Bazaar: Strengthening user reputations in online marketplaces

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Online marketplaces

Online marketplaces:

Sites allowing users to buy/sell goods

Among most successful Web sites

E.g., eBay, Overstock, Amazon Marketplace

eBay alone: $60B in 2009

Allows buyers and sellers to connect

Regardless of location

Enable esoteric products to find a market

Democratized commerce

But, known to suffer from fraud

Identities and reputations

Sites support reputations for identities
- Feedback from others interacted with
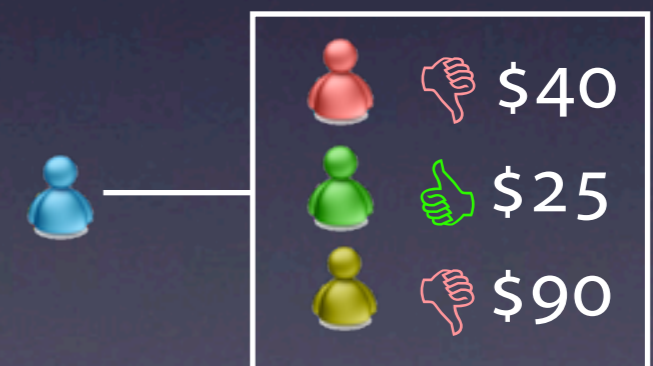
Buyers use reputations
- Reputable sellers get better prices

Feedback profile

Complicating detail:
- Accounts often "free" to create
- Requires only solving CAPTCHA
- Can be used to defraud…

Feedback profile

Manipulating reputations for fraud

Feedback profile

👤	👍	$2
👤	👍	$5
👤	👍	$1

Can create identities to

Whitewash (erase bad behavior)

Collude (with other attackers)

Sybil attacks (create multiple accounts)

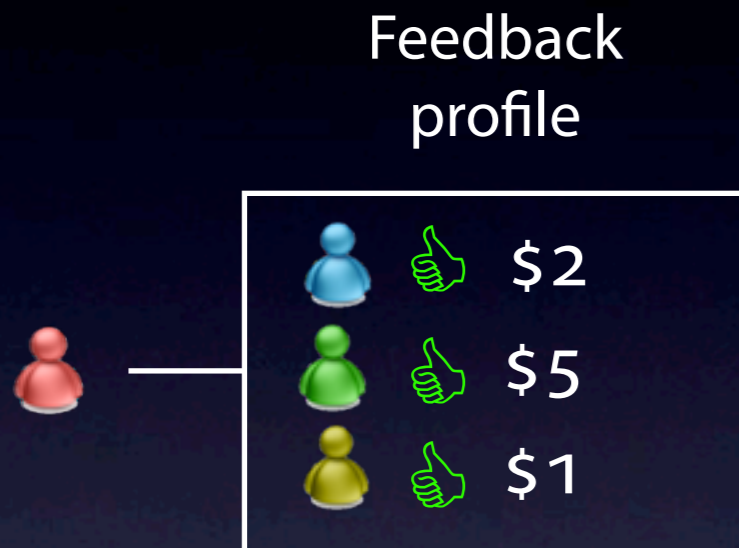Can observe fraud taking place

Search for "positive feedback guaranteed"

Undermines usefulness of marketplace

Significant monetary losses

Recent arrest of malicious user

Stole $717K from 5,000 users

Used >250 accounts

Manipulating reputations for fraud

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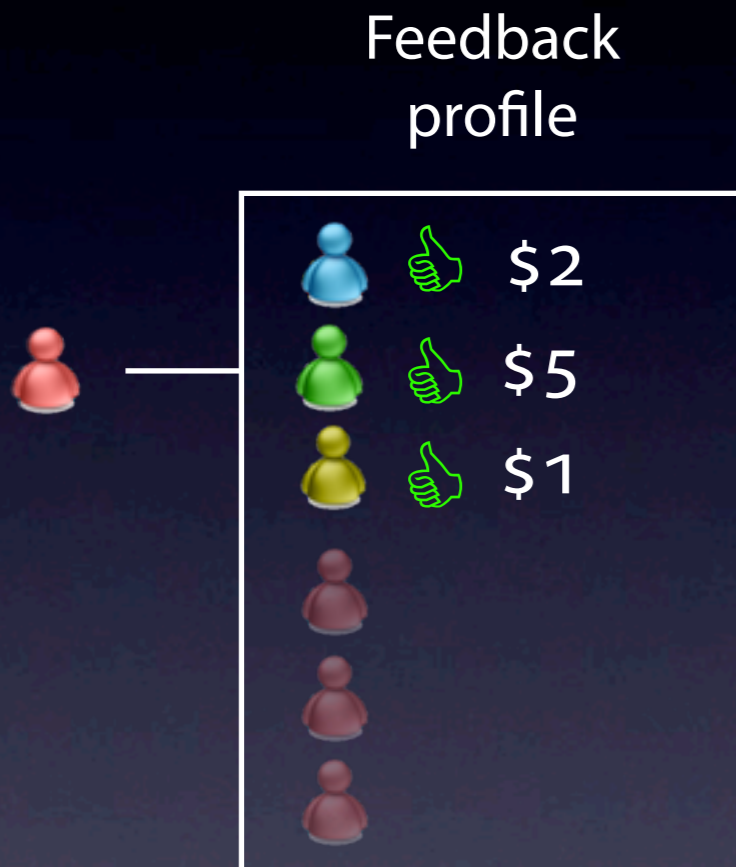Can observe fraud taking place

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👤	👍	$300
👤	👍	$90
👤	👍	$50

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Alternate approaches

Make joining difficult
  Limits applicability, usefulness

Using brokers, escrow
  Only feasible for expensive items

Requiring in-person transaction
  Restricts buyer/seller population

Providing insurance
  Spreads cost of fraud to all users

Others in paper...

Bazaar: A new approach

New approach to strengthening user reputations
  Provides strong bounds on fraud

Works in conjunction with existing marketplace
  Assumes same feedback system as today
  No additional monetary cost
  No strong identities

Insight: Successful transactions represent shared risk
  Buyer and seller more likely to enter into future transactions

Outline

1. ~~Motivation~~

2. Bazaar design

3. Challenges faced

4. Evaluation

Risk network

Reputations calculated using risk network

Buyer satisfied → two identities linked
  Weighted by amount of transaction
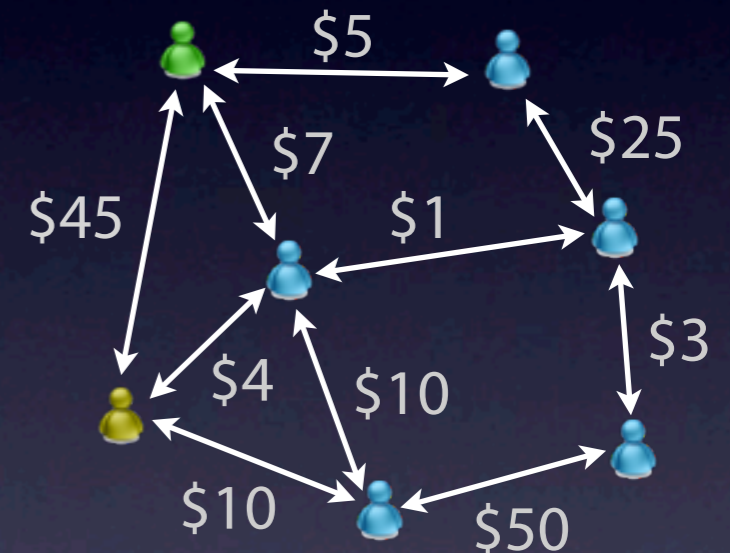 Multiple transactions additive

Risk network automatically generated
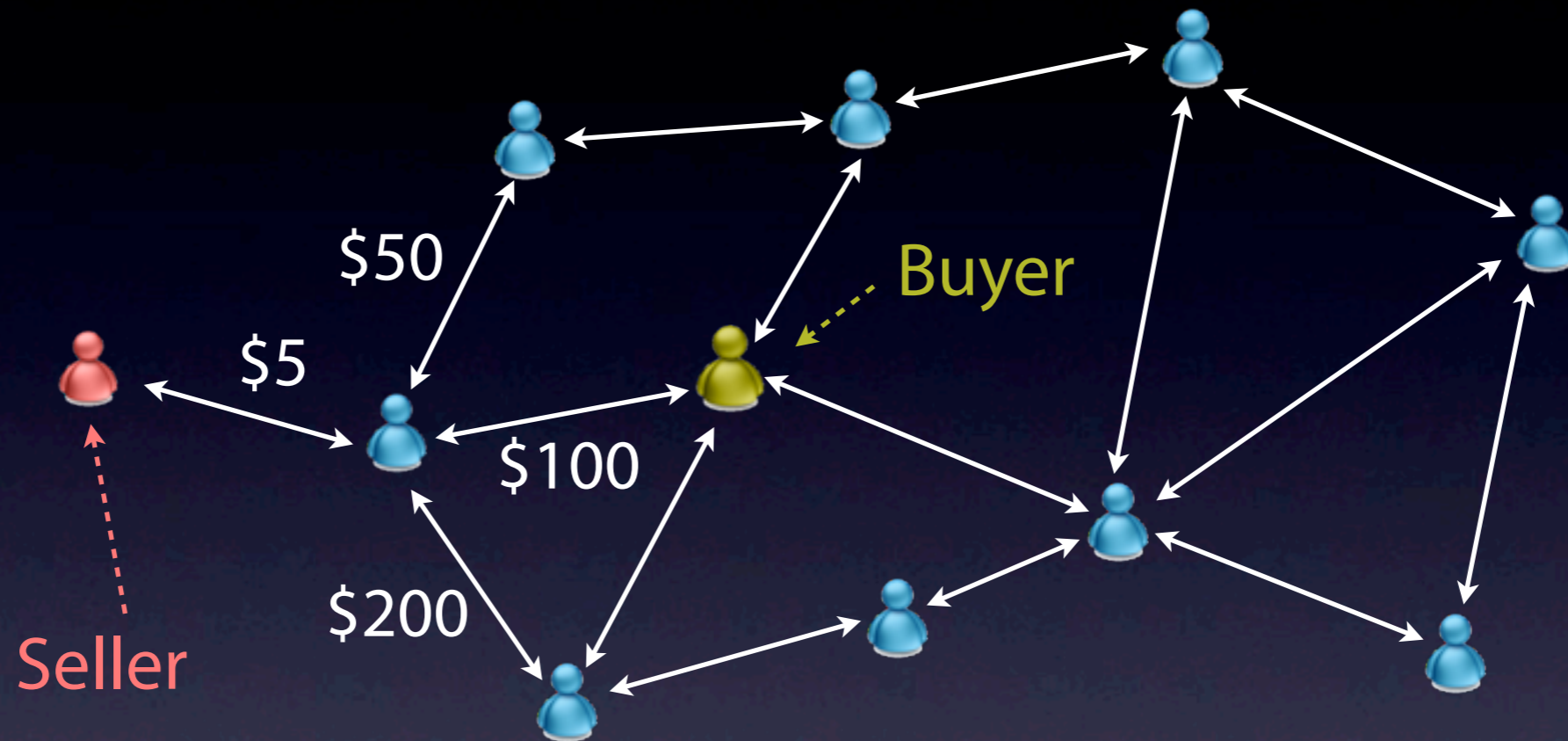 Users need not even know about it
  Site operator maintains risk network

