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Using Autonomics to Exercise Command and Control of Networks in Degraded Environments

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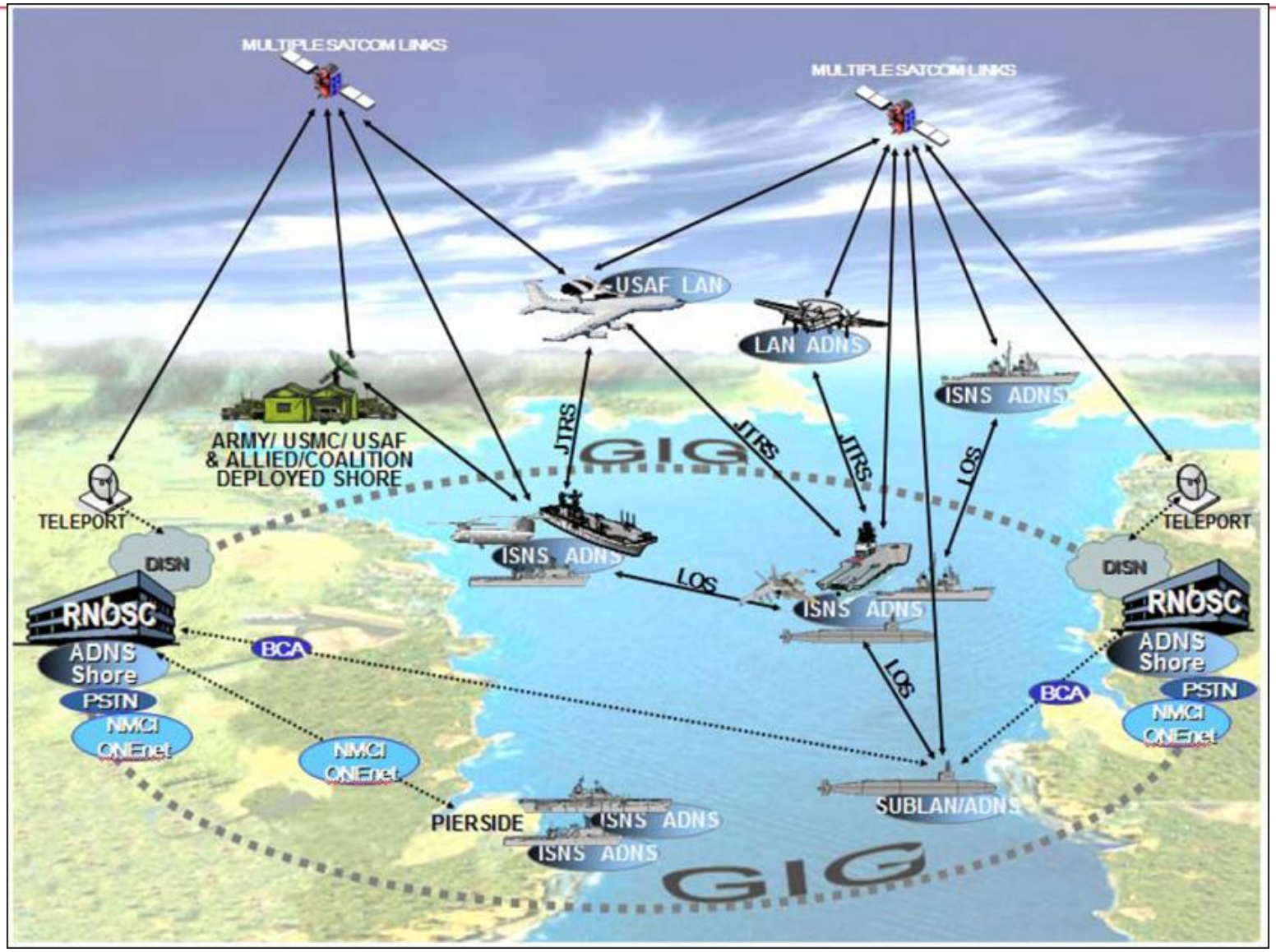
Phillip Verbancsics
phillip.verbancsics@navy.mil
Doug Lange
doug.lange@navy.mil
Space and Naval Warfare Systems Center - Pacific

Introduction: Architectural Complexity

- Increasingly Complex Infrastructure
  - Satellite, Wireless, Wired
  - Manned, Unmanned
  - Mobile, Immobile
  - Sea Surface, Underwater, Land, Air
  - High heterogeneity
  - Cloud Computing, Virtual Machines, SoA

- Timely delivery of data and decision support essential

Teams ⇔ Networks → C2 ⇔ Network Control



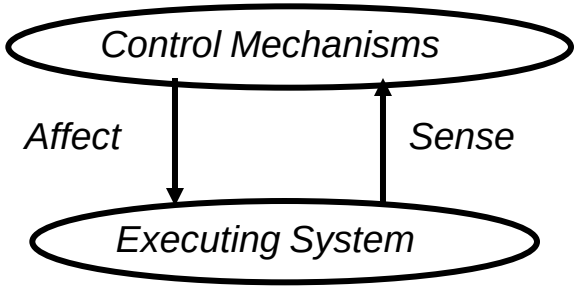
Autonomics

- Decision Support System for Infrastructure Management
  - Collect data from the infrastructure
  - Analyze performance metrics and system requirements
  - Effect changes to meet requirements/improve performance
  - Decrease system failure/inefficiency and human labor

- Functional areas:
  - Self-configuration
  - Self-healing
  - Self-optimization
  - Self-protection

