False-name-proofness in Online Mechanisms

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False-name manipulations

- In highly anonymous environments such as the Internet, an agent can pretend to be multiple agents.
- A mechanism is false-name-proof (FNP) if for each agent, truthful telling by using a single identifier (although he can use multiple identifiers) is a dominant strategy.
  - In combinatorial auctions, even theoretically well-founded Vickrey-Clarke-Groves mechanism is not FNP (i.e., vulnerable against false-name manipulations) .

Online Mechanism Design

- Mechanism Design has focused on static (offline) environments.
  - All agents arrive and depart simultaneously.
- In real electronic markets, each agent arrives and departs over time.
- Mechanism must make decisions dynamically without knowledge of the future.

Summary

- This is the first work that deals with false-name manipulations in online mechanisms.
- We identified a simple condition called (value, time, identifier)-monotonicity, which fully characterizes FNP online auction mechanisms.
- Based on the characterization, we developed a new FNP online auction mechanism.
  - An application of Bruss's optimal stopping strategy to online auctions

Outline

- Preliminaries
  - Mechanism Design
  - Online Auctions
  - HKP Mechanism
- Characterizing False-name-proof Online Mechanisms
- New False-name-proof Online Mechanism
- Conclusions / Future Work

Mechanism Design

- The study of designing a rule/protocol
  - Assumption: each agent hopes to maximize his utility
  - Goal: achieving several desirable properties (e.g., strategy-proofness)
- A mechanism consists of an allocation rule and a payment rule.
- SP mechanisms can be characterized only by allocation rules.
  - Online Auctions: Hajiaghayi, Kleinberg, and Parkes, 2004
  - Combinatorial Auctions: Bikhchandani et al., 2007

Online Auctions with Single-item, Limited-supply

- Sell an indivisible item to multiple agents who arrive and depart over time.
  - Agent i has a type (private information) $\theta_i=(a_i, d_i, r_i)$.
  - a_i, d_i: arrival and departure times of i
  - r_i: a valuation of i for the auctioned item
- We assume no early-arrival and no late-departure misreports.
  - Type $\theta'_i=(a'_i, d'_i, r'_i)$ reported by i always satisfies $a_i \leq a'_i \leq d'_i \leq d_i$.

Online Auction Mechanism

Definition [Hajiaghayi, Kleinberg, and Parkes. 2004]

Let n be a number of agents and α be the arrival time of $\lfloor n/e \rfloor$–th agent.

1. At period α , sort bids observed so far in descending order r_1 , r_2 ,... .
2. If an agent who bids r_1 (the highest value) is still present at α , sell to that agent at price r_2.
3. Sell to the next agent who bids at least r_1 at price r_1.

- An application of the optimal stopping rule for the classical secretary problem

Ex. HKP Mechanism

- There are 6 agents.
  - Mechanism waits for the second ($\lfloor 6/e \rfloor = 2$) agent.
  - Agent  wins the item at period 4 and pays 6.
- If there's no false-name manipulations, HKP is strategy-proof.

 : (1, 3, 6)

