Distributed Collective Decision Making: From Ballot to Market

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Discovery Workshop:
Applying Complexity Science to Organizational Design and Multistakeholder Systems

Overview

Collective Decision Making Systems

Dynamically Distributed Democracy

Prediction Markets

Conclusion

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The History of Computer-Mediated Decision Making.

- Group Decision Support Systems (GDSS)
  - Approximately 20 individuals to formulate problems and derive solutions.
  - Removes issues associated with face-to-face meetings.
    - Pecking order.
    - Asynchronous decision making.
    - Lack of participation.

- Social Decision Support Systems (SDSS)
  - Scalable solution for individuals to formulate problems and derive solutions.
  - Collaborative discourse systems.
    - A network of statements, opinions, arguments, comments, etc.
    - Vizualize the flow of argument.
      - Helps to yield consensus prior to voting on an issue.

What is a Collective Decision Making System?

- Collective Decision Making Systems (**CDMS**)
  - Definition: *"a development perspective in which the systems use humans as computational components. The behavior of all human participants plus the algorithm used to aggregate that behavior generates the system's solution."*
  - Engineering question? How do I structure an environment such that it will yield an optimal solution from a collection of humans.
    - Collaborative, competitive, expert-based, dumb-agent, complex tasks, simple tasks?

- Used for various problems.
  - Ranking artifacts.
  - Categorizing artifacts. (Flickr, Delicious)
  - Collaborative development. (Wiki, Open source)
  - Voting. (Dynamically Distributed Democracy)
  - Prediction. (Prediction Markets)

Taxonomy of Collective Decision Making Systems.

	Document Ranking	Folksonomy	Recommender	Vote	Wiki	Open Source	Prediction Market
Problem Space							
Decision Type	information retrieval	information retrieval	information retrieval	governance	content creation	content creation	prediction
Decision Principle	centrality	frequency	similarity	frequency	consensus	consensus	trade
Goal	quality retrieval	quality retrieval	quality retrieval	satisfaction	document utility	code utility	predictive accuracy
Accuracy Metric	precision recall	precision recall	precision recall	fairness	usability	usability	forecast standard error
Implementation							
Solution Space	number of artifacts	number of artifacts	number of artifacts	ballot	creative output	creative output	disjoint + exhaustive
Interface Complexity	very restrictive	not restrictive	not restrictive	not restrictive	restrictive	very restrictive	restrictive
Skill Set	web-page design	basic skills	basic skills	basic skills	wikitext syntax	programming	market trading
Contributor/User	both	both	contributors	contributors	both	both	both
Individual Features							
Motivation	connectedness	organization	personalized advice	cooperative	critical	critical	competitive
Expertise	unnecessary	unnecessary	unnecessary	unnecessary	necessary	necessary	necessary
Membership	co-opted	self-selecting	auto/self-selecting	self-selecting	self-selecting	self-selecting	self-selecting
Collective Features							
Size	large	large	large	variable	variable	variable	variable
Diversity	coverage	coverage	coverage	none	improvement	improvement	coverage + improvement
Interaction	none	imitative	none	strategic	stigmergic	stigmergic	strategic

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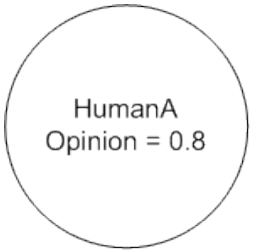
The Problem of Fluctuating Levels of Participation.

- As groups grow in size…
  - **PROBLEM**: You can't expect full participation constantly and on all decisions.
    - Asynchronous voting?
  - **PROBLEM**: You can't always wait for everyone to ultimately participate before yielding a decision.
    - Ignore the perspective on non-participants?

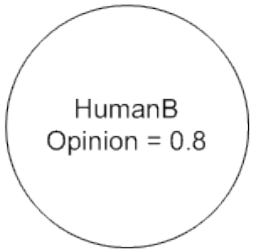
- You can expect many individuals to share a similar perspective.
  - **SOLUTION**: Social compression.
    - Weighting active participants by their degree of representation supports a model of the whole with only a subset of the active participants.
    - Any subset of the whole can serve as a lossy model of the whole. Like a hologram.

Direct Democracy.

- 4 member group.
- Only 2 are participating even though all 4 have an opinion.
- What happens if we ignore the perspective of non-participants?



- If everyone participates:
  - (0.8 + 0.5 + 0.8 + 0.9) / 4 = **0.75**
- If only the two active members participate:
  - (0.5 + 0.9) / 2 = **0.7**
- Error in decision: |0.75 - 0.5| = **0.05**



= active participant

The Trust-Based Social Network for Voting Systems.

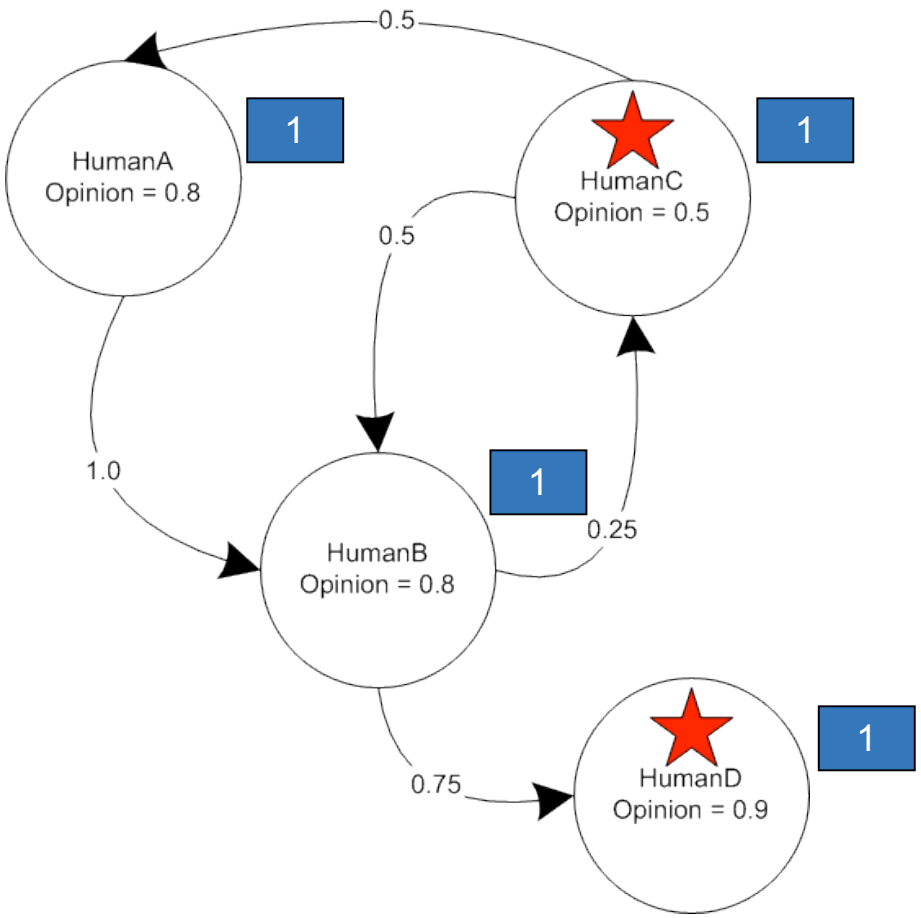
- "In the case that I'm not there to participate, I trust **Human-A** and **Human-B** to utilize my voting power as they see fit."
  - Premised on the idea that socially-close individuals (e.g. friends, peers) are more representative of your values than socially-removed individuals (e.g. politicians).

- Propagate the voting power from inactive participants to active participants using a trust-based social network as the propagation medium.
  - This algorithm is called Dynamically Distributed Democracy (DDD).