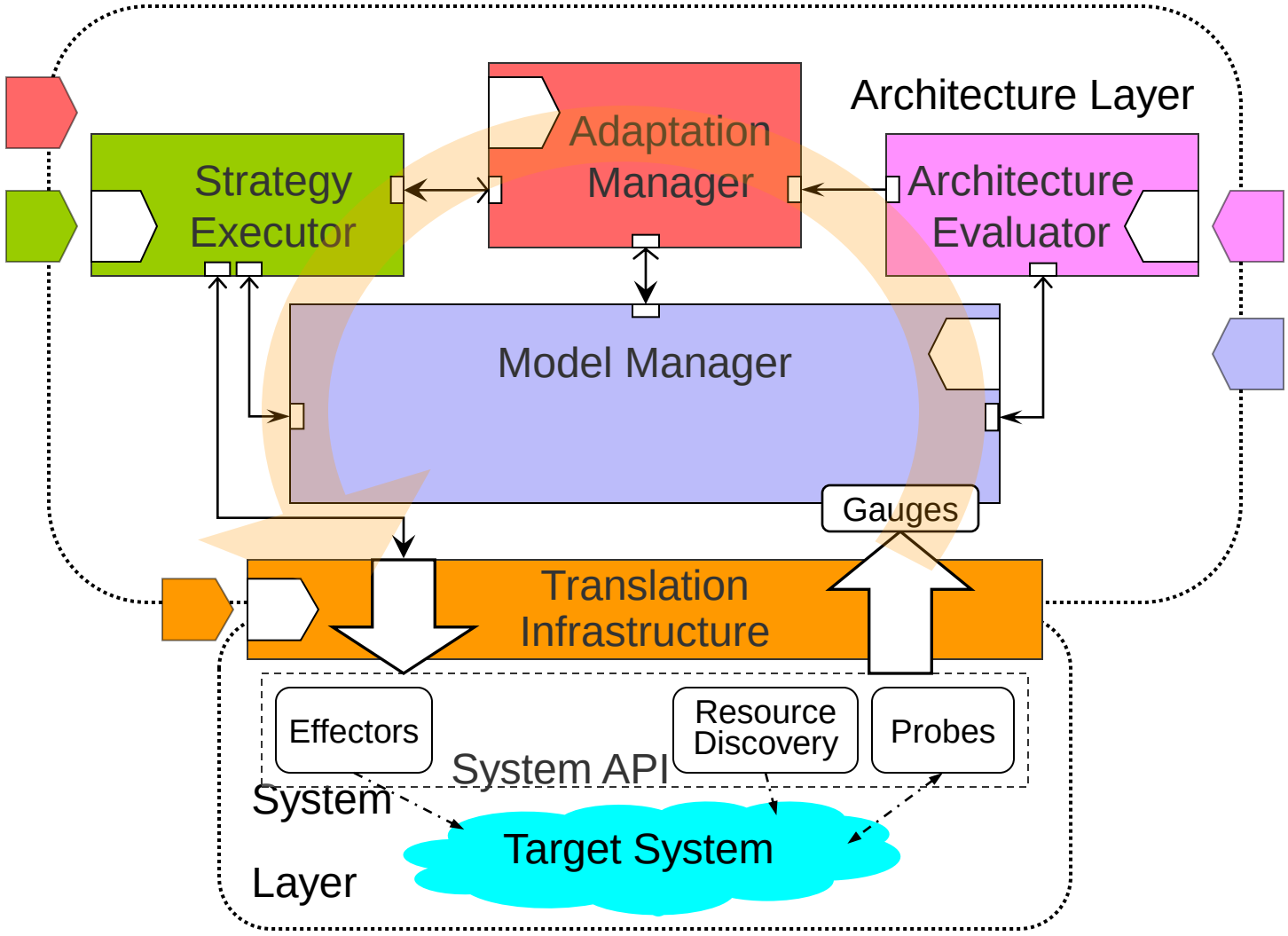
Autonomics (2)

Move from open-loop to closed-loop systems



- *Software Architectures* for dynamic self-adaptation
  - *Rainbow*: a framework in which architectural models can be used to adapt systems
  - *Stitch*: a language to define self-adaptation strategies
  - *Analysis*: Using model checkers to analyze properties of architecture-based adaptation

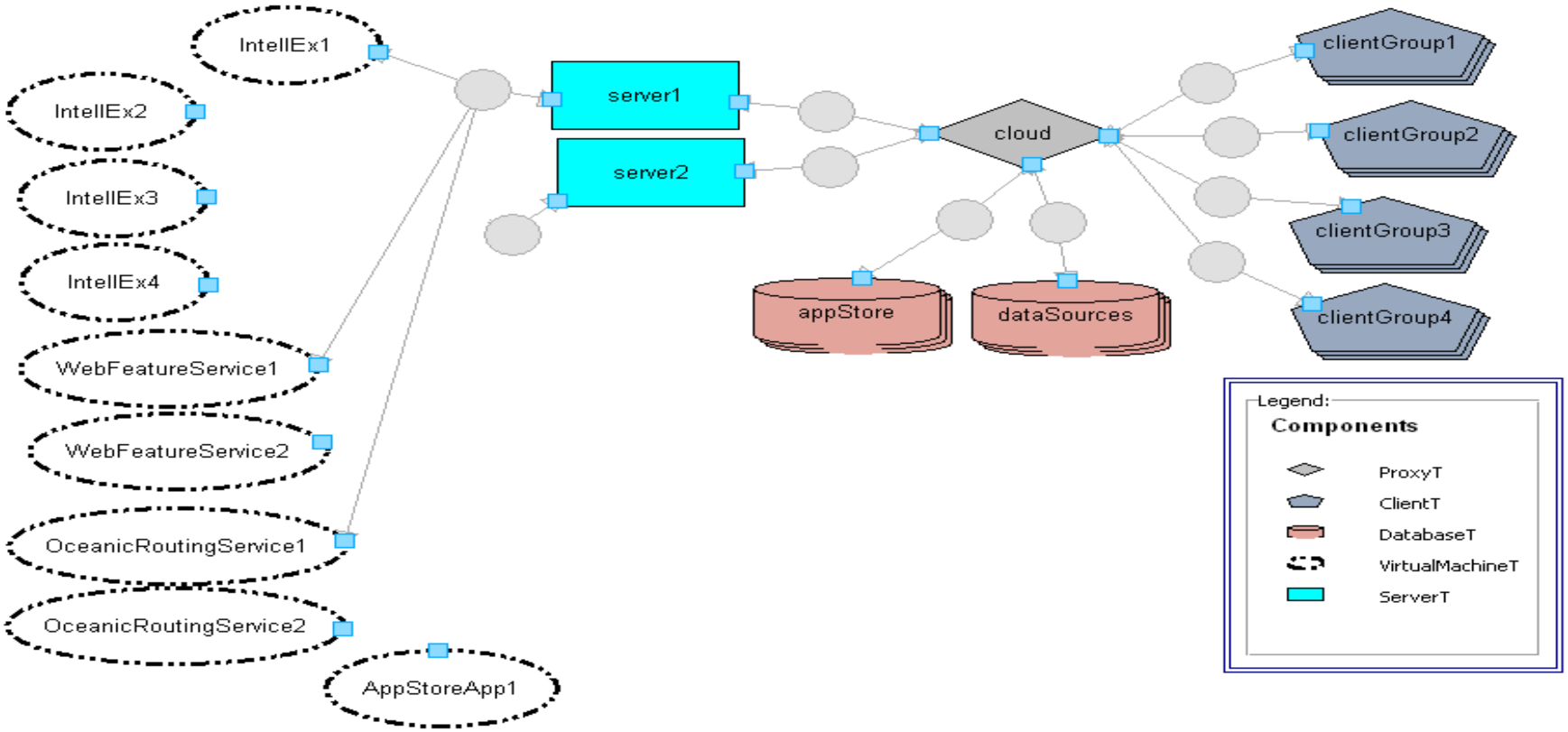
Rainbow Framework (Garlan, 2010)



