Making Data Center Digital Twins a Reality

CFD-based digital twin data center models

Paul Harrison, Sr Principal Application Engineer

October 2024

cādence®

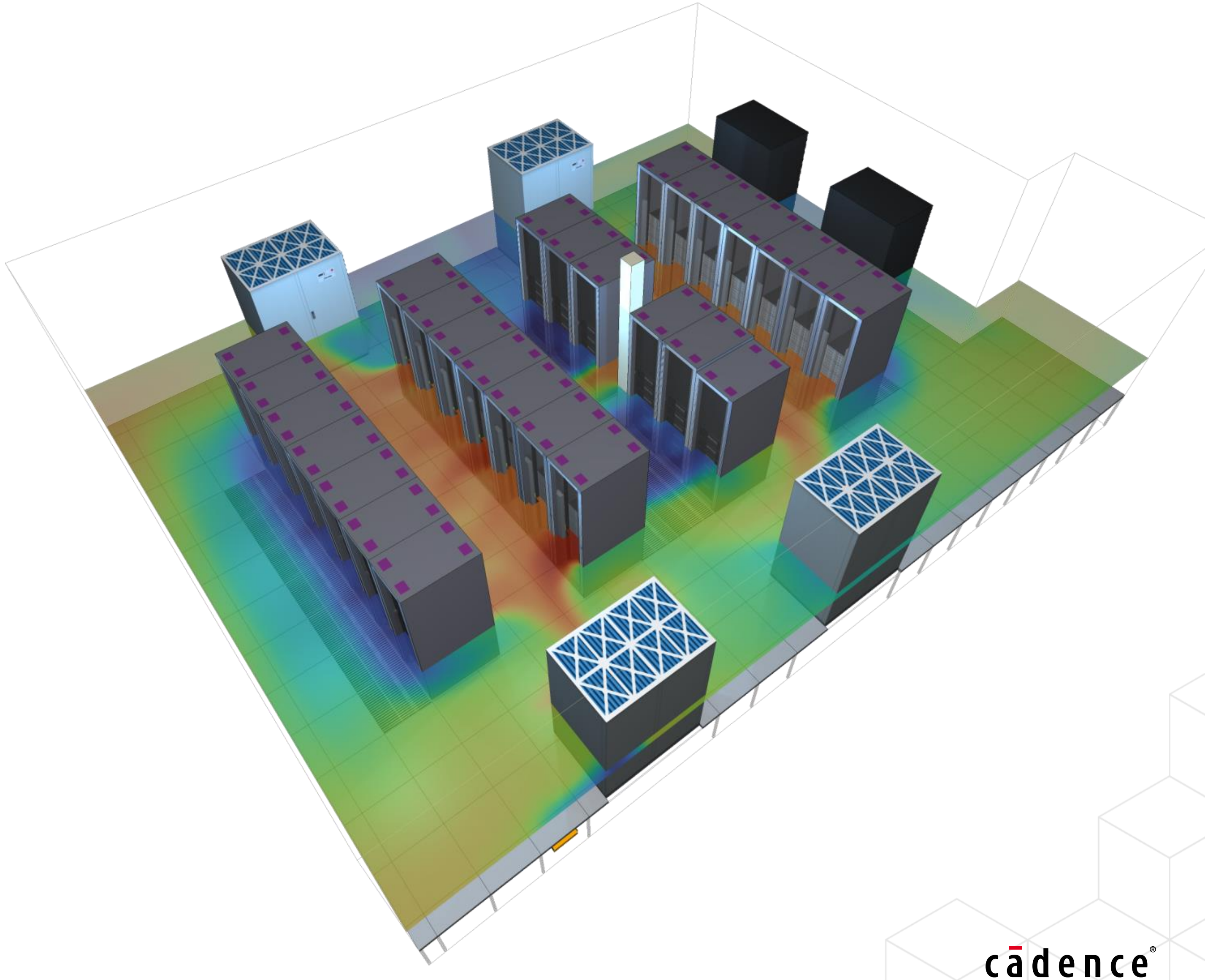
Agenda

- Introduction
- Creating a Data Center Digital Twin
- Challenges with Creating Them
- How They Integrate with Data Sources and Existing Processes
- Benefits to Operators