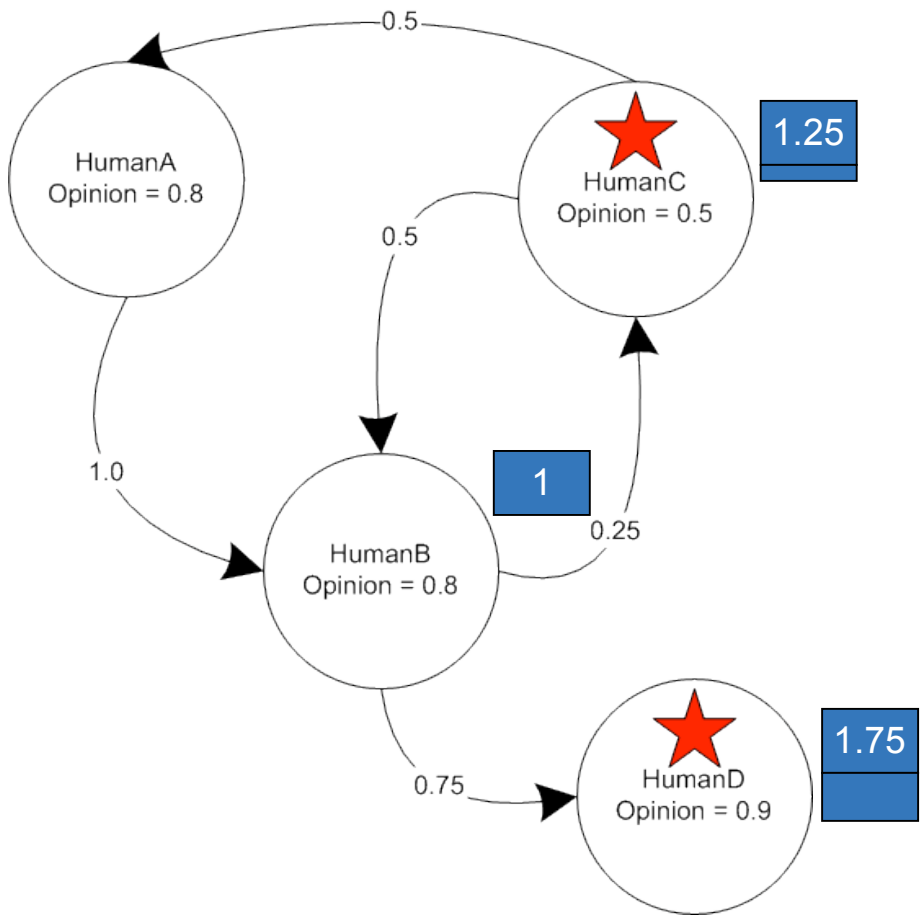
- Formally, the trust-based social network is defined as:
  - trust(me, **Human-A**)

    = **P**(**Human-A** is "good" **|** my knowledge of **Human-A**).
  - "my trust in **Human-A** is the probability that **Human-A** is subjectively good given my knowledge of **Human-A**."

Dynamically Distributed Democracy.



Dynamically Distributed Democracy.



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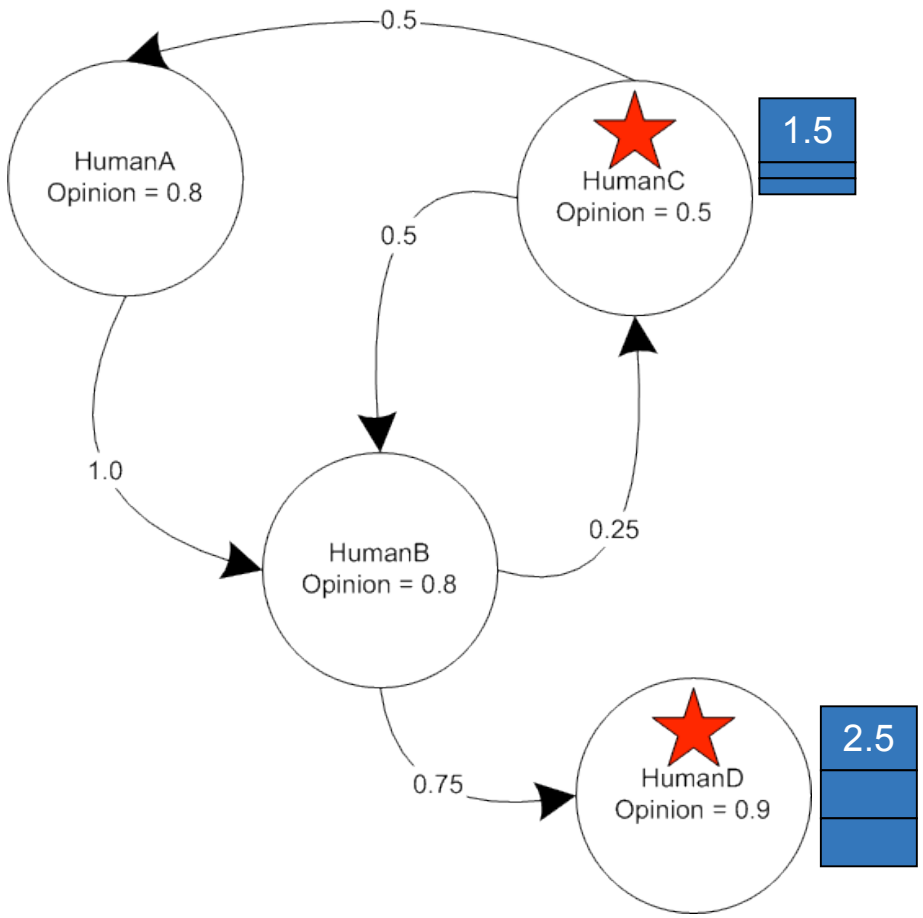
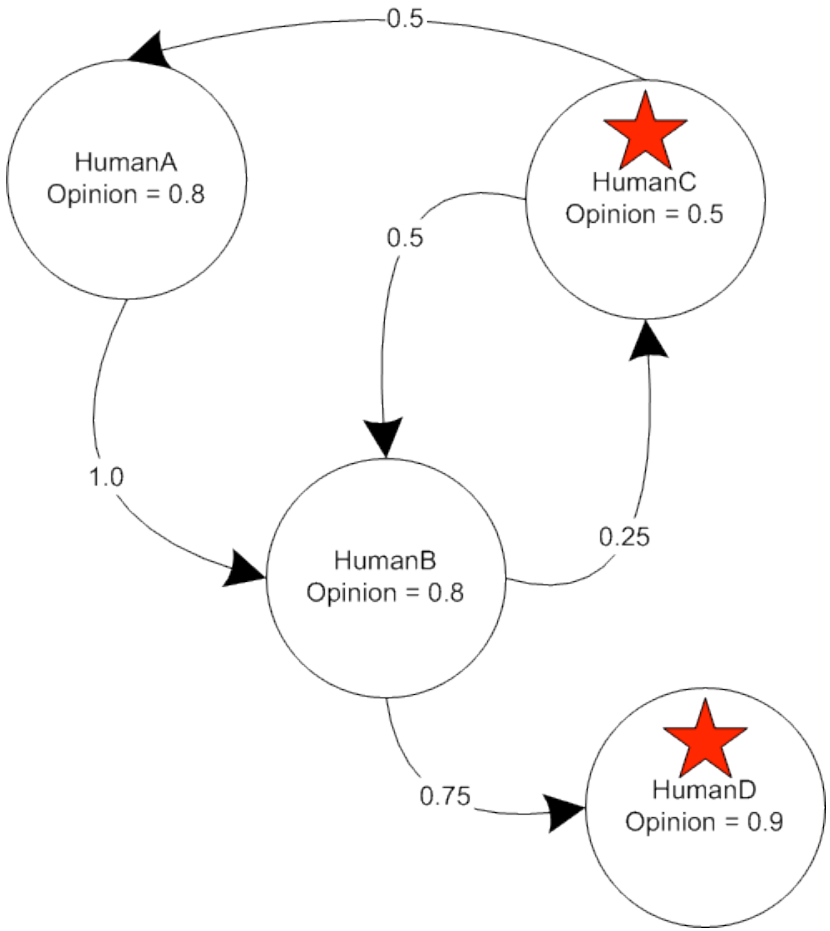


Dynamically Distributed Democracy.

- 4 member group.
- Only 2 are participating even though all 4 have an opinion.
- What happens if we utilize a trust-based social network to propagate unused vote power to active participants?

