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Introduction

Data centers and telecommunications rooms that house datacom equipment are becoming increasingly more difficult to adequately cool. This is a result of IT manufacturers increasing datacom performance year after year at the cost of increased heat dissipation. Even though performance has, in general, increased at a more rapid rate than power, the power required and the resulting heat dissipated by the datacom equipment has increased to a level that is putting a strain on data centers. However, in the struggle to improve the thermal management characteristics of data centers it is sometimes important to assess today's data center designs. The objective of this book is to provide a series of case studies of high density data centers and a range of ventilation schemes that demonstrate how loads can be cooled using a number of different approaches.

This introductory chapter describes the various ventilation designs most often employed within data centers. This book does not present an exhaustive resource for existing ventilation schemes but, rather, a wide variety of schemes commonly used in the industry. Seven primary ventilation schemes are outlined here. In the case studies that follow, each of these will be shown with detailed measurements of airflow, power, and temperature.

The most common ventilation design for data centers is the raised-access floor supply, with racks arranged in a cold-aisle/hot-aisle layout (see Figure 1.1). The chilled-air supply enters the room through perforated tiles in the raised floor, washing the fronts of the racks facing the cold aisle. The hot exhaust air from the racks then migrates back to the inlet of the computer room air-conditioning units (CRACs) typically located on the perimeter of the data center.

Another version of the raised-access floor supply is shown in Figure 1.2, where the air-handling units (AHUs) are located beneath the floor containing the IT equipment. One of the key advantages of this arrangement is that all the mechanical equipment is located in a room separate from the IT equipment, which allows for ease of maintenance.

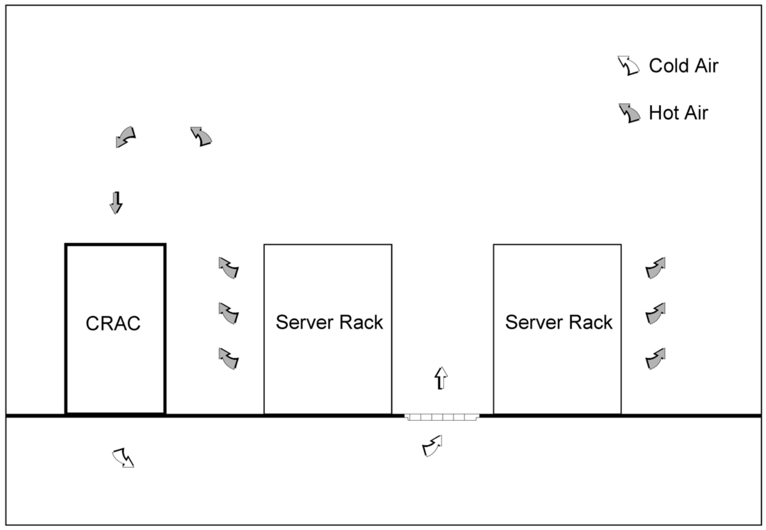

Figure 1.1 Raised-access floor supply.