Can be used to gauge risk between identities
  Model: Query Bazaar before purchase

$5

$25

$7

$45

$1

$3

$4

$10

$10

$50

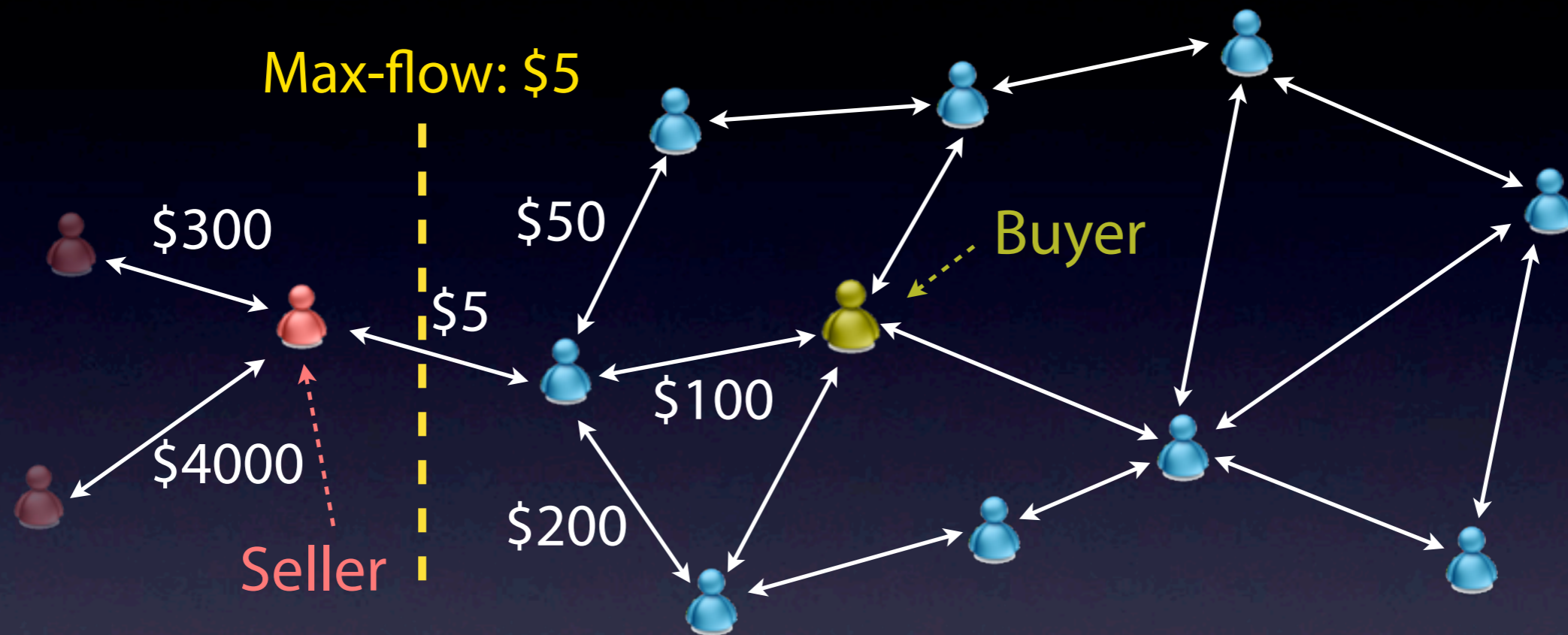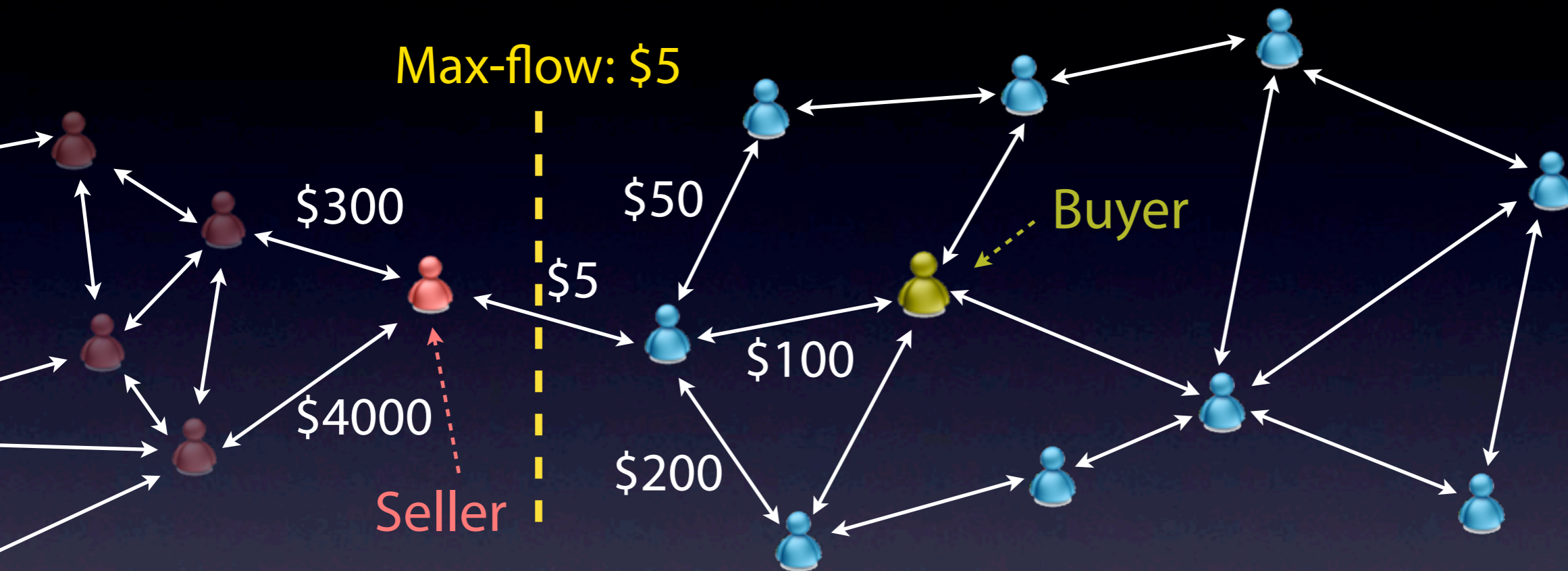# Fraud detection with max-flow

$50

$5

$100

$200

Buyer

Seller

Site operator queries Bazaar before purchase
Bazaar calculates max-flow between buyer and seller

If max-flow lower than potential transaction, flag as fraudulent
Otherwise, wait for feedback from buyer

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Fraud detection with max-flow

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Fraud detection with max-flow

Max-flow: $5

$300

$50

Buyer

$5

$100

Seller

$4000

$200

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Fraud detection with max-flow

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Handling feedback

$5 $100

Transaction amount: $4

Original state
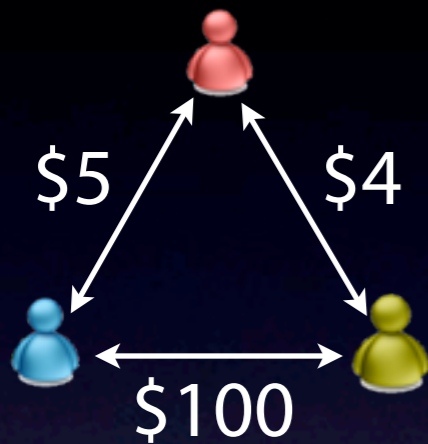
Modify risk network when buyer provides feedback

Positive: Create new link

Neutral: Make no changes

Negative: Remove flow from network

Malicious sellers punished if they defraud

Handling feedback

$5 $4

$100

Positive feedback

$5 $100
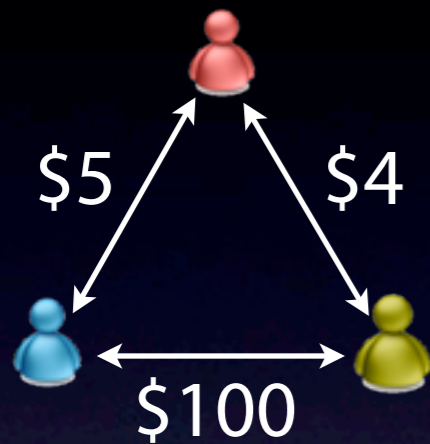
Original state

Transaction amount: $4

Modify risk network when buyer provides feedback

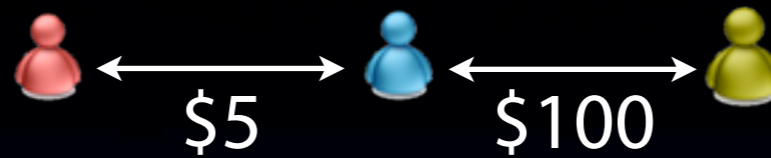   Positive: Create new link

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Handling feedback

$5 $4

$100

Positive feedback

$5 $100

Original state

Transaction amount: $4

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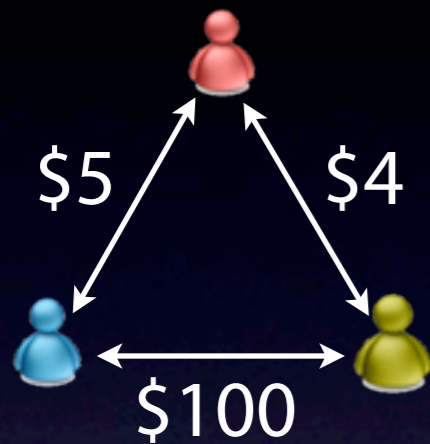
Neutral feedback