Introduction

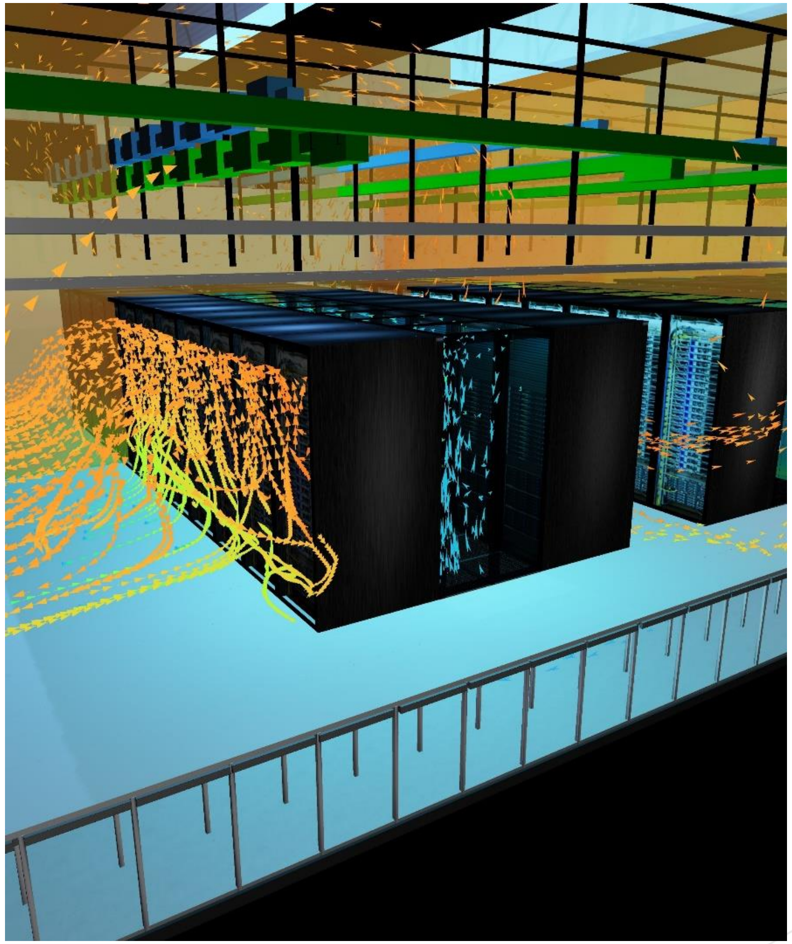
Introduction

- Many talks focused on electronics and chip-level challenges
- This talk centers on the environment we place these electronics in – **data centers**
- Data centers are like a big electronics box, but component placement is more dynamic
- CFD-based digital twins can be used to help with operational planning of data centers



Introduction to Data Center Operations

- Data centers designed making lots of assumptions
- However, over ~20-year lifecycle:
  - Business needs can change
  - Infrastructure is refreshed
  - New technologies can be deployed
  - Regulations change
- Managing data centers even more difficult with higher loads (HPC and AI driven), but some operators deploying digital twins to help manage data center

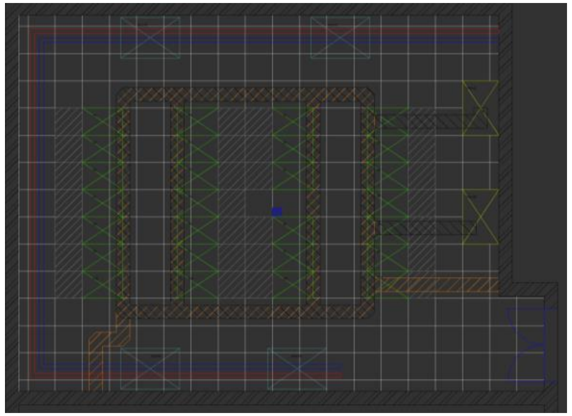


How to Create a Data Center Digital Twin

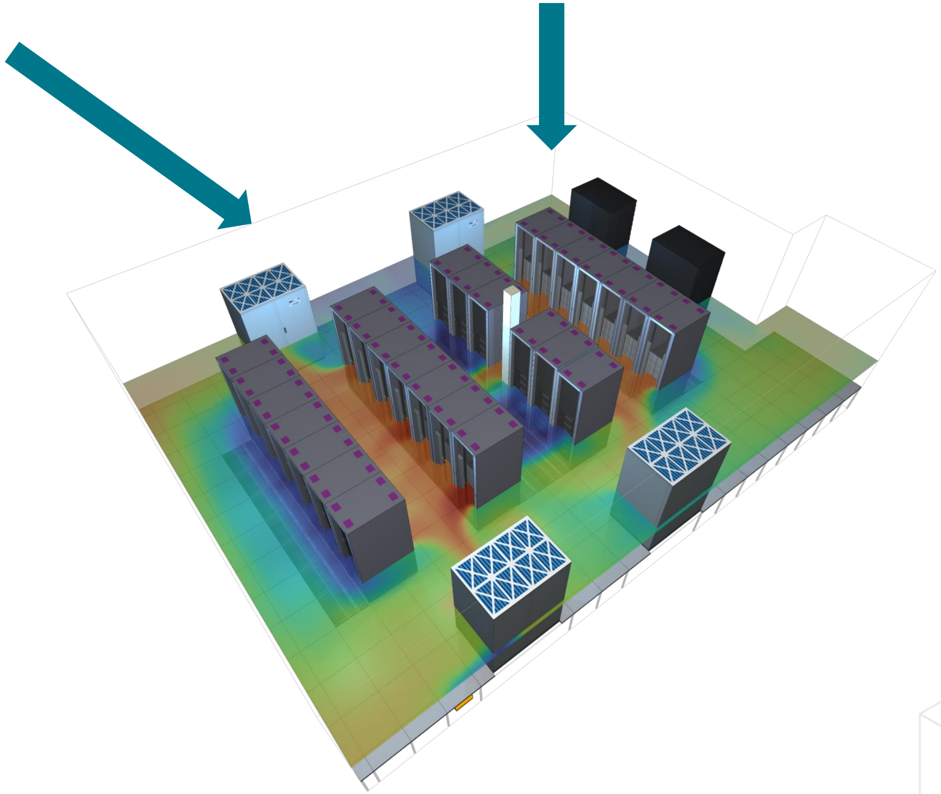
How to Create a Data Center Digital Twin

Generate a model using customer data such as CAD drawings, asset information, and equipment datasheets:

Cab No	RACK_NA	MANUFACTURER	MODEL	DEVICE TYPE	BOTTOM_RACK_UNIT	DEVICE_NAME
	G4	Cisco Sytems	System 2511	SERVER	40	dev 68
	G4	HP	Proliant DL360 G4	SERVER	20	dev 43
	G4	HP	Proliant DL360 G4	SERVER	21	dev 44
	G4	HP	Proliant DL360 G4	SERVER	22	dev 45
	G4	HP	Proliant DL360 G4	SERVER	23	dev 46
	G4	HP	Proliant DL360 G4	SERVER	24	dev 47
	G4	HP	Proliant DL360 G4	SERVER	25	dev 48
	G4	HP	Proliant DL360 G4	SERVER	31	dev 49
	G4	HP	Proliant DL360 G4	SERVER	32	dev 50
	G4	HP	Proliant DL360 G4	SERVER	33	dev 51
	G4	HP	Proliant DL360 G4	SERVER	34	dev 52
	G4	HP	Proliant DL360 G4	SERVER	35	dev 53
	G4	HP	Proliant DL360 G4	SERVER	36	dev 54
11	G4	IBM	Blade Centre	SERVER	5	dev 10
11	G4	IBM	Blade Centre	SERVER	12	dev 11