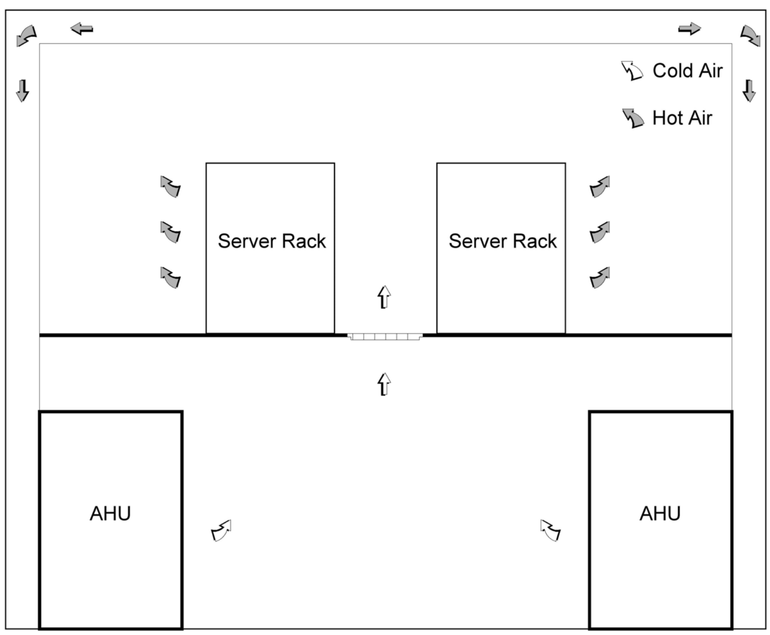

Figure 1.2 Raised-access floor with air-handling unit on floor below.

A slightly different version of the raised-access floor supply is the raised-access floor supply and ceiling return, as shown in Figure 1.3. This is an advantageous design for high-powered racks with hot exhaust, since the hot air is pulled from the hot aisle before it is allowed to mix with the cold air. The higher return air temperature allows the CRACs to operate much more efficiently given the higher return air temperature.

A unique layout for raised-access floors is shown in Figure 1.4. In this case, the modular CRACs are laid out in the data center in the hot aisle. The advantage of this ventilation scheme is that the hot-air exhaust from the racks has a short path to the inlet of the CRACs, and the chilled air exhausting from the CRACs has a short path to the cold-aisle perforated tiles. Both paths are short, thereby minimizing the impedance to airflow. The heat load capability of the CRACs needs to be somewhat balanced with the heat load of the racks in the immediate vicinity.

Since the heat load of the racks has become quite high, there are several options now offered in the industry that provide localized air-to-liquid heat exchangers. In these cases, the localized air-to-liquid heat exchanger, as shown in Figure 1.5, removes most—if not all—of the heat load from the rack before it exhausts into the larger data center room. This removes any hot-spot potential in the room.

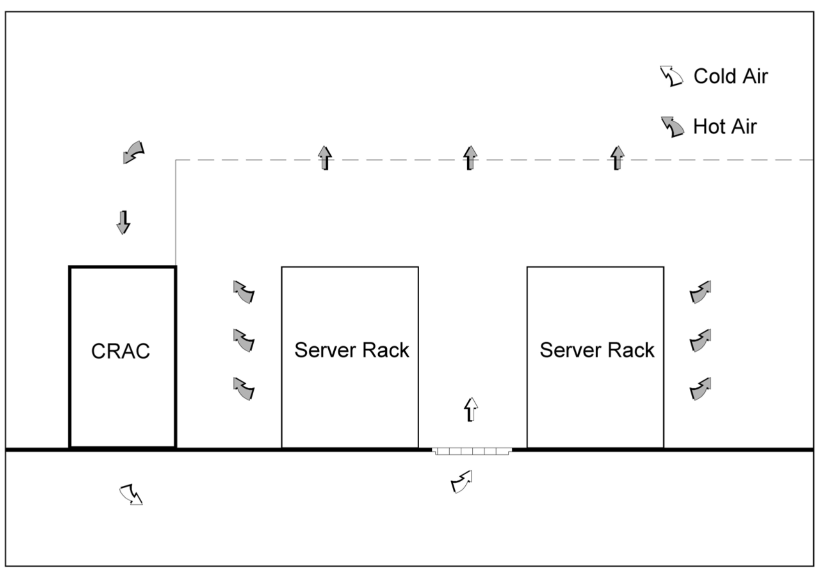

Figure 1.3 Raised-access floor supply/ceiling return.

