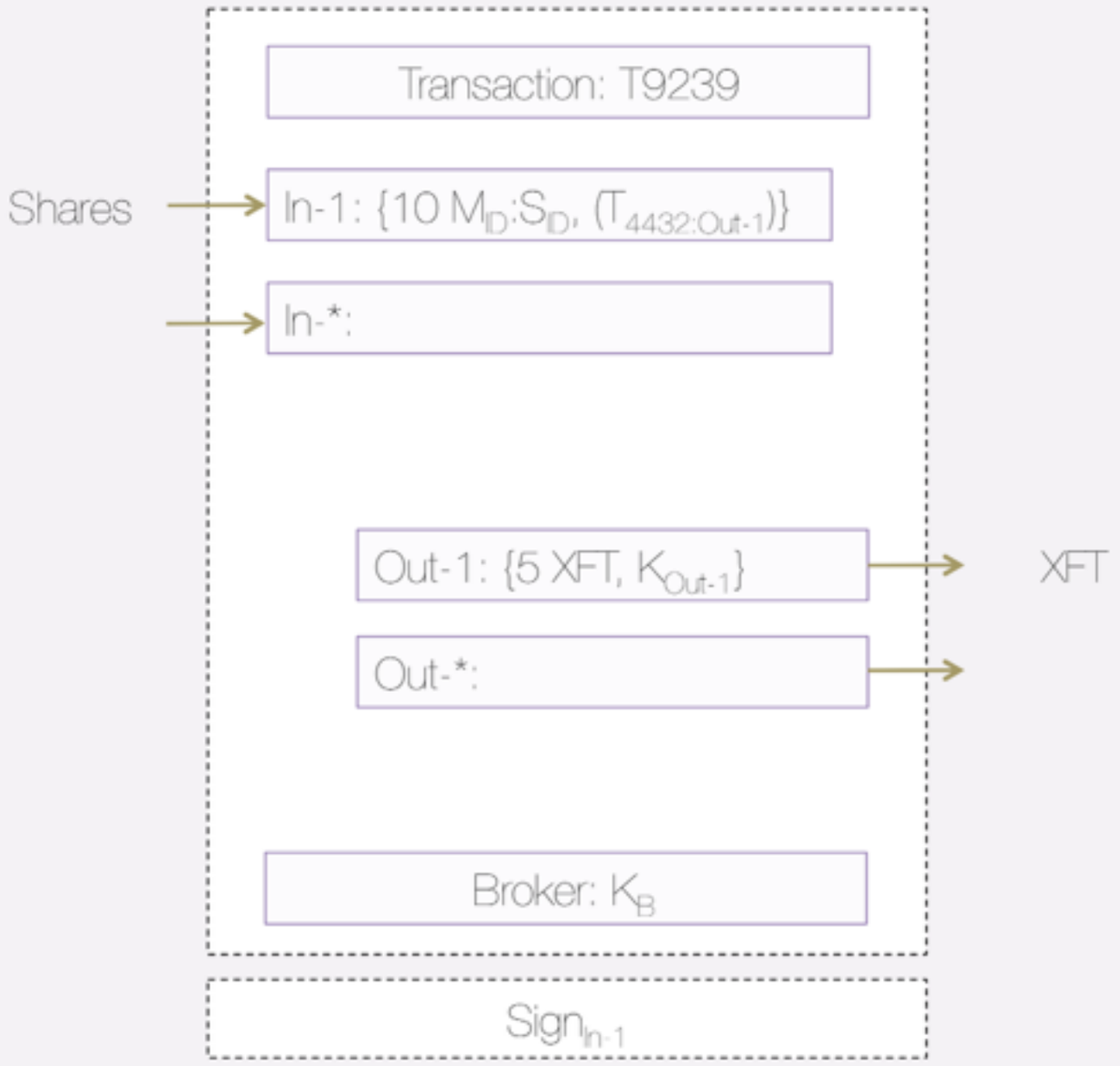
Matching: Lowest ask matched to highest bid until no more matching possible