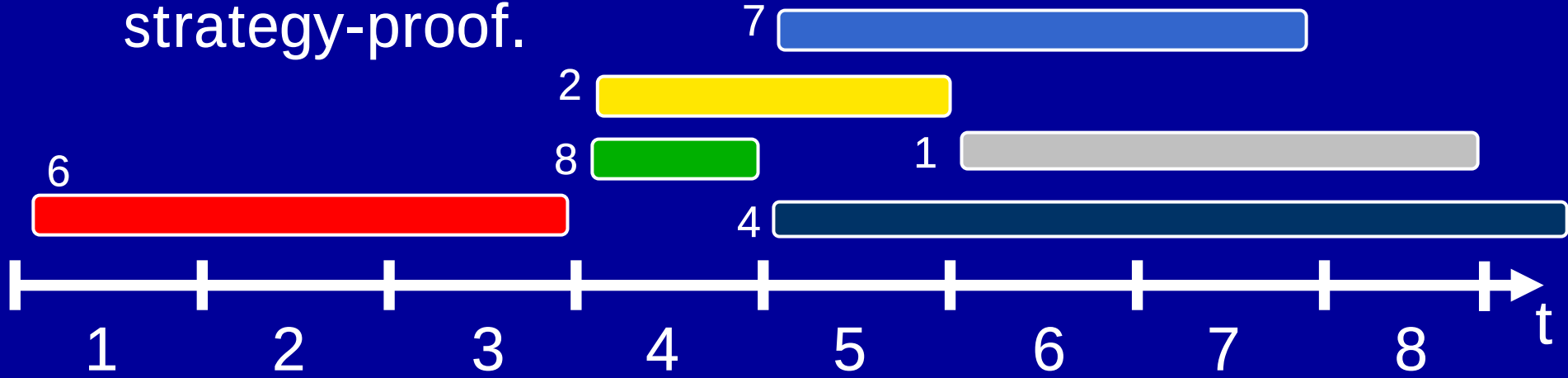
 : (5, 7, 7)

 : (4, 4, 8)

 : (5, 9, 4)

 : (4, 5, 2)

 : (6, 8, 1)



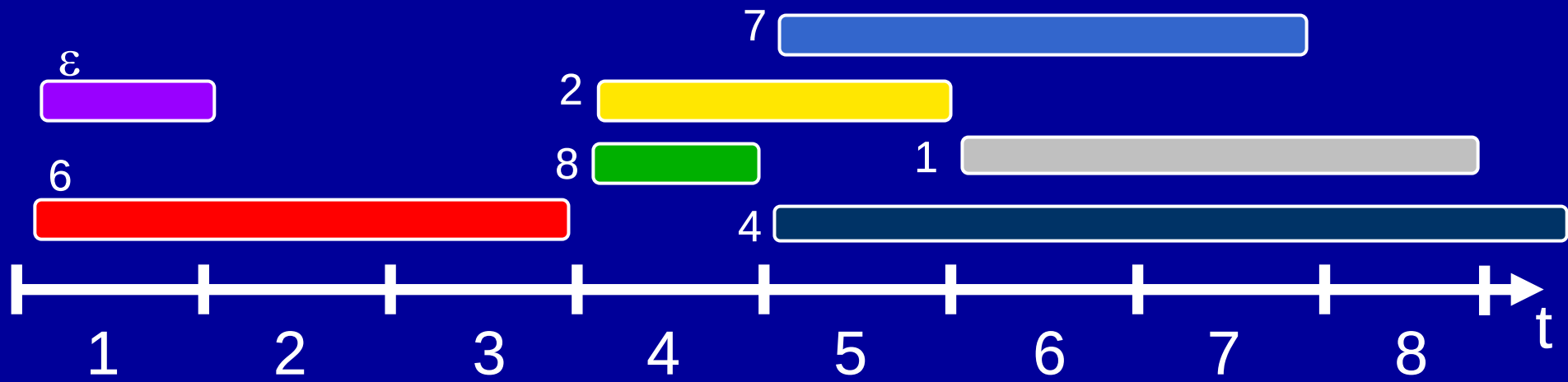
False-name Manipulation in HKP

- If agent adds another false identifier , he can win the item.
  - reports (1, 1, ε) from identifier .
  - Mechanism waits for the second ($\lfloor 7/e \rfloor = 2$) agent.

: (1, 3, 6) : (5, 7, 7)

: (4, 4, 8) : (5, 9, 4)

: (4, 5, 2) : (6, 8, 1)



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Characterizing FNP Online Mechanisms