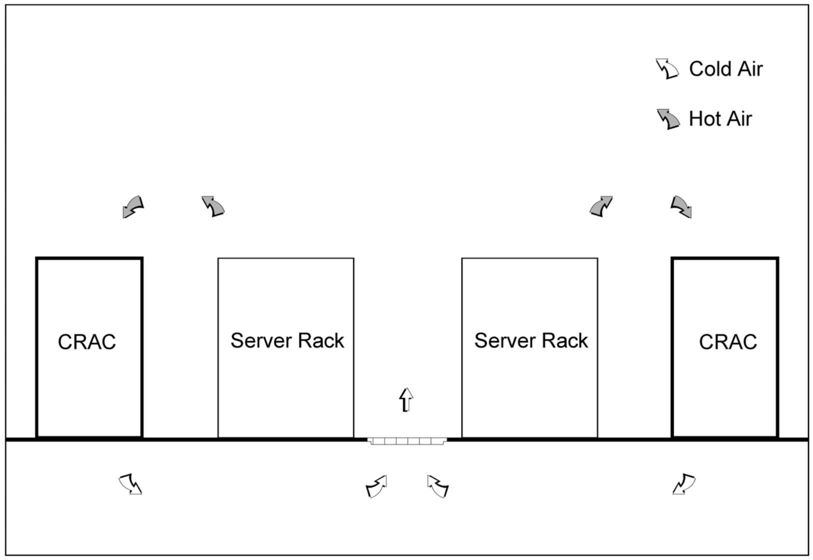

Figure 1.4 Raised floor with modular CRACs in hot aisle.

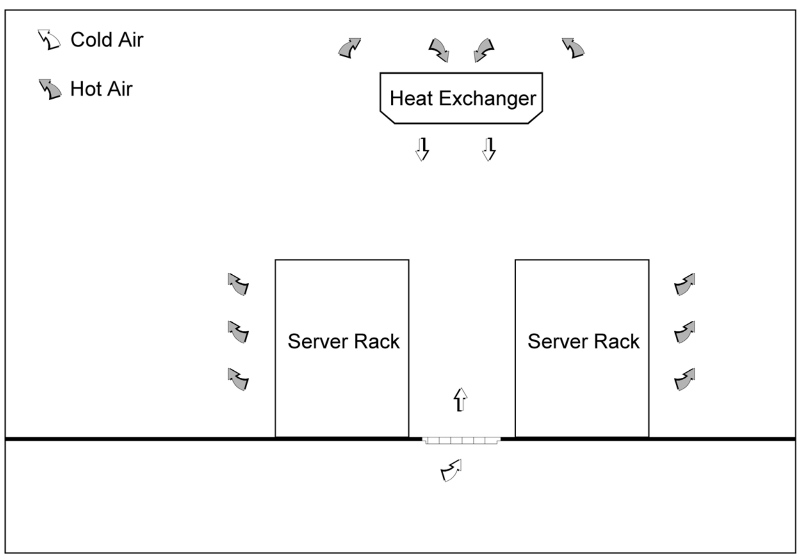

Figure 1.5 Raised-access floor with air-to-liquid heat exchangers adjacent to IT racks.

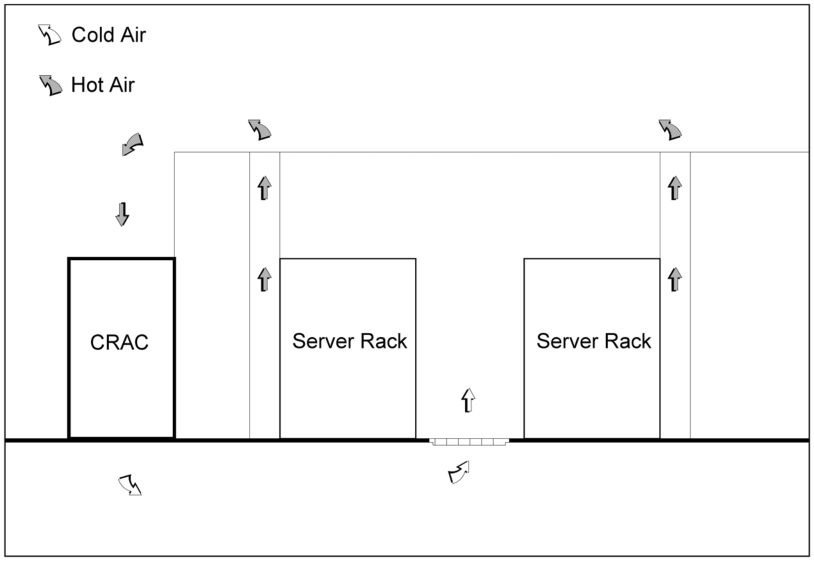

Figure 1.6 Raised-access floor supply/ducted ceiling return.

