Stochastic Control

• Static Techniques vs. Adaptive Techniques

• Predictive approaches:
  – Address workload uncertainty
  – But assume deterministic response and transition times

• Stochastic model
  – Safe
  – General
Limitations of Predictive Techniques

- Based on a **two-state** system model
- Heuristic
- Parameter tuning can be difficult
- Can’t control performance penalty
Stochastic Control Approach

- Not to eliminate uncertainty by prediction
- To formulate policy optimizations as an optimization problem under uncertainty.
- Power management optimization
  - Controlled Markov Processes
  - System and Workload are modeled as Markov Chains
Markov Chain Models

- Model uncertainties in system power consumption, response times, and transition times.
- Model systems with multiple power states
- Computer power management policies that are globally optimum
- Explore tradeoffs between power and performance in a controlled fashion

Who should take this approach to conduct research…?
Markov Model

• A service requester (SR): it models the arrival of service requests for the system (i.e., the workload).

• A service provider (SP): Its states represent the modes of operation of the system (i.e., its power states), its transitions are probabilistic, and probabilities are controlled by commands issued by the power manager.
Markov Model (cont.)

• A power manager (PM): it implements a function from the state set of S (service provider) and R (service requester) to the set of possible commands A.

\[ f: S \times R \rightarrow A \]

• Cost metrics: Associate power and performance values with each system state-command pair in \( S \times R \times A \).
Example: Service Requester
Two-state Markov Chain
Example: Service Provider
Two-state Markov Chain

When a command is issued, the SP will move to a new state in the next period with a probability dependent only on the command, and on the departure and arrival states.
Static Techniques

- The problem of finding a minimum-power policy that meets given performance constraints can be cast as a linear program (LP).
- Globally optimum
- Can be solved in polynomial time
- Policy optimization for Markov processes is exact and computationally efficient.
Advantages of Markov Models

• To capture the global view of the system, thus allowing the designer to search for a global optimum that possibly exploits multiple inactive states of multiple interacting resources.

• To enable the exact solution (in polynomial time) of the performance-constrained power optimization problem.

• To exploit the strength and optimality of randomized policies.
Markov Models

- Expected values
- Need SP and SR models. We may not know SR.
- An approximation of a more complex stochastic process