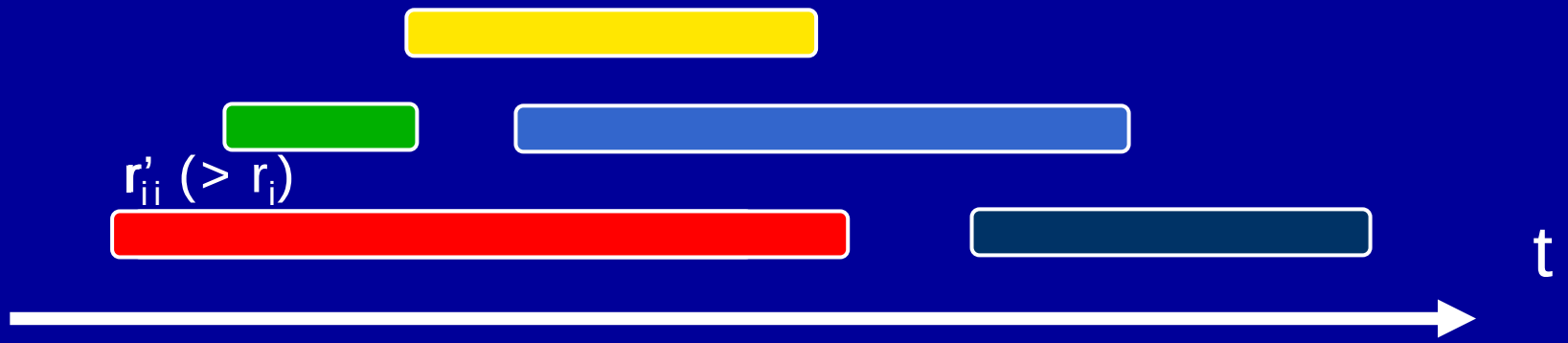
Definition (value, time, identifier)-monotonicity

An allocation rule is *(value, time, identifier)-monotonic* if for any winner, if he bids higher, stays longer, or his rivals drop out from the auction, then he still wins.

Theorem [Todo, Mouri, Iwasaki, and Yokoo, 2010]

An online auction mechanism is false-name-proof if and only if the allocation rule is (value, time, identifier)-monotonic.

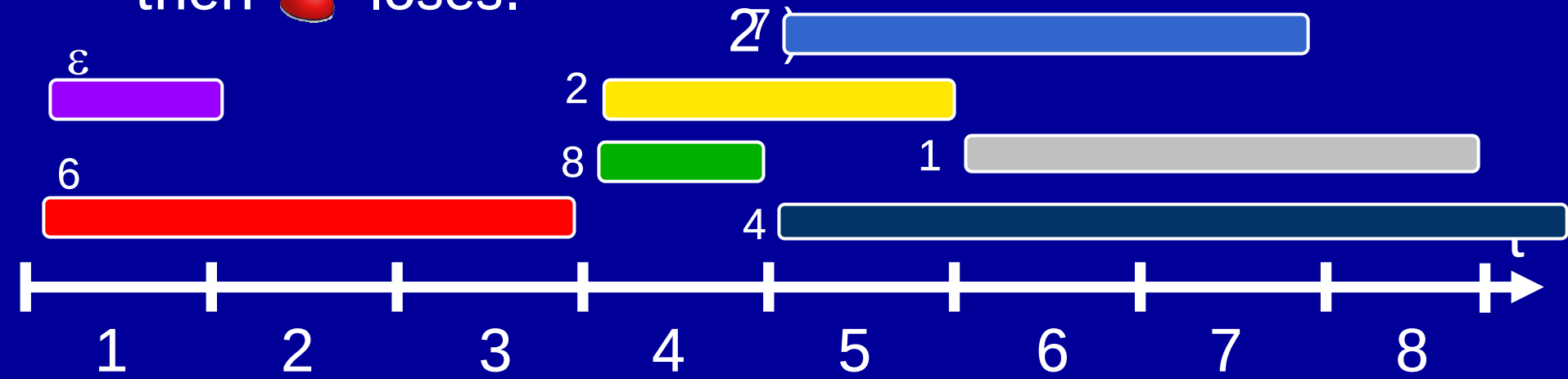
(value, time, identifier)-monotonic Allocation Rule



- *rival* of i: an identifier j whose report $\theta_j=(a_j, d_j, r_j)$ satisfies $a_i \leq a_j \leq d_j \leq d_i$.
  - Identifier is a rival of identifier .
- Assume that identifier is winning with bid $\theta_i=(a_i, d_i, r_i)$.
- In a (value, time, identifier)-monotonic allocation rule, identifier still wins if bids higher, stays longer, or drops out from the auction.