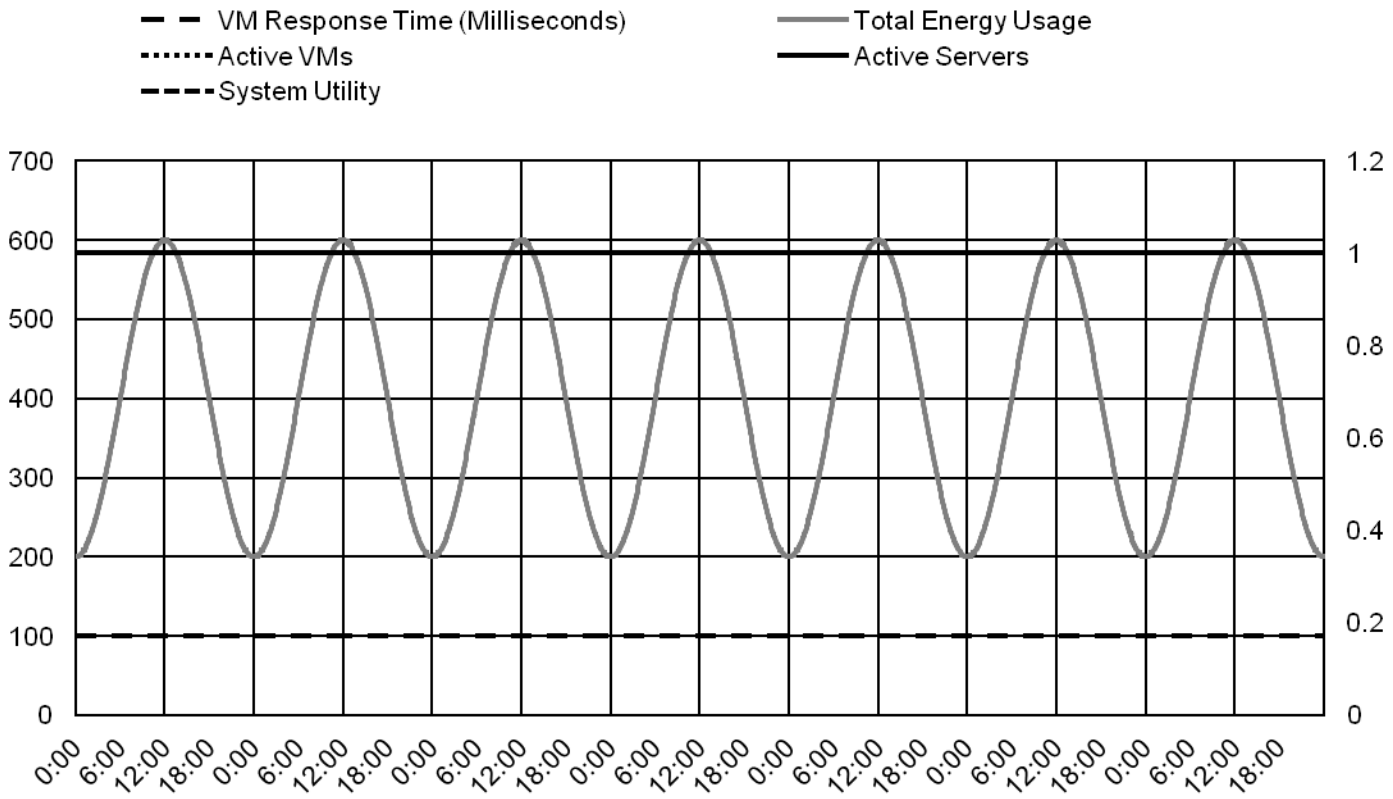
Investigate: Autonomics in Degraded Environments

- Autonomics for C2 will encounter DIL connectivity
  - Elements moving in and out of network
  - Environmental/Situational changes in available communication
- DIL environments present challenges
  - Limited information
  - Limited ability to exert control
- Also opportunities
  - Autonomics can react faster
  - Autonomics meant to respond to changing environments

