Advancing DCIM with IT Equipment Integration



ASHRAE Datacom Series 14

Advancing DCIM with IT Equipment Integration

Advancing DCIM with IT Equipment Integration is authored by ASHRAE Technical Committee (TC) 9.9, Mission Critical Facilities, Technology Spaces and Electronic Equipment. ASHRAE TC 9.9 is composed of a wide range of industry representatives, including but not limited to equipment manufacturers, consulting engineers, data center operators, academia, testing laboratories, and government officials who are all committed to increasing and sharing the body of knowledge related to data centers.

For more information on the ASHRAE Datacom Series, visit
www.ashrae.org/datacenterefficiency

For more information on ASHRAE TC 9.9, visit
https://tc0909.ashraetcs.org

Updates and errata for this publication will be posted on the ASHRAE website at www.ashrae.org/publicationupdates.

Advancing DCIM with IT Equipment Integration

ASHRAE Datacom Series
Book 14



Atlanta

ISBN 978-1-947192-30-0 (paperback)
ISBN 978-1-947192-31-7 (PDF)

© 2019 ASHRAE
1791 Tullie Circle, NE
Atlanta, GA 30329
www.ashrae.org

All rights reserved.
Printed in the United States of America

Cover image by Joe Lombardo of DLB Associates.

ASHRAE is a registered trademark in the U.S. Patent and Trademark Office, owned by the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

ASHRAE has compiled this publication with care, but ASHRAE has not investigated, and ASHRAE expressly disclaims any duty to investigate, any product, service, process, procedure, design, or the like that may be described herein. The appearance of any technical data or editorial material in this publication does not constitute endorsement, warranty, or guaranty by ASHRAE of any product, service, process, procedure, design, or the like. ASHRAE does not warrant that the information in the publication is free of errors, and ASHRAE does not necessarily agree with any statement or opinion in this publication. The entire risk of the use of any information in this publication is assumed by the user.

No part of this publication may be reproduced without permission in writing from ASHRAE, except by a reviewer who may quote brief passages or reproduce illustrations in a review with appropriate credit, nor may any part of this publication be reproduced, stored in a retrieval system, or transmitted in any way or by any means—electronic, photocopying, recording, or other—without permission in writing from ASHRAE. Requests for permission should be submitted at www.ashrae.org/permissions.

Library of Congress Cataloging-in-Publication Data

Names: ASHRAE (Firm)
Title: Advancing DCIM with IT equipment integration.
Description: Atlanta, GA : ASHRAE, [2019] | Series: ASHRAE datacom series ; book 14 | Includes bibliographical references.
Identifiers: LCCN 2019019133| ISBN 9781947192300 (pbk.) | ISBN 9781947192317 (pdf)
Subjects: LCSH: Data centers--Equipment and supplies--Maintenance and repair--Standards. | Data processing service centers--Management--Standards.
Classification: LCC TK5103 .A67 2019 | DDC 004.068--dc23 LC record available at https://lccn.loc.gov/2019019133

ASHRAE STAFF

SPECIAL PUBLICATIONS	**Cindy Sheffield Michaels,** Editor
	James Madison Walker, Managing Editor of Standards
	Lauren Ramsdell, Associate Editor
	Mary Bolton, Editorial Assistant
	Michshell Phillips, Editorial Coordinator
PUBLISHING SERVICES	**David Soltis,** Group Manager of Publishing Services
	Jayne Jackson, Publication Traffic Administrator
DIRECTOR OF PUBLICATIONS AND EDUCATION	**MARK S. OWEN**

Acknowledgments

PRIMARY CONTRIBUTORS

Christian Lindberg, Book Lead, Author, Member ASHRAE
Managing Director, Cloud & Infrastructure Services, Accenture, Seattle, WA

Andrew Calder, Author, Member ASHRAE
Principal Engineer, Data Center Design Professional, Panduit, Chicago, IL

Dustin Demetriou, PhD, Author, Member ASHRAE
Senior Engineer, Advanced Thermal Energy Efficiency Lab, IBM Corporation, Poughkeepsie, NY

Charles Freda, Author, Member ASHRAE
VP, Mission Critical, EMS Technologies, Washington, D.C.

