Rittal White Paper 509: Inner-Rack Airflow Patterns & Data Center Efficiency

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Executive Summary

Understanding airflow patterns in the data center environment requires knowledge of several different airflow areas. The typical hot and cold aisle airflow configuration adopted several years ago, and still commonplace in data centers today, usually consists of an airflow pattern under the raised floor, above the raised floor and through the racks themselves. Precisely controlling and reducing airflow patterns through the racks drastically improves the cooling and overall efficiency of a data center. This white paper aims to assist designers and users by explaining the patterns that can exist inside the rack and the steps that can be taken to minimize them.

Introduction—Airflow in the Data Center

Data center airflow patterns can differ in small ways from one installation to another, but the typical raised floor data center has an airflow pattern that follows the circuit below:

1. Air is pushed from the cooling units that ring the data center and is passed under the raised floor.
2. Air follows the under-floor air path until it reaches the perforated tiles of the data center floor.
3. The air passes into the above-floor area (Cold Aisle).
4. A percentage of the air is drawn back to the cooling units directly.
5. Ideally, a larger portion of the air is passed through the IT equipment where it picks up and removes heat (Hot Aisle).
6. This air then passes back to the cooling unit (again, ideally) and is cooled. The process is then repeated.

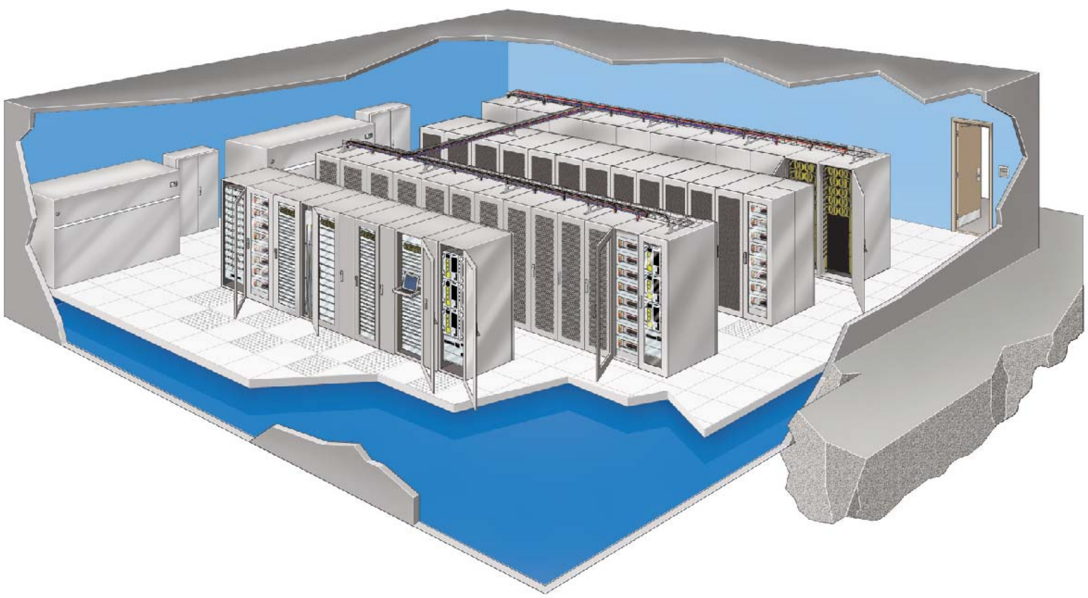

Figure 1: Typical Data Center Environment

In the ideal data center, all of the air provided by the cooling units would pass through IT equipment, taking on and removing the heat energy generated by it before returning directly back to the cooling units. Unfortunately, as most experienced data center professionals know, this idyllic scenario is rarely the case in practice. A portion of air volume is often passed directly back to the cooling units, or may pass from the IT equipment to another piece of IT equipment before returning to the cooling units. Both of these occurrences can be considered to have a negative impact on the efficiency of the data center equipment. Air that bypasses the IT equipment and returns directly to the cooling units has wasted the fan energy required to move it from the cooling unit in the first place. This air also lowers the average return temperature to the cooling unit, reducing its practical capacity as well. Air that passes from one piece of IT equipment into another can result in higher than allowable air temperatures to the second piece of equipment, leading to hardware failure or unreliable operation (these related efficiency concepts are covered in other Rittal Corporation white papers).

