How to Make Specialists NOT Specialised in TAC Market Design Competition? Behaviour-based Mechanism Design

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CAT Tournament

Trading Agent Competition Market Design (CAT Tournament, since 2007):

- a simulation of double auction markets, e.g. stock exchanges
- each participant/specialist designs and operates a double auction market
- traders (buyers and sellers) choose profitable markets to trade

How to win the game for a market/specialist:

- attracting more traders, i.e. higher market-share
- make more transactions
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Challenges

- Traders have different intelligence.
  - markets don't know a trader's intelligence level
- Traders are profit-driven.
  - markets can loose a trader very easily, but hard to get it back
- You are not alone!
  - each market competes with one another

So what?

A market performing very well in one environment might perform very badly in another environment.

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How to Solve It?

The goal (*reminder*):

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A Solution

Attracting more good traders and being adaptive.

Questions

- How to distinguish good traders?
- How to attract them?

Behaviour-based Mechanism Design

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Behaviour-based Mechanism Design

Outline

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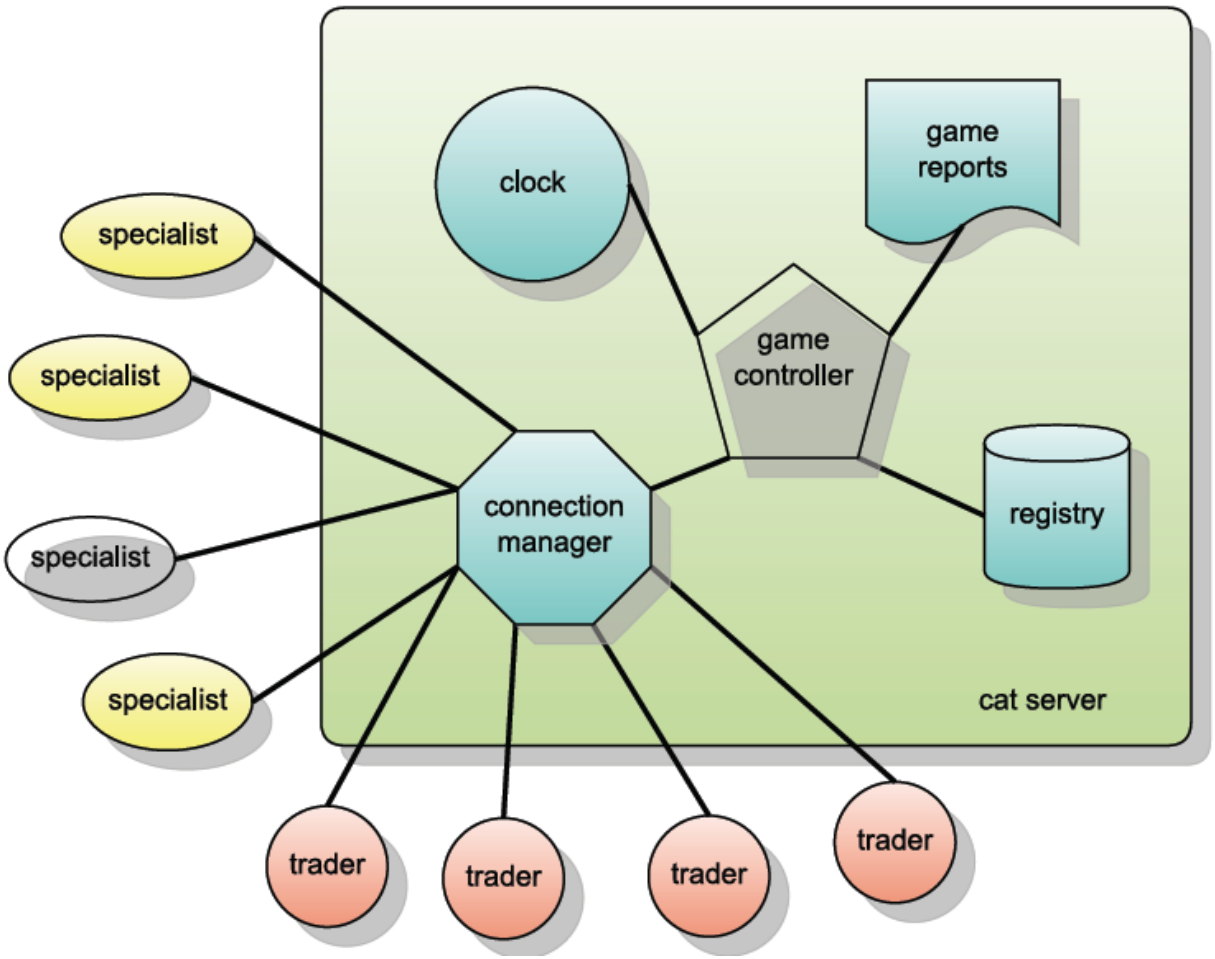
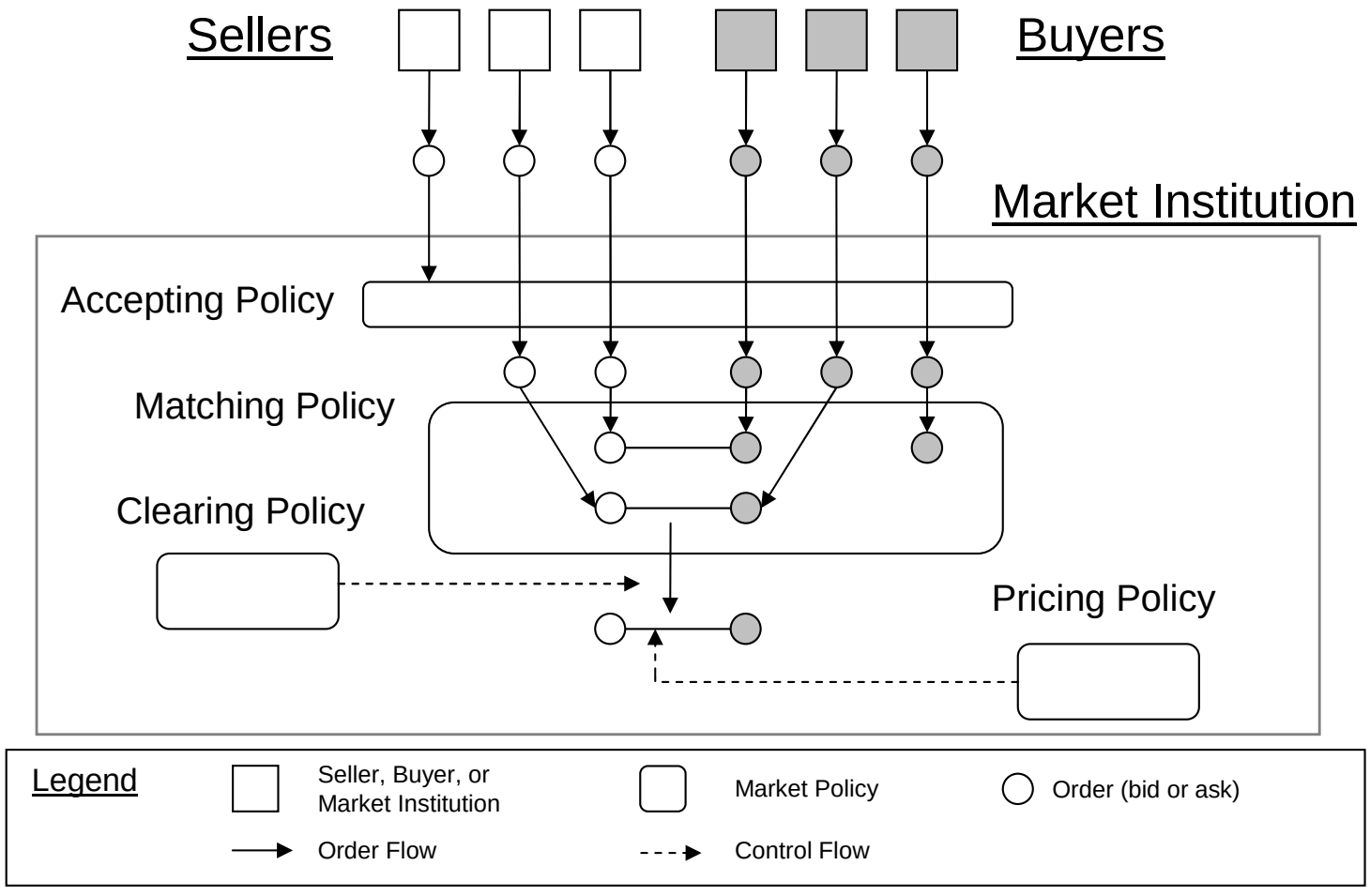
Overall Structure