Modify risk network when buyer provides feedback
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Handling feedback

$5 $100   Transaction amount: $4

Original state

$5 $4

$100

Positive feedback

$5 $100

Neutral feedback

$1 $96

Negative feedback

Modify risk network when buyer provides feedback
Positive: Create new link
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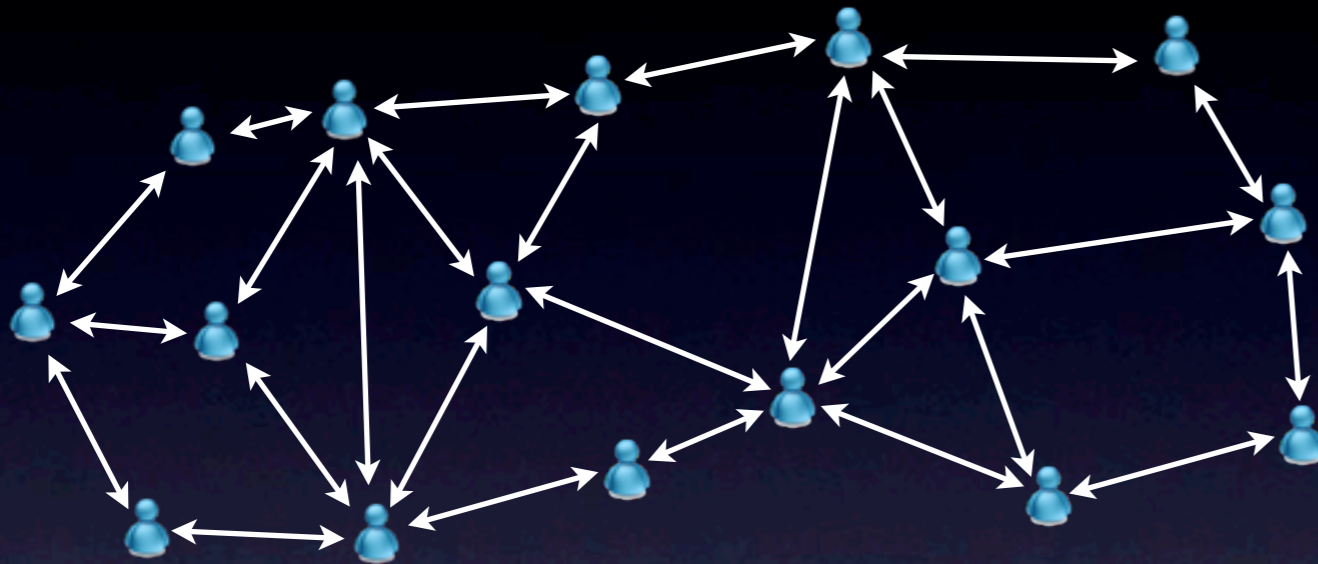
Malicious sellers punished if they defraud

Guarantees
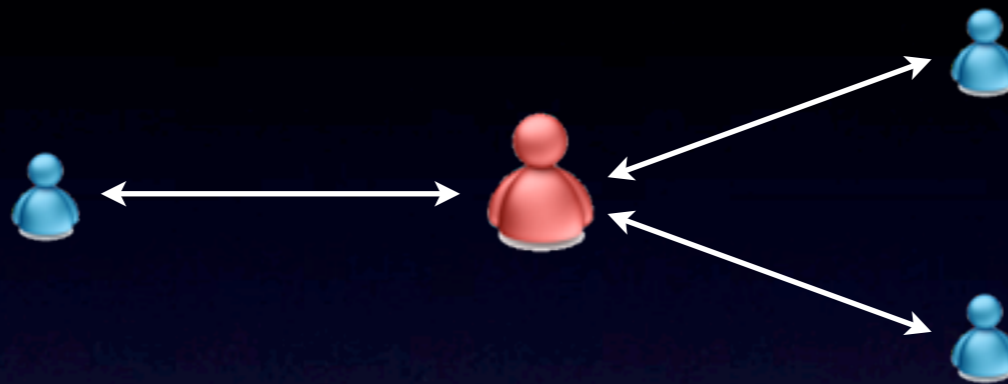
What is the per-user bound on defrauding?

Link weight

$$\sum_{l \in L} w_l$$

Set of risk
network links
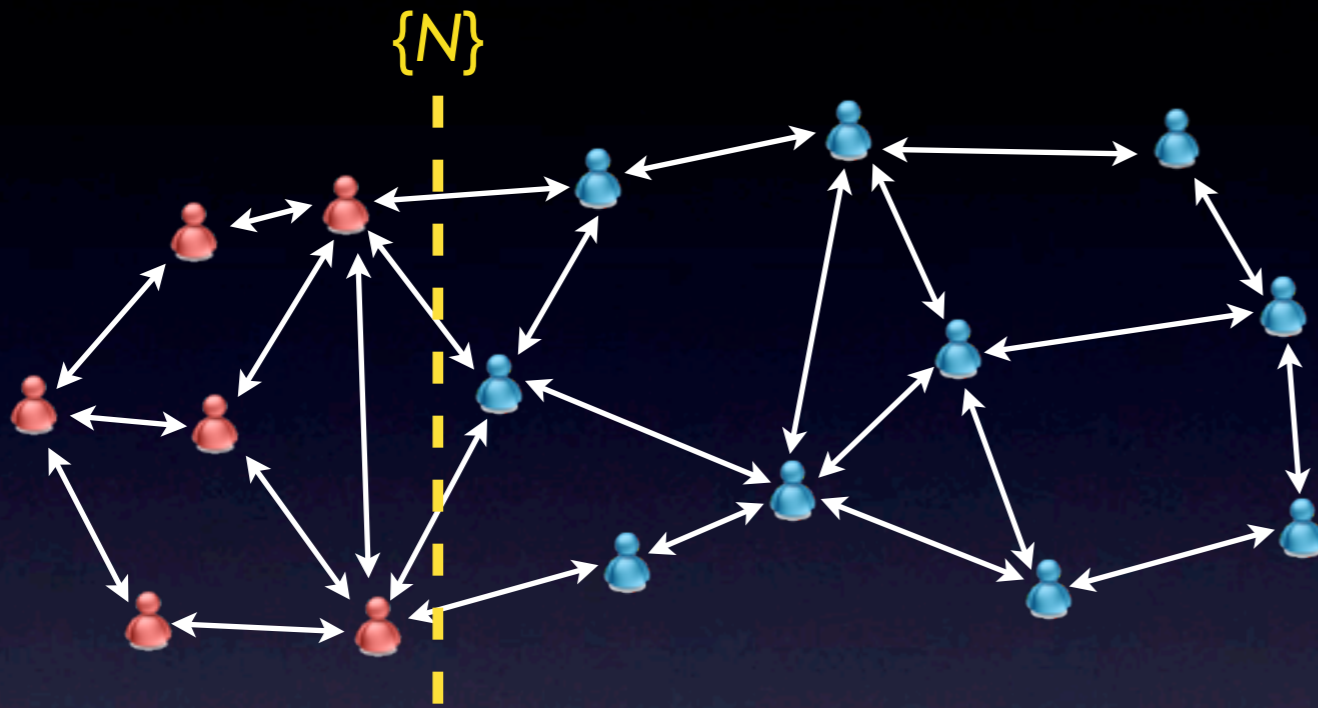
Guarantees for groups

$$\sum_{l \in N} w_l$$

Analysis is same for any subgraph

Only way to defraud more: Participate in real transactions
   Provides bound on fraud

Result: Collusion, Sybil attacks, white-washing doesn't help

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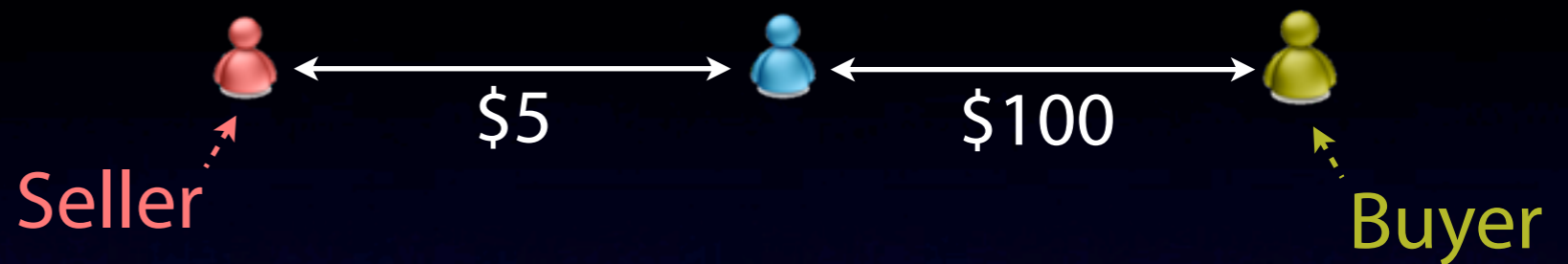
Outline