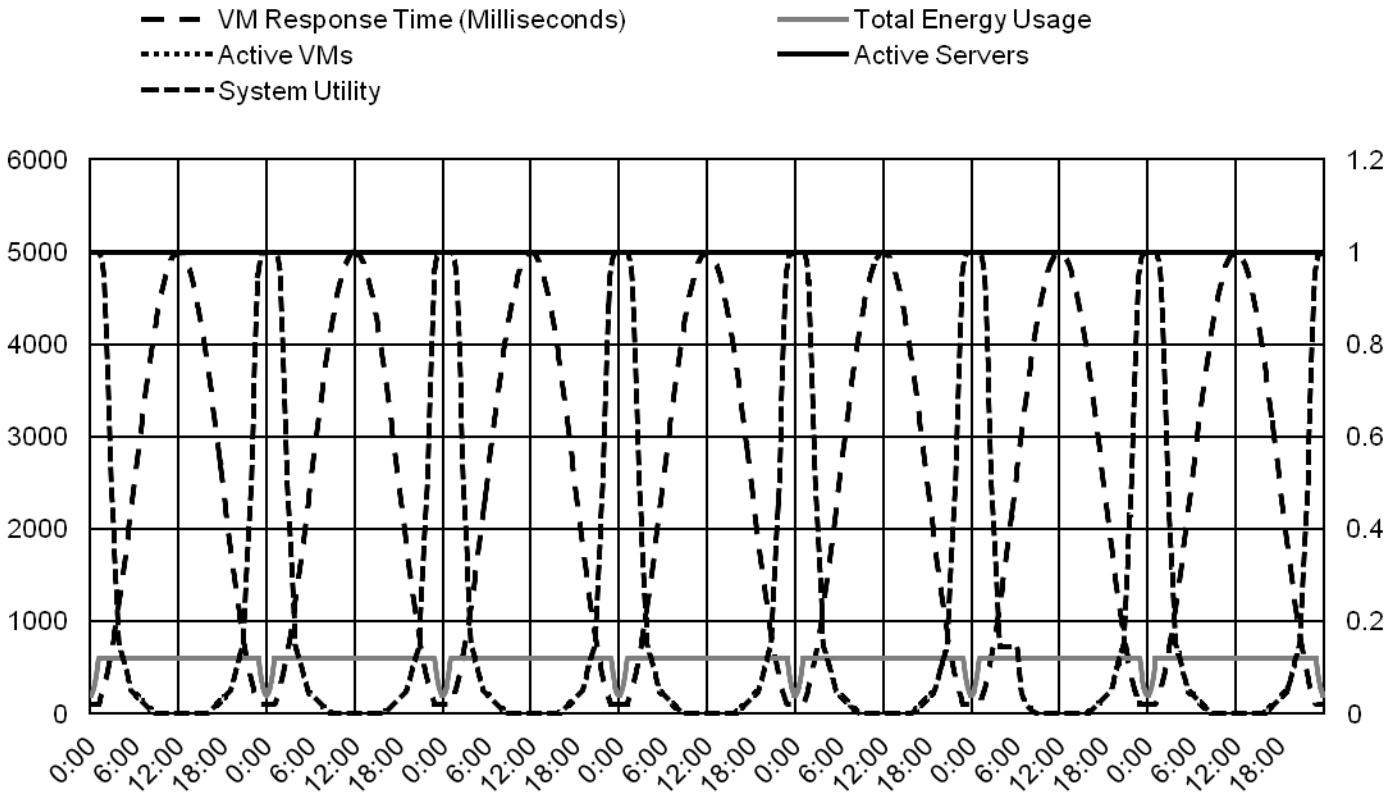
Experimental Setup: Cloud-like System



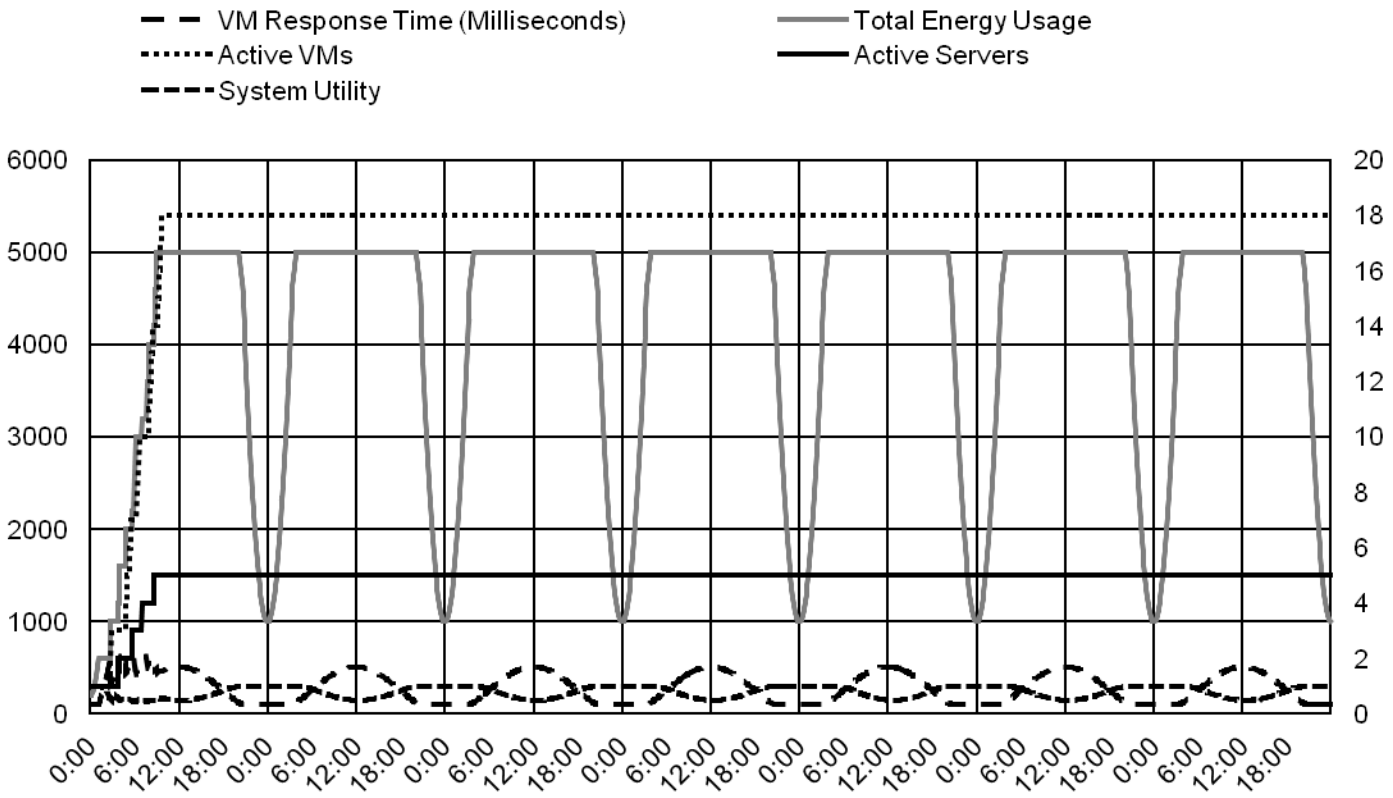
