CONTENT CHANGES

Page 101:   Replace case study 8, Figure 2.49 with the following:
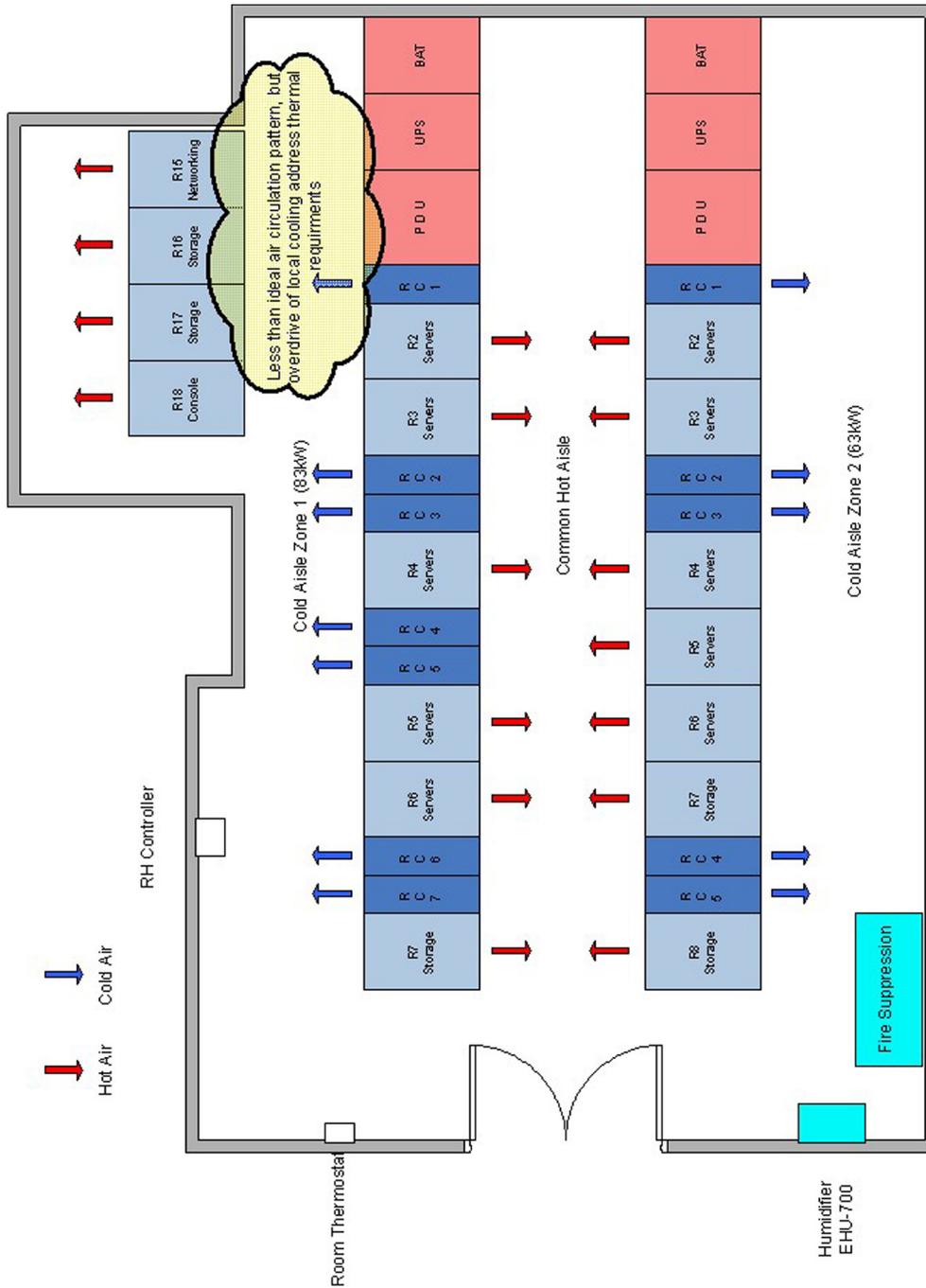
Page 100: Reclassify case study 8 as "Non-Raised-Access Floor with Row Cooling"

Page 126: Change: "The data center for this case study has a 12,000 ft^2 (1115 m^2) high density area with an average load of 170 W/ft2 (16 W/m2), or an average rack density of 6.8 kW over the total 640 racks. The system utilizes raised-access floor air supply and hotair containment through a rack exhaust duct to a ceiling plenum return. A supplemental fan in the exhaust duct helps overcome the additional pressure loss. The floor layout is divided into five 2400 ft^2 (233 m^2) sections. For this study, environmental attributes for one of the five 2400 ft^2 (233 m^2) sections were collected and analyzed; these attributes are rack power loads, floor tile flow rates, IT equipment flow rates, IT equipment intake air temperatures, and exhaust air temperatures. Spot measurements taken for the other 2400 ft^2 (233 m^2) sections showed good comparison with the first section; therefore, detailed information for one of the five sections will be shown in detail."