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Challenge 1: Feedback delay

Transaction amount: $4

Seller $5 $100   Buyer

Buyer cannot immediately determine if fraudulent

Could be used as "window of vulnerability"
    Malicious seller could defraud many users quickly
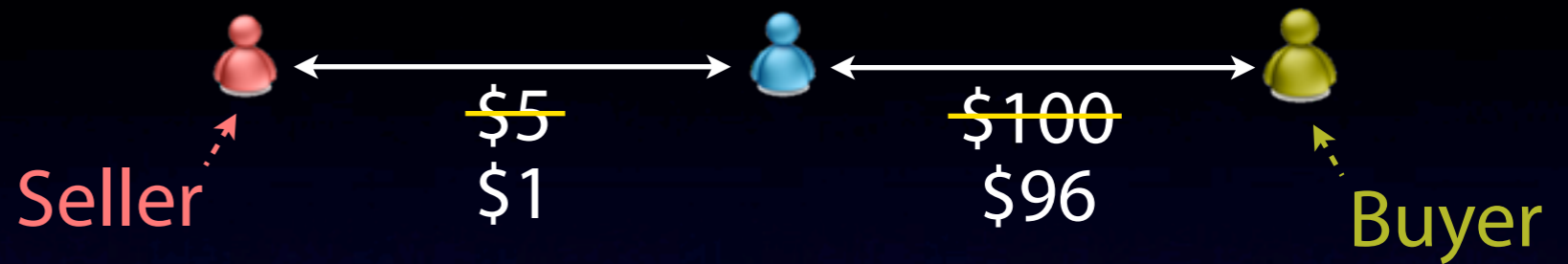
Address by putting credit "on hold"
    Set of paths with flow equal to transaction amount
    Cannot be used by any other transactions
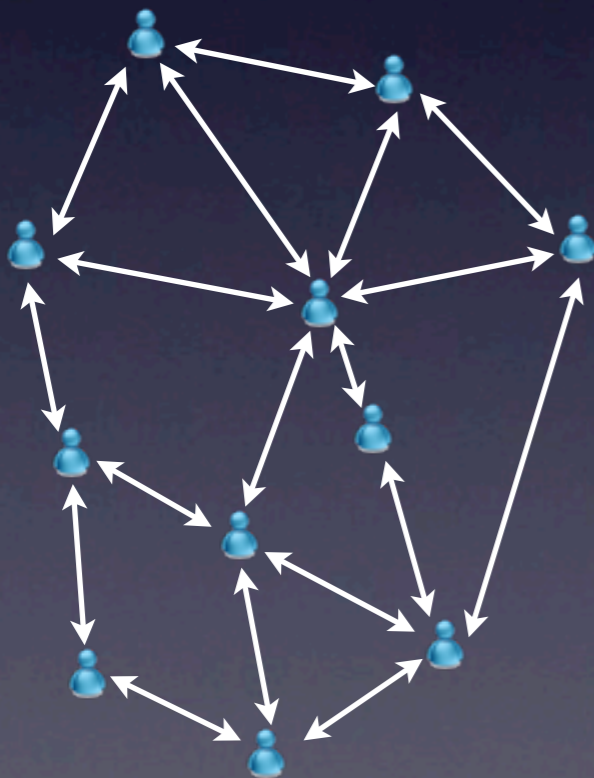   Restore if positive/neutral feedback received

Challenge 1: Feedback delay

Transaction amount: $4

Seller

~~$5~~
$1

~~$100~~
$96

Buyer

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Challenge 2: Bootstrapping

New users have zero max-flow

How to securely bootstrap new users?

New user

Option 1: Use social network

Users can "vouch" for friends, create links
Put their own links at risk

Option 2: Provide link escrow service
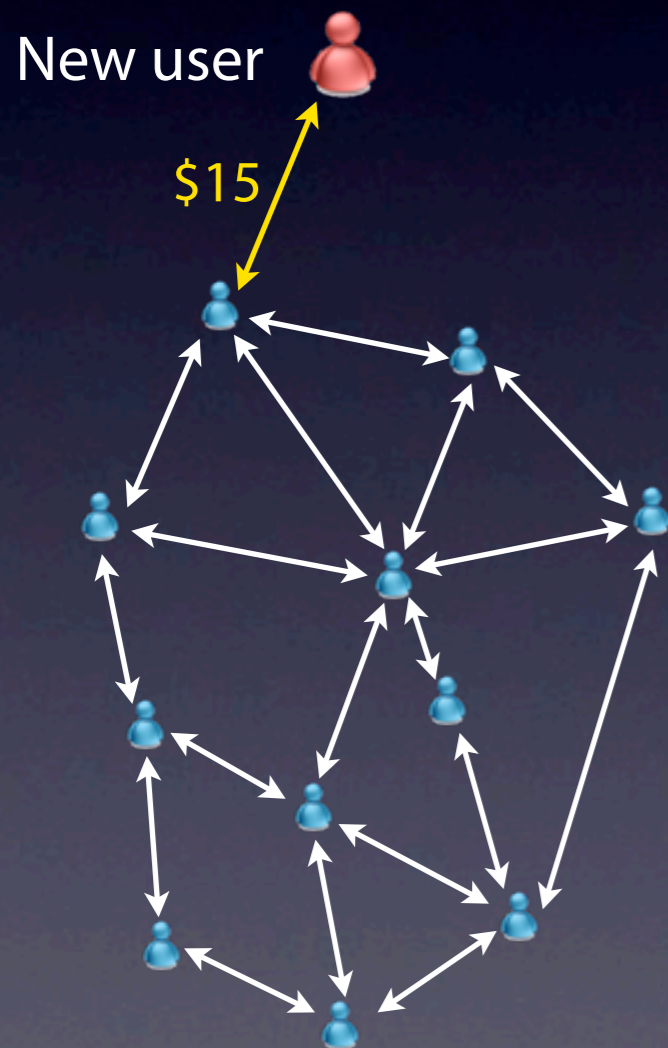
New user "escrows" for links
Can later ask for escrow back
Links removed; no money returned if lost

Challenge 2: Bootstrapping

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$15

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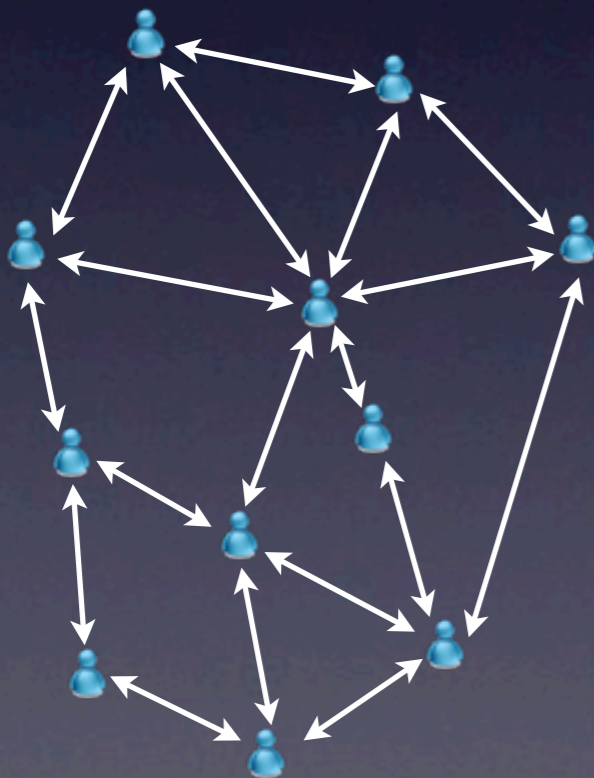Can later ask for escrow back
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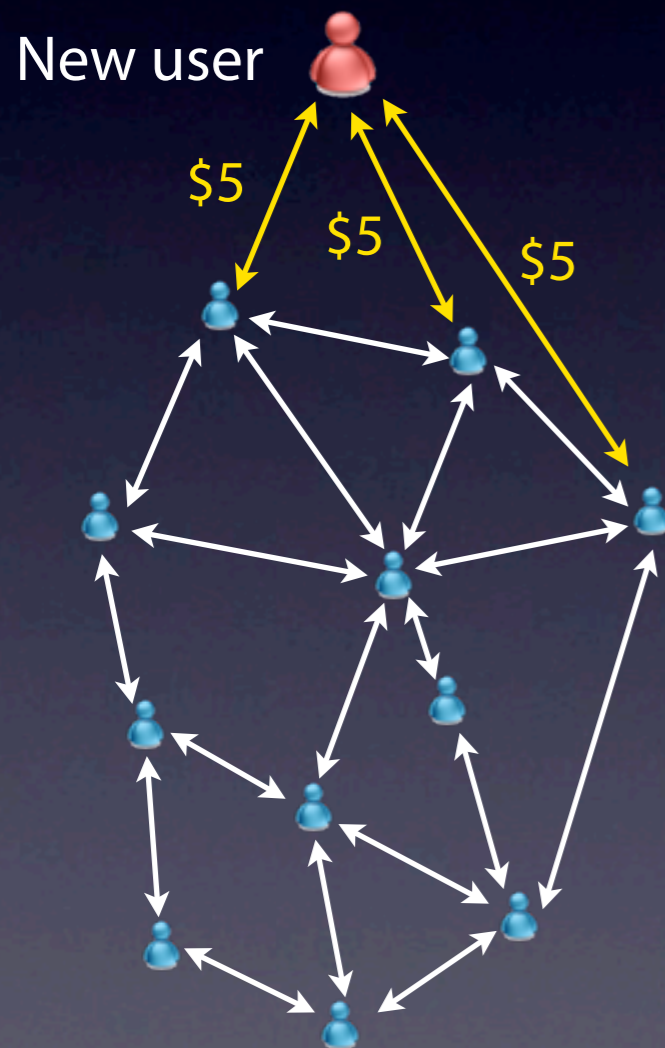New user "escrows" for links

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$5
$5
$5

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Challenge 3: Scaling max-flow

Computing max-flow is expensive

   Especially on large, dense graphs

   Standard approaches (Gomery-Hu, Goldman-Rao) are poor fit

But, can leverage two observations:

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    High-weight links form mostly-connected subgraph

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2. Don't need actual max-flow value