Experimental Setup: Environment Optimal



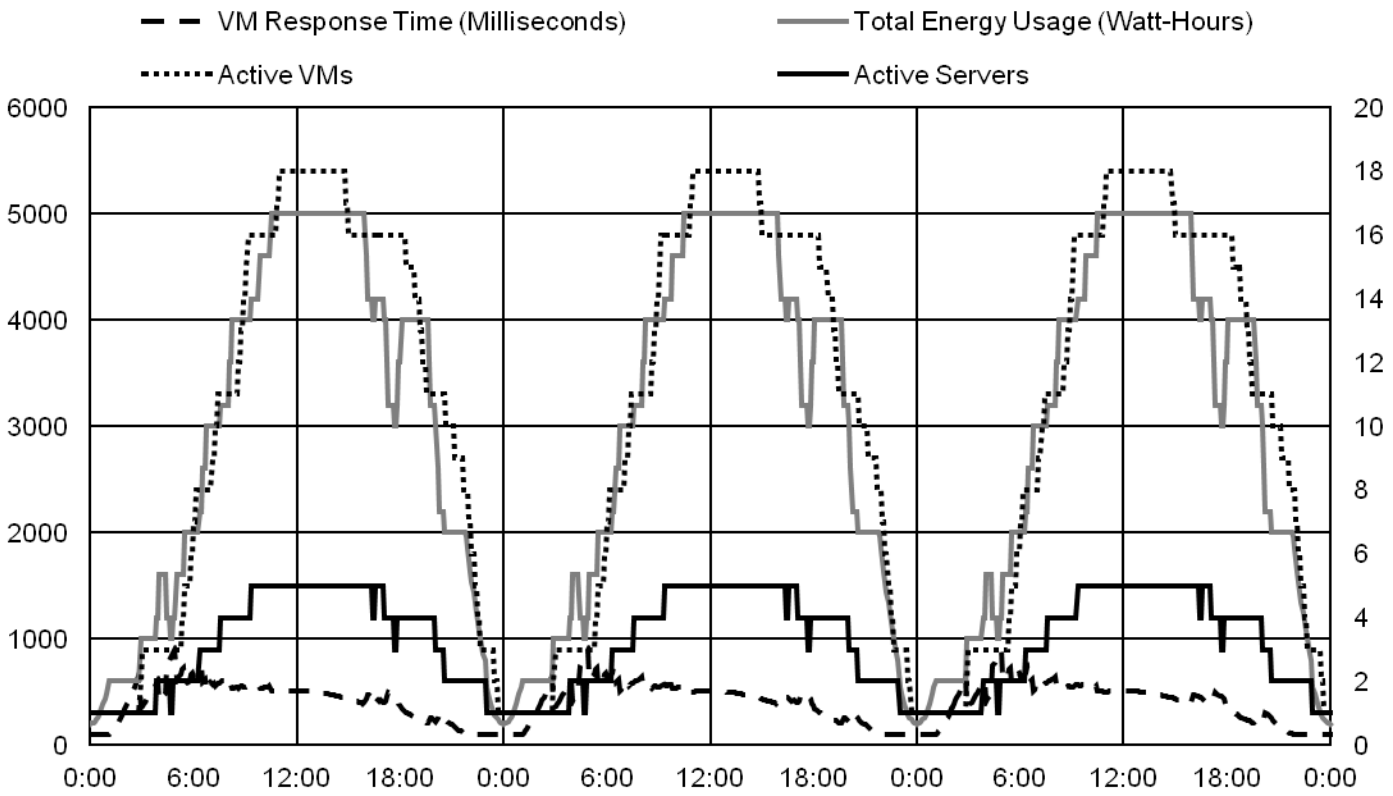
Experimental Setup: Environment Overloaded