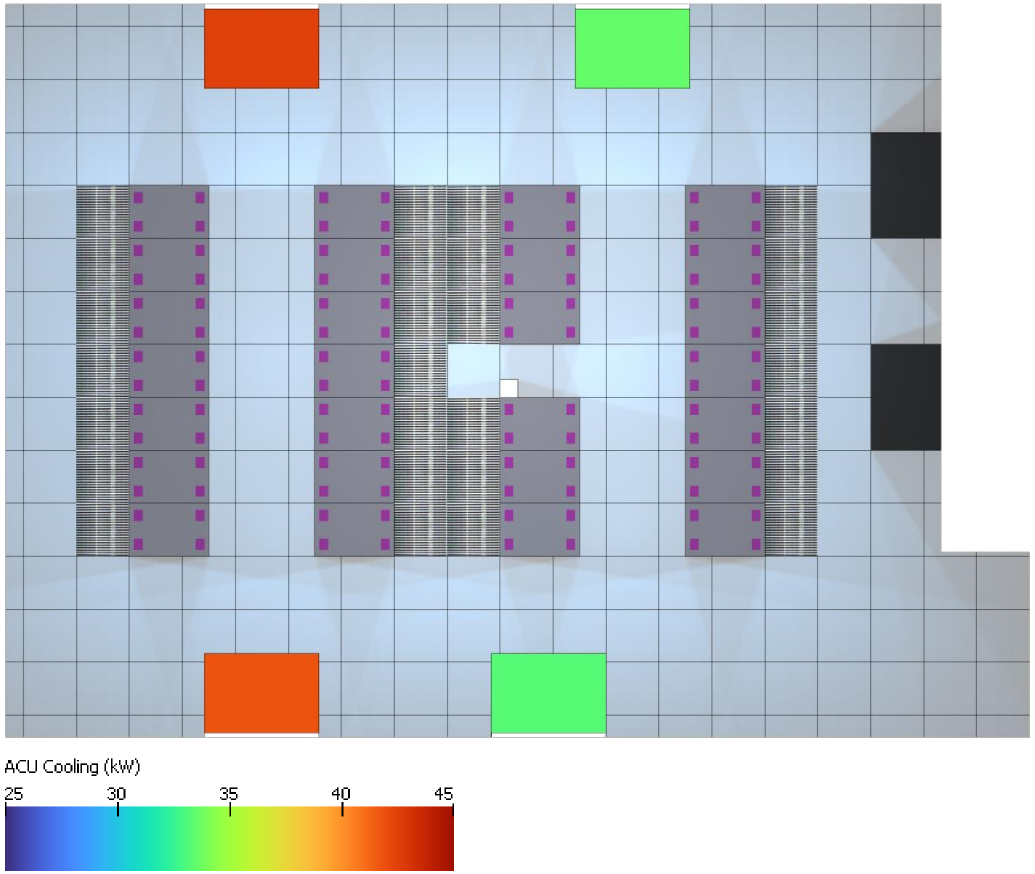


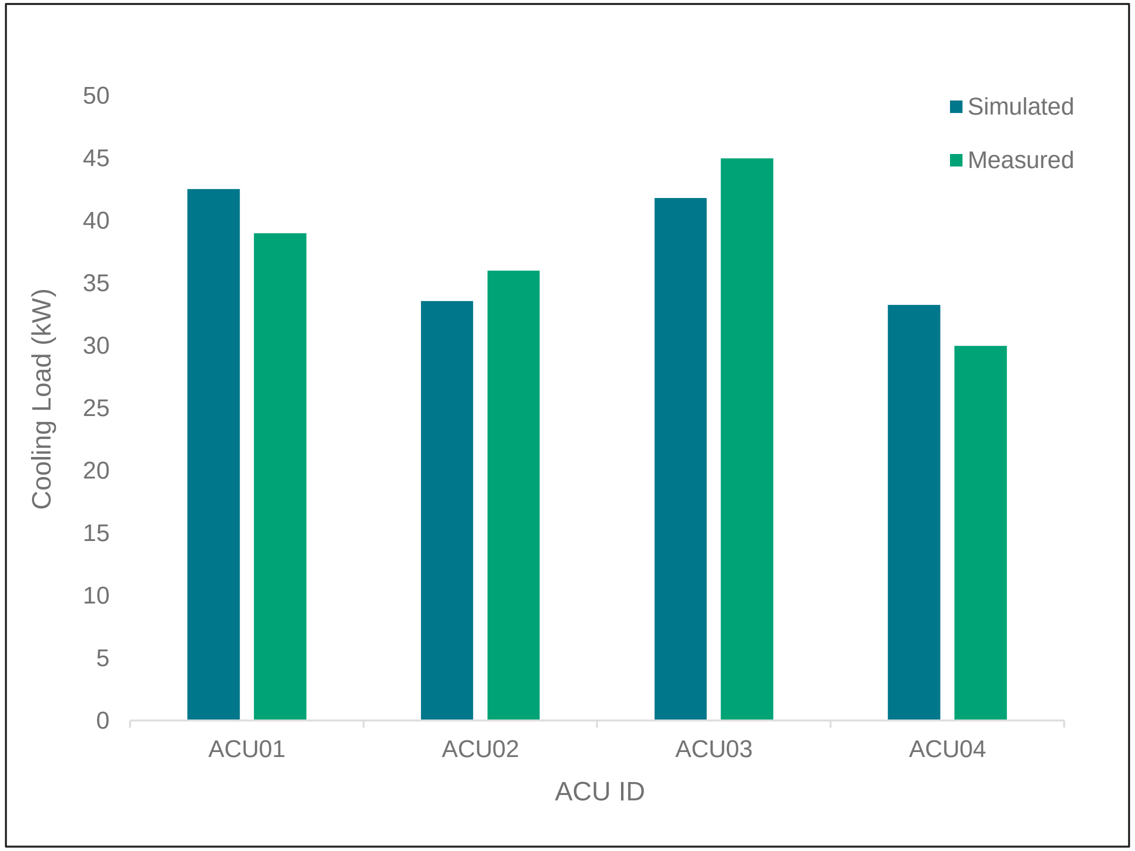
Unit inlet air temperature	**34.1**	°C	Fluid	**ETHYLENE GLYCOL 25%**		
Unit inlet air relative humidity	**30.0**	%	Inlet fluid temperature		**20.0**	°C
Unit airflow	**52400**	m³/h	Outlet fluid temperature		**28.2**	°C
ESP	**100**	Pa	Unit fluid flow		**6.39**	l/s
Sea level	**0**	m	Unit power supply	**400 V/3 ph/50 Hz**		



