Dynamic Energy Consumption Management of Routing Telecom and Data Centers through Real-Time Optimal Control

Dynamic energy consumption management through real-time optimal control.

Introduction

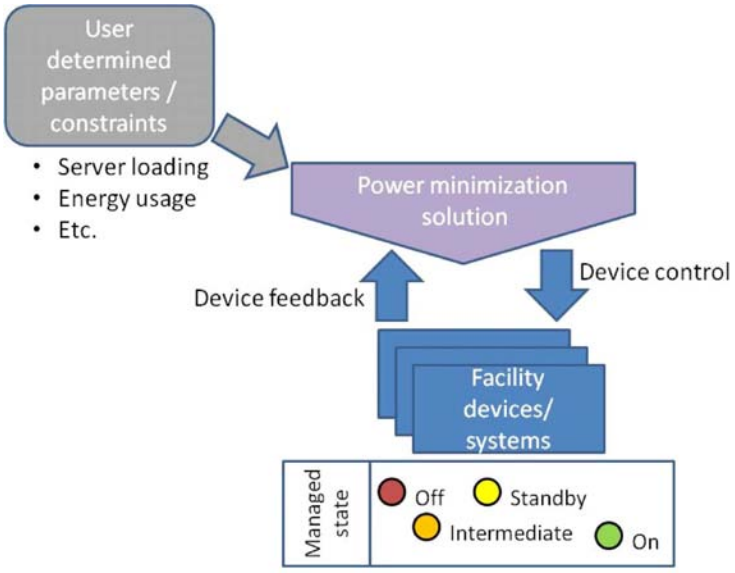
Underutilization of servers is one of the most often cited reasons for suboptimal energy efficiency in data centers. This occurs because servers typically operate at an average processor utilization level of only 5%–15%. The typical U.S. volume server, the fastest growing data center server type, will consume anywhere from 60%–90% of its maximum system power at these low utilization levels. This is because power-management methods for server and network devices are currently constrained by linear approaches (assuming a consistent pattern of power requirements) to what are really non-linear power management problems (computing power requirements fluctuate in response to a variety of constantly changing factors).

This concept definition studyhas investigated a novel solution to this power-management problem. A concept definition study identifies critical research and development (R&D) paths for developing a commercial application or product that addresses a significant market opportunity.

The study investigated the use of a real-time optimal control (RTOC) algorithm designed to shift network power consumption up or down, based on the need for services within a data or telecommunications center.

Benefits for Our Industry and Our Nation

The implementation of an RTOC algorithm for power management is predicted to reduce network routing and telecom data center power consumption by approximately 50%. Such algorithms will significantly reduce the energy wasted by computing assets during low-utilization periods. This savings is possible through user-configured, automated-algorithm-driven management tools that can control the power state of devices within facilities. In addition, notable cooling energy savings are expected, driving overall energy savings even higher.



Real-time algorithm to control device energy consumption.

Illustration courtesy of the U.S. Department of Energy's Industrial Technologies Program.

Applications in Our Nation's Industry

A complex, non-linear, algorithmic control methodology for exploiting these methods was developed for Control Moment Gyro energy management as part of NASA's contribution to the International Space Station program. Development team members on this project, who were pivotal to the success of this application for NASA, played a key role in this concept definition study. The algorithm-based control systems iutilized in this project will be applicable to many industries, the most significant being the following:

- Building Management System manufacturers, installers, and owner operators
- Computing, network, and telecommunications equipment manufacturers
- Data center and telecommunication facility owners and operators
- Internet application and network and telecommunications service providers
- Standards organizations for computing, electrical, and network devices and protocols

Project Description

This concept definition study will couple new, autonomous RTOC algorithms with currently deployed microelectronics to create a systems-resource-loading and power-management control system. This system provides the capability to realize significant power savings not only in the data center but also across entire facilities and networks.

By utilizing industry-standard protocols, the control algorithms can control the flow of energy based on network traffic and energy-management information that will be reported from network devices and in computing devices such as mainframes and servers.

Using new advances in control theory, the modern control algorithms can provide optimal solutions, given a complex set of user-defined rules or constraints. The algorithms can control non-linear system behavior, providing improved system performance over conventional power-management methodologies. In addition, they will be predictive in nature, able to sense server-related activity at the network switch level and adjusting server power states appropriately.

Newer releases of networking and telecom equipment provide increased remote control authority to hardware with a finer level of control than ever before. As newer equipment is deployed, the automated control system will be able to move across different levels of power systems, enabling these systems to work in a unified manner and reducing inefficiencies of uncoordinated power management across devices. The control algorithm would monitor key control indicators to shift equipment into different power states (off, standby, on, and other intermediate states) in order to maintain required quality of service while minimizing power consumption. This power-management control is not limited to the data center, but can be extended throughout the facility as the ability to control power states of equipment and devices increases.

Barriers

The data center and telecommunications industries have not taken full advantage of these powerful, modern, control algorithms. This leaves much room for efficiency improvements, which can be achieved by using newer real-time algorithms that utilize dynamic and non-linear approaches. Recent advancements in micro-processors and information communications technology components enable the accommodation of these algorithms. This project has shown the practical application of the algorithms which should enable the first steps toward market adoption.

Pathways

- Explore and document the technical requirements and impediments of implementing an RTOC algorithm in network and telecommunications facilities.
- Identify the critical elements of the RTOC algorithm that require feasibility demonstrations.
- Translate computing and telecommunications facility behavior into preliminary technical specifications and models.

Milestones

- Documentation of initial key critical condition states, control authority elements, and suggested test cases
- Development and documentation of a data center system mathematical control model
- Documentation of an RTOC algorithm Data Center test scenario

Commercialization

This early-stage R&D facilitates the opportunity to incorporate the algorithms into Cisco's network service solutions and includes the following pre-commercialization activities:

- Increase understanding and mitigate market introduction and technical risks.
- Create a benchmark algorithm model that can be utilized to enhance industry understanding regarding the potential of RTOC algorithms to reduce computing and telecommunications center energy consumption.

Project Partners

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DOE/EE-0496 • May 2011
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