Only need to know if higher than potential transaction amount

Challenge 3: Scaling max-flow

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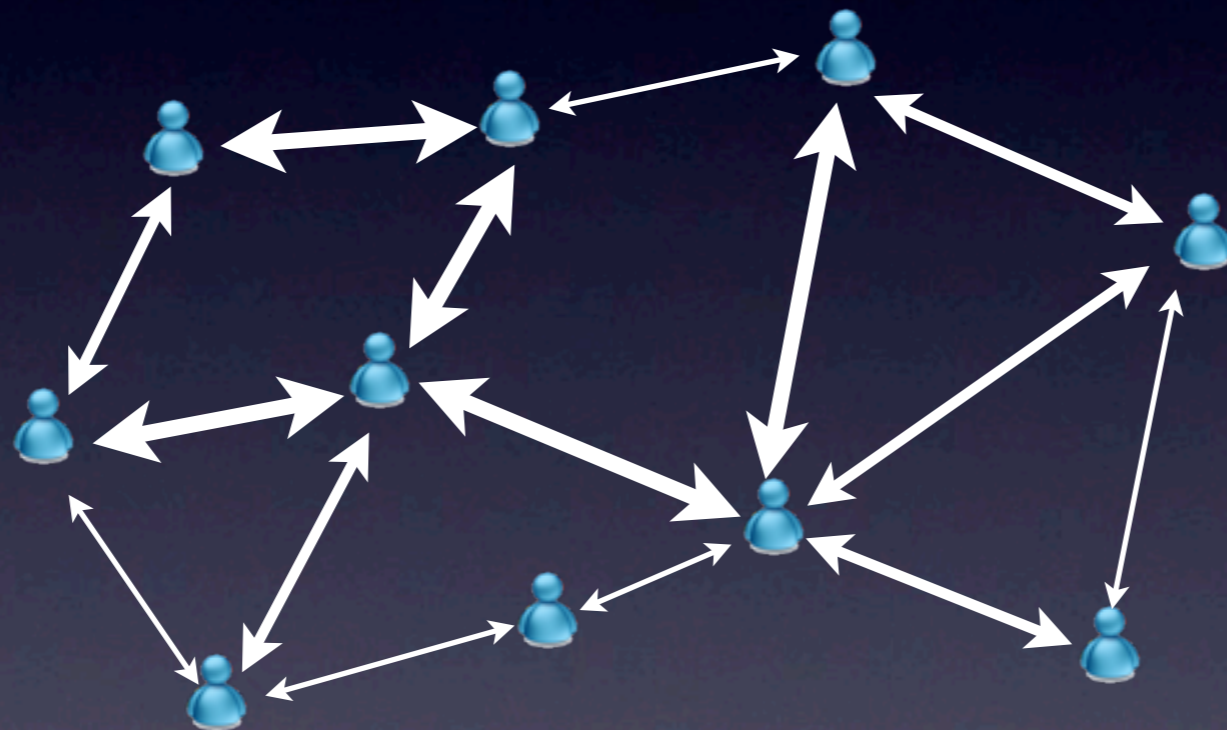
Leverage observations with multi-graphs
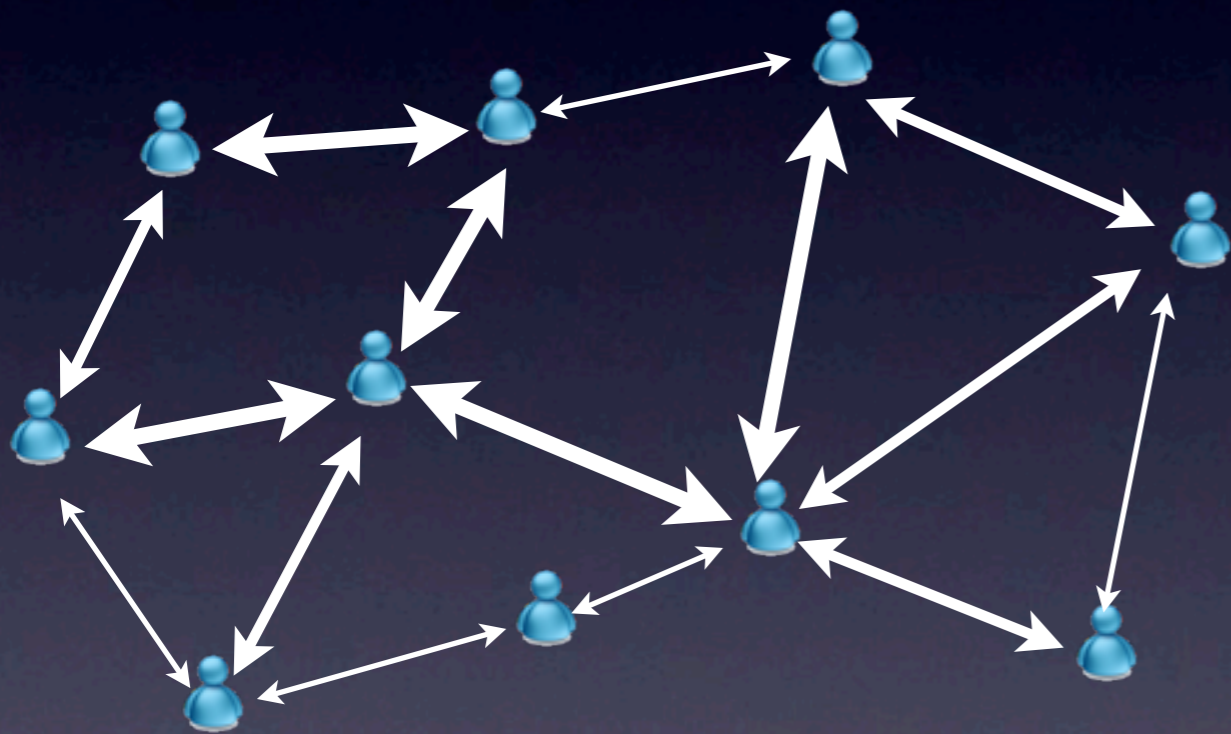
Multi-graph construction
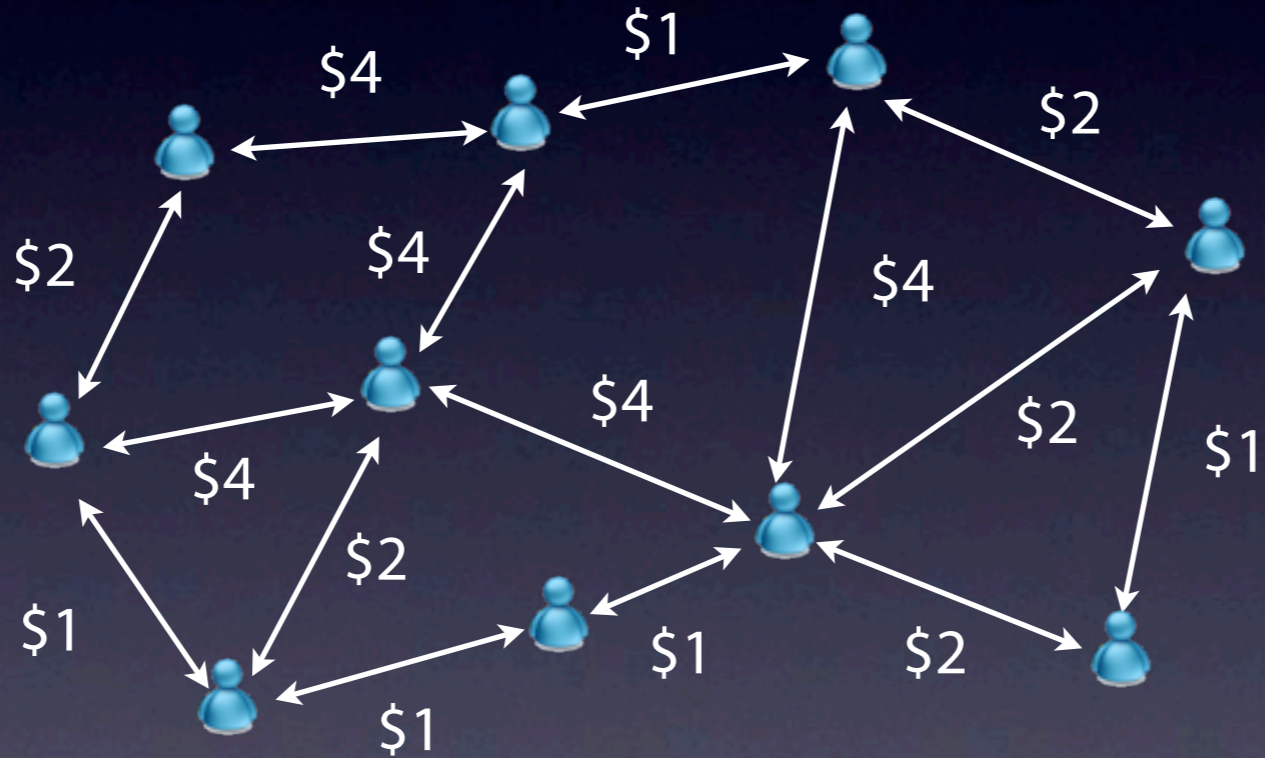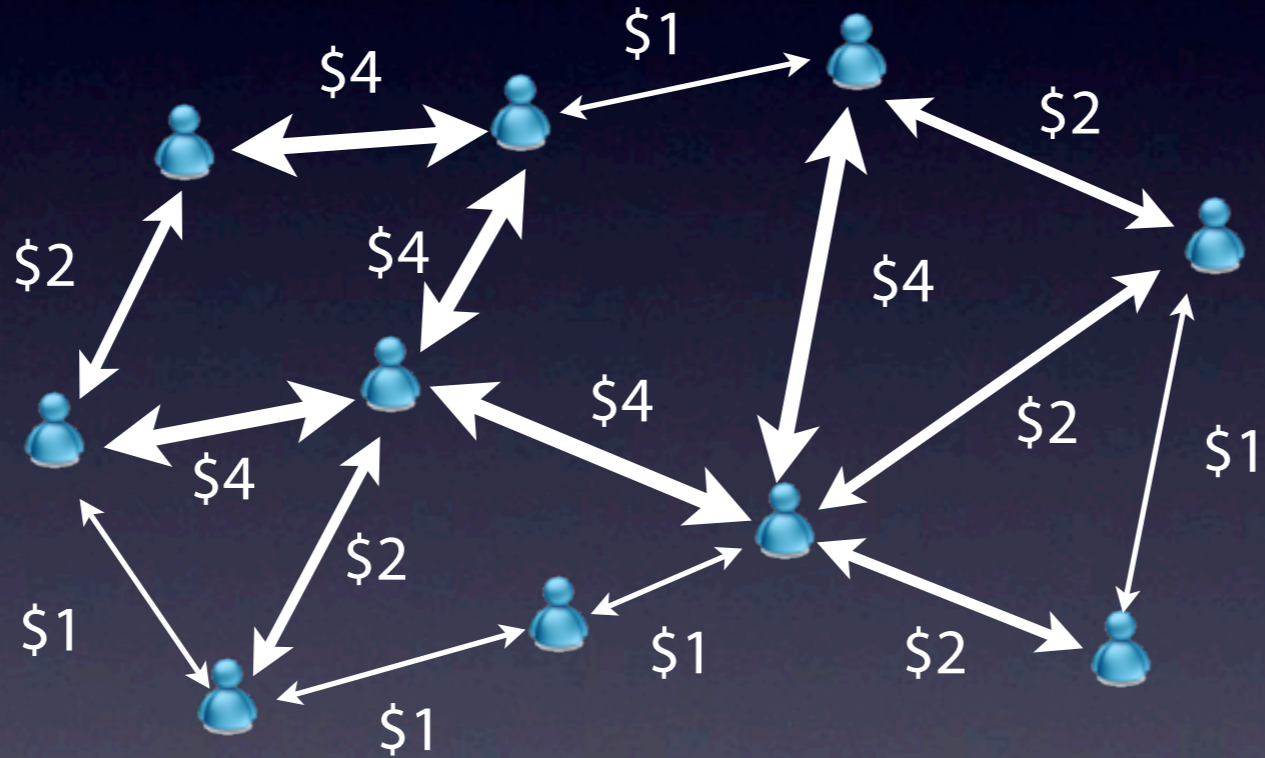
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Multi-graph construction