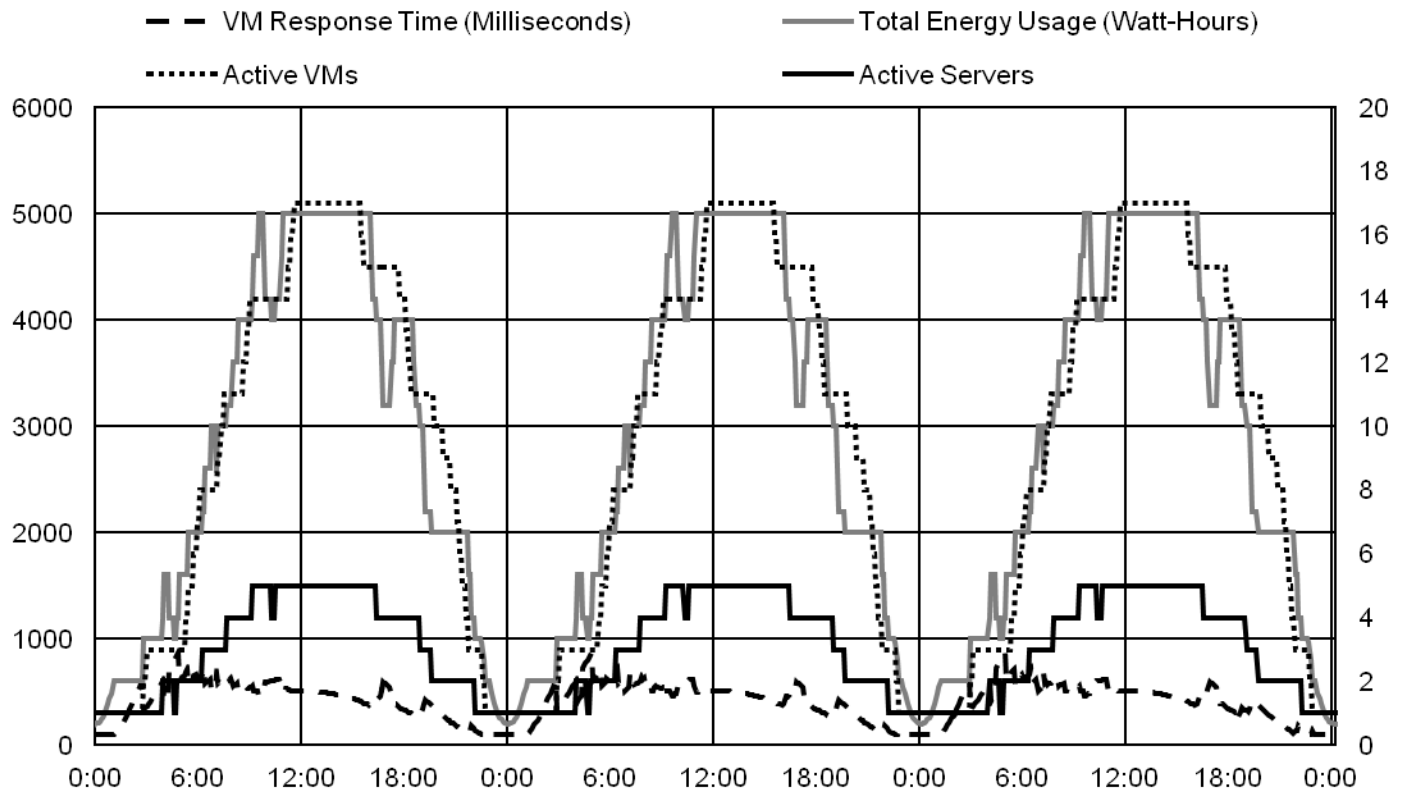
Experimental Setup: Example of Autonomic Response



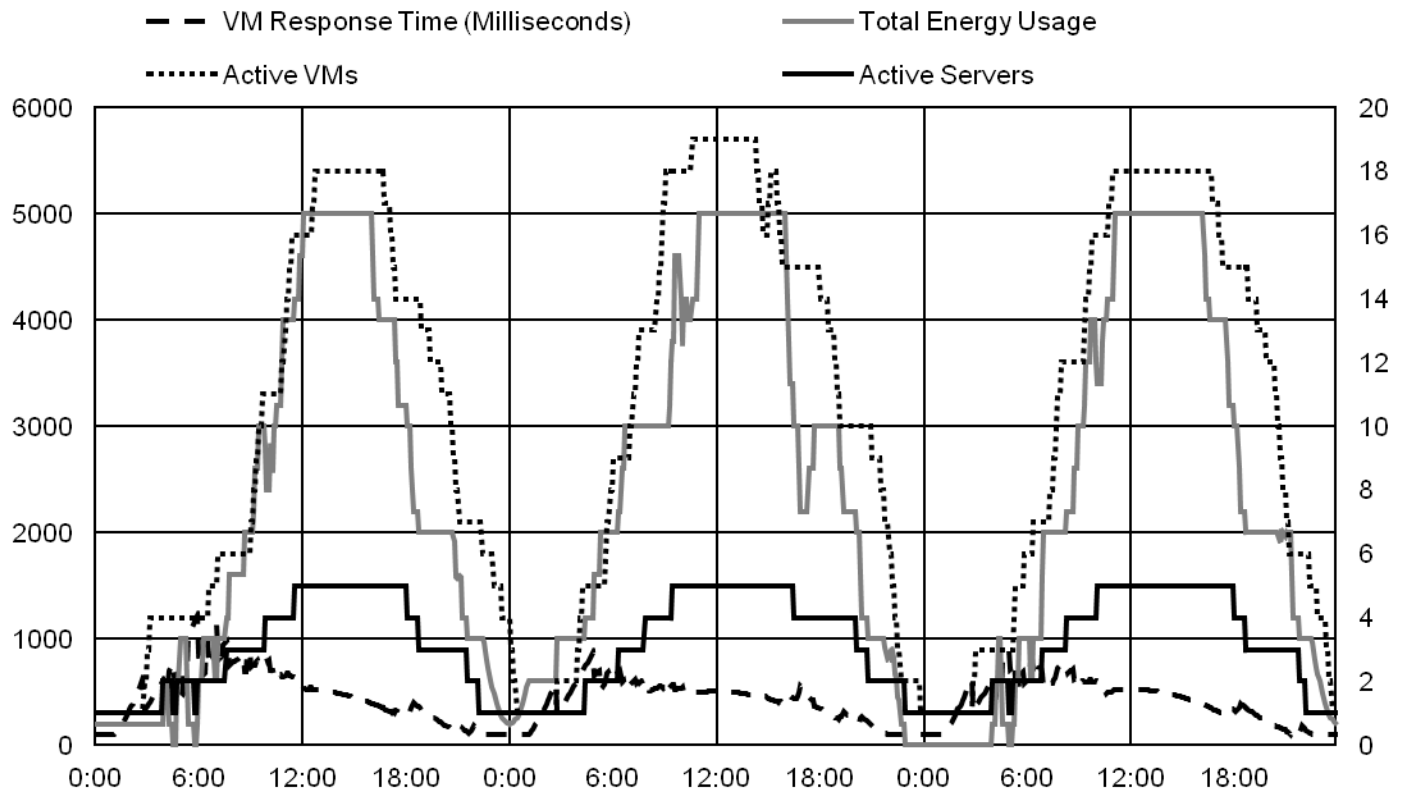
Results: DIL Effects on Autonomics (Baseline – 5 minute update intervals)