Trading Agent Competition Market Design (CAT) Platform:



Structure of Specialists/Markets



Structure of Traders

Each trader has:

1. a private valuation of the commodity
2. number of commodities to trade in each day
3. two strategies

The two strategies:

1. market selection strategy
   - determines which market to trade, e.g. always choose the most profitable one
2. bidding strategy, e.g. ZIC, ZIP, GD and RE
   - determines a bidding price for each order

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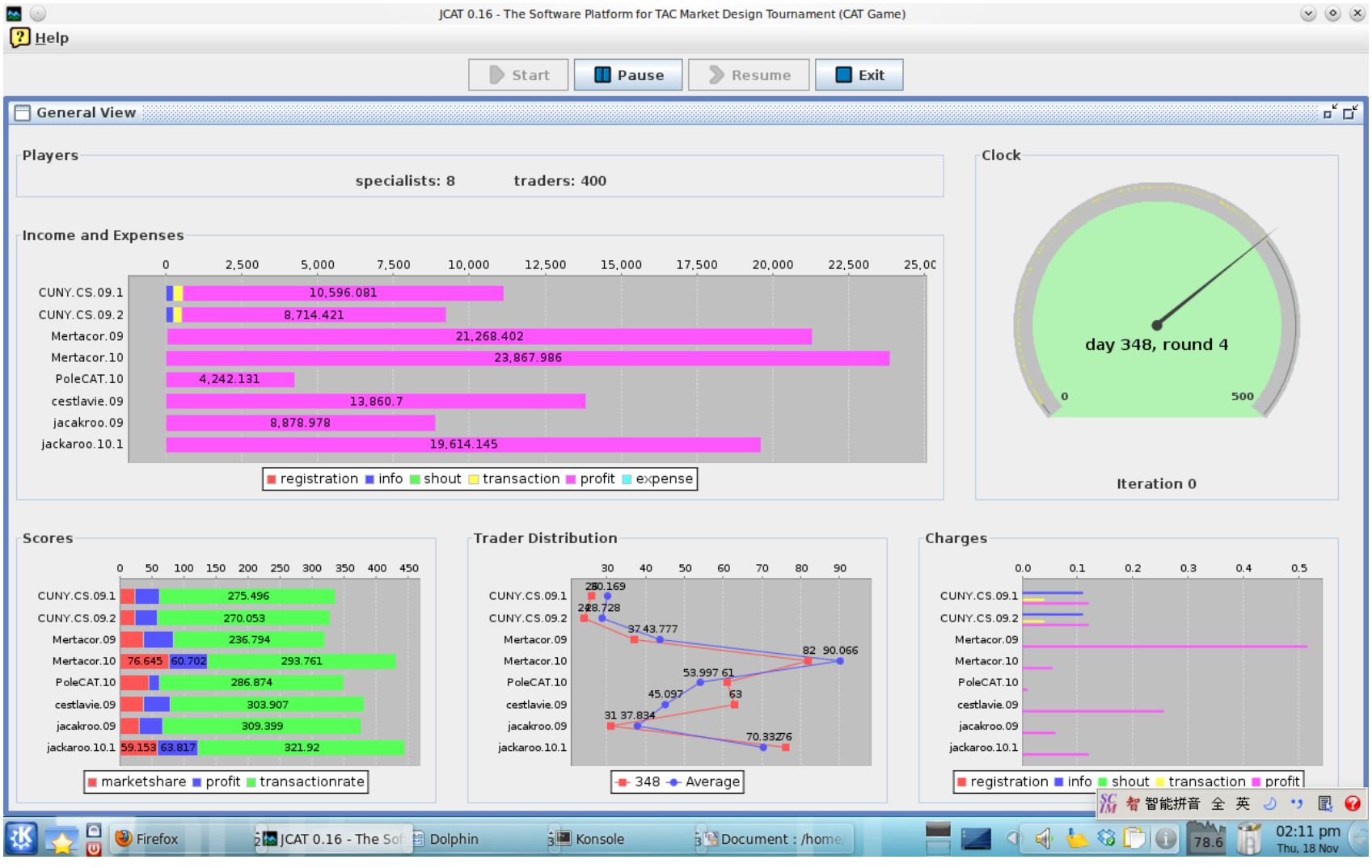
A Snapshot