Jason Matteson, Author, Member ASHRAE
Senior Solutions Architect, Data Center Solutions, Vertiv, Raleigh, NC

Camelia Mititelu, Author, Member ASHRAE
Mission Critical Project Manager, CAI, Chicago, IL

Christian Pastrana, Author, Member ASHRAE
Consultant, Data Center Operations, Digital Realty, New York, NY

Mark Seymour, Author, Member ASHRAE
Chief Technology Officer, Future Facilities Ltd, London, UK

ADDED THANKS TO OTHER COMMUNITY CONTRIBUTORS

Kevin Cash (HPE), Tony Cooper (Vertiv), Patrick Donovan (Schneider Electric), Austin Shelnutt (Dell), Baohong Li (ProPlus), Samer El-Haj-Mahmoud (Lenovo), Dave Moss (Dell), and Mark Steinke (Cray).

ADDED THANKS TO REVIEWERS

Robin Steinbrecher (Retired Intel), Roger Schmidt (Syracuse University)

SPECIAL THANKS TO DON BEATY AND DLB ASSOCIATES

Neil Chauhan (DLB)

DISCLAIMER

Features and implementations described in this book do not necessarily represent those for any specific information technology (IT) equipment or IT equipment manufacturer, but rather general concepts and capabilities available in volume servers.

Contents

Foreword . . . . . **ix**

Chapter 1—Introduction **1**

1.1 Purpose and Objective 1

Chapter 2—DCIM Overview **3**

2.1 Definition and Value of a DCIM System 3
2.2 Components of a DCIM System 3
2.3 Keys to an Effective DCIM Implementation 5
2.4 The Chasm between Data Center Facilities Operators and IT System Administrators 5
2.5 Focus of DCIM for ASHRAE Technical Committee 9.9 7

Chapter 3—ASHRAE DCIM Compliance **11**

3.1 Fundamentals of IT Equipment Management 11
3.2 DCIM Compliance for IT Equipment 15
3.3 Data Center Efficiency Initiatives 24
3.4 DCIM Compliance for Facility Operational Technology (OT) Equipment 26

Chapter 4—DCIM-Connected Framework **35**

4.1 DCIM Holistic Ecosystem and Stakeholders 35
4.1 DCIM Physical Layer and Communication Protocols 38

Chapter 5—Using Measured and Model-Based Data **49**

5.1 Standard Data Manipulations 49
5.2 Events, Alerts, and Metrics 55
5.3 Data Analytics 60

Chapter 6—DCIM Use Cases 71

6.1 Power Use Case Examples 71
6.2 Thermal Use Case Examples 77
6.3 Capacity Panning Use Case Examples 87

Appendix A—A DMTF Redfish Sensor Mapping for IT Equipment 93

Appendix B—Data Center Performance Metrics 99

B.1 Data Center Space Metrics 99
B.2 Data Center Power Metrics 99
B.3 Data Center Thermal Metrics 99
B.4 Combined Data Center Performance Metrics 100

Glossary 109

References and Bibliography 119

Foreword

After working in the data center industry for any length of time, it's common to develop blinders and forget to look at the periphery of the field. It is critically important to note that data centers have changed and come a long way since the earliest days. Looking at cloud data center architectures and new concepts such as edge data centers, it is clear solutions only continue to grow and evolve. It is publications such as this that help shine a light on current industry happenings, indicate how to interact with others in the field, and most of all share ideas on how to improve data center operations.

In October 2018, the Association For Computer Operations Management (AFCOM) Leaders Lab met in Dallas to focus on data center infrastructure management (DCIM). This session wasn't just about DCIM concepts—rather, it was about sharing stories and experiences. This made this entire lab so much more valuable because those in the industry got to hear others' experiences, how they resolve issues, and where improvements can be made. One of the best parts of the meeting was learning that all in the industry face the same common challenges. Whether it is the fast evolution of data center operations or trying to squeeze out the last drop of efficiency, all are working hard to make data centers operate optimally. Most of all, it was exceedingly valuable to hear stories from people who are boots on the data center ground. Between outages and best practices, together we learned a lot.

DCIM—DON'T LET DATA CENTER GREMLINS KEEP YOU UP AT NIGHT

The data center business continues to evolve and, as a part of that evolution, experience growth in the market alongside new solutions that effect overall data center operations. So, what has been the general theme of data center operations? What is actually changing?

- Growth in the data center space
- More businesses adopting some type of data center model
- New developments around advanced data center solutions

Growth in the Data Center Industry

In the 2019 AFCOM State of the Data Center survey[1], respondents cite that ownership, renovations, and building were on the upswing. In fact, respondents

1. Data Center World. 2019. *The state of the data center industry—annual report*. Phoenix, AZ: AFCOM. https://tmt.knect365.com/data-center-world/agenda/3#keynote-programming_the-state-of-the-data-center-industry-annual-report.

expect meaningful increases in all data center measures over the next three years. The report indicates the following:

- The average organization manages around 12 data centers today (including smaller telco sites and edge locations). This is up from 8 in the previous survey taken in 2018.
- On average, about 4 data centers will be renovated per organization. That number increases to 5.4 data centers over the course of the next three years.
- New data center construction will grow by more than five times over the next three years.
- The average number of data centers to be built over the next 12 months sits at around 4.3 per organization. That number increases to 5 over the course of three years.

