

Data Center Airflow Modeling

Helps Facilities Planners Make Informed Decisions

Track the heat to its source

BY PAUL BEMIS AND LIZ MARSHALL

The placement of computer equipment in a new or existing data center is not always obvious. In many cases, common-sense placements will give rise to equipment hot spots resulting from inadequate airflow, even though there might be enough total cooling capacity in the room. Computational fluid dynamics (CFD) can be an effective way to simulate the proposed changes and understand their implications prior to implementation. This can save time in the short term, and because of the potential to reduce the overall cooling requirement, it can save operating costs over the longer term.

History of CFD

CFD has been around for over 30 years, and the use of commercial CFD software has grown rapidly during this time.



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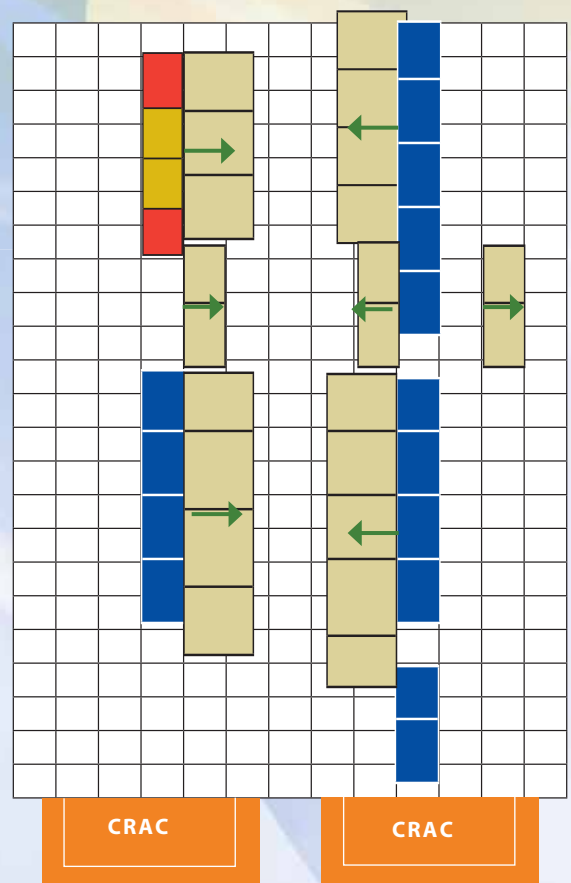


Figure 1: Air flow rates, ranging from low (blue) to high (red) in one section of a data center show that the cooling of servers mounted in racks (pink) is not always best closest to the CRACs (orange).

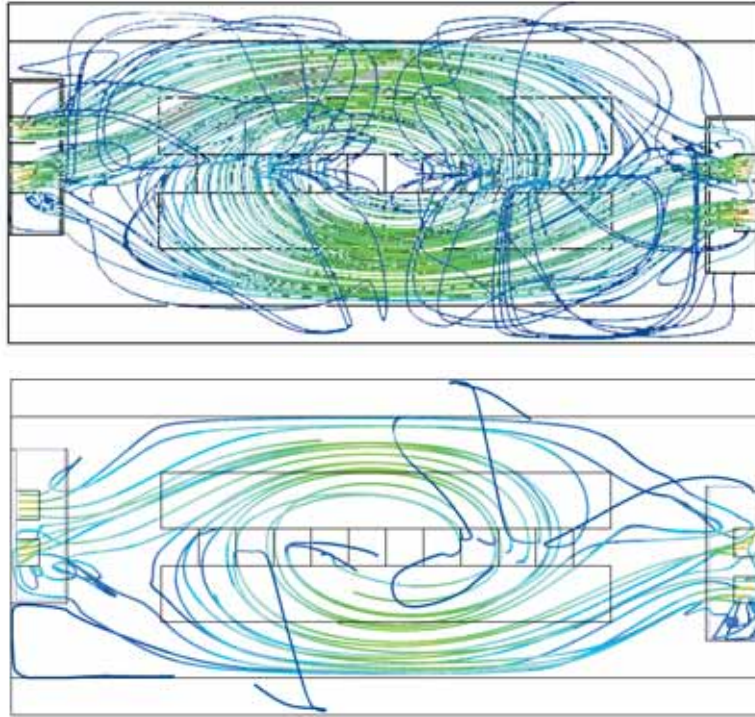


Figure 2: Path lines of air in the supply plenum (a, top) colored by speed, show colliding jets of cold air from CRAC units on opposite walls; the resulting recirculation pattern causes weak upward flow (blue) at the center of the tile row (b, bottom) and stronger flow (red and orange) through the tiles at the ends of the row.

General-purpose CFD software has many capabilities that allow for simulations of flames, supersonic flow, multiphase mixtures (such as bubbly flow), and the deformation of viscoelastic materials, for example. Typically, an analyst must generate a model, direct the solution, and process the results. Many engineers and technicians do not need all of the capabilities in a general purpose product, however, and furthermore do not wish to spend long hours or even days generating a model and overseeing the path to solution. They have a need for the information that CFD provides, but do not want to invest in long training times and the associated learning curve. In contrast, CoolSim is an application-specific implementation of CFD that targets the sole task of modeling the airflow in data centers. This approach lowers the learning curve significantly by making the application highly automated and easy to use.