JCAT 0.16 - The Software Platform for TAC Market Design Tournament (CAT Game)
Help
Start
Pause
Resume
Exit
General View
Players
specialists: 8
traders: 400
Clock
day 348, round 4
0
500
Iteration 0
Income and Expenses
0
2,500
5,000
7,500
10,000
12,500
15,000
17,500
20,000
22,500
25,00
CUNY.CS.09.1
CUNY.CS.09.2
Mertacor.09
Mertacor.10
PoleCAT.10
cestlavie.09
jacakroo.09
jackaroo.10.1
10,596.081
8,714.421
21,268.402
23,867.986
4,242.131
13,860.7
8,878.978
19,614.145
registration info shout transaction profit expense
Scores
0 50 100 150 200 250 300 350 400 450
275.496
270.053
236.794
76.645 60.702 293.761
286.874
303.907
309.399
59.153 63.817 321.92
marketshare profit transactionrate
Trader Distribution
30 40 50 60 70 80 90
280.169
248.728
37.43.777
82 90.066
53.997 61
45.097
63
31 37.834
70.33276
348 Average
Charges
0.0 0.1 0.2 0.3 0.4 0.5
registration info shout transaction profit
Firefox
JCAT 0.16 - The Sof
Dolphin
Konsole
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Thu, 18 Nov

Outline

What Kind of Traders are Attractive?

Given the perfect equilibrium price p_e^* of a market, we say a trader i is

- attractive (intra-marginal): if trader i's private valuation $v_i \leq p_e^*$ ($v_i \geq p_e^*$)
- not attractive (extra-marginal): otherwise.

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Question

p_e^* and v_i are unknown to all markets, how to recognize attractive traders?

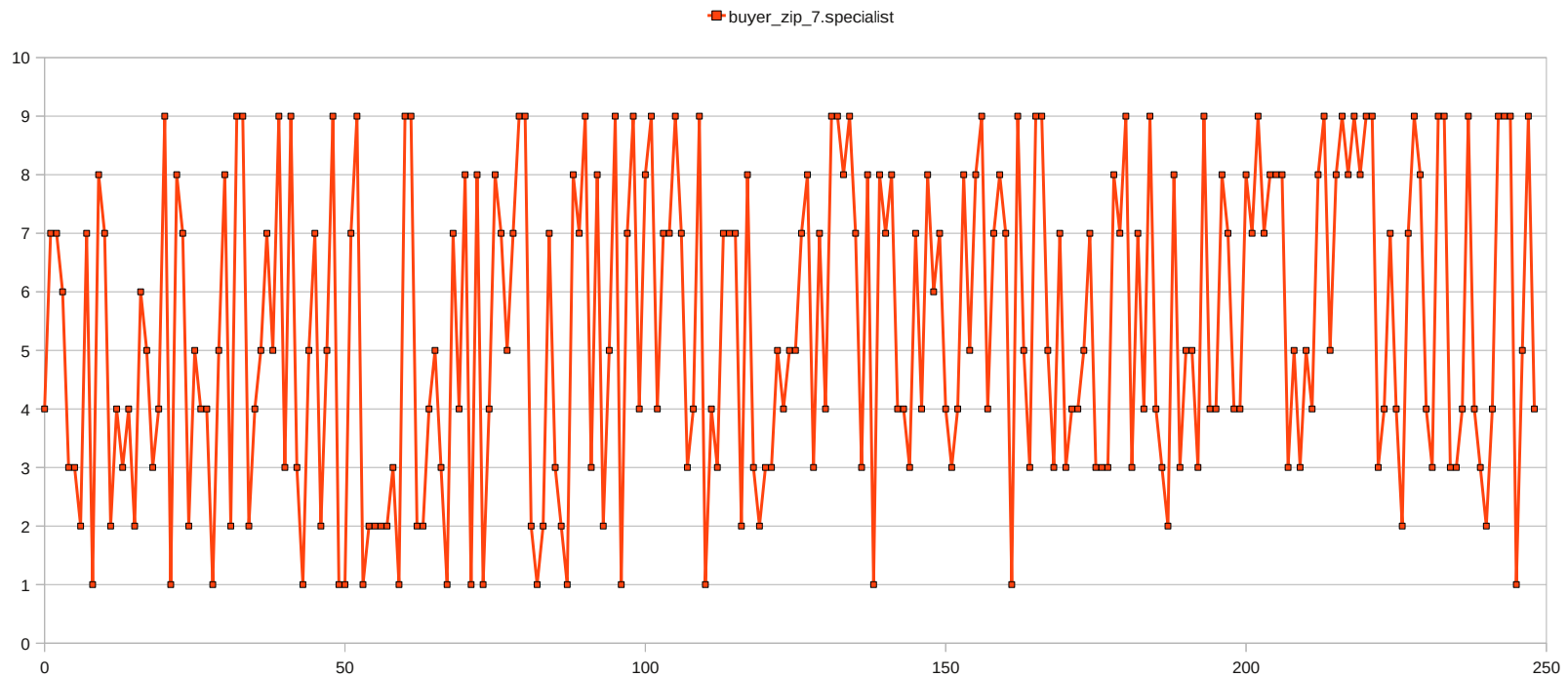
By Utilizing Their Behaviour

We can get from a trader's limited trading history:

- trading time distribution
- average transaction price
- ...