To further separate the hot exhaust air from the racks and the cold air in the cold aisle, Figure 1.6 shows a ducted hot-air exhaust back to the CRACs. The ducting is an effective separation technique but needs to be closely integrated with the IT racks.

Figure 1.7 shows a non-raised-access floor design in which supply chilled air enters from the ceiling, and hot-air exhaust from the racks returns to the CRACs located on the perimeter of the data center.

The following chapters provide case studies of operational data centers with the ventilation schemes described above. The purpose of these studies is to be as complete as possible in deploying measured thermal parameters of the data center. For most cases, these include inlet air temperatures to each rack; airflow rates from perforated tiles and other openings, such as cable openings; power measurements of all elements within the data center, including IT equipment, lighting, and power distribution units (PDUs); and, finally, a complete set of geometric parameters that describe the data center, including rack layouts, raised-access floor heights (if a floor is raised), ceiling heights, and any other information pertinent to the thermal management of the data center. Although thermal modeling is not the subject of this book, one could theoretically use the data from these case studies to construct a thermal model of the data center and then make comparisons.

The format for displaying the data is the same for most of the case studies so that comparisons can be made between the various ventilation schemes as desired.

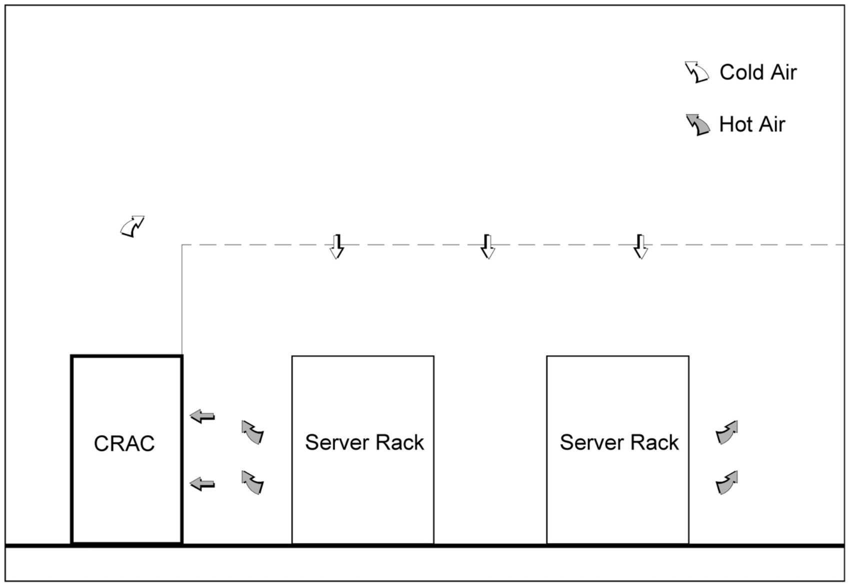

Figure 1.7 Non-raised-access floor ceiling supply.

The two chapters devoted to case studies cover raised-access floors and non-raised-access floors. Since most measurements are for raised floors, several subcategories are provided in which case studies are shown for each subcategory. Chapter 4 is devoted to best practices for each of the primary categories of ventilation schemes—raised-access and non-raised-access floors. These guidelines are based on technical papers published mostly within the last five years, and also from the case studies presented herein.

Chapter 5 provides an expanded list of references and a bibliography with additional, related materials. Chapter 6 provides a useful glossary of common terms used throughout this book.