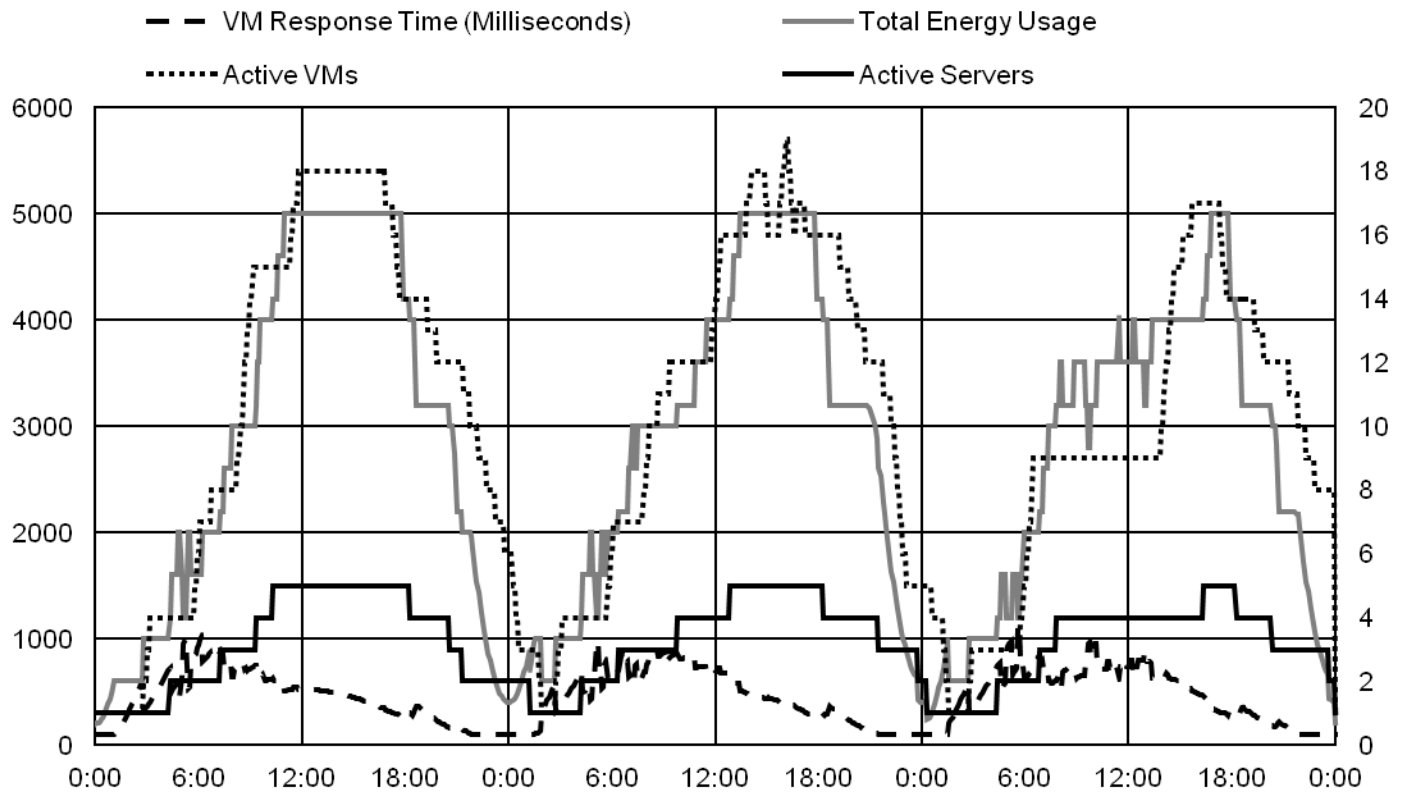
DIL (10 minute intervals)



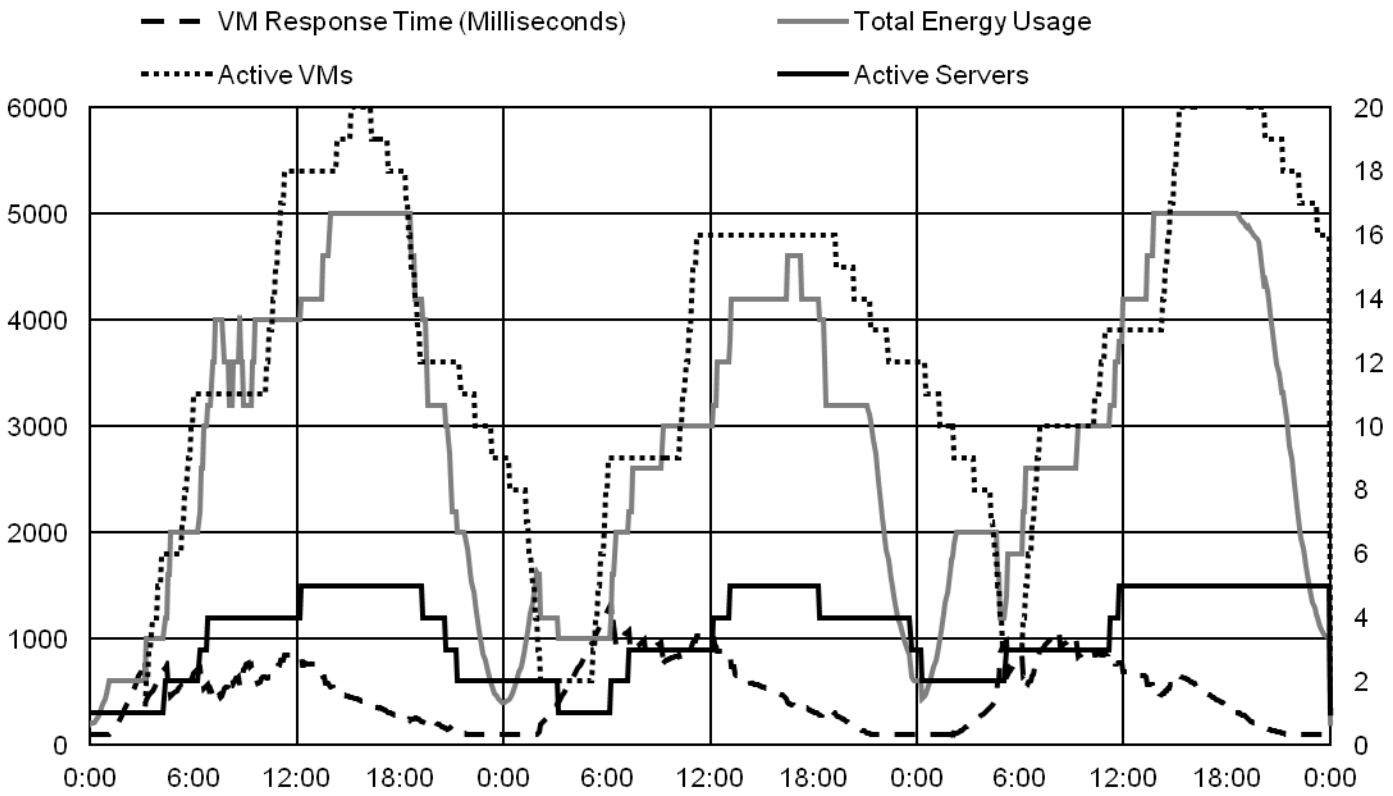
DIL (15 minute intervals)