How to Create a Data Center Digital Twin

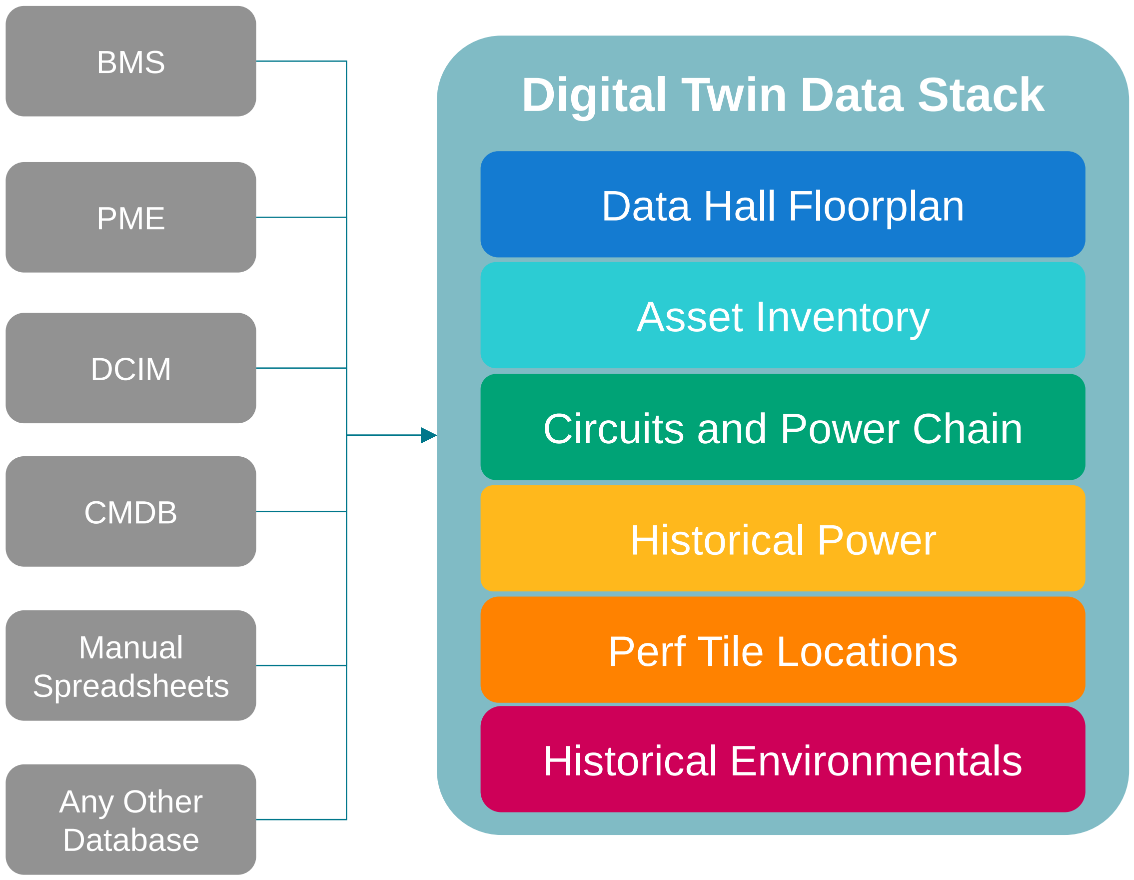
Calibrate the model for current day conditions against measured data, to gain good agreement with simulation results