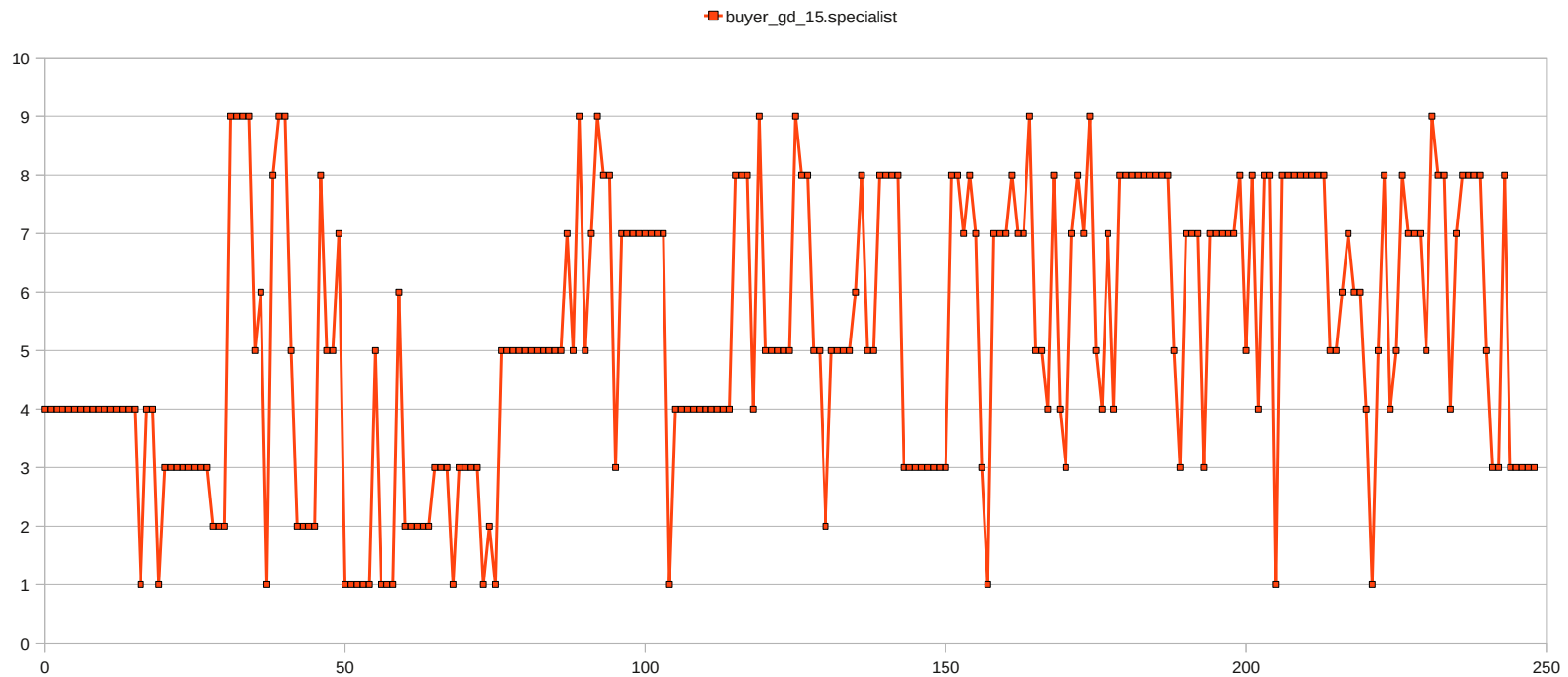
Trading Time Distribution

Very unstable trader



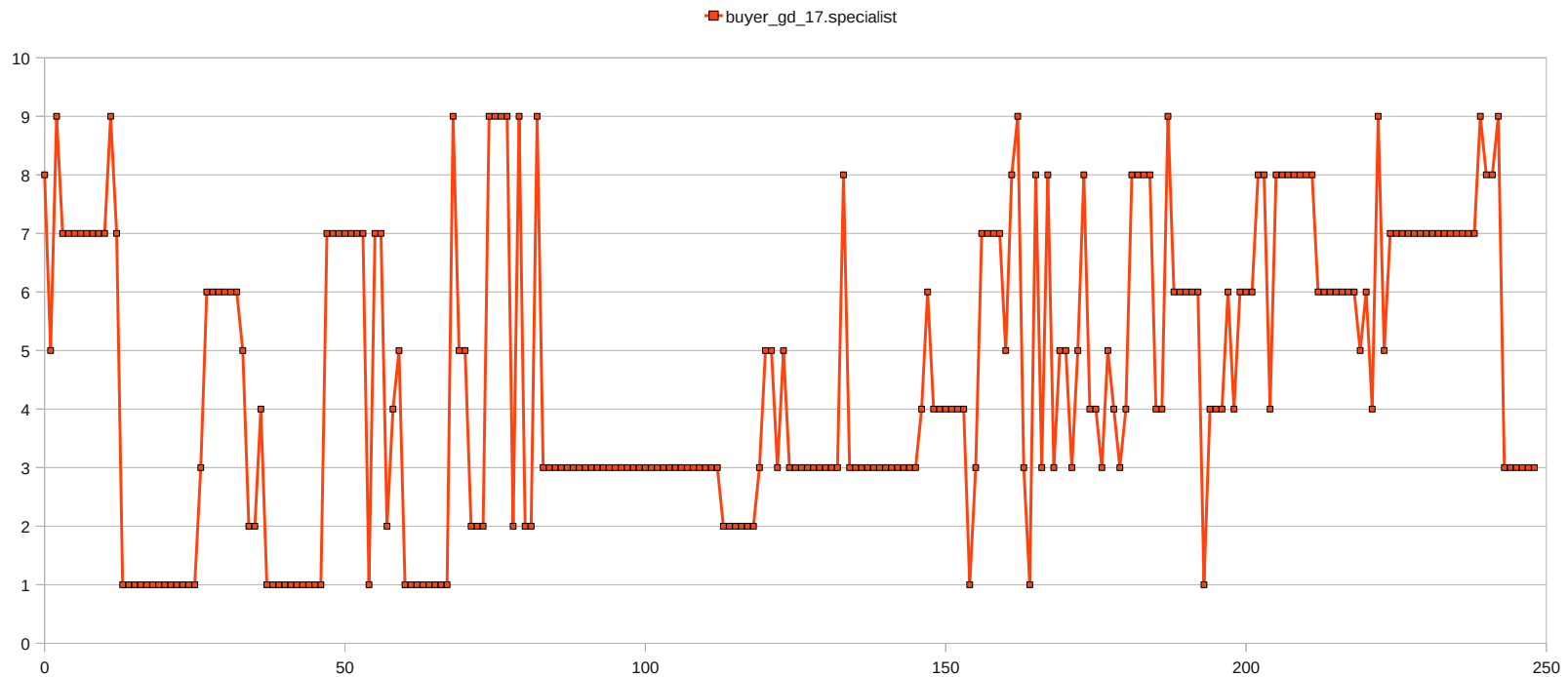
Trading Time Distribution

Unstable stable trader



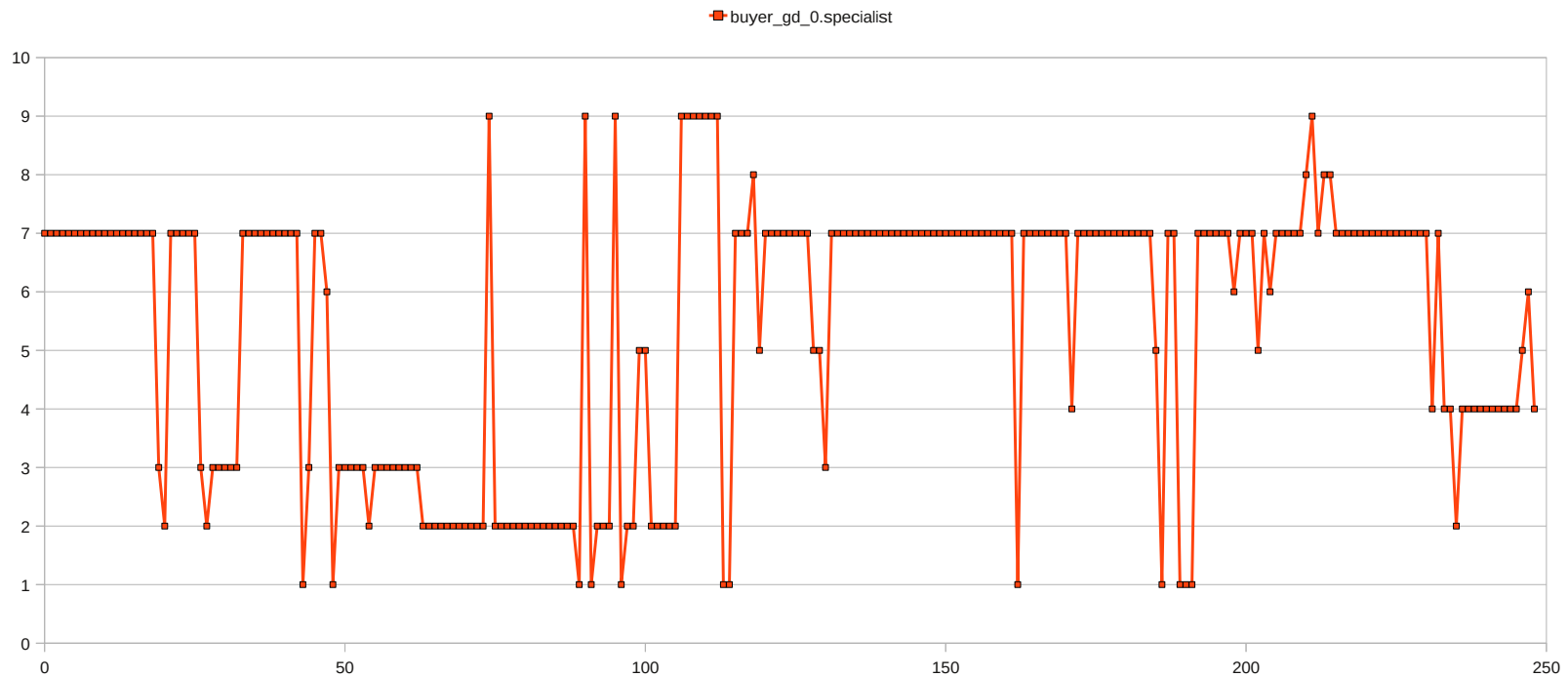