The bypassing of air can take place in several locations throughout a data center. As seen in Figure 2, air can bypass the racks overhead or even around the ends of them as well. One particular bypass airflow pattern not shown in the figure takes place inside the racks themselves. This inner-rack recirculation of air is the primary focus of this paper.

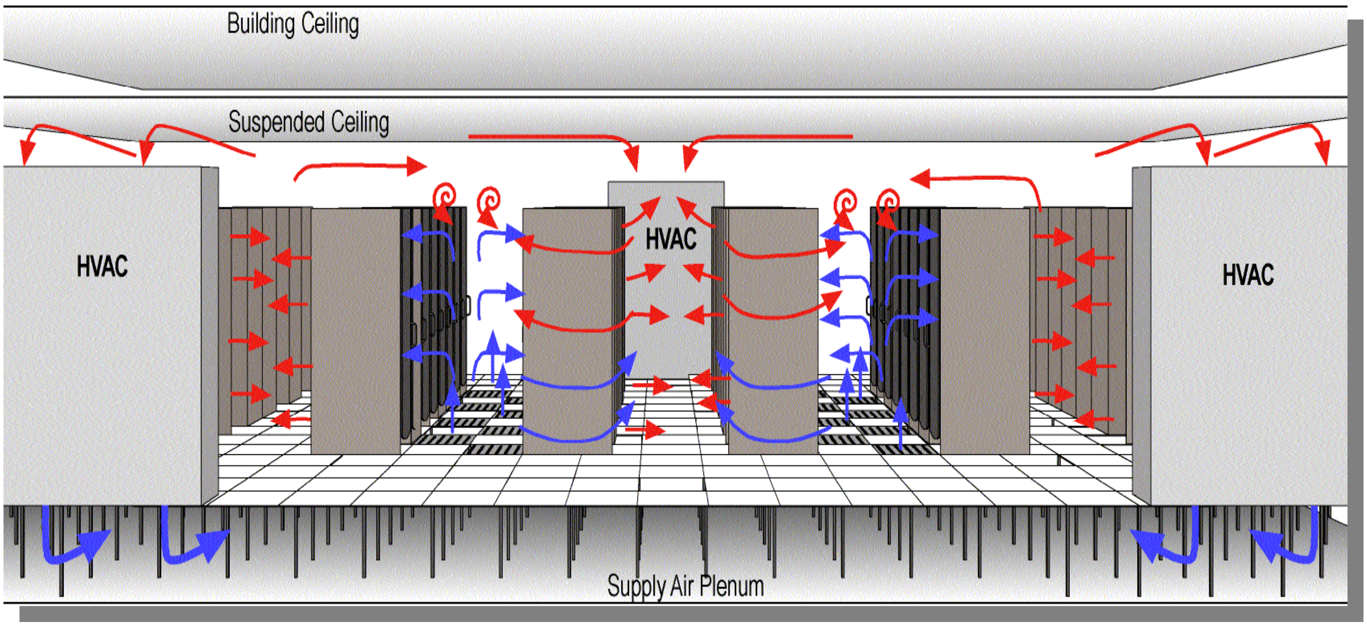

Figure 2: Bypass Air in the Data Center

The "Typical" Rack

The typical IT rack intended for the mounting of server and networking equipment consists of the following parts:

- Frame
- Rails (typically EIA-310 standard)
- Doors (usually front and rear—perforated in most open loop configurations)
- Roof Assembly

These assemblies can interact in various ways, and the configuration of these components can allow for airflow patterns that vary from one rack manufacturer to another.

Figure 3: Typical IT Rack

Airflow Through the U-Space

The most obvious location for air to flow through the rack space is what is typically referred to as the "U-space." U-space is another term for an "RU," or "Rack Unit"—the standardized 1.75" vertical height sections that divide the useable space found in IT racks. This space is normally filled with IT equipment such as servers and other rack-mounted devices that, as stated before, draw air into them, add energy in the form of heat, and then expel it into the hot aisle.

