

Probability Collectives
for Distributed Optimization and Control
in Ad-hoc Networks

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Golden Rule for Probability Collectives

DO NOT:

Search for a variable x , that optimizes a function

INSTEAD:

Consider a distribution over x , that optimizes an expectation value

Allows very powerful tools to be used from

1. Bounded rational game theory
2. Statistical physics (mean field theory)
3. Adaptive control
4. Optimization, constrained or not, over *any* measurable space
5. Reinforcement learning

Probability Collectives

Consider a multi-dimensional system with state

$$x = (x_1, x_2, \dots)$$

Viewing it as a **collective** means:

1. You associate a **private utility function** $g_i(x)$ with some of the components x_i
2. You associate a **world utility function** $G(x)$ with the entire system

Optimization of private utilities leads to global utility optimization

Examples of Collectives

A corporation of human ‘agents’

The Internet

UAV’s flying in formation

Combinatorial Optimization

Probability Collectives for Distributed Control

- Search the space of solutions using multiple simultaneous local searches
- Breadth vs. depth of search relates to *entropy*
- Entropy is related to
 - bounded rationality (statistical inference)
 - Lagrange multipliers (optimization)
 - mean field theory (statistical physics)
 - Distributed information and control
 - Incentive schemes for local agents (game theory)

Probability Collectives for Ad hoc networks

Ad-hoc networks problem:

- Define the clusters and cluster heads to organize a network

Using Probability Collectives:

- Each node in network is an agent
- Agent has limited knowledge of other agents
- Agent updates probability of becoming a cluster head based on feedback

ie Rather than storing a ‘yes’ or ‘no’ decision, the node records a ‘probability’, indicating how advantageous it would be to become a cluster head.

Team

- Currently have team of
 - UCSC faculty (optimization, networks)
 - Stanford faculty (networks, control)
 - NASA scientists (optimal control)
- Looking for
 - Industry partnerships
 - Test beds
 - Data!