To:

"This case study highlights the importance of creating a physical barrier between cold supply (see Figure 2.70) and hot return air on the data center floor. A conventional hot-aisle/cold-aisle rack configuration in data centers has worked well when rack power loads are low—typically less than 4 kW per rack. However, with increasing rack loads, excess cold air must be supplied to the cold aisle to reduce hot spots near the top of the racks that result from hot air diffusing into the cold aisle. A large fraction of the excess cold air also bypasses the electronic equipment and returns back to the air conditioning units. This practice is energy inefficient; it increases fan energyuse and requires more energy to produce colder air. A physical barrier between hot and cold air streams within a data center is needed to avoid mixing of cold air with hot air. A new approach to physically separate the cold and hot air streams within a rack was selected and implemented in a high power density section of a large data center. The selection was based on energy as well as other practical considerations. This case study discusses the high-density rack hot-air containment approach—the rationale for its design and its advantages and limitations—and presents data on its energy performance.The field performance of the high power density section of a large enterpriselevel data center is reported here. This data center was constructed in phases. The first phase used the then state-of-the-art practice of hot-aisle/cold-aisle rack arrangement on the data center floor. The chilled-water CRACs are located on both ends of the rack aisles and supplied cold air under the raised floor. Supply air is delivered to cold aisles through perforated tiles in front of the equipment racks. Hot air from the equipment racks is discharged into the hot aisle, from which it is drawn back into the CRAC units. Our field observations confirmed the increased supply air temperatures to equipment near the top of the racks since the discharged air from hot aisles was being drawn back in to the cold aisles. We also noticed that some of the cold air did not go through the electronic equipment but was instead drawn directly back to the CRACs without providing any cooling. A further review of data for total airflow from the CRACs and total airflow required for the electronic-equipment cooling indicated the CRACs supplied far more air than was required. The data center design and operations team decided to address the above issues during the design and construction of the second-phase expansion of the data centerin 2003. The expansion included a 12,000 ft^2 (1115 m2) high power density area with an average rack power of 6.8 kW per rack for 640 racks, or an average power load of 170 W/ft^2 (16 W/m^2). The team decided to increase the cooling energy efficiency by reducing unnecessary airflow on the data center floor; by supplying enough cold air to match the airflow requirements of the electronic equipment, the airflow rates would be reduced to less than one-half those of the existing system. In order for us to adjust airflow demand to electronic equipment, which would vary as new equipment was brought in or older equipment was removed, we decided to install variable-speed drives on the CRAC fans. However, CFD modeling showed that slowing the airflow increased the risk of hot-air infiltration in the cold aisle, causing high supply air temperatures, especially near the top of the rack and racks on the end of the aisle. The high temperatures, in turn, required even colder supply air temperatures, thus negating some of the energy efficiency gains from the airflow reduction. The team decided to create a physical barrier between the hot and cold air on the data floor to prevent mixing. This also allowed us to raise our supply temperature without concern for reaching unacceptably high temperatures near the top of the rack due to hot-air infiltration if there was no physical separation. The team considered different arrangements of barriers between hot and cold air, such as cold-aisle containment and hot-aisle containment, but elected to use a rack enclosure with a discharge duct to ceiling return air plenum. The system worked very well and provided excellent energy savings with measured simple payback of less

than six months. The fact that the CRAC fan speeds could be adjusted to meet the equipment load requirement, and the equipment in the data center was loaded gradually over a period of time, meant that the fans could run more slowly. This reduced the direct energy use and indirect cooling energy use required to remove heat generated by fans. The system utilizes raised-floor access air supply and hot-air containment through a rack exhaust duct to a ceiling return plenum. A supplemental fan in the exhaust duct aids in overcoming additional pressure loss. The floor layout is divided into five 2400 ft^2 (233 m^2) sections. For this study, the environmental attributes—rack power loads, floor-tile flow rates, IT equipment flow rates, IT equipment intake, and exhaust air temperatures—for one of the five 2400 ft^2 (233 m^2) sections were collected and analyzed. Spot measurements were also taken from the four other 2,400 ft^2 (233 m^2) sections, which reinforced the reported data for the first section."

Page 126: Added the following figure:

Figure 2.70 *Rack layout showing the cold supply-air row.*

Page 127: Delete reference in text to Figure 2.77 and renumber figures accordingly.

Page 128: Delete Figure 2.77

LAYOUT

General: Begin case studies in Chapters 2 and 3 on a separate page.

Page 100: Move case study 8 ("Cedars-Sinai Medical Center Data Center") from Chapter 2 to the beginning of Chapter 3 and renamed as case study 10; renumber figures and tables accordingly.

Page 109: Rename case study 9 ("Hewlett-Packard Richardson DataCool™ Data Center") as case study 8.

Page 126: Rename case study 10 ("Oracle Data Center") as case study 9.