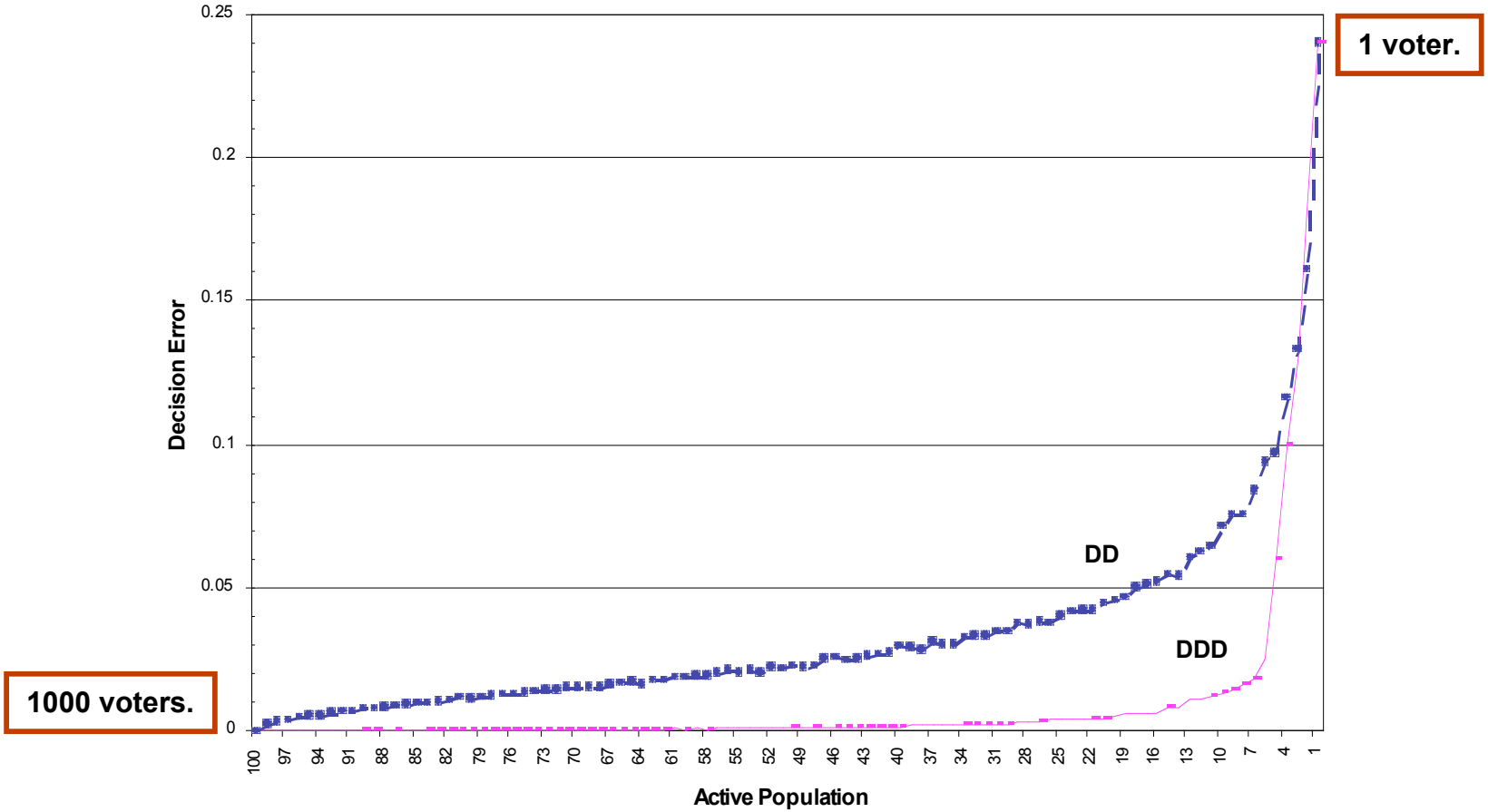
- If everyone participates:
  - (0.8 + 0.5 + 0.8 + 0.9) / 4 = **0.75**
- If only the two active members participate:
  - [(1.5 * 0.5) + (2.5 * 0.9)] / 4 = **0.75**
- Error in decision: |0.75 - 0.75| = **0.0**

★ = active participant



Direct Democracy vs. Dynamically Distributed Democracy.

- A simulation with 1000 agents.



The Problem of Human Diversity in Voting Systems.

- "I trust **Human-A** in **Domain-X**, but not in **Domain-Y**."
  - Premised on the idea that humans are diverse in their values and trust is context-dependent.

- Formally, a domain/trust-based social network is defined as:
  - trust(me, **Human-A, Domain-X**) =

    P(**Human-A** is "good" in **Domain-X** **|** my knowledge of **Human-A** in **Domain-X**).
  - "My trust in **Human-A** in **Domain-X** is the probability that **Human-A** is good in **Domain-X** given my knowledge of **Human-A** in **Domain-X**."

DDD in the Real-World.

- As the size of a group scales and there is an increase in the number of problems facing the group, it will be important to...
  - Ensure that even non-participants are represented.
  - Reduce the amount of cognitive overload on the individual.

- DDD was originally developed to support governance-systems that utilize an information technology infrastructure.
  - No “official” representative position.
  - Everyone is at least a representative of themselves.
  - Movement towards open policy systems and a distribution of governance.
    - Individuals create the policies (Wiki-based)
    - Individuals vote on the policies (DDD-based)
    - Individuals implement the policies (OpenSource-based)

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The Problem of Forecasting.

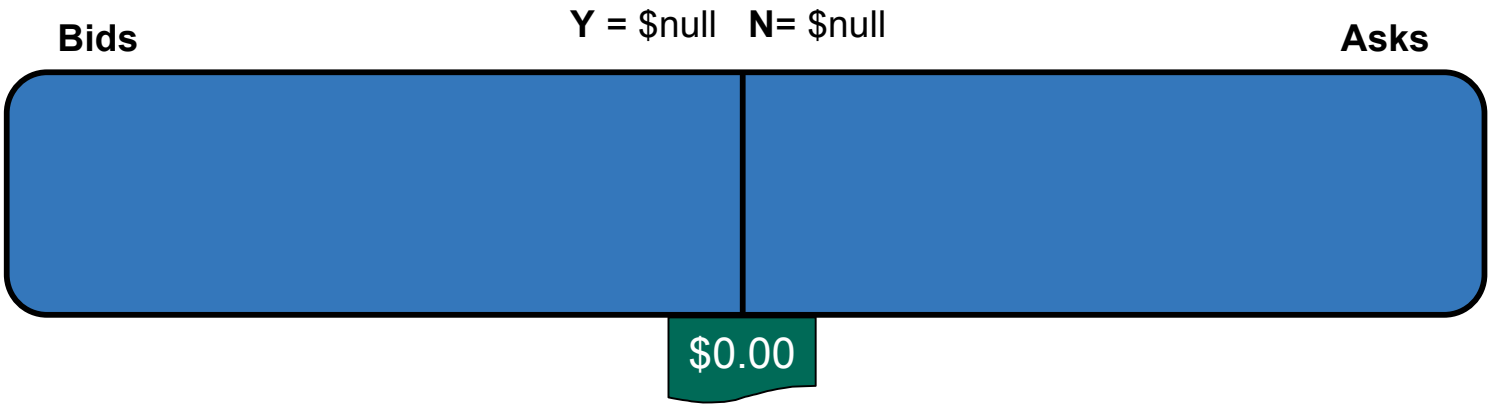
- As the complexity of an event grows…
  - **PROBLEM**: You can't assume that a single individual has global knowledge.
    - Poll individuals?
  - **PROBLEM**: Accuracy of polls depends on the accuracy of your participating population?
    - Get a more representative sample?

- You can expect monetary repercussions and incentives to yield proper evaluations.
  - **SOLUTION**: Prediction market.
    - Individuals trade in futures contracts.
    - The market price denotes the probability of an event occurring.

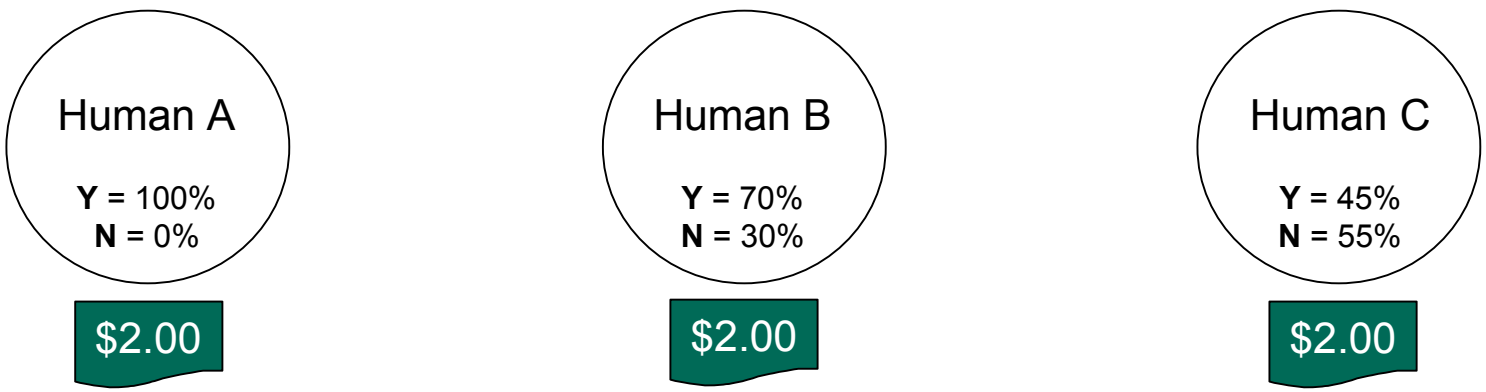
The Components of a Prediction Market.

