

Preface

With the proliferation of cloud computing and Internet online services, more and more data and computation are migrated to geographical distributed Internet data centers (IDCs), which can provide reliability, management, and cost benefits. However, IDC operators encounter several major problems in IDC operations, such as huge energy consumption and energy cost, and high carbon emission. To deal with the above problems, IDC operators have to efficiently manage the way of energy consumption and energy supply. Considering the potential of smart grid, we focus on the energy management of IDCs in smart grid from several perspectives, i.e., power outage, carbon emission, heterogeneous service delay guarantees, and operation risk.

With the introduction of smart grid, some cyber-related vulnerabilities may also be created and may ultimately lead to power outages when cyber attacks are launched. When power outages occur in main grids, the energy cost of IDC operators increases. If power outages caused by cyber attacks occur frequently, the increased energy cost of IDC operators become very large. Therefore, it is necessary to consider power outages when running the IDCs in smart grid. In this book, we study the problem of minimizing the long-term energy cost of distributed IDCs in smart grid considering power outages. Moreover, we propose an operation algorithm to achieve the above aim based on Lyapunov optimization technique by jointly considering the use of renewable and backup generators, battery management, and electricity purchasing/selling. Note that the proposed algorithm can operate without requiring any statistical information about system dynamics.

Some socially responsible IDC operators (e.g., Google) expect to reduce energy cost and carbon emission simultaneously. In this book, we consider the problem of minimizing the long-term weighted summation of energy cost and carbon emission with guaranteed quality of service for incoming requests in smart grid by deciding the service request distribution, number of active servers, operations of energy storage, schedule of backup generators, and quantity of power transactions between microgrids and main grids. Moreover, we propose an operation algorithm and analyze the feasibility of the proposed algorithm as well as its performance guarantee.

Providing homogeneous service delay (or average delay) guarantees may lead to violations of service level agreements for delay-tolerant requests. Moreover, IDC operators could reduce energy cost by fully exploiting the temporal diversity of electricity price when heterogeneous service delay guarantees are provided. Thus, it is necessary for IDC operators to provide heterogeneous service delay guarantees for delay-tolerant requests. In this book, we investigate the problem of minimizing the energy cost for an IDC in deregulated electricity markets considering heterogeneous service delay guarantees for delay-tolerant requests. Moreover, energy storage devices are adopted to fully exploit the temporal diversity of electricity price. In addition, we design an operation algorithm to schedule workload and battery jointly.

When IDC operators only procure electricity from spot electricity markets to supply IDCs, the spatial and temporal diversities of prices could be fully utilized to reduce energy cost. Meanwhile, spot price and workload uncertainties will result in the uncertain energy cost in the future, which is a risk for IDC operators as they may experience high probability of having high energy cost. To manage such risk, we study the problem of risk-constrained operation for IDCs in deregulated electricity markets. Moreover, we propose an operation algorithm to achieve the optimal tradeoff between operation risk and expected energy cost according to the risk preferences of IDC operators.

All comments and suggestions for improvements to this book are welcome.

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Energy Management of Internet Data Centers in Smart
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