River Cooling System™

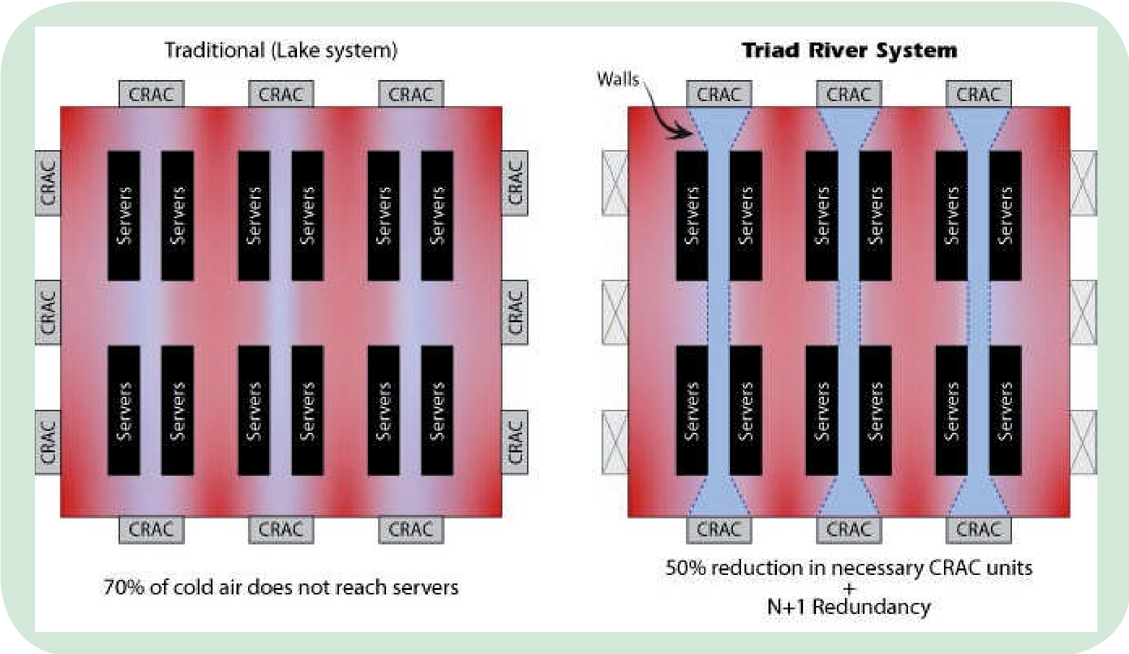
The River and The Lake

Data Centre managers are learning about the inefficiencies of the tile and the costs associated with adding more and more cooling capacity to the Data Centre airflow system. As a result of their pursuit of reducing hot spots and improved cooling, they have developed two, competing, design philosophies.

We call these two methods the "**River**" and the "**Lake**".

The Lake environment relies on creating a large pool of cold air under the floor and in the cold aisle. This pool, or lake of air, is pressurised under the floor. As the pressure is released through the tile, it is expected to fill the cold aisle. The servers are cooled by the internal fans pulling the cold air from the middle of the aisle through the server.

The River environment, on the other hand, is designed to use the flow of air to cool. It relies on the movement of air to provide a dissipative effect on the servers and through the server fans. The river method treats the Data Centre as an ecosystem of airflow. A molecule of cool air leaves the CRAC unit, moves through the under floor plenum, through the tile and directly into the front of the server, cooling the server then retreating through the hot upper plenum back to the CRAC unit.



There are three benefits to the River system.

- First of all, by breaking down the boundary layer at the front and top of the rack, you are able to improve the cooling capabilities of the airflow system.
- The second benefit of the River system is that you need less air than you do in a Lake system. The River system contains the air under the floor, focuses the air to the server by managing the air out of the tile, uses the cabinet door to further channel the air to the servers.
- It supports an 18 degree delta T in the hot aisle to pull the air from the back of the servers.

A well-designed River system can reduce the need for CRAC/CRAH generated air by up to 50% and can lower upper server temperatures by 10 to 20 degrees Fahrenheit. This can lead to a reduction in energy costs by as much as 60% while reducing the need for 40% of the air handling devices. You get the best of both worlds, lower energy costs for a lower acquisition cost.

The Lake Environment

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The River Environment

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Airflow Utilization Efficiency©

Since the temperature at the top of the rack drives the cooling strategy for the whole Data Centre, creating a measurement that factors in this reading seems only logical. And, since the temperature supplied by the CRAC unit is our cooling source, creating a measurement that evaluates the integrity of the air as it moves through the floor and to the server seems logical as well. The Airflow Utilization Efficiency (AUE)© calculation provides us with a way of evaluating the thermal loss in our airflow system. We compare the temperatures at the top of the rack to the supply air temperature.

Here is an example:

55 degree supply air
85 degrees top of rack
AUE = 30

58 degree supply air
83 degrees top of rack
AUE = 25

In other words;

1 degree = 4% reduction in energy costs
12 degrees = 48% reduction in energy costs
River systems quite often support an AUE of 10.
That is:
70 degrees supply air
80 degrees top of rack
AUE = 10

This is a simple way to determine if the cool air coming out of the CRAC unit experiences thermal loss leading to a low set point and higher energy usage. The smaller the AUE number, the more efficient your airflow system is working. In addition to the supply air temperatures, we would offer that the CRAC unit / supply air, should be optimised to have airflow temperatures at the top of the rack as close to 80 as possible. Lastly, since the difference is shown in temperature by degree, you can compare the difference and determine the reduction in energy costs.

River systems can do this with half the CRAC units utilised in a lake system. Additionally, the impact on energy consumption is improved as well. In the end, the reduced impact on capital expense and recurring costs make the "