What about DCIM? A 2017 report from the Market Research Engine[1] shows that the DCIM market is projected to see an increase in demand globally because of the increased emphasis on energy efficient data centers. The rising impact of regulatory standards pertaining to data centers is also estimated to accelerate the requirement for DCIM solutions. As the report points out, DCIM is driven by increasing power consumption because of the adoption of cloud computing, virtualization, consolidation, higher heat density equipment, and the ever-increasing dependency on IT systems.

The Market Research Engine report shows that the DCIM market is expected to exceed $2.85 billion by 2024. Furthermore, according to the AFCOM State of the Data Center survey, organizations are gearing up their DCIM implementation plans with the following variety of key current implementation focus areas:

- Security: 64%
- Environmental (temperature, humidity, airflow): 60%
- Power/energy: 58%
- Facility management: 58%
- Cable management: 57%

Data Center Management is at the Center of it All

The environmental concerns of the data center are not going anywhere. In fact, there is still a need to focus on issues such as power, cooling, and airflow. The biggest difference today is we have smarter sensors and better integration of those sensors with DCIM systems. A major takeaway from the October 2018 AFCOM Leaders Lab involved looking for solutions that not only help the data center with airflow and power

1. Market Research Engine. 2017. *Data center infrastructure management (DCIM) market by solution (IT asset management, facility management, consulting and other services); by component (IT Asset, DCIM software, power, cooling); and by industry (banking, financial services, and insurance (BFSI), information technology, telecom, health care, retail)—Global industry analysis and forecast 2018–2024.* Deerfield Beach, FL: Market Research Engine. www.marketresearchengine.com/reportdetails/data-center-infrastructure-management-dcim-market.

management, but also that integrate new solutions such as machine learning so the industry can start making better, data-driven decisions about overall data center health.

When it comes to data center management, it's not always smooth sailing. In fact, the 2018 AFCOM Leaders Lab started by polling what datacom problems keep the participants up at night. Resoundingly, outages and downtime were first. These events are never fun, and no one wants to experience this kind of emergency. Plus, data center outages are expensive. Disasters and outages occur with and (more often) without warning, leaving serious business disruption in their wake. At the same time, increasing dependency on the data center means that outages and downtime have become costlier over time. According to a 2016 Ponemon study[1], the average cost of a data center outage has steadily increased from $505,502 in 2010 to $740,357 in 2016, with the maximum downtime costs for 2016 topping out at $2,409,991. Beyond outages, when it comes to data center operations, the top five things concerning AFCOM leaders are as follows:

- Disaster recovery and business continuity (DRBC)
- Putting the wrong people in charge of data center operations
- Lack of investment in smaller facilities
- Lack of good redundancy practices
- The "data center versus the business" challenge

The good news is that as technology evolves, so will the tools that help govern and manage our data centers.

DATA CENTER MANAGEMENT: A LOOK AHEAD

The 2019 AFCOM State of the Data Center study asked what data center leaders were doing when it came to taking advantage of new and innovative solutions. Remember, these solutions are aimed at improving data center efficiency while still delivering new capabilities to the customer. The survey found four solutions are leading the charge: data analytics and big data are the top two, and other major initiatives around machine learning and artificial intelligence. So, we know that leveraging data and even machine learning is top of mind for innovative data center leaders. Towards the end of the October 2018 AFCOM Leaders Lab, the 20-plus participants were asked what they thought the future of data center management looked like. Unprompted to what responses should be, they came back with the following predictions:

- The ability to delivery proactive operations, management, and data center control
- Multiple integrated IT and infrastructure subsystems
- Integrated data modeling used for prediction, service management, multiple views, and optimizing in real time
- Self-optimizing, autonomic data center management

1. Ponemon Institute. 2016. *2016 Cost of data center outages*. Traverse City, MI: Ponemon Institute. www.ponemon.org/blog/2016-cost-of-data-center-outages.