One of the most common bypass air locations in the rack occurs at this location. U-space that is not filled with IT equipment is left open allowing cold air directly from the cold aisle to pass through the rack and into the hot aisle space. This air is then mixed with the air in the hot aisle, cooling it and reducing the air temperature returned to the cooling unit, thereby reducing overall efficiency.

This inefficiency can be easily rectified through the use of blanking panels. These accessory panels fill the empty spaces in racks, blocking the airflow from passing directly through vacant rack space that doesn't require cooling—forcing the air to pass through the rack where needed. These panels can easily be installed during the integration of IT equipment and removed if and when the space in the rack is required for use at a later date.

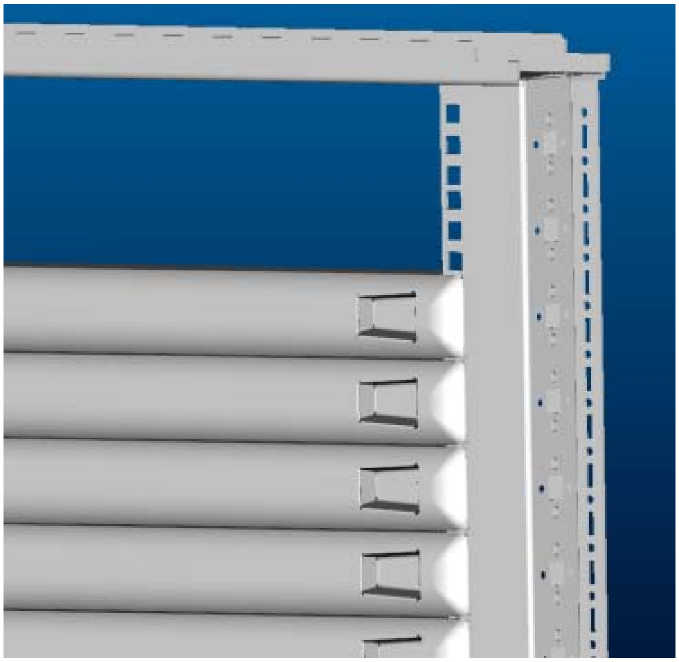

Figure 4: Blanking Panel

Airflow Around the Rail System

Many rack configurations are equipped with a “floating” rail system installed inside of the rack frame. An example of this type of rail system can be seen in Figure 5 below.

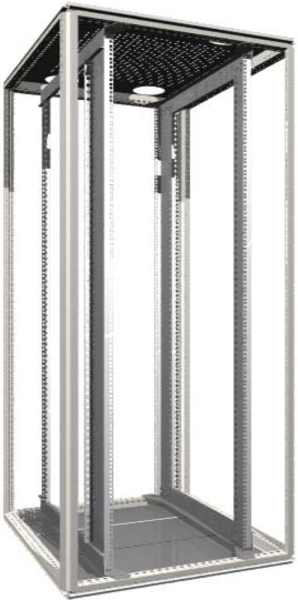

Figure 5: Floating Rail System

Floating rail systems offer several advantages to the average data center rack user. The rails can be used on the left and right sides, respectively, for mounting various pieces of data center hardware. This may take the form of power distribution units (PDUs), cable management systems, or other vertically mounted networking gear. This space can prove invaluable to the IT user, but as can be seen in Figure 5, a large section of the rack could allow air to bypass the equipment as discussed earlier. Closing off this space is important since the bypass air can have a negative impact on the performance of the data center cooling system, as well as the operational reliability of the IT equipment. The most common method employed to combat this issue is the use of brush-type baffles to close the cold aisle space off from the hot aisle space. This strategy is shown in Figures 6, 7 and 8.