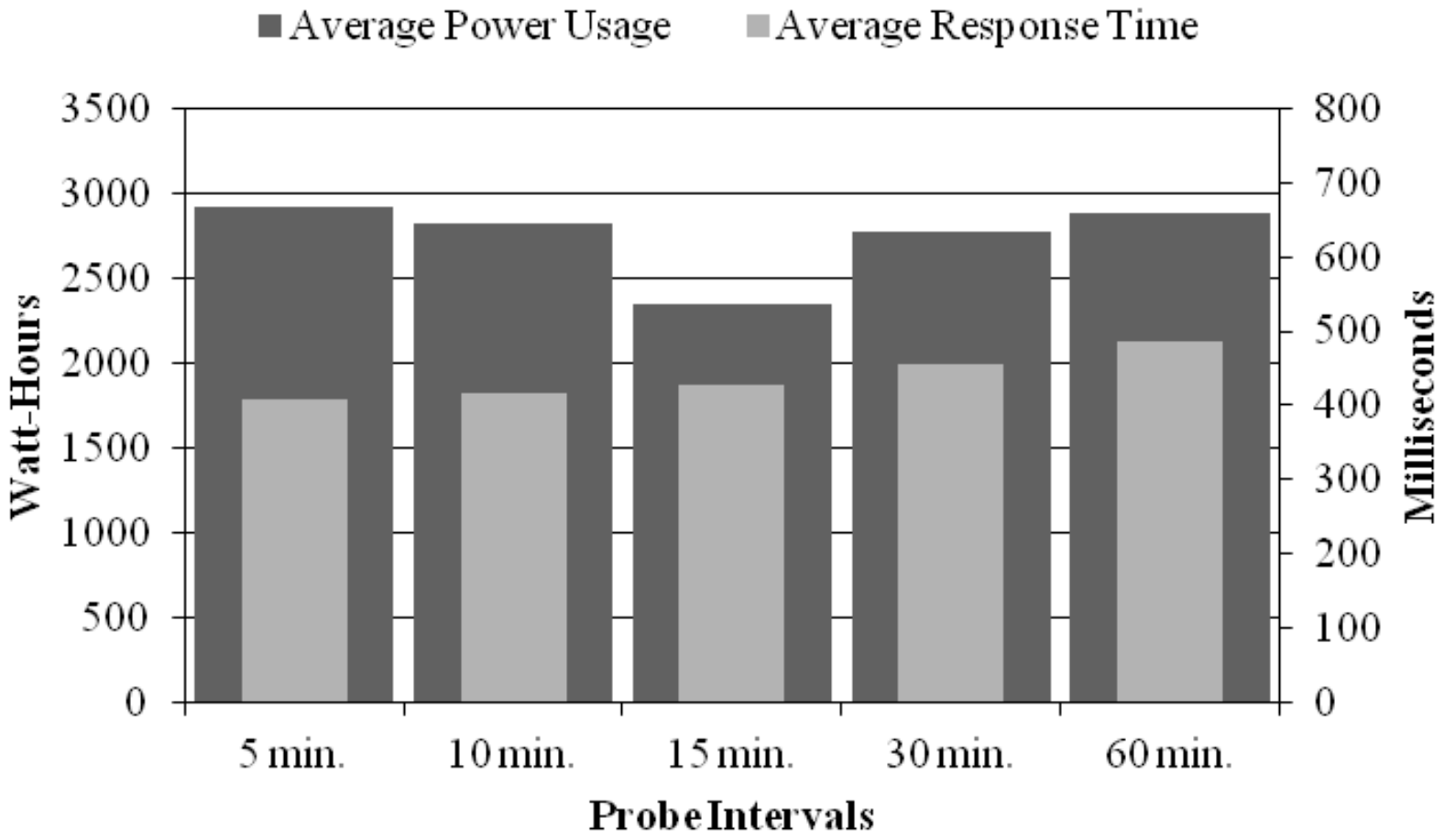
DIL (30 minute intervals)



DIL (60 minute intervals)



DIL – Average Power Usage and Response Time



Discussion & Future Work

- DIL negatively impacts autonomic performance
  - Begins with degraded ability to manage (up to 15 min intervals)
  - Ends with destabilization
- Challenge is in timing events
  - Too late in responding to events
  - Responding to events that have already passed
- Ways forward
  - Machine learning for prediction of future states
  - Distributed autonomics

End and Thank you!

- Phillip Verbancsics
  phillip.verbancsics@navy.mil
  SSC Pacific

- Doug Lange
  doug.lange@navy.mil
  SSC Pacific