- Cognitive systems in DCIM
- Image processing for data centers
- Augmented reality DCIM capabilities
- Voice-powered and/or voice-controlled data center management with direct DCIM integration

Interestingly, the group was asked to go into further detail around this DCIM-integrated, voice-powered assistant, and each group stated that they absolutely see this in the near future. They mentioned that they're already seeing smarter DCIM systems that help with predicting usage. They are already seeing smarter rack systems that give granular details around the data center, including component elevation, vibration metrics, biometric access data, and more. Using voice-powered controls, to the group, almost seemed like the logical next step. That said, they also mentioned drones in the data center, but that's a bit harder to imagine[1]! Even the 2019 AFCOM State of the Data Center report indicated that a majority of respondents (76%) foresee more DCIM integration with virtualization and cloud solutions, including 30% who are already seeing it. Finally, there was the following great feedback in 2018 for getting started with DCIM:

- Really get to know the data center and IT operations
- Determine what supports key business and IT functions
- Determine the value of the current solution and if it is meeting expectations
- Understand gaps (IT, business, and data center)
- Challenge suppliers about feature and function statements
- Work with trusted suppliers
- Leverage new and advanced technologies to support evolving data center and business functions
- Proof-of-concepts and trials are great practical training

As a final thought, innovation in DCIM solutions will only continue to grow if it is aligned with the importance to the business. This means that as the data center becomes more critical, management tools will play a key role in helping keep critical systems operating optimally. Most of all, it's always great to see how much practitioners have in common, including our most pressing concerns. This book takes a deep dive into the world of data center management from a number of different perspectives, including everything from best practices, compliance, enabling IT equipment, and helping people become more proactive. It even looks at advanced integration options around application programming interfaces (APIs), the Internet of things (IoT), and cloud computing. Hopefully the points in this book will resonate and result in a healthier data center ecosystem—and, hopefully, fewer gremlins and more hours of sleep.

Bill Kleyman, Executive Vice President of Digital Solutions at Switch

1. AFCOM. 2018. *Industry trends: State of the data center report*. White Paper

1

Introduction

1.1 PURPOSE AND OBJECTIVE

Data center infrastructure management (DCIM) is the supervision, administration, and operational control of data center assets and resources with the aim to optimize cost and performance in terms of infrastructure availability, energy efficiency and operational efficiency. Managed assets include both the supporting physical infrastructure systems as well as the IT and telecom equipment (i.e., the load). The primary resources managed within a DCIM system to achieve effective capacity planning and workload scheduling are power, cooling, networking, and space. All should be maintained and provided in the right amounts at the right time even as load and environmental conditions dynamically change. An imbalance can strand resources, limiting capacity and operations, as well as be financially wasteful. Worse still, poor management and planning of these resources can put data center assets and their continued operation at risk.

When properly implemented and maintained, DCIM systems and their software tools will achieve the following:

- Prevent or reduce the impact of critical events
- Improve asset, change, and workflow management
- Help match resource supply and demand for greater operational and energy efficiency
- Improve capacity planning through key performance indicators and resource tracking and trend analysis
- Facilitate reporting, auditing, compliance, and general performance monitoring efforts

The end goal for a DCIM implementation should be to take a comprehensive approach to the data center's power, cooling, and space resources across both the facility and IT domain. Systems that best communicate the interconnections and dependencies of the load to all supporting components, systems, and resources are best positioned to yield the full value of DCIM. Software tools have matured over the years, making the implementation and use of comprehensive, multifunction DCIM suites easier.

This book is divided into the following chapters:

- **Chapter 1—Introduction.** The introduction states the purpose and objectives of the book as well as gives a brief overview of the other chapters.
- **Chapter 2—Overview.** This chapter describes in more detail the focus areas

of the book to show where opportunity exists for the deployment of DCIM systems. It helps readers qualify or begin to quantify an investment to acquire and/or properly implement and operate a data center management and controls system.

- **Chapter 3—ASHRAE DCIM Compliance.** This chapter describes the classification criteria for being ASHRAE DCIM compliant for hardware vendors and DCIM providers. It defines naming conventions and the key telemetry the hardware device should expose to any DCIM software toolset. This chapter also introduces, for the first time, the ASHRAE DCIM Compliance for IT Equipment (CITE).
- **Chapter 4—DCIM Connected Framework.** This chapter presents a DCIM connective framework as a means to achieve the value of a DCIM system. The aim is for the guidelines defined by the connective framework to simplify and accelerate deployment while ensuring the value of DCIM is realized throughout the operational phase of the facility.
- **Chapter 5—Using Measured and Model-Based Data.** This chapter provides a framework and methodology for collecting, preparing, and analyzing data from the many distributed data sources found in a data center facility. These analytical and simulation techniques help ensure operators are able to make the most out of the big data these systems are capable of providing.
- **Chapter 6—DCIM Use Cases.** This chapter describes case studies highlighting examples of automation and control, as well as predictive analytics to demonstrate how these functions would be done using a modern DCIM system.