System Improvement Using Structural Conservation

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Outline

- Two examples of a modeling strategy
- Stochastic network improvement via 2-moment approximations
  - Current work of Julien Granger
  - Uses deterministic approximation to estimate an optimizer
  - Validates “betterness” with simulation
- Generalized equations
  - Developed area, payoffs now better known
- Can we push this farther? If so, how?
Network improvement

- Stochastic networks with parameters
  - Service rates, # of servers, etc.
  - Can (pay to) change parameters
  - Try to improve a performance measure
    - E.g. steady-state mean throughput

- Idea: use 2-moment approximations
  - Replace nodes by renewal processes with infinite buffers
    - Can model hard constraints with fork/join, kanban
  - Characterize process by mean, SCV
  - Form system of nonlinear equations
Network improvement 2

- Nonlinear system: parameters plus other performance measures
- Use deterministic methods to adjust parameters for good performance
  - 1 simulation to validate improvement (not necessarily optimization) at end
- Previous work: Whitt, Sanders, Suri, Kamath, Krishnamurthy, others
  - Current work is thesis of J. Granger
  - More info: granger@cae.wisc.edu
What’s the abstract approach?

- We have a system involving
  - Nodes (servers) of various forms
  - A topology that connects them and enforces certain relationships

- Model this for improvement by:
  - *Simplifying* the nodes (perhaps greatly)
  - *Retaining* the structure to connect the simplified nodes

- This we’ve seen before
Generalized equations

- This same idea occurs in solving generalized equations
  - Original: $0 \in f(x) + N_C(x)$, where $C$ is closed convex, $N_C$ is normal cone to $C$
  - Approximation: $0 \in a(x) + N_C(x)$, with $a$ being a function much simpler than $f$
  - Here $N_C$ represents “system topology,” e.g. introducing corners into problem

- Contrasts with direct approximation
Empirical insight, and question

- This approach, conserving system *structure* while simplifying system *elements*, has produced good tools
  - These have performed very well vs. attempts at direct approximation of the system output
- Is it more generally applicable?
- If so, what guides does it provide to where we might concentrate effort?
Implications for investigation

- If we wanted to learn more about exploiting this idea, we could ask:
  - For common systems, *what kinds of simplified elements* would make it easy to estimate the system performance?
  - *What elements of system structure* are particularly critical to defining the important output characteristics?
  - *How good* is resulting approximation, & why?

- Answers could pay off in better methods
Questions?