Ex. HKP allocation rule violates (value, time, identifier)-monotonicity

- Identifier is a winner in this 7 agents case.
- Identifier is a rival of identifier .
- If drops out from this auction, then loses.



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New FNP Online Auction Mechanism

Definition [Todo, Mouri, Iwasaki, and Yokoo. 2010]

Let τ be a predefined time period.

1. At period τ , sort bids observed so far in descending order.
2. If an agent who bids r_1 (the highest value) is still present at τ , sell to that agent at price r_2.
3. Sell to the next agent who bids at least r_1 at price r_1.

Theorem [Todo, Mouri, Iwasaki, and Yokoo, 2010]

TMIY is false-name-proof.

Ex. TMIY Mechanism

- Assume that $\tau=4$.
- Even if agent  adds false identifiers, the item isn't sold to any agent until period 4.
- Winner  cannot decrease his payment by using false-identifiers.

 : (1, 3, 6)

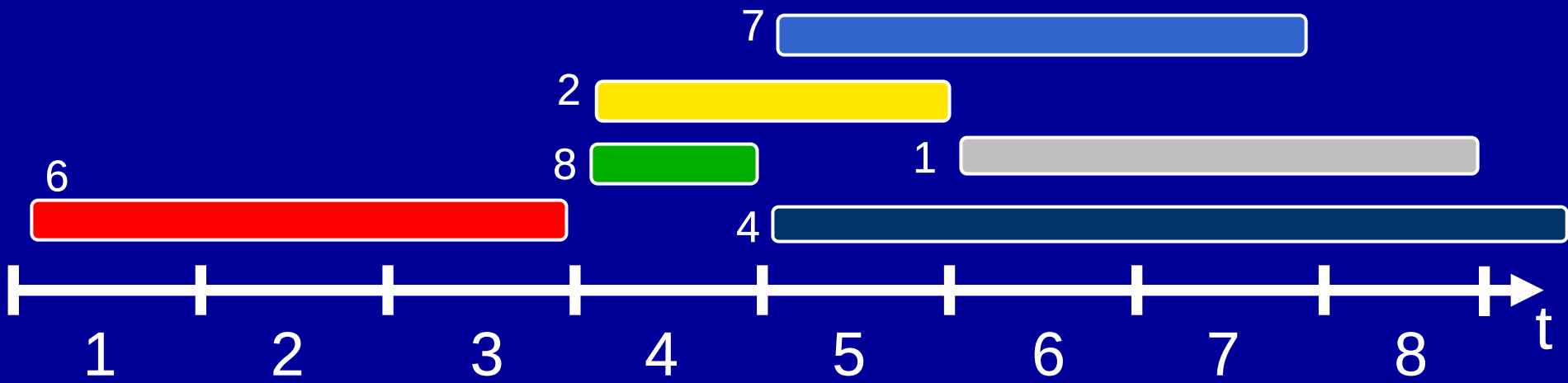
 : (5, 7, 7)

 : (4, 4, 8)

 : (5, 9, 4)

 : (4, 5, 2)

 : (6, 8, 1)



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Conclusions

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Future Work

- Analyze the performance of TMIY
- Obtain a lower bound of the competitive ratio for the efficiency and revenue in a single-item, limited-supply environment
- Generalize our FNP mechanism to k-items environments
- Extend our results beyond single-valued settings
  - e.g., FNP CAs in dynamic environments

(Incomplete) References

False-name-proofness

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Secretary Problem

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Thank you.

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改良メカニズム

- 勝者は  ，支払額２．
- このメカニズムは戦略的操作不可能
  - 先に参加したエージェントを無視せず，最高額を入札していれば優先的に販売
  - 参加時刻に関して単調





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Average-case Analysis