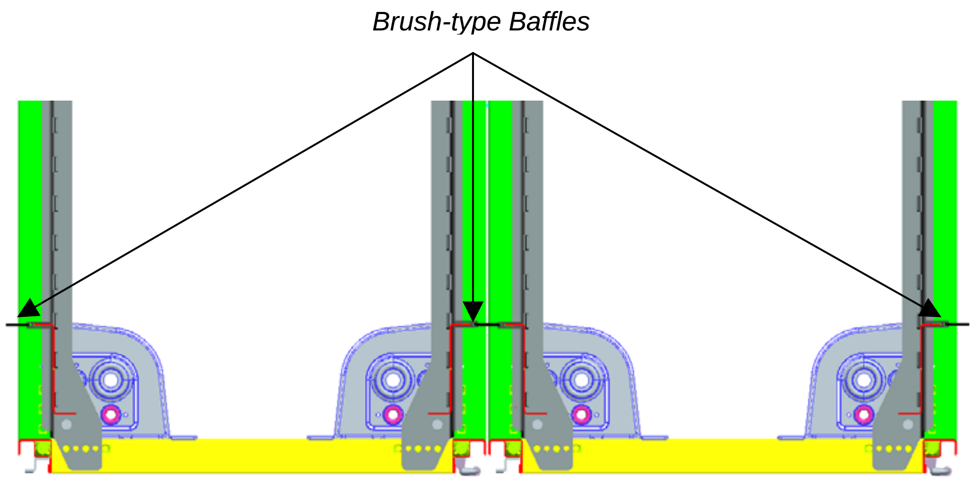

Figure 6: Brush-type Baffles Top Down View

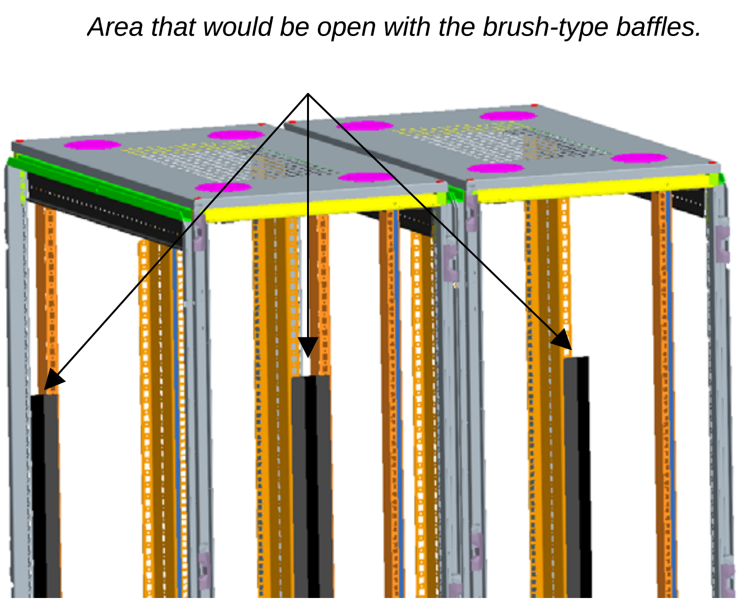

Figure 7: Brush-type Baffles Cutaway View

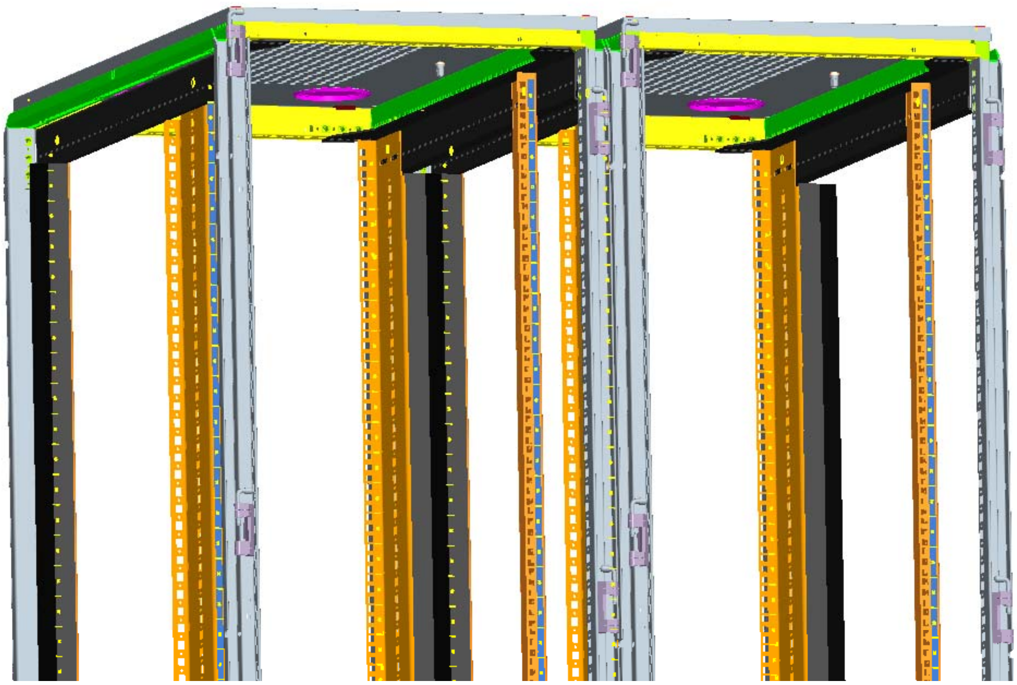

Figure 8: Looking Forward into the Rack with Baffles in Place

Brush-type baffles effectively prevent air from passing through from the cold aisle into the rear of the rack—bypassing the IT equipment. This system, when coupled with blanking panels and IT hardware, effectively prevents bypass air from occurring inside the rack.

What may not be obvious from the previous passages and illustrations is that the rear space in the rack, referred to as the “Zero-U” or, “interstitial” space, is not blocked by the airflow management solutions and is still accessible for IT use. Possible uses of this space can be seen in Figure 9 below.

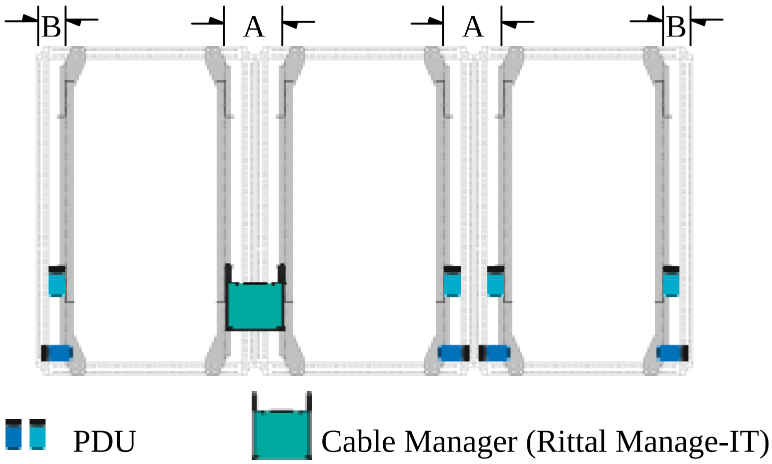

Figure 9: Interstitial Space Usage

This interstitial area is unique to some rack configurations and can prove extremely useful. Racks that contain this organizational space that are equipped with air baffles and blanking panels eliminate bypass air. Many other rack configurations require the use of divider panels or side panels between each rack to prevent this bypass air from occurring. A rack enclosure such as the Rittal TS8 (featured in above illustrations) does not have this restriction as long as vertical baffles and blanking panels are used as discussed in this paper. Side panels or divider panels are useful for physical protection, but actually have a negative impact on the open space in the rack available for cable management and PDU mounting. They can also restrict the passing of cables between racks, often resulting in a need to pass all cables overhead which requires the use of longer cables and complicates cable management within the rack.

Conclusion

Although sometimes overlooked in favor of a focus on total-room airflow patterns, airflow inside of racks themselves can complicate the design of a data center and must be considered to achieve optimum efficiency and performance. If internal bypassing is not adequately addressed, the efficiency and effectiveness of cooling solutions and thus, the overall efficiency of the data center, can be compromised. The installation of blanking panels and vertical baffling in the fronts of racks adequately deals with these issues while allowing for the full utilization of remaining rack space—providing the flexibility to maximize energy efficiency and the use of available space.

About the Author

Daniel Kennedy is Rittal Corporation's RimatriX Solution Center Coordinator and has been with the company since 2003. He holds a degree in Electrical Engineering and is the lead engineer for the design, implementation and support of high density IT deployments in North America.