- A set of disjoint **contracts** that exhaust the solution space.
  - A contract represents a distinct future state.
    - e.g. winner of an election, price of fuel at a certain date.
- A **collective** of self-interested traders.
  - Traders vie for contracts.
- A **market** mechanism to facilitate trading.
  - A way for traders to post "for sale" contracts.
  - A way for traders to buy "for sale" contracts.
- A **payout** mechanism when outcome is determined.
  - Traders that own the contract that reflects the true outcome make money.
  - Traders that buy low and sell high also make money.

A Prediction Market.



"Will X happen? Yes or No."



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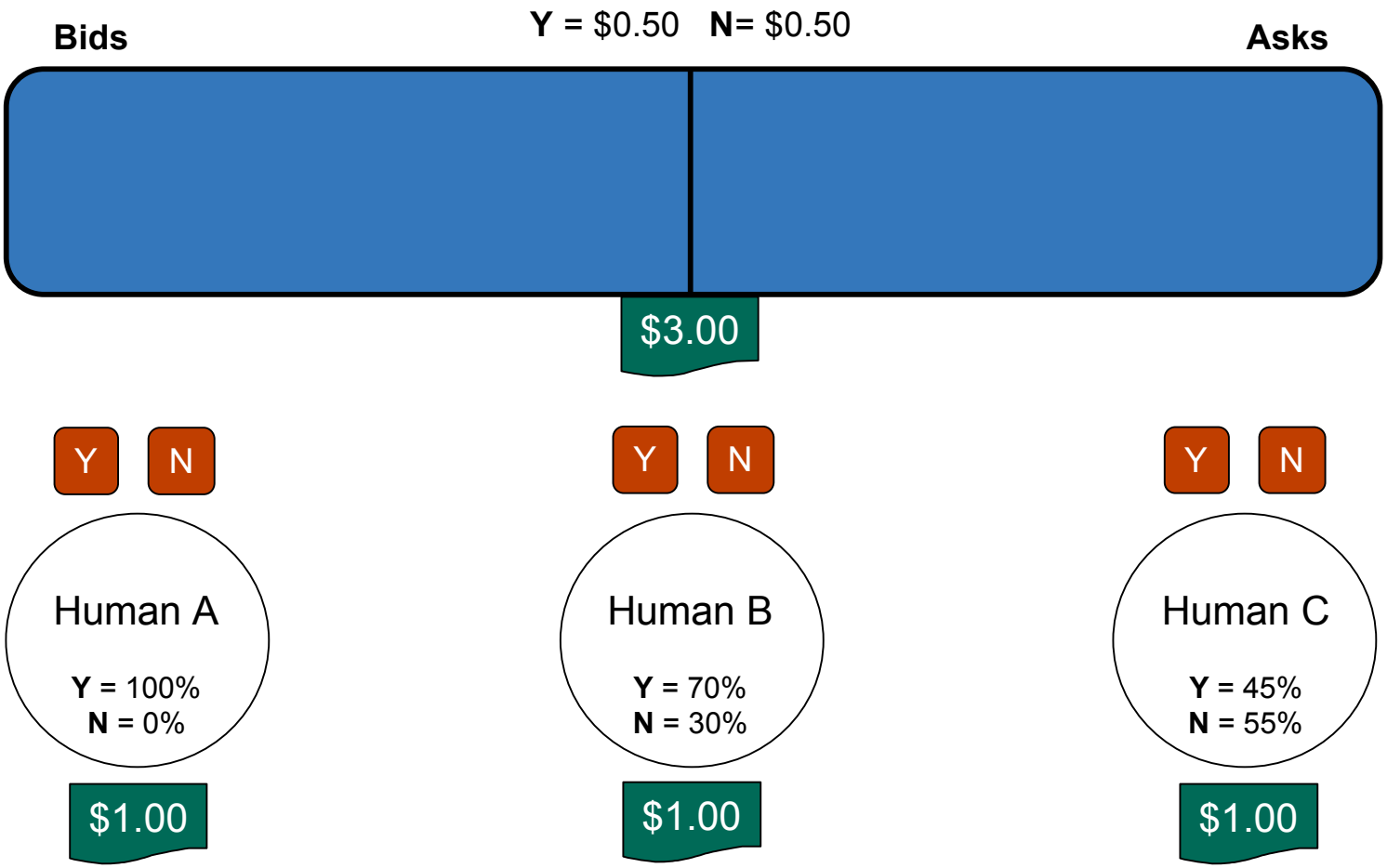

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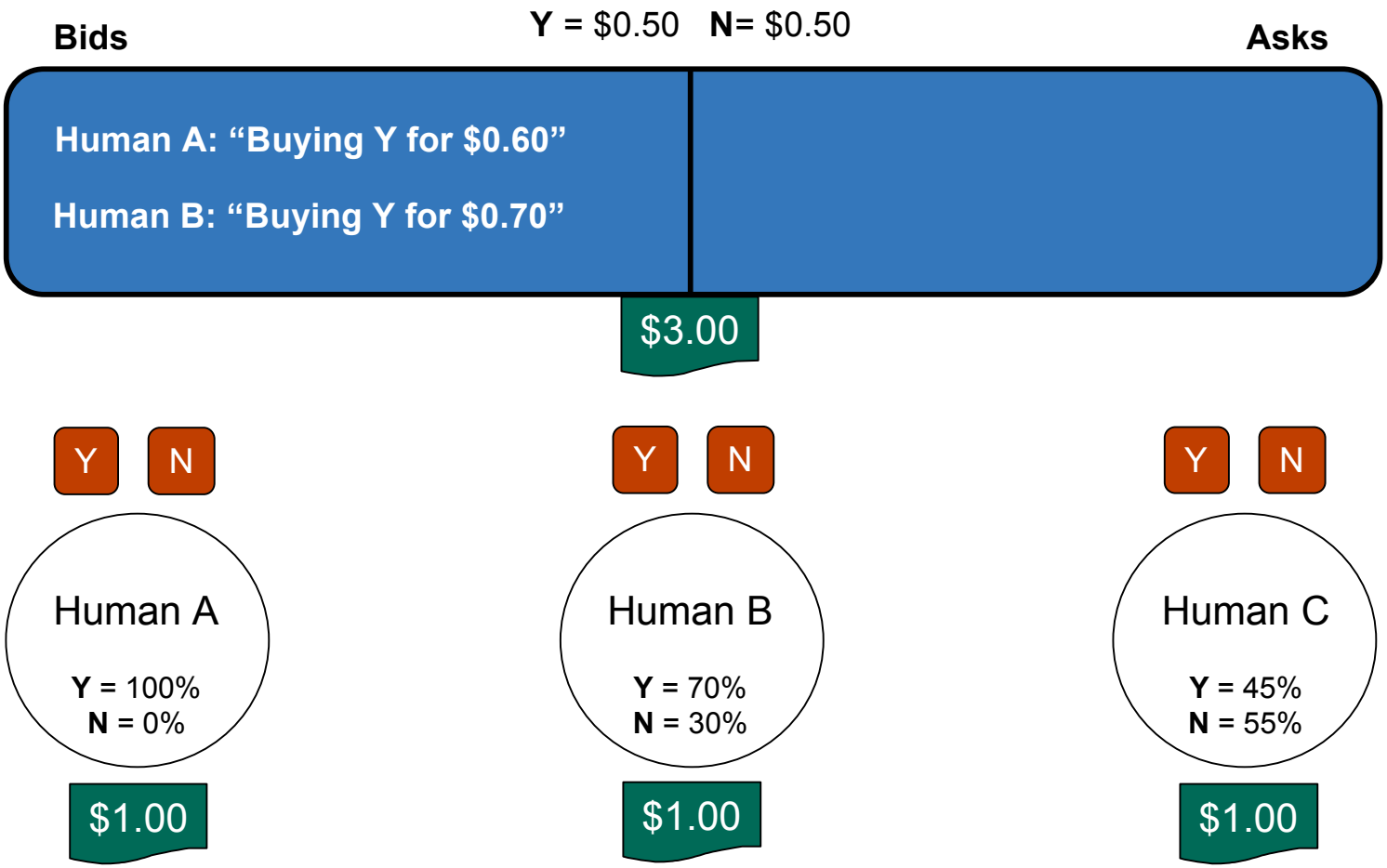

