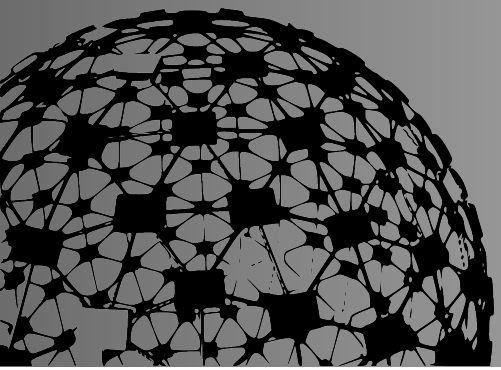
Dynamic Markets for Wireless Congestion Pricing



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A&M

Societal Networks

- Congestion Pricing
  - Road Networks
  - Public Transportation
  - Smart Grid
  - Cellular Data?

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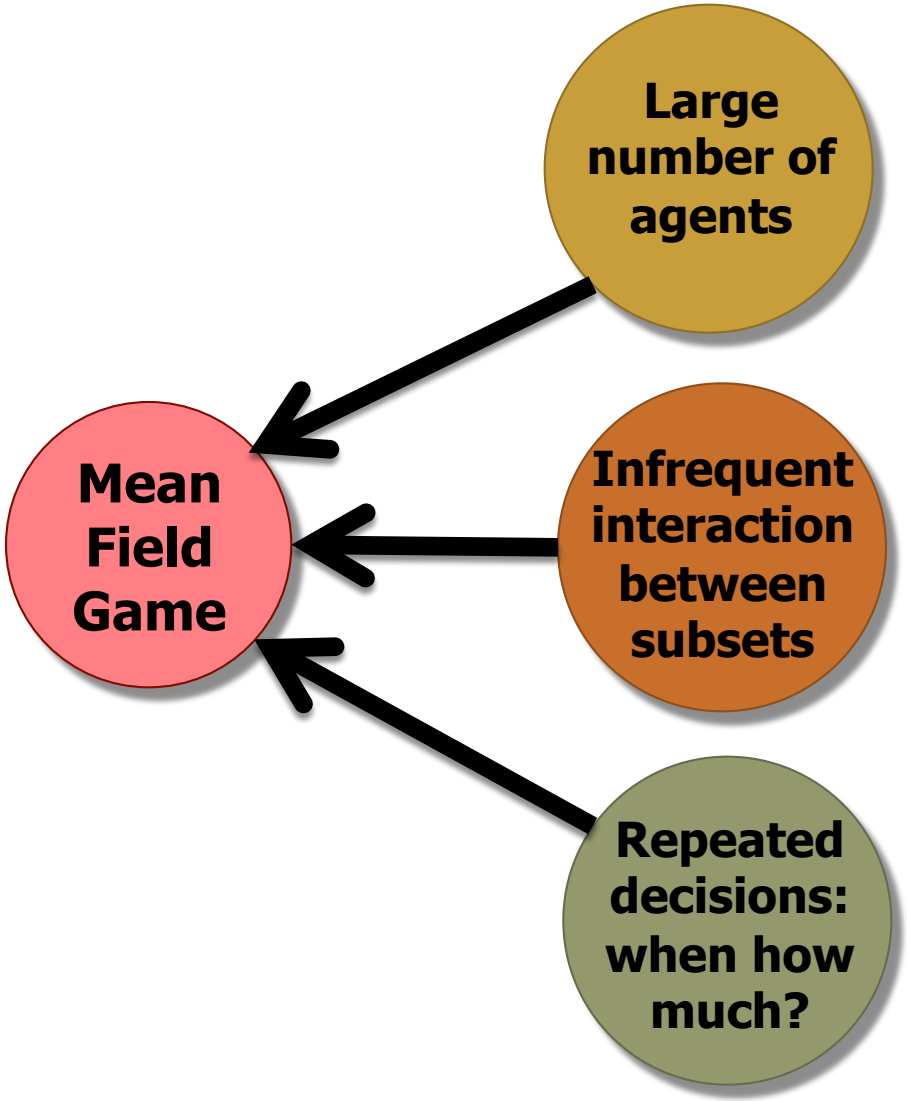