Trading Time Distribution

Stable trader



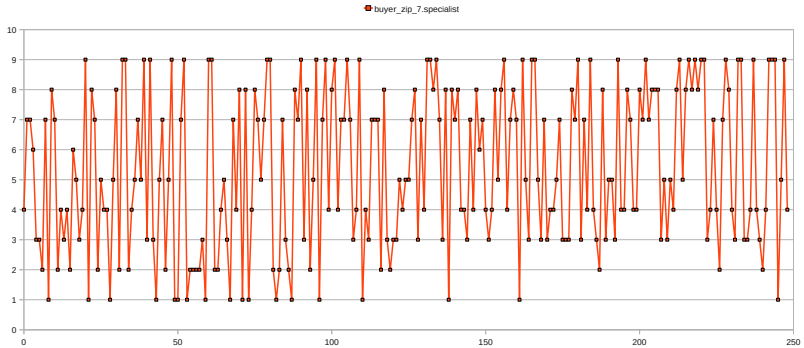
Trading Time Distribution

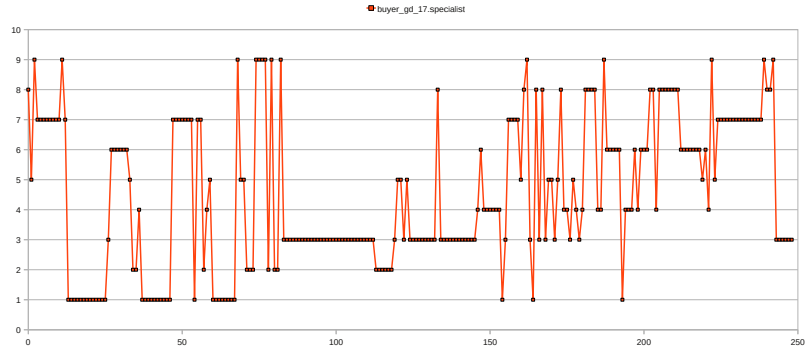
Very stable trader

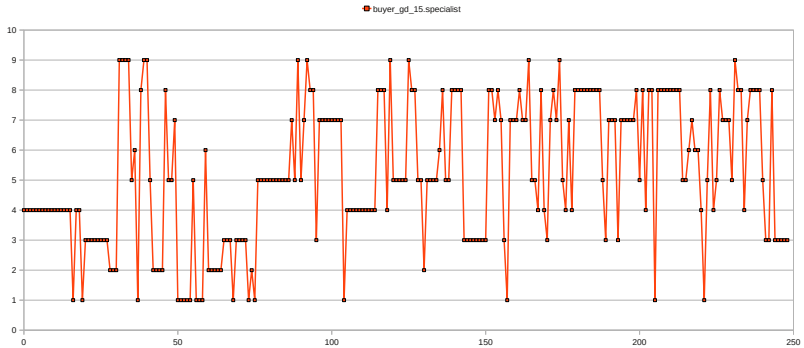