How to Create a Data Center Digital Twin

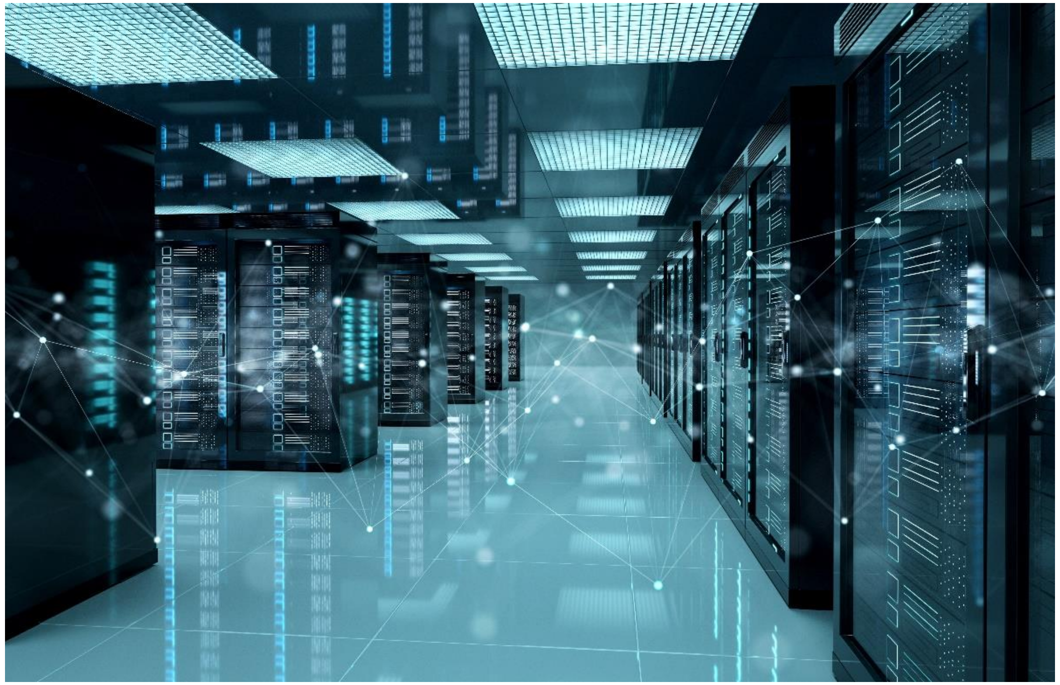
Integrate with their workflows and processes to keep the digital twin up to date



cadence

Challenges with Creating a Data Center Digital Twin

Three Challenges When Creating Data Center Digital Twin



Getting Results in a Reasonable Timeframe

Giving value to the customer quickly

Capturing Complex Systems in Compact Models

Capturing behavior of some of the complex systems is important to gain a representative model

Missing or Poor Data

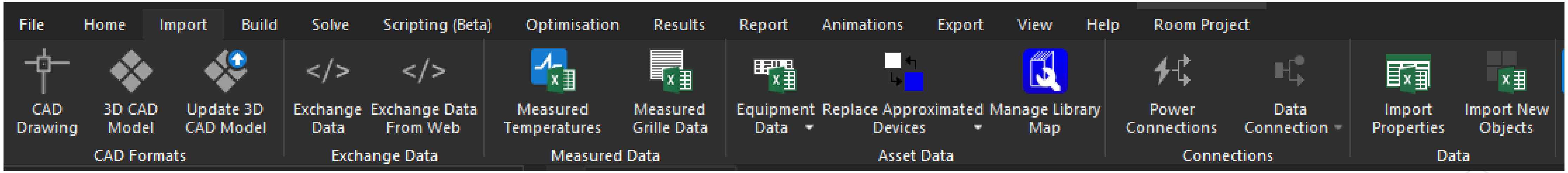
Some key areas of the data hall may have limited or no data, so we need to work around this

cadence

Challenges – Results in Reasonable Timeframe

- Providing the operator **useful engineering insight as soon as feasible** is a key aim

- First stage of model construction can be significantly sped up using import functionality
  - Importing model using IFC files
  - Using pre-configured library items of vendor objects
  - Importing IT inventory from an asset management tool
  - Importing cabinet powers

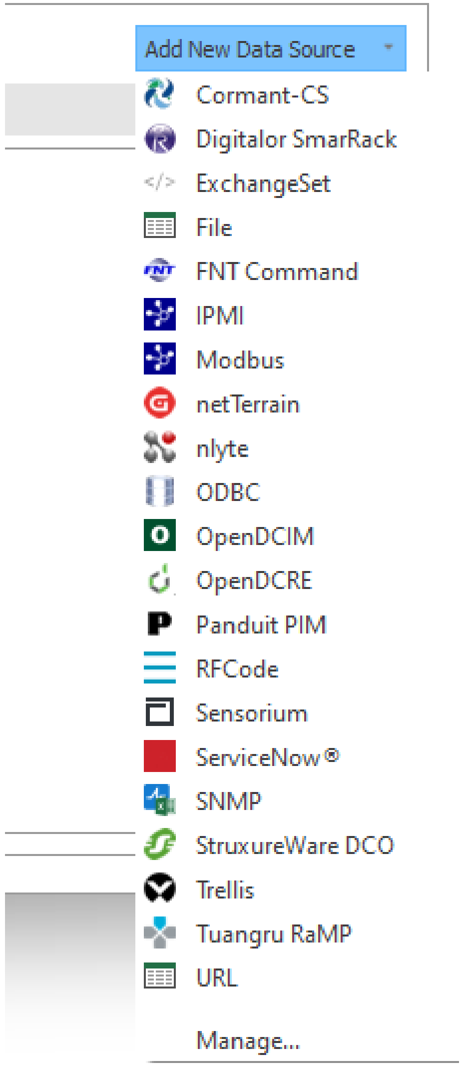


Challenges – Results in Reasonable Timeframe

- Connecting their digital twin to other data sources and processes is vital for making a successful digital twin

- Manual updating, while possible, is very time intensive

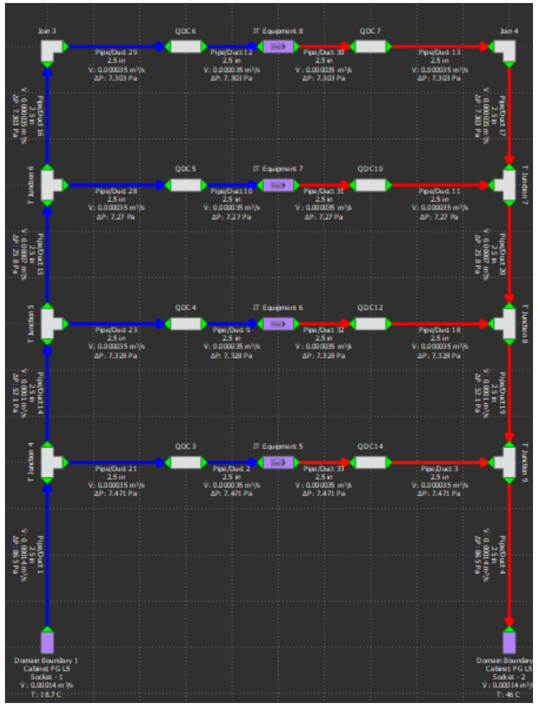
- Useful data might be logged elsewhere and pulling it into digital twin can help the operator run frequent simulations to help with operational planning