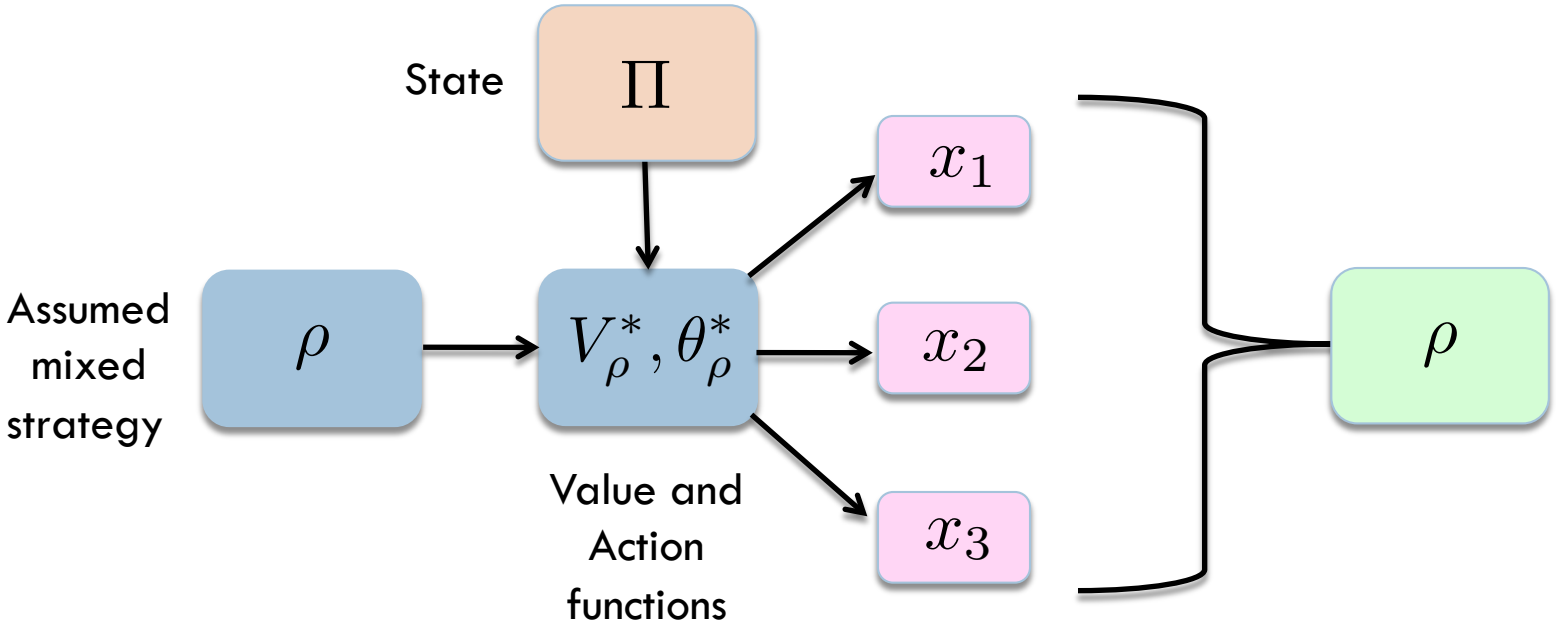
Related Work

- Time Dependent Pricing System:
  - S. Ha, S. Sen, C. Joe-Wong, Y. Im, and M. Chiang, "TUBE: Time Dependent Pricing for Mobile Data", ACM SIGCOMM 2012.

- Theory of Mean Field Games:
  - K. Iyer, R. Johari and M. Sundararajan: “Mean field equilibria of dynamic auctions with learning”, ACM Conference on Electronic Commerce 2011.

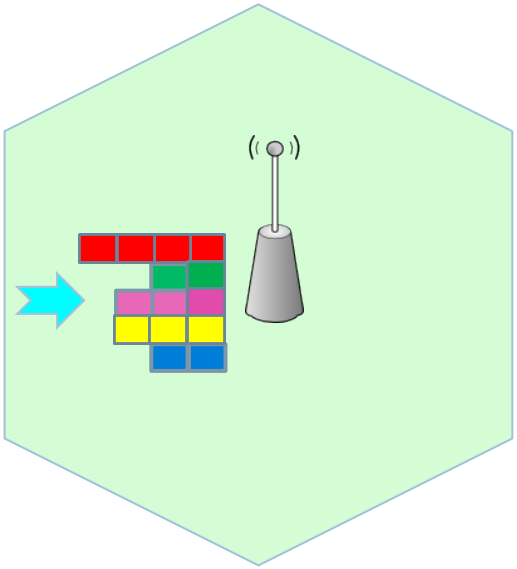
Mean Field Equilibrium

- Steady state action distribution of single agent = Empirical distribution of infinite agents over one step.



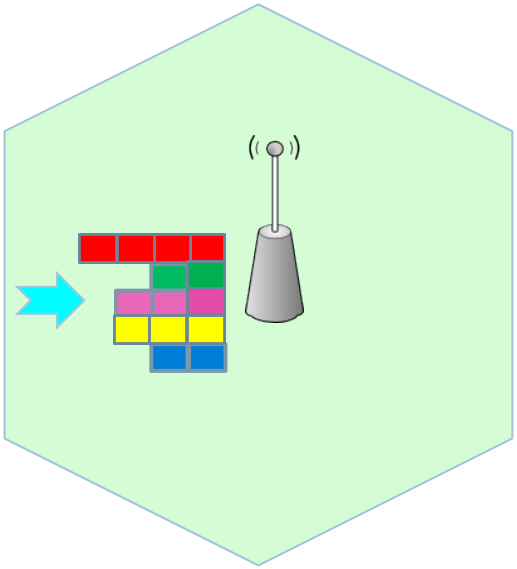
Motivation

- A now-standard approach to scheduling in queueing systems is the Max-weight idea (Tassiulas & Ephremides '92).
- In our context, (weighted) Longest Queue First would yield short queue lengths.
- How do you get queue length and cost functions?
- Will users reveal their true values? Conduct an auction?



System Model

- Users of cellular data networks use apps that have differing service requirements: delay sensitivities → holding cost for queue.
- Users terminate apps and start new ones periodically → geometric lifetime and regeneration.
- The base station must schedule uplink/downlink in a "fair" manner → auction with M agents.
- Users move around between different cells → independence among queues.



Theoretical Results

- MFE exists.
- Bid is strictly monotone increasing if holding cost is strictly convex.
- Essentially gives rise to max-weight (longest queue first regime).
- Max-weight is not just throughput optimal, it is also incentive compatible!
- Extendable to multiple classes of cost functions.
- M. Manjrekar, V. Ramaswamy and S. Shakkottai, "A Mean Field Game Approach to Scheduling in Cellular Systems" in IEEE INFOCOM '14

Implementation?

- Use a token-based scheme to conduct auctions →
  3 Giga-tokens instead of 3 GB limits?
- Bid-distribution updated periodically
  → Low demand → Low bid.

- LTE frame uplink control requires stations to indicate if they wish to transmit.
- Supports declaration of buffer size as well.
- Smart phone laboratory, partially supported by Google Inc.
- Open WRT based scheduling in 802.11 APs.