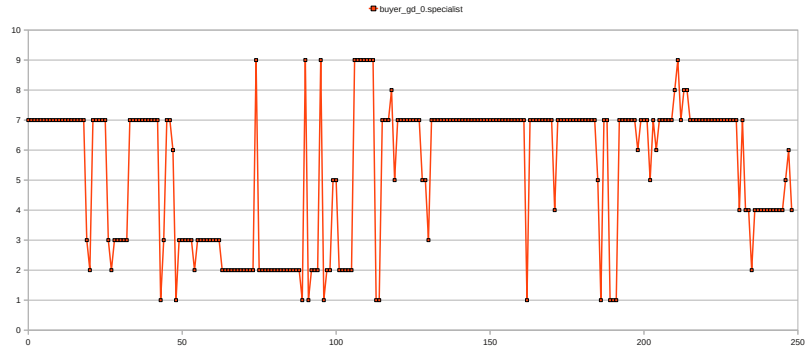
Trading Time Distribution

Attract stable traders









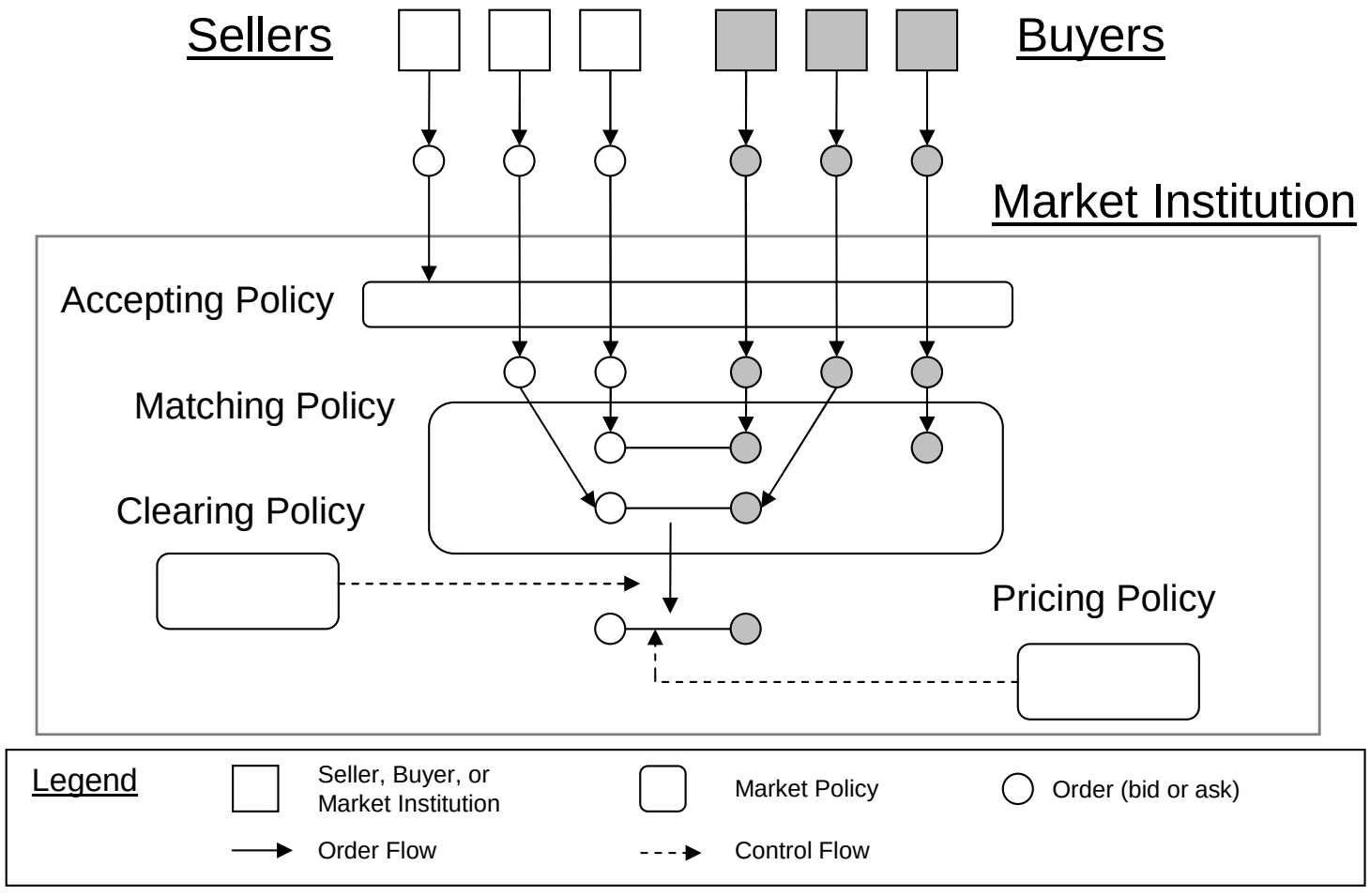
We Know What Kind of Traders to Attract, Then...