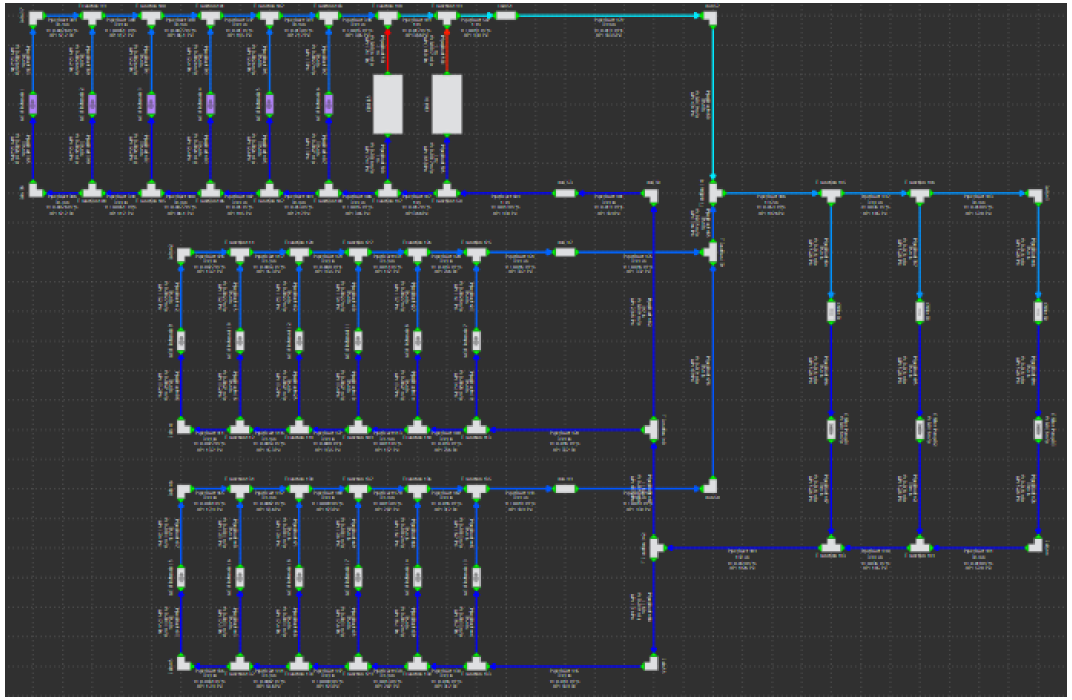
Challenges – Capturing Complex Systems

Many complex data center systems to capture

3D Cabinet Model



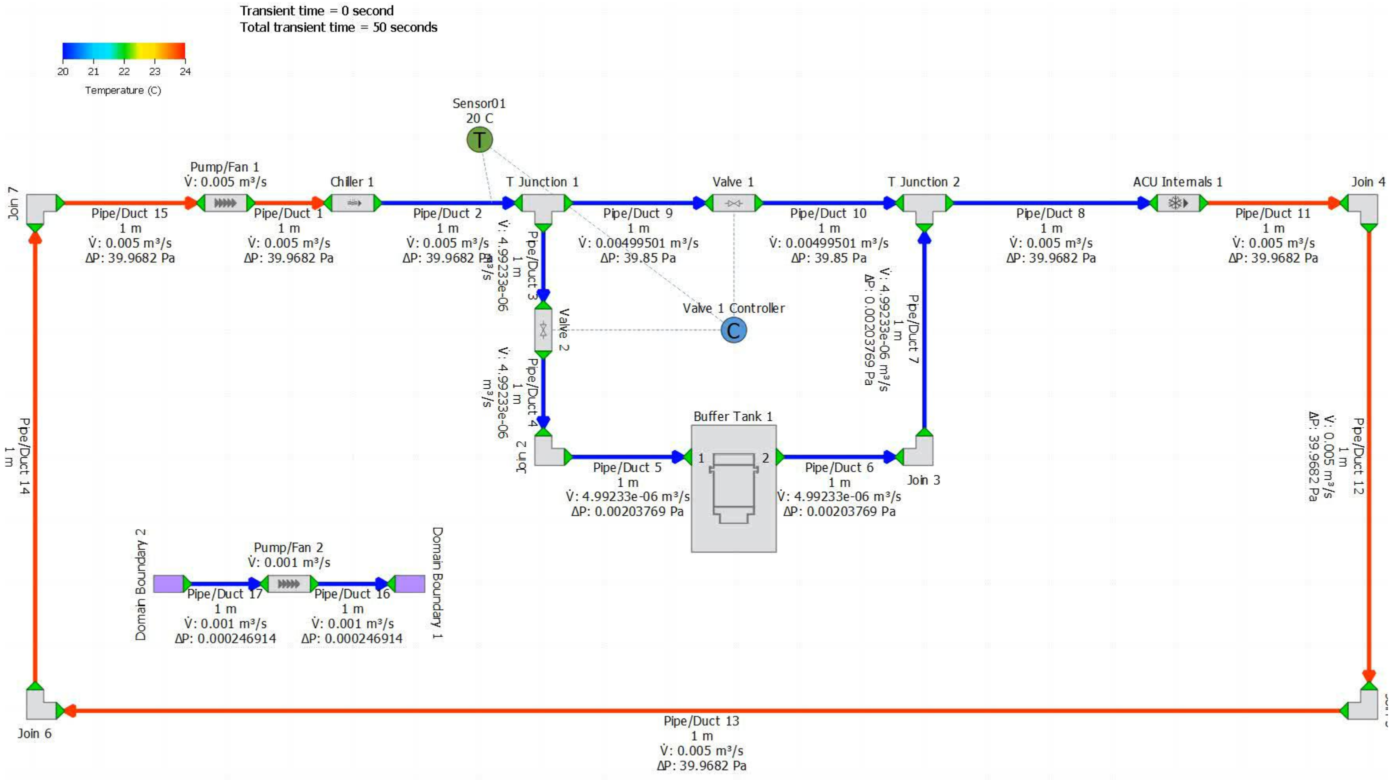
Flow Network Cabinet Model

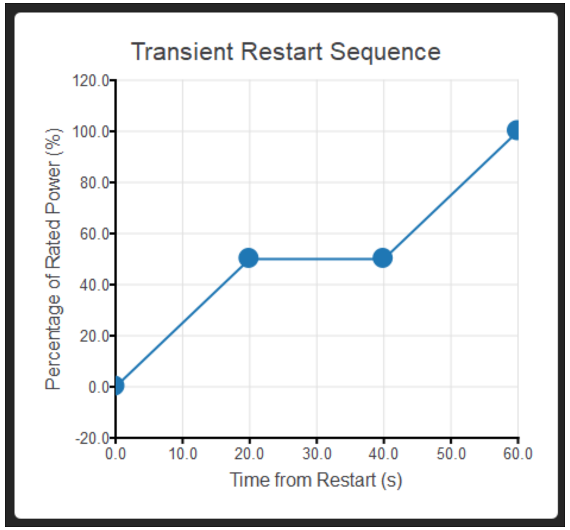


Flow Network Site-Level Model

Challenges – Capturing Complex Systems

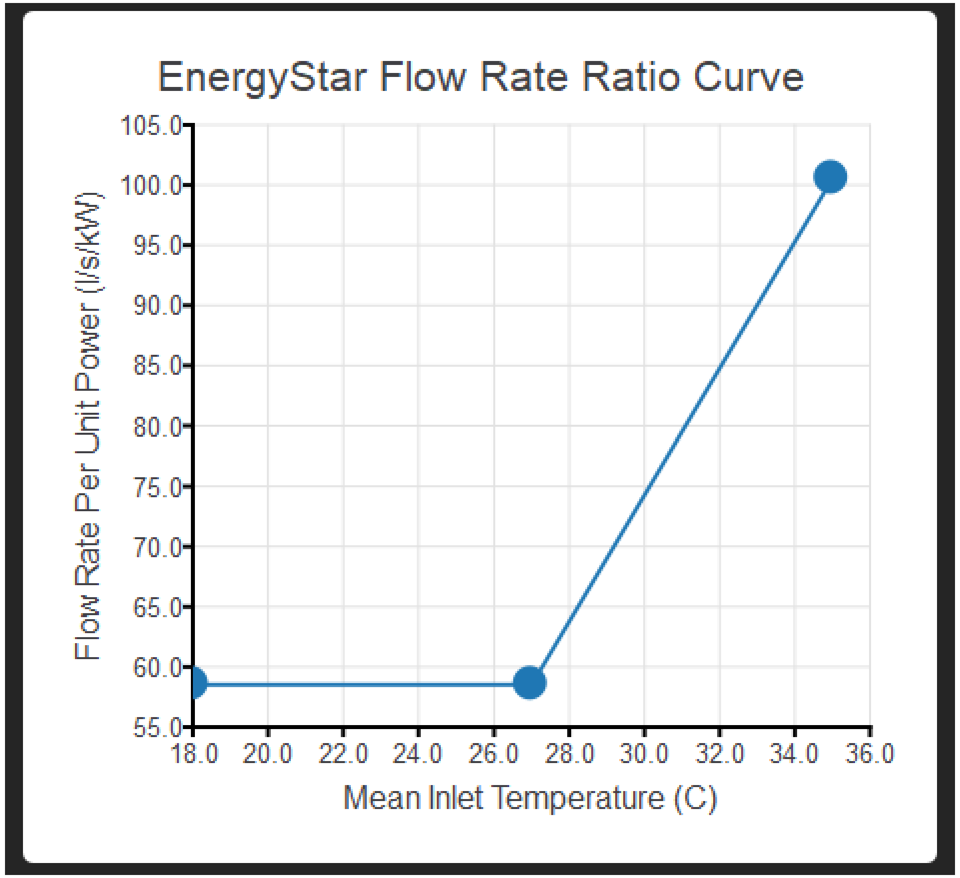
We may also need to capture these complex systems in complex scenarios, for example during a transient power failure scenario





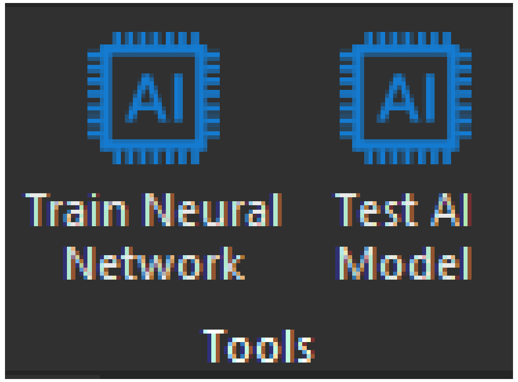
Challenges – Missing and Poor Data

- IT airflow is important variable in simulation; however, data is not always available
- Take published data from useful sources:
  - Manufacturer data sheets
  - EnergyStar data
  - ASHRAE
- Apply this to black box model of IT equipment to gain reasonable representation



Challenges – Missing and Poor Data

- If we have willing manufacturers, work with them to get the data. Servers have complex control systems that are based on many factors.