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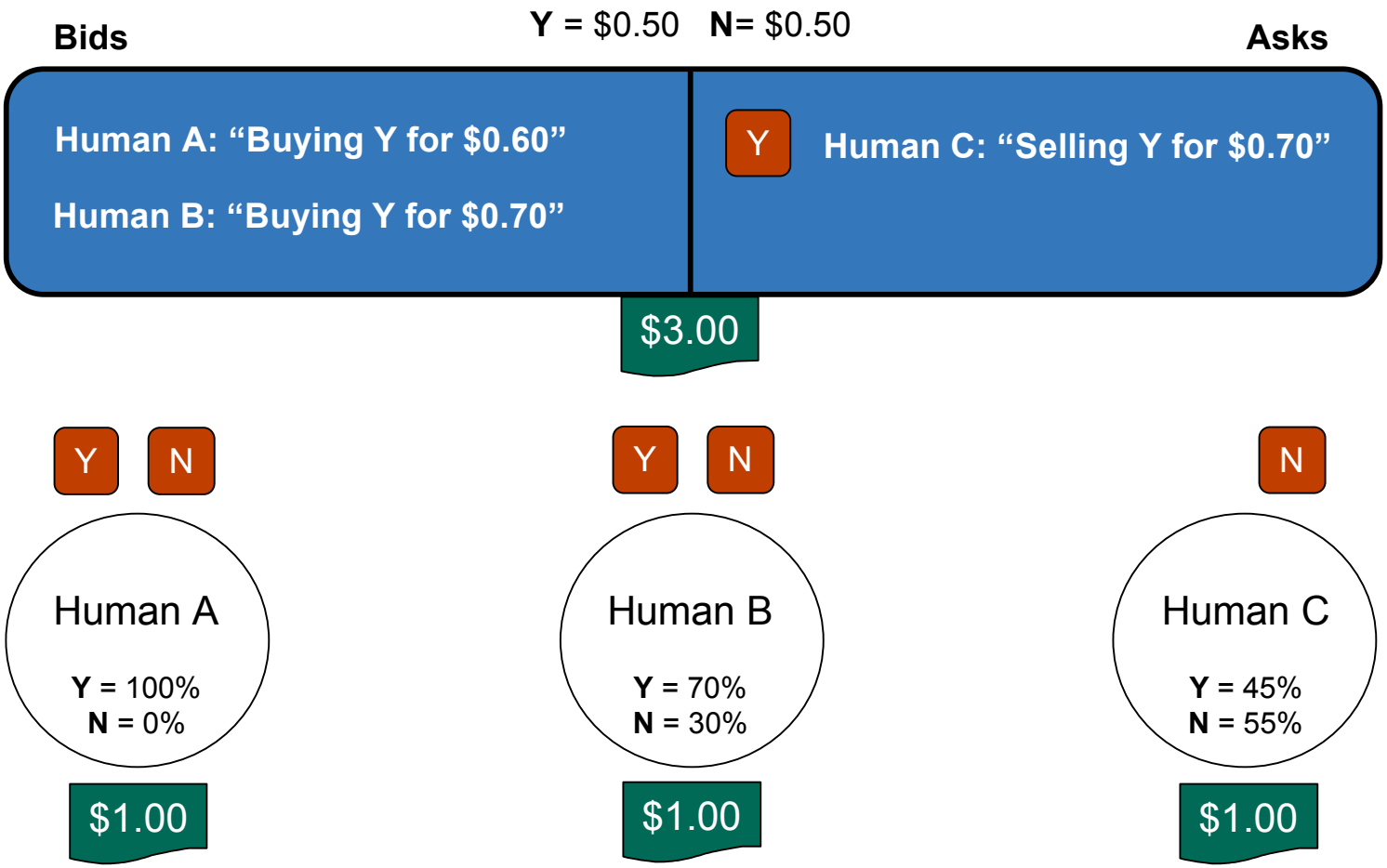

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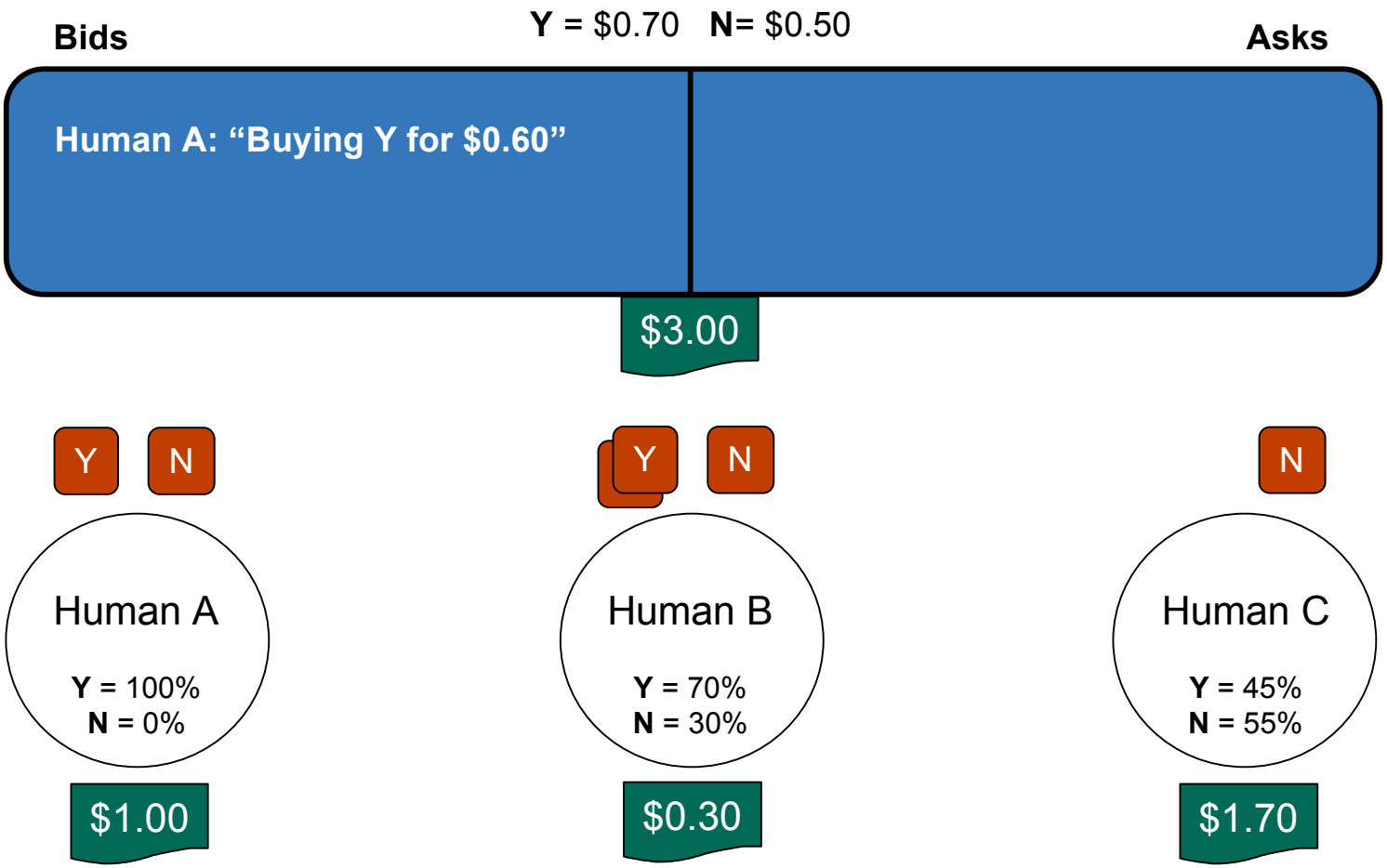