Question

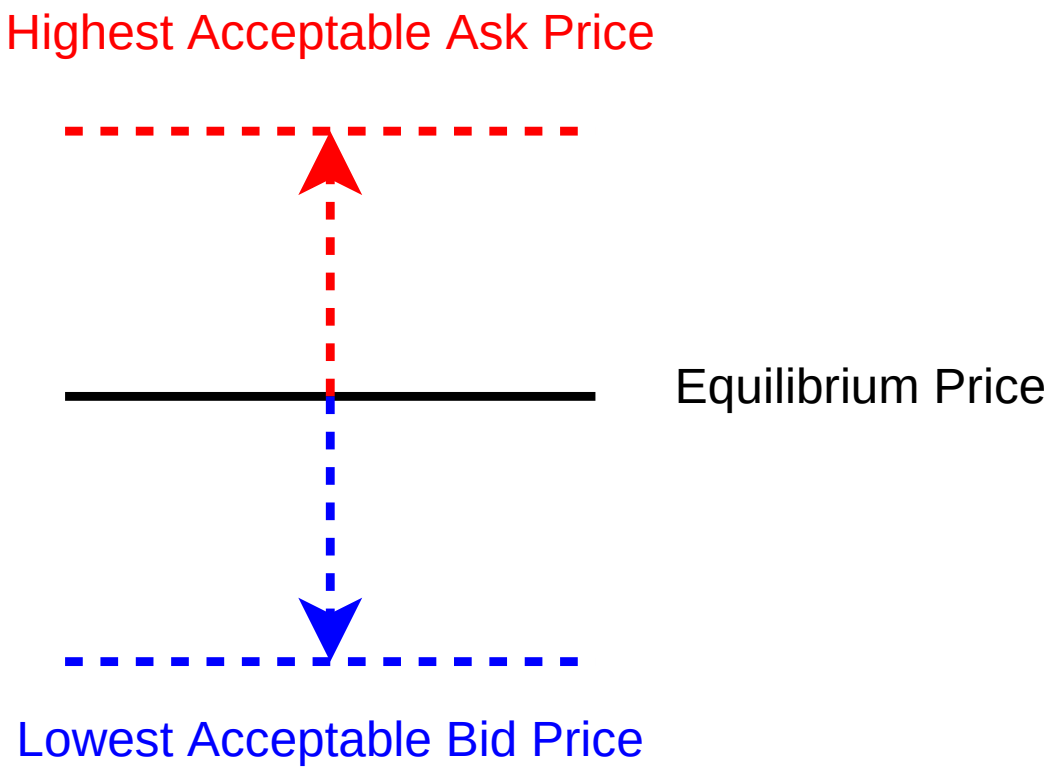
How to attract them?

Outline

Policies of Specialist



Accepting Policy

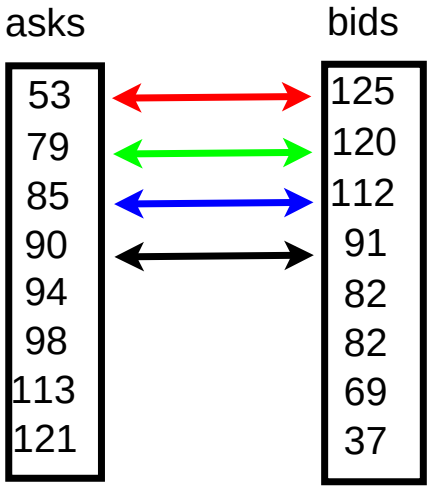


Matching Policy

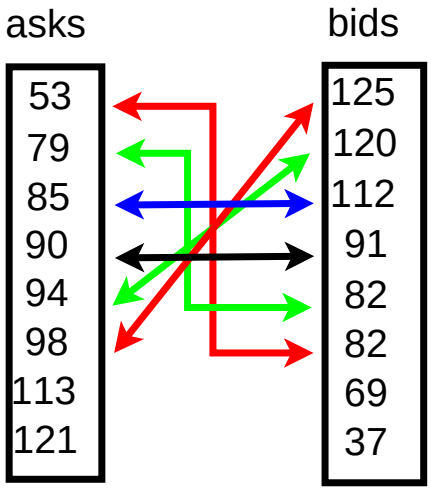
Two most commonly used matching policies:

- equilibrium matching
- maximal matching

Equilibrium Matching vs Maximal Matching



1. profit maximizing
2. can have more transactions

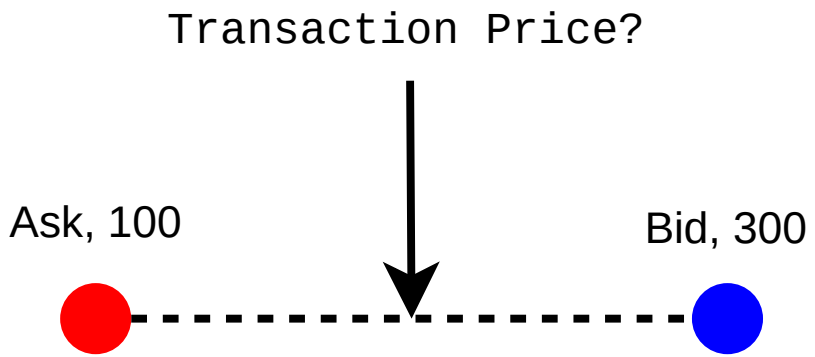


1. not profit maximizing
2. transaction maximizing

Behaviour-based Matching Policy

- double equilibrium matching
- behaviour-based maximal matching

Pricing Policy



Mechanism Design in Specific Enviroments

Input: m_0: initial mechanism, f_m: a function of mechanism to maximise, δ: the minimum improvement
Output: m^*: the local best mechanism

```
1  begin
2      CurrBest ← m_0;
3      repeat
4          m* ← CurrBest;
5          foreach policy parameter r do
6              m' ← monotonically update r in m*;
7              if f_m(m') > f_m(CurrBest) then CurrBest ← m';
8          end
9      until f_m(CurrBest) < f_m(m*) + δ;
10 end
```

Why Do We Need Trader-dependent Mechanisms?

	Specialists								StdDev
	Cu09.1	Cu09.2	Me09	Me10	Po10	Ce09	Ja09	JaGD	
ZIC Sellers	39.60	40.40	54.20	**136.27**	56.83	55.07	42.87	74.77	31.95
ZIC Buyers	41.77	36.13	46.23	**125.53**	67.13	53.93	46.17	83.10	29.64
ZIP Sellers	15.43	16.77	50.00	**179.20**	62.50	50.83	59.40	65.87	51.04
ZIP Buyers	18.30	21.07	49.00	**197.83**	64.50	40.90	45.37	63.03	57.24
GD Sellers	20.73	22.46	49.29	77.80	87.43	62.37	37.84	**142.09**	40.21
GD Buyers	22.91	19.57	51.23	69.50	79.84	69.66	41.34	**145.94**	40.26
RE Sellers	53.10	47.31	53.59	**89.76**	69.46	67.90	55.91	62.97	13.43
RE Buyers	55.19	51.56	55.61	**86.56**	73.07	64.94	55.07	58.00	11.91

From Trader-dependent to Trader-independent

- Dynamically combine/select trader-dependent mechanisms according to online market environment.

Outline

Example: GD Attractive Mechanism

	Specialists								Standard Deviation
	Cu09.1	Cu09.2	Me09	Me10	Po10	Ce09	Ja09	JaGD	
intra-marginal buyers (with valuations between 160 and 110)									
ZIC	27.60	17.27	34.13	**181.27**	65.27	46.20	36.73	91.53	53.39
ZIP	18.70	20.85	42.10	**256.15**	58.85	27.40	40.90	35.05	79.31
GD	23.97	18.64	36.72	70.92	75.42	64.81	18.53	**191.00**	57.02
RE	42.53	39.88	48.84	**113.66**	82.91	68.22	47.84	56.13	25.12
lower extra-marginal buyers (with valuations between 110 and 90)									
ZIC	48.25	49.38	56.13	79.38	71.88	58.75	50.38	**85.88**	14.62
ZIP	16.60	23.40	46.00	89.80	71.80	60.20	34.20	**158.00**	45.77
GD	28.44	21.44	38.89	47.67	108.89	65.22	33.56	**155.89**	46.81
RE	68.86	57.86	55.14	66.00	**70.29**	62.71	59.14	60.00	5.43
other extra-marginal buyers (with valuations between 90 and 60)									
ZIC	64.71	61.43	60.86	58.86	**65.71**	65.00	61.57	61.86	2.39
ZIP	18.40	19.60	79.60	72.60	**79.80**	75.60	74.40	80.00	26.99
GD	19.40	20.24	76.56	75.32	75.76	**78.24**	77.00	77.48	26.36
RE	**65.16**	62.19	62.71	63.23	63.55	62.06	61.61	59.48	1.64

Our CAT Specialist: *jackaroo*

jackaroo achievements:

- CAT 2007: 4th
- CAT 2008: 3rd
- CAT 2009: 1st
- CAT 2010: 2nd
- CAT 2011: 1st

CAT 2011

Basic settings:

- 400 traders, 3 items to trade in each day.
- 5 teams/specialists
- three final games, each game lasts 500 virtual days.

Traders' bidding strategy distribution:

- Game 1: 120 GDs, 100 ZIPs, 120 REs and 60 ZICs.
- Game 2: 120 GDs, 80 ZIPs, 150 REs and 50 ZICs.
- Game 3: 160 GDs, 60 ZIPs, 140 REs and 40 ZICs.

CAT 2011 Results

jackaroo, PoleCAT and Mertacor:

- Game 1: 120 GDs, 100 ZIPs, 120 REs and 60 ZICs.
  - 251.396 (242.094, 216.103):
    - market-share: 119.173 (106.248, **120.008**)
    - transaction rate: 469.089 (405.873, 429.494)
    - profit: 165.901 (**214.145**, 98.798) *[0.031,0.149,0.033]*
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    - transaction rate: 463.772 (390.146, 421.937)
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- Game 3: 160 GDs, 60 ZIPs, 140 REs and 40 ZICs.
  - 207.759 (**221.798**, 210.426):
    - market-share: 112.333 (100.75, 98.341)
    - transaction rate: 444.394 (397.434, 379.493)
    - profit: 66.52 (**167.251**, 153.481) *[0.032,0.147,0.093]*

Outline

Summary

We have proposed a framework for behaviour-based mechanism design which consists of:

- behaviour-based trader classification
- behaviour-based policy design
- searching trader-dependent mechanisms
- integrating trader-dependent mechanisms online

What we can improve in the future:

- better trader classification
- build clearer relationship between loosely coupled policies

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Thank you for your attention!

Welcome!

Welcome to Toulouse!

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Welcome to join CAT games!