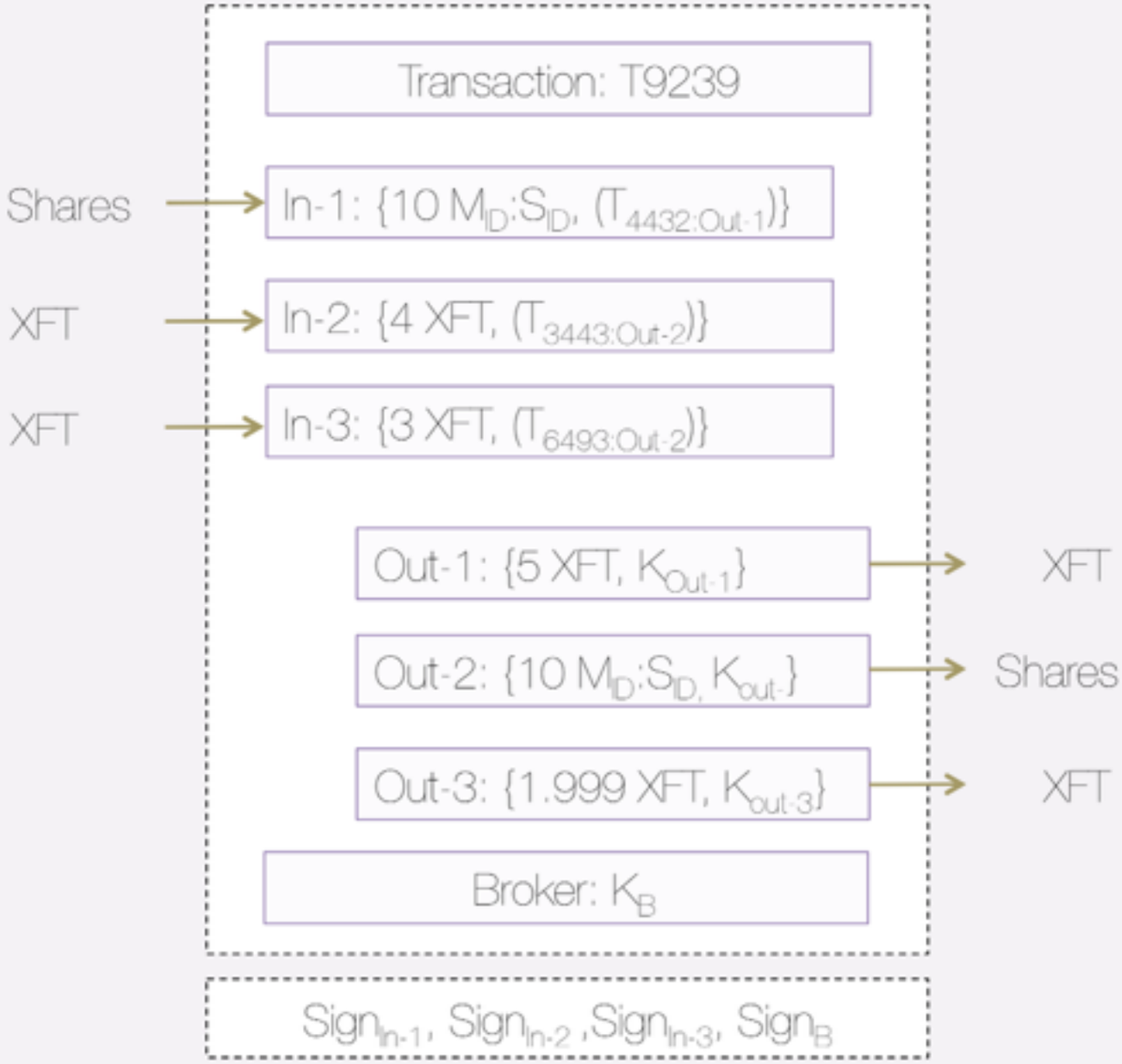
Order Book

- Nodes drop competitive orders
- No way to establish time
- Blockchain: updated in batches
- Miners drop competitive orders
- Miners front-run well-priced orders

Miners keep spread: spreads can replace fees & miners can execute at best price (added perk)

Order Book


Transaction: T9239
Shares
In-1: {10 M_{ID}:S_{ID}, ($T_{4432:Out-1}$)}
In-*:
Out-1: {5 XFT, K_{Out-1}}
XFT
Out-*:
Broker: K_B
$Sign_{In-1}$


Transaction: T9239
Shares
In-1: {10 M_{ID}:S_{ID}, ($T_{4432:Out-1}$)}
XFT
In-2: {4 XFT, ($T_{3443:Out-2}$)}
XFT
In-3: {3 XFT, ($T_{6493:Out-2}$)}
Out-1: {5 XFT, K_{Out-1}}
XFT
Out-2: {10 M_{ID}:S_{ID}, K_{out}}
Shares
Out-3: {1.999 XFT, K_{out-3}}
XFT
Broker: K_B
$Sign_{In-1}$, $Sign_{In-2}$, $Sign_{In-3}$, $Sign_B$

Discussion

Design landscape, not a specific proposal

Regulatory issues: not attempting regulatory avoidance

Platform for other financial exchanges

Not suitable for forecasts about underlying currency

Questions?

@PulpSpy
@josephbonneau
@EdFelten
@realjoshkroll
@socrates1024
@random_walker


FOX