CFD as a Service

Throughout most of its life, commercial CFD has been delivered as a product that runs on a client's desktop computer or on a server at the client's workplace. License keys are purchased for some number of concurrent processes. This model works best if usage of the software is high enough to warrant the license and IT costs associated with local deployment. The modeling of airflow in data centers is more periodic, however, tending to be done only when equipment changes are under consideration. Periodic use favors the "Software as a Service" (SaaS) model where the CFD application executes

on a remote web-based server, and the local application is for pre- and post-processing only. The SaaS approach provides the benefits of off-loading local IT costs through provider economies of scale, saving time by allowing users to begin using the application immediately, and lowering costs by allowing users to pay as they go for use of the application.

Explaining the Unexpected

Whether delivered as a product or a service, CFD is often the only tool that can explain certain observations that, at first glance, appear puzzling. For example, placing IT equipment as close as possible to the computer room air conditioners (CRACs) should provide the maximum cooling. In a typical raised-floor configuration, the supply air from the CRACs travels through an under-floor supply plenum. The supply air travels along the path of least resistance, and often, this air is more likely to travel through the open expanse of the supply plenum than turn and enter the room through a nearby floor tile with a restricted opening. Of course, obstacles in the supply plenum, such as pipes and cable trays, act to deflect the airflow, and in some cases, such obstacles may make it easier for the air to pass through one floor tile rather than another. The bottom line is that each data center is unique, and through CFD modeling, airflow patterns that accompany equipment change can be better understood than if simple guesswork is used. Figure 1, in which the airflow rate through a region of flooring is shown, illustrates this point. The flow rate closest to the CRACs is less (dark blue) than that farther away (red and yellow) as a result of the supply plenum fluid dynamics.

Placing New Equipment

Airflow modeling can be the best method for understanding how much equipment can be placed in a data center and where to place it. If a rack of high-density servers is slated to replace a rack of older equipment, for example, it is important to know that adequate airflow will be available for the increased cooling demands. As suggested above, the airflow in the supply plenum plays an important role in dictating the distribution of flow through the grates in the floor. In Figure 2a, two CRACs are positioned on opposite walls in one section of a data center, and the supply air jets emanating from them collide in the under-floor plenum. A recirculation pattern forms, at the center of which, very little air is forced up through the floor tiles (blue, Figure 2b). The flow rates through the floor tiles at the ends of the row are greater because the colliding jets in the plenum force the air to be deflected upwards. If nothing else in the data center is free to be moved, this information suggests that the high-density replacements should be positioned near the ends of the rack rows rather than at the centers. Indeed, this knowledge could make the difference between failure of the new equipment and long-term survival.

Identifying Hot Spots

Figure 3 reveals another data center problem. In this data center, the air from the hot side of some of the racks is re-entrained into the cold side. This situation can occur if the distance between the hot aisle and nearest CRAC is great enough that the draw of the rack fans exceeds that of the CRAC. In addition to predicting likely hot spots that result from re-entrainment, CFD can be used to spot the potential for excess heating at the ends of rack rows where the equipment may receive less air than racks positioned elsewhere.

Optimal Cooling Configurations

As energy prices continue to rise, so will the need to achieve optimal cooling configurations for today's data centers. In a recent survey by the Uptime Institute, data centers were shown to provide an average of 2.6 times the required cooling capacity for the heat load, yet these same data centers still experienced hot spots 10 percent of the time. By understanding the airflow distribution within the data center and having the ability to model changes before they are implemented, data center and IT managers and planners have the opportunity to optimize the overall cooling capacity on hand, and reduce the costs associated with excess cooling. ■

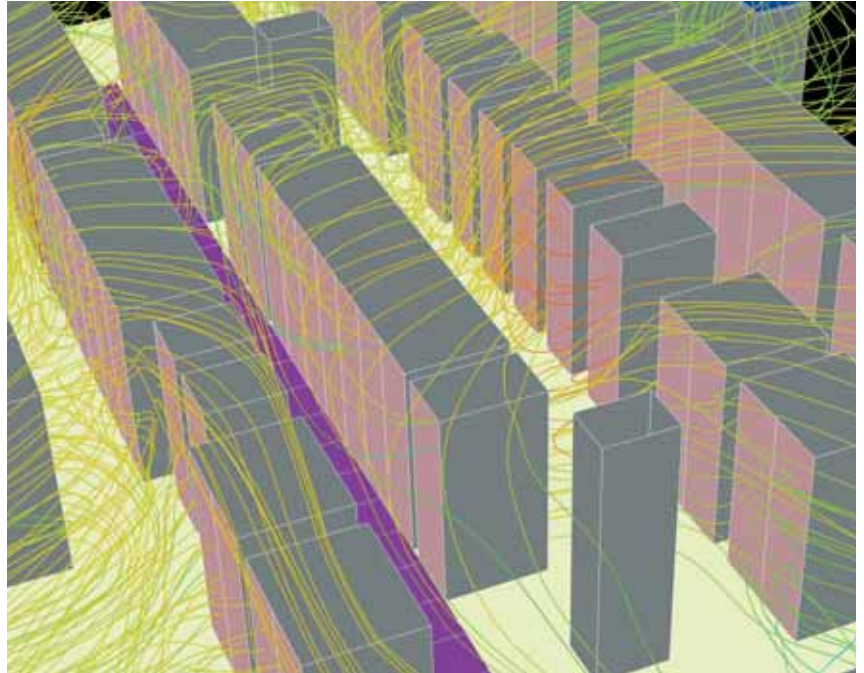


Figure 3: Path lines are used to illustrate the problematic flow of air in the vicinity of two rack rows, where hot air (outer aisles) is shown to pass over the tops of the racks and be re-entrained into the racks on their supply sides (center aisle, with the floor vents shown in purple); the pathlines are colored by temperature, ranging from cold (blue) to hot (red).



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