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Multi-graph construction

Normal graph

Multi-graph

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Multi-graph construction

Normal graph

Multi-graph

Level 0

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Multi-graph construction

Normal graph

Multi-graph

Level 1

$w_e \geq 2^1$
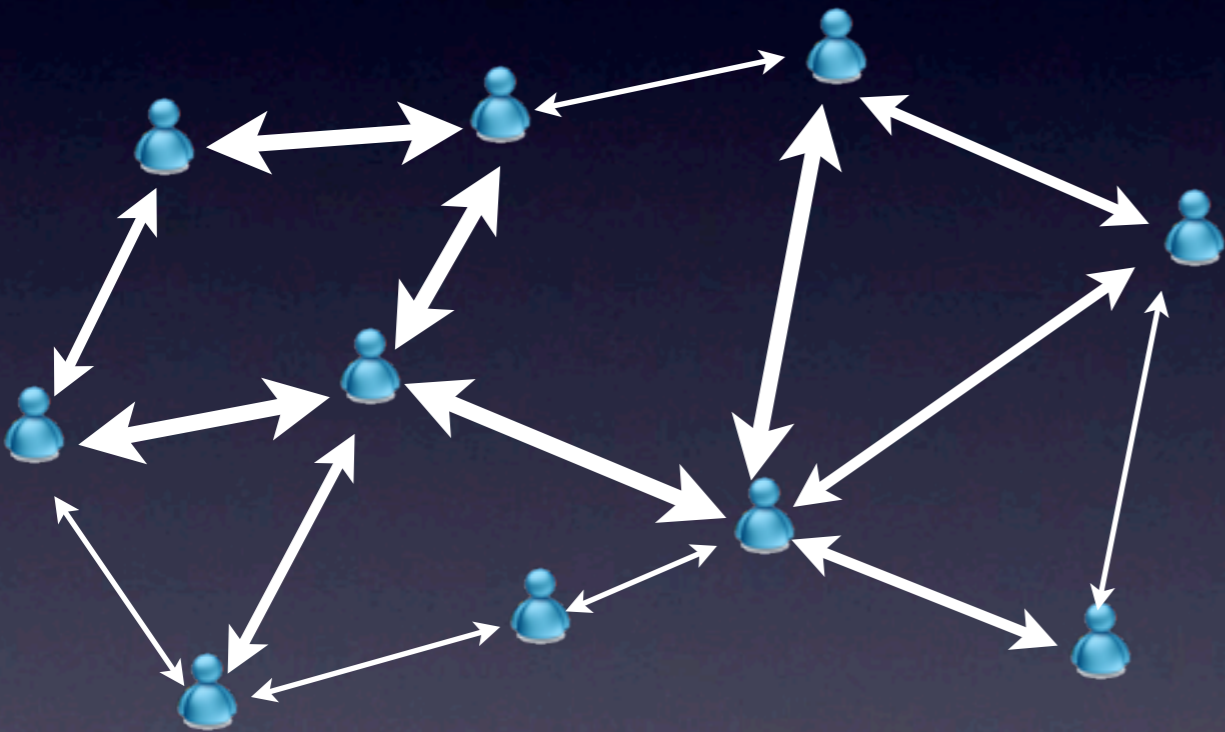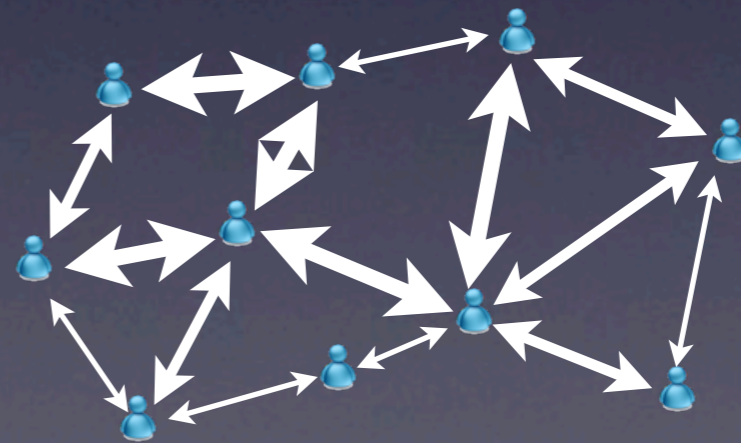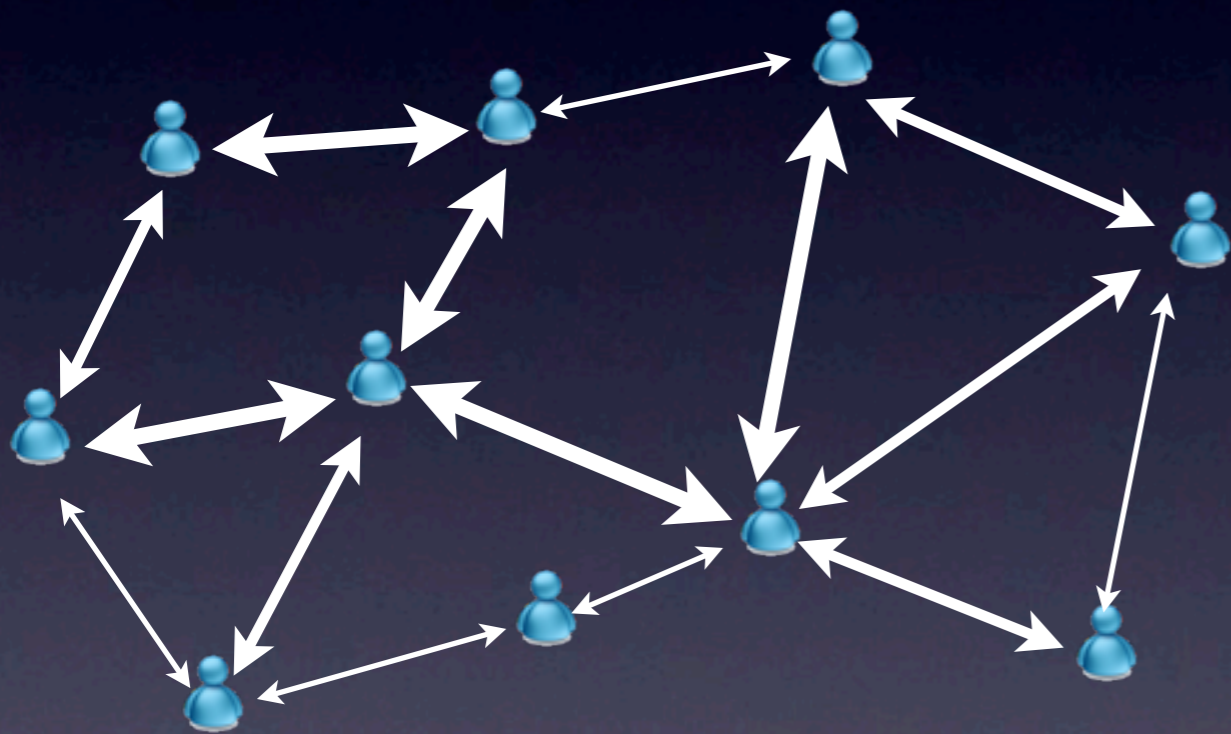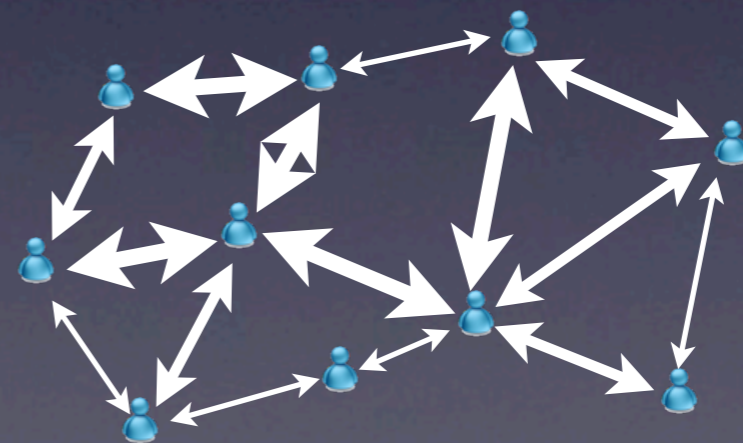
Level 0

Multi-graph construction

Level 2

$$w_e \geq 2^2$$

Level 1

$$w_e \geq 2^1$$

Level 0

Normal graph

Multi-graph

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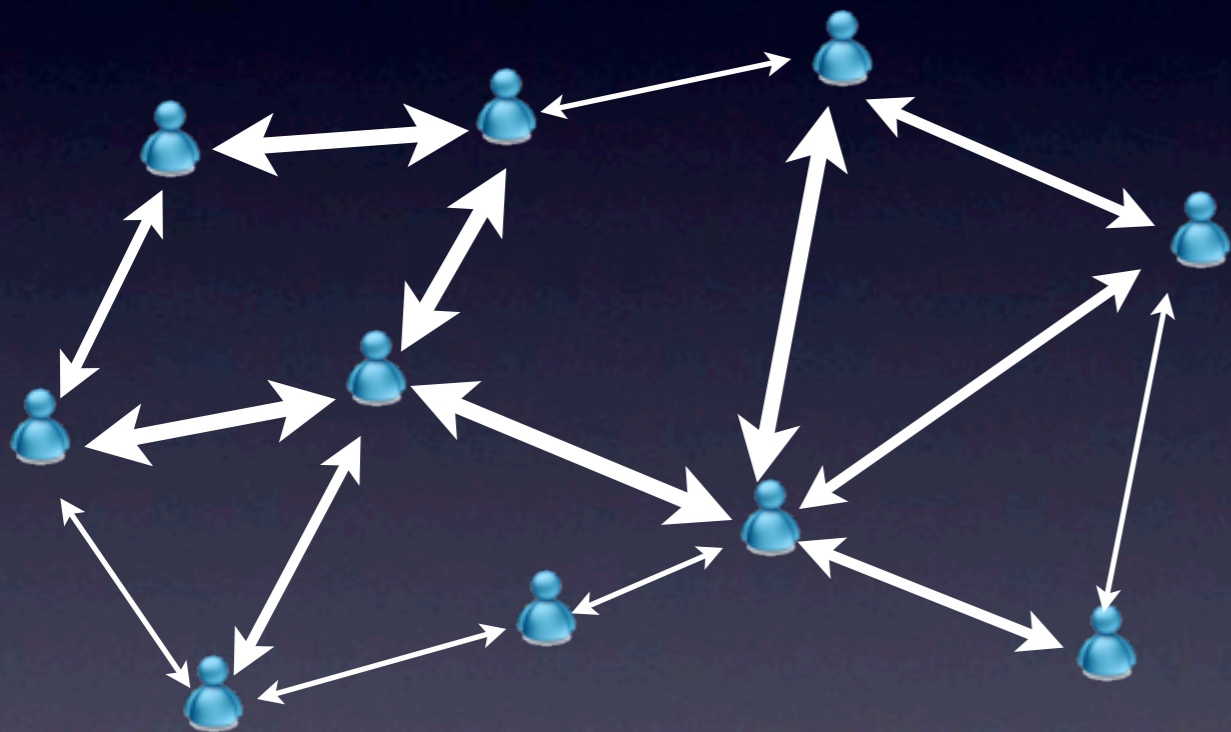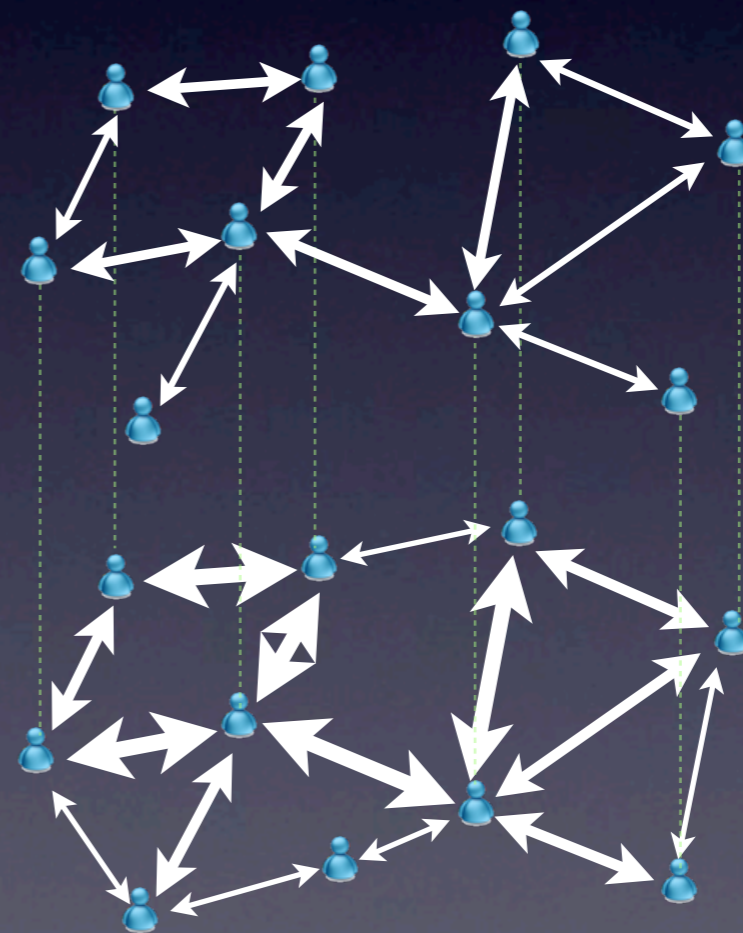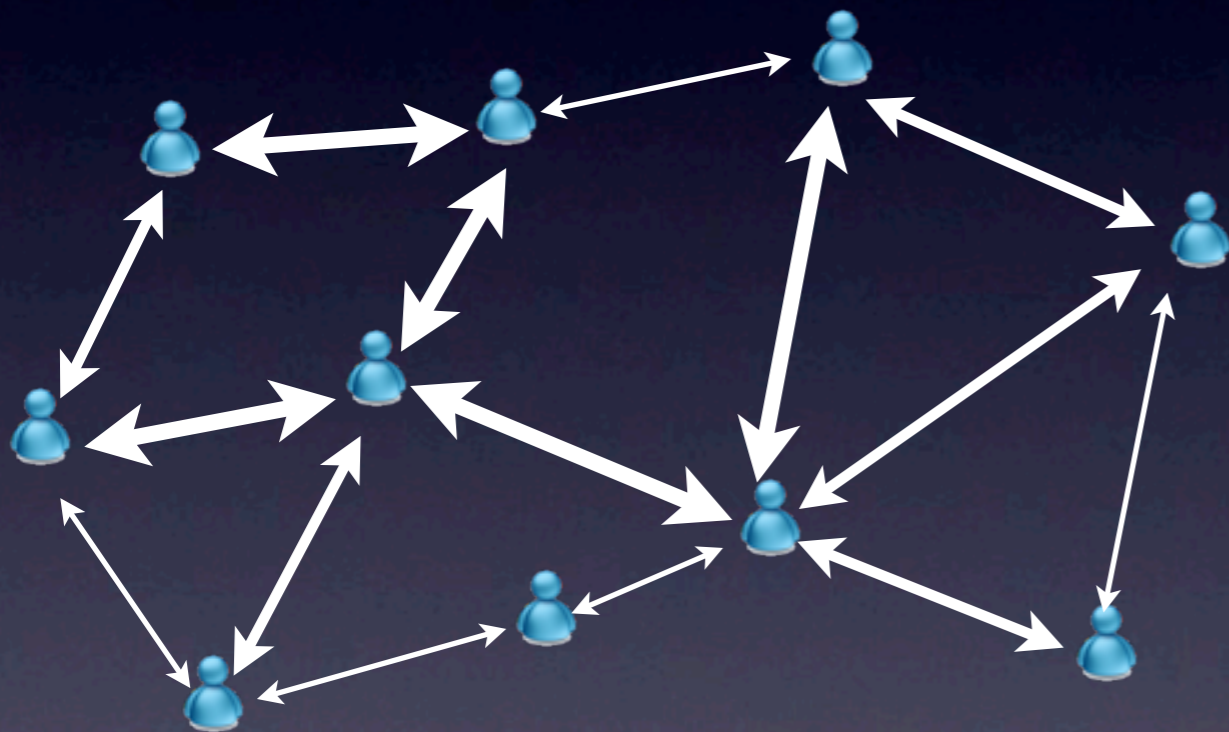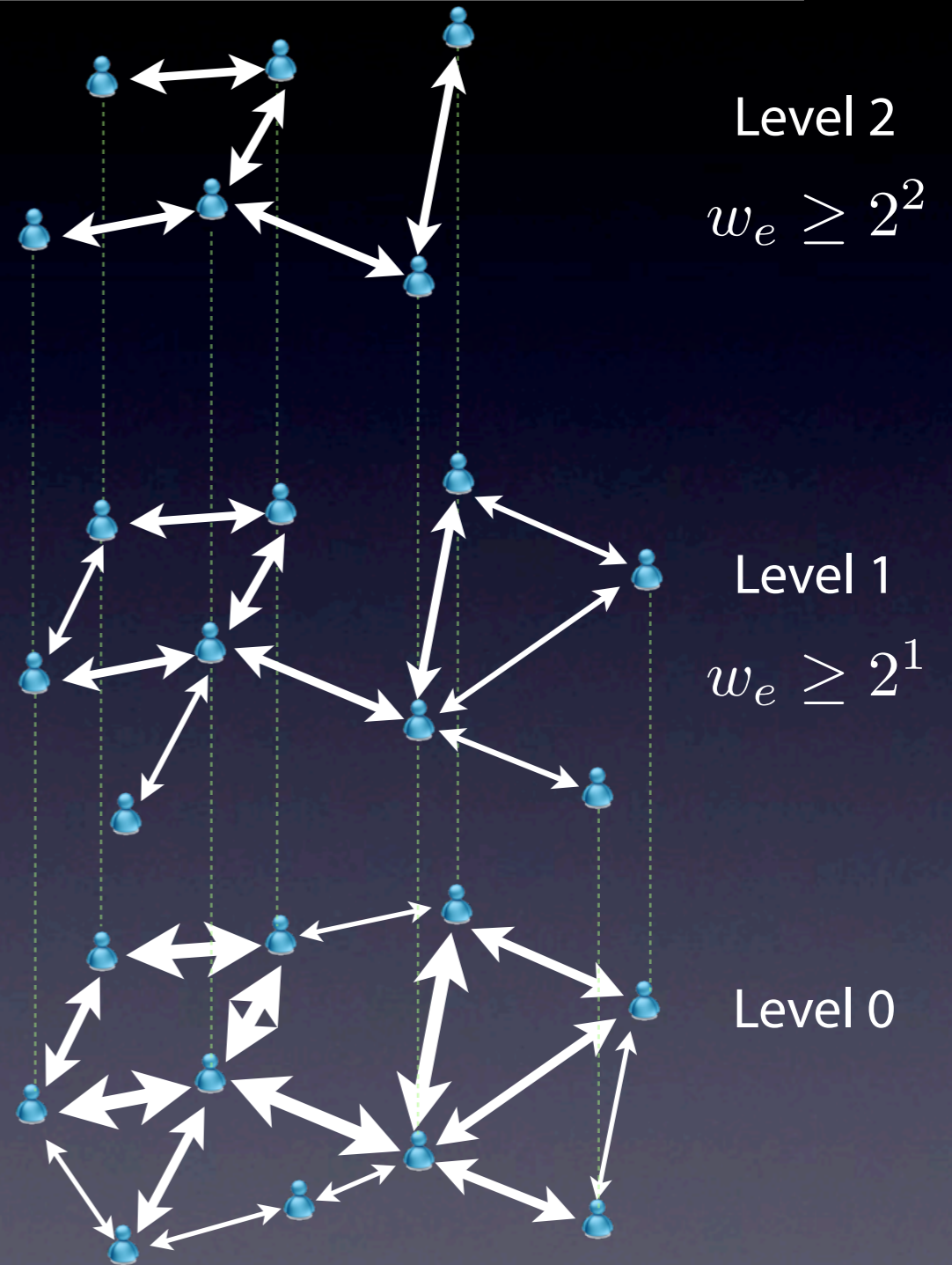
Max-flow with multi-graphs
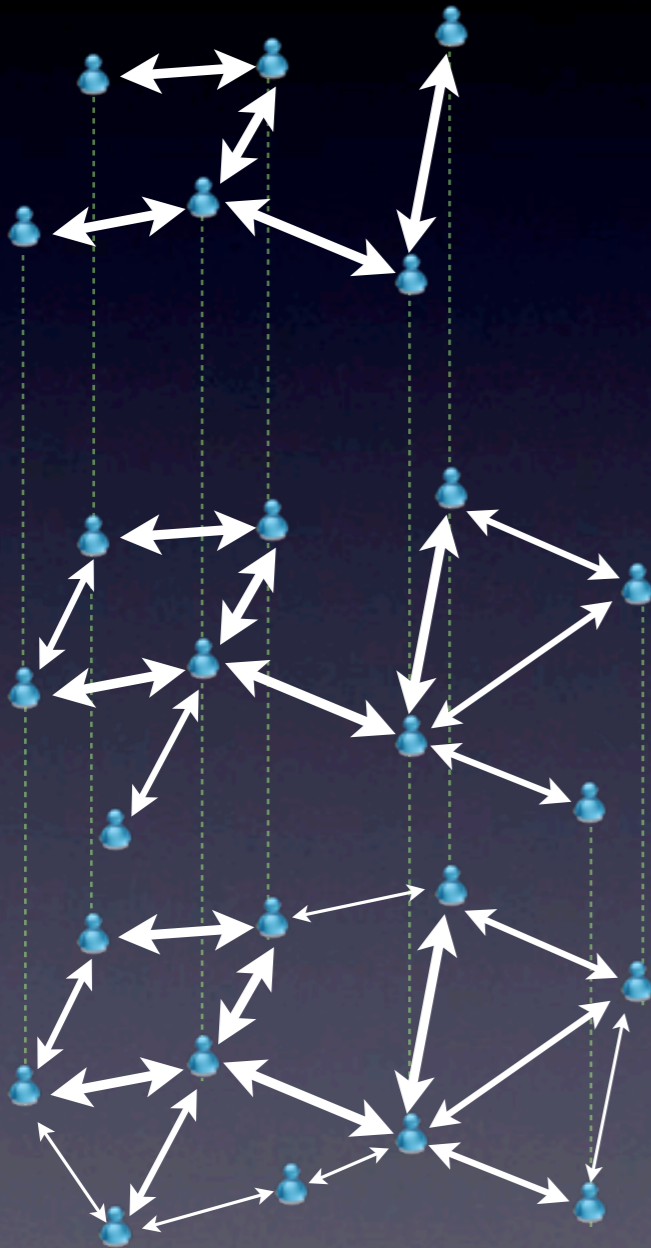
Check for sufficient flow in each level
Starting with the highest