- Including an AI model of IT airflow behavior can help improve simulations. AI model can be trained using either measured data or simulation data.

- Helps improve IT airflow representation, but also adds benefit of helping mask IP of manufacturer - previously highlighted as a concern.

cādence®

How They Integrate with Other Data Sources and Existing Processes

Integrate with Data Sources and Existing Processes

- Successful digital twin sits within existing processes and integrates with other data center tools the client is using

- Data sources might be:
  - Asset management tool (IT inventory)
  - Building Management System (BMS)
  - Electrical Power Monitoring System (EPMS)
  - Monitoring system (temperature sensors, pressure sensors)

- Gateway service that gets format into an importable format for digital twin

Integrate with Data Sources and Existing Processes

- Datasets can be read in via Gateway, aggregated, and imported into the model. This allows different types of assessment from the model.
- Sometimes, when this data is attempted to be imported into the digital twin, we get errors, which necessitate a review of the original data.
- By errors being highlighted in the digital twin, this can then mean an improvement to how data is recorded, or a review of sensor accuracy.

Benefits

Benefits to Operators

- Ability to assess different what-if scenarios in a virtual testing ground. Examples might be:
  - Energy efficiency drives
  - Big change in deployments
  - Analyzing what would happen in a power failure without risking real IT infrastructure
- Helps work toward optimal operations for their data hall, by understanding where inefficiencies lie
- Improved understanding of risk before implementing changes to their data hall

Benefits to Operators

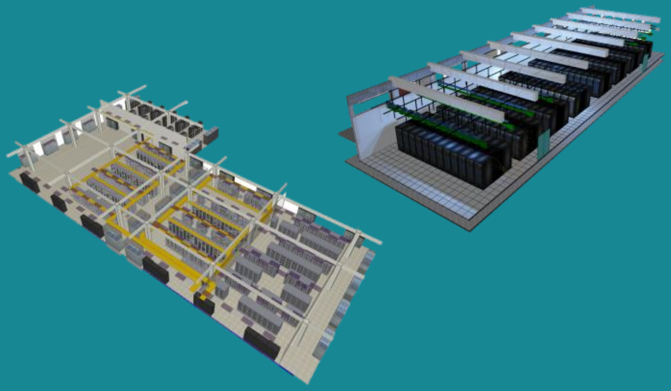
- Digital twins can help highlight where their processes and data sources need improvement. By trying to improve the digital twin model, it highlights areas where the data is insufficient or not recorded correctly.
- If the user has configured some of the automation available to them, the models can update with the latest data from data sources, run the simulation, and export a report showing user-defined key results.
- The platform allows an understanding not just one data hall, but their portfolio!

Benefits to Operators

Cadence® Reality™
Digital Twin Platform:

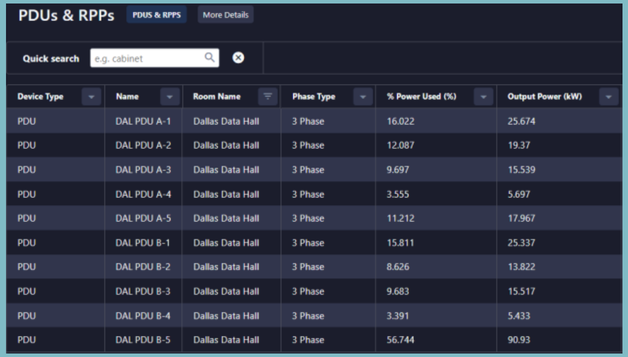
Database

Multi-Site Digital Twin Portfolio



Cadence Reality DC Insight Web Portal

Spreadsheet-Ready Reports

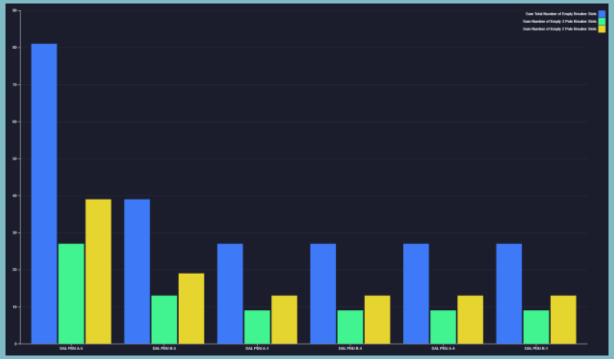


PDUs & RPPs | PDUS & RPPS | More Details

Quick search: e.g. cabinet

Device Type	Name	Room Name	Phase Type	% Power Used (%)	Output Power (kW)
PDU	DAL PDU A-1	Dallas Data Hall	3 Phase	16.022	25.674
PDU	DAL PDU A-2	Dallas Data Hall	3 Phase	12.087	19.37
PDU	DAL PDU A-3	Dallas Data Hall	3 Phase	9.697	15.539
PDU	DAL PDU A-4	Dallas Data Hall	3 Phase	3.555	5.697
PDU	DAL PDU A-5	Dallas Data Hall	3 Phase	11.212	17.967
PDU	DAL PDU B-1	Dallas Data Hall	3 Phase	15.811	25.337
PDU	DAL PDU B-2	Dallas Data Hall	3 Phase	8.626	13.822
PDU	DAL PDU B-3	Dallas Data Hall	3 Phase	9.683	15.517
PDU	DAL PDU B-4	Dallas Data Hall	3 Phase	3.391	5.433
PDU	DAL PDU B-5	Dallas Data Hall	3 Phase	56.744	90.93

Charts



Capacity Dashboards

CFD Reports

cadence®

Questions & Answers

cādence®