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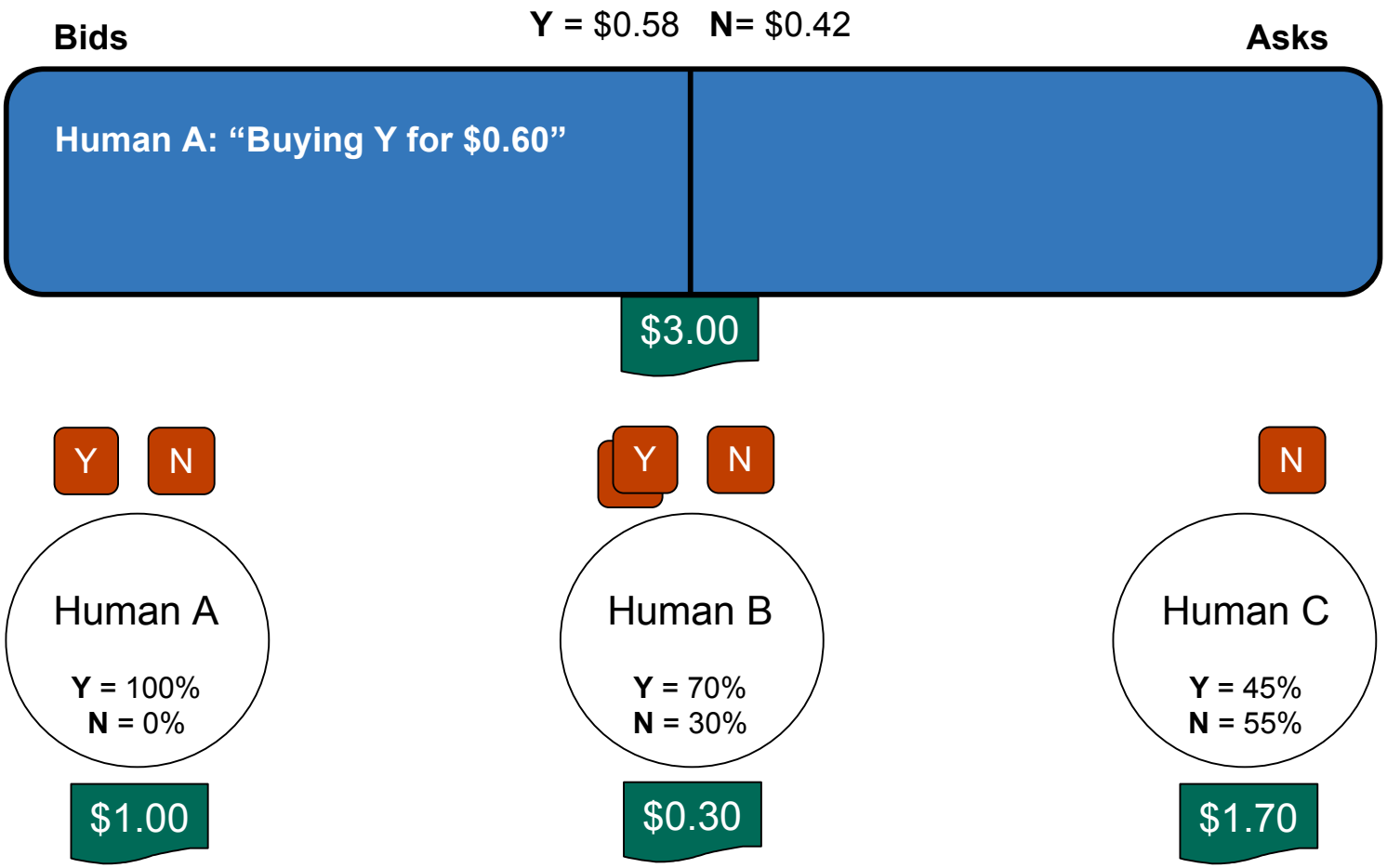

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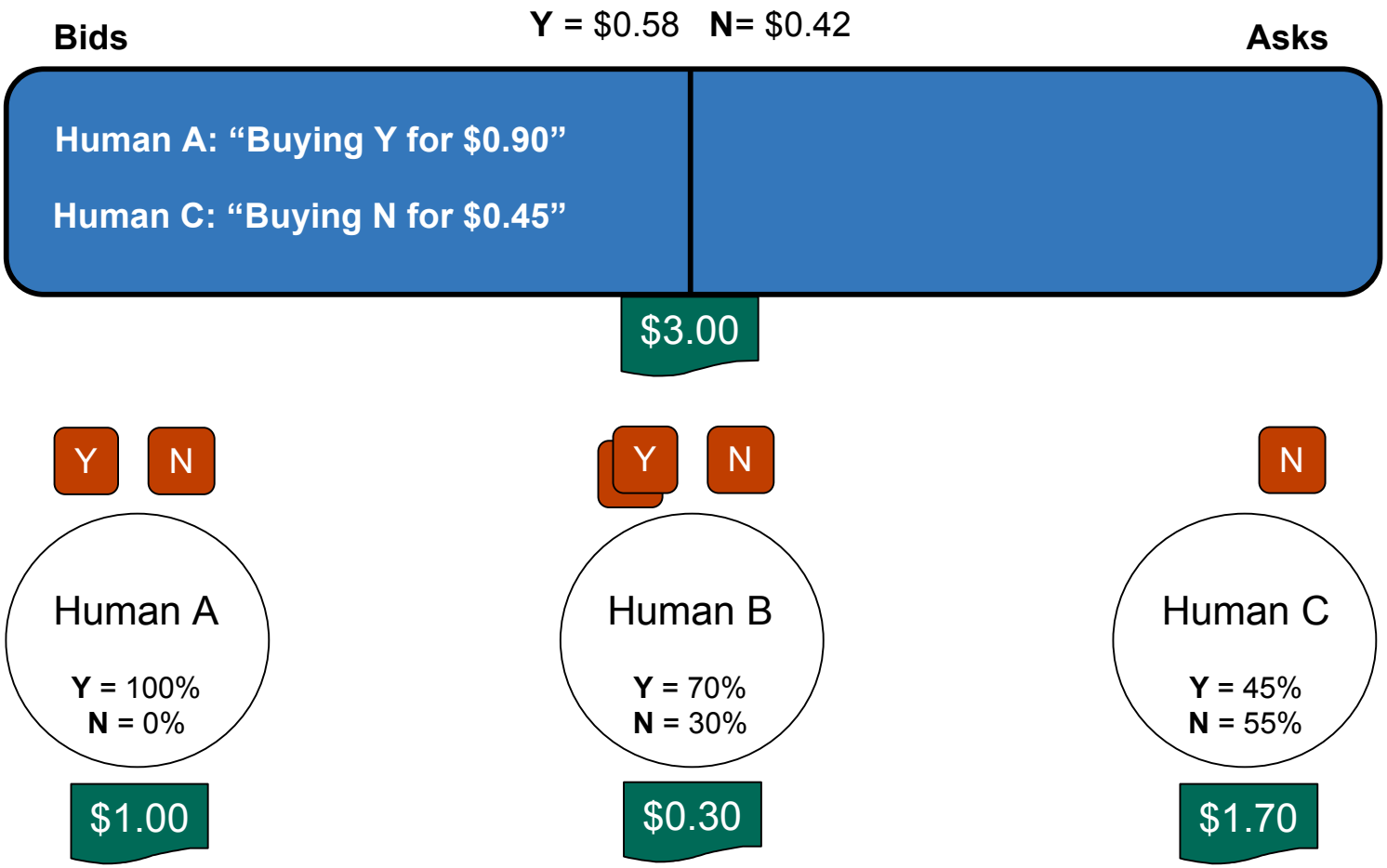


A Prediction Market.

Y = $0.58 **N**= $0.42

Bids

Human A: "Buying Y for $0.90"

Human C: "Buying N for $0.45"

Asks

Y **Human B: "Selling Y for $0.90"**

N **Human B: "Selling N for $0.45"**

$3.00

Y N

Human A

Y = 100%
N = 0%

$1.00

Y

Human B

Y = 70%
N = 30%

$0.30

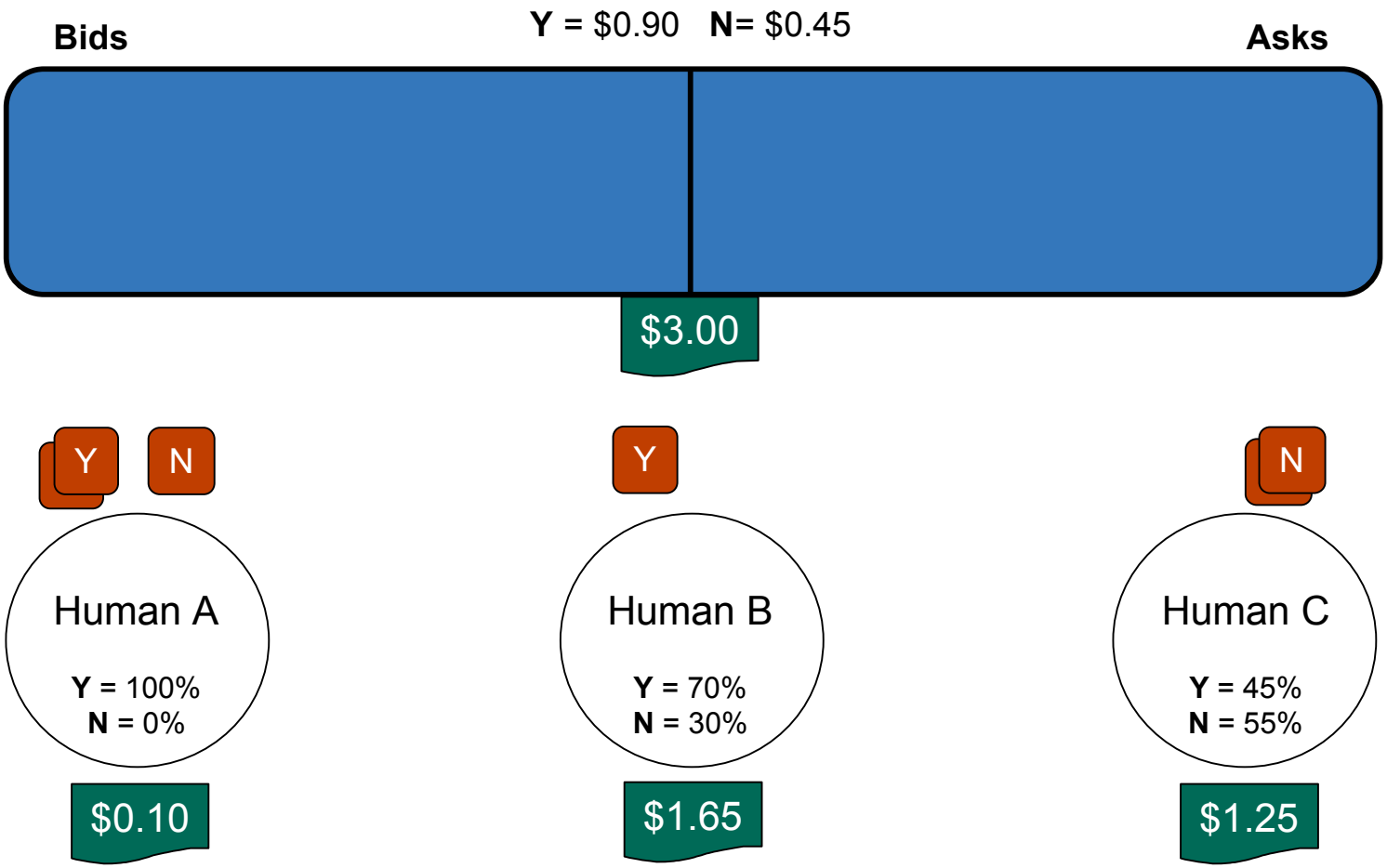
N

Human C

Y = 45%
N = 55%

$1.70

A Prediction Market.



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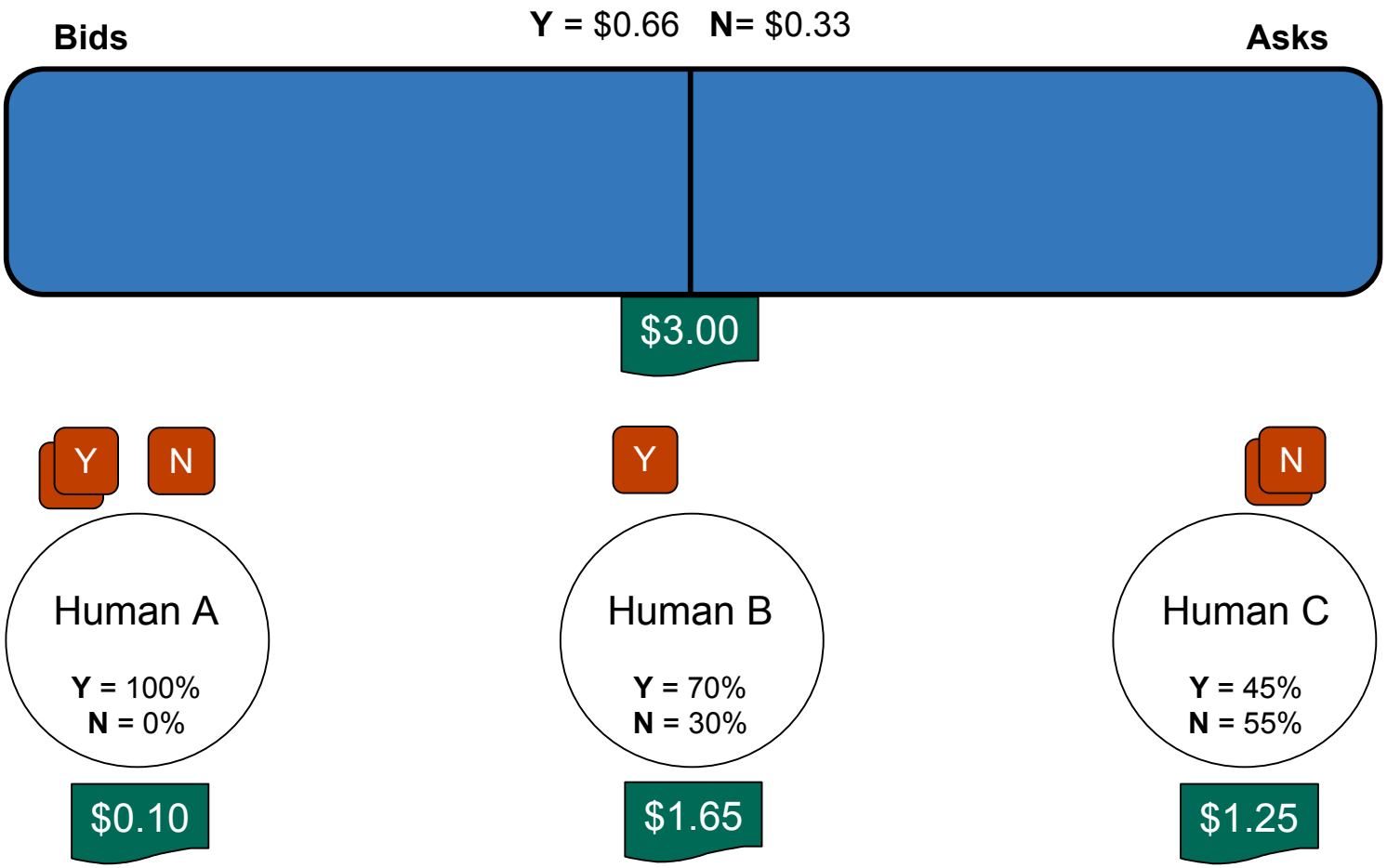

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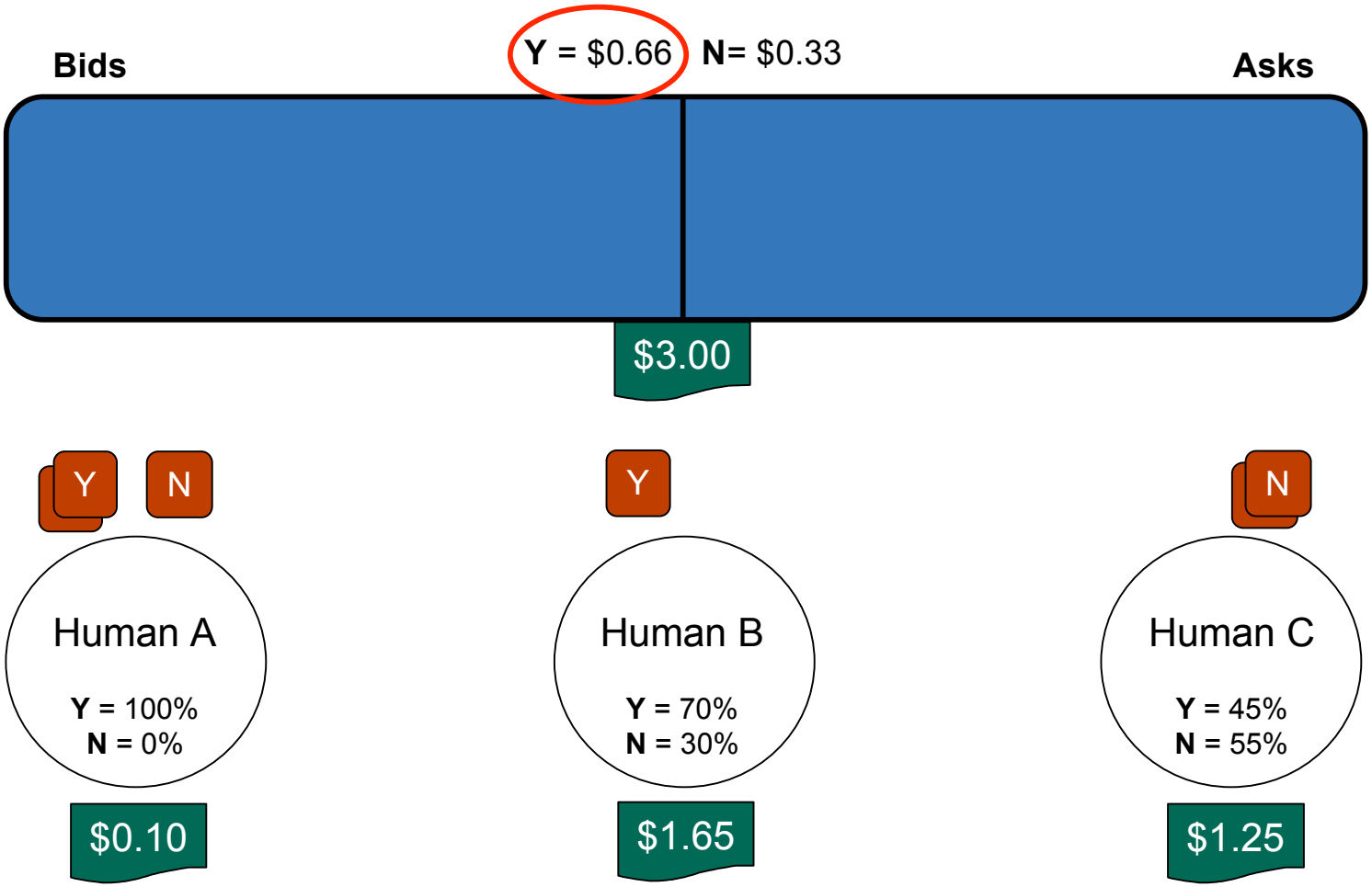

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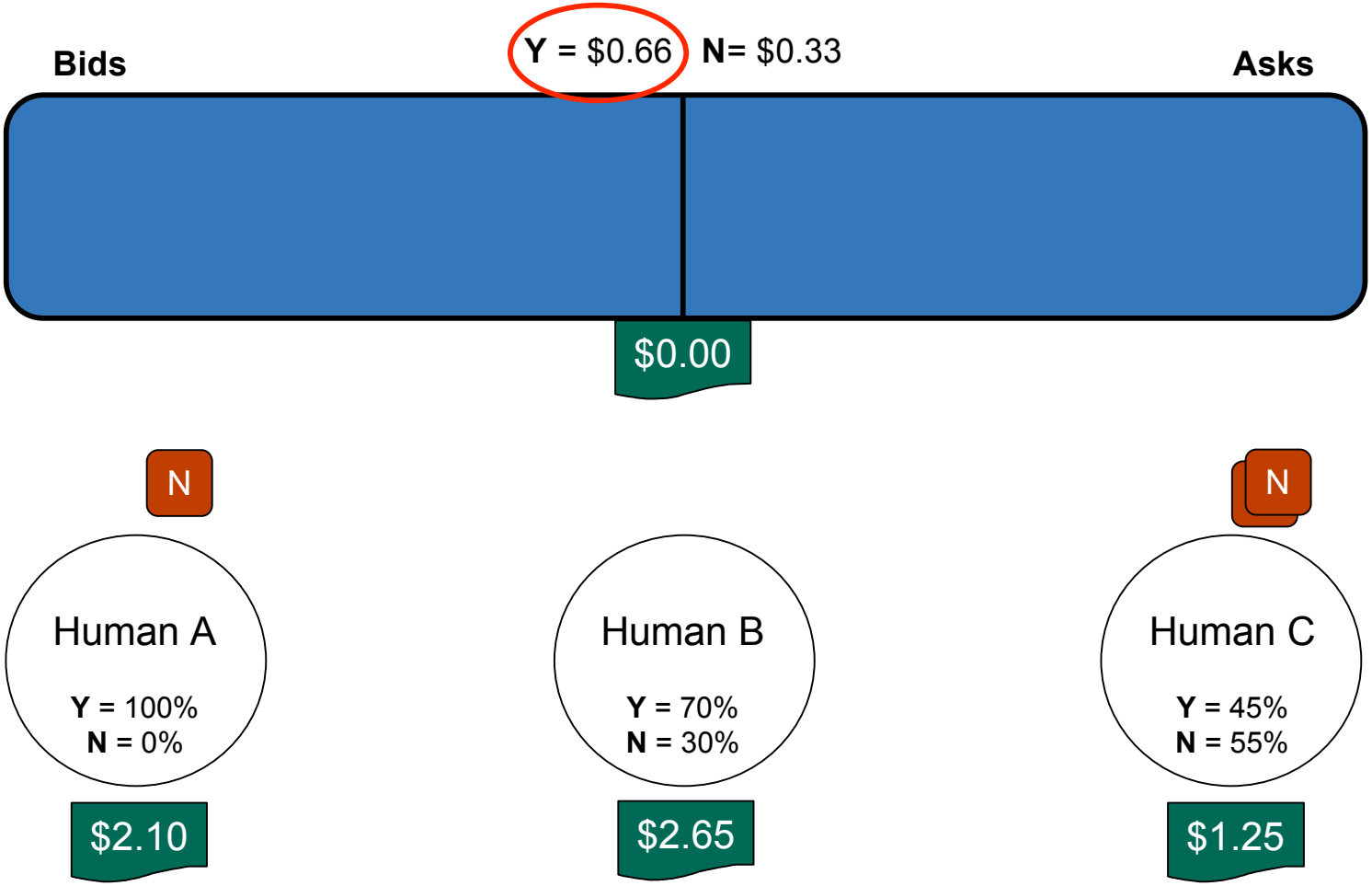

Prediction Markets in the Real-World.

- A useful tool for harvesting information from a large group of individuals.
- Iowa Electronic Market
  - Correctly predicted the number of electoral votes by which George Bush won in 2004.
  - Out predicts polls 75% of the time.
- Hollywood Stock Exchange
  - Correctly predicated 7 out of the 8 most popular Oscar categories in 2006 and 2007.
  - Correctly predicated all 8 popular Oscar categories in 2005.

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Related Publications.

- Rodriguez, M.A., Steinbock, D.J., "Societal-Scale Decision Making Using Social Networks", North American Association for Computational Social and Organizational Science Conference Proceedings, Pittsburgh, Pennsylvania, 2004.

- Rodriguez, M.A., Steinbock, D.J., Watkins, J.H., Gershenson, C., Bollen, J., Grey, V., deGraf, B., "Smartocracy: Social Networks for Collective Decision Making", 2007 Hawaii International Conference on Systems Science (HICSS), Track: Electronic Government - E-Democracy, pages 90-100, Waikoloa, Hawaii, January 2007.

- Rodriguez, M.A., "Social Decision Making with Multi-Relational Networks and Grammar-Based Particle Swarms", 2007 Hawaii International Conference on Systems Science (HICSS), Track: Collaboration Technology - Social Cognition and Knowledge Creation Using Collaborative Technology, pages 39-49, Waikoloa, Hawaii, January 2007.

- Watkins, J.H., “Prediction Markets as an Aggregation Mechanism for Collective Intelligence”, Proceedings of the Human Complex System Conference, Lake Arrowhead, CA, April 2007.

- Watkins, J.H., Rodriguez, M.A., “A Survey of Web-Based Collective Decision Making Systems”, [in review], August 2007.

Questions?

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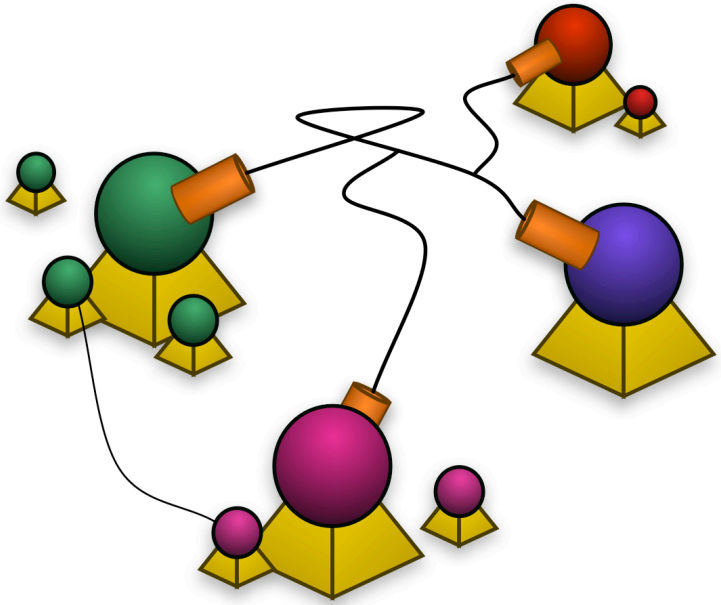

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