Sufficient flow found → success
Since each level is a subset of the next

Insufficient flow found in all levels → failure
Since Level 0 is entire graph

Possibility of ending quickly
Higher levels have bigger links
Higher levels are smaller networks

Outline

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Evaluating Bazaar

Goal: Determine how Bazaar would work in practice

 Does it prevent fraud?

 How much does it "cost"?

 Does it incorrectly flag honest transactions?

Implemented Bazaar in C

 Use multi-graph representation to store risk network

 Run simulations on single processor

How to simulate?

 Need real-world data

Data from eBay

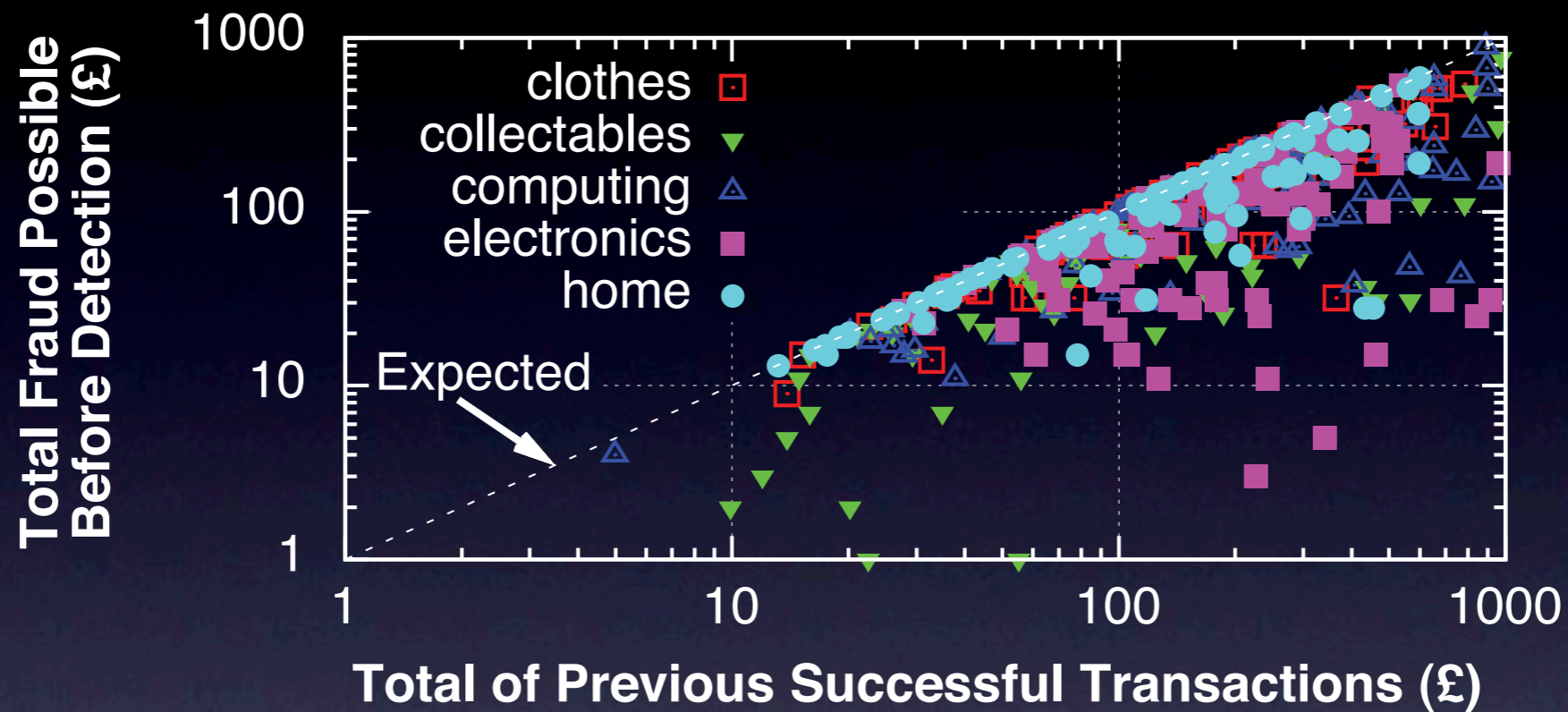| Category	Purchases	Users	Avg. Price (£)
Clothes	3,311,878	1,436,059	9.74
Collectibles	940,815	454,773	8.90
Computing	964,925	661,285	21.31
Electronics	861,108	652,350	20.67
Home/Garden	2,795,795	1,426,785	16.57

Crawled eBay UK site
Collected 90-day trace
Focused on five of the most popular categories

Total: Over 8M pieces of feedback

Does Bazaar prevent fraud?

Simulated Bazaar on each eBay category

80% of data creates risk network, remaining is simulated

Random "malicious" users conduct as much fraud as possible

Bazaar bounds malicious users as expected

How expensive is Bazaar?

Category	Time (s)		Speedup
	Single	Multi-graph	
Clothes	18.0	6.29	2.86 $\times$
Collectibles	2.53	1.18	2.14 $\times$
Computing	3.78	1.66	2.27 $\times$
Electronics	2.71	1.41	1.92 $\times$
Home/Garden	11.6	5.34	2.15 $\times$

What is the time taken to run max-flow?
Practical with a few servers provided by site
Can use additional tricks to lower average time

What is the impact on good users?

Category	Fraction of honest transactions incorrectly flagged
Clothes	1.11%
Collectibles	1.12%
Computing	3.23%
Electronics	4.68%
Home/Garden	2.43%

What is Bazaar's false positive rate?

Assumes mechanism for "bootstrapping" new users

Less than 5% false positive rate

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Summary

Online marketplaces very successful

Democratized commerce, many billions $ per year

But, known to have significant fraud

Partially due to "free" nature of accounts, reputation manipulation

Bazaar: A new approach to strengthening reputations

Leverages risk network between participants

Deployable on sites of today

Were Bazaar deployed during trace

Would have prevented £164k of negative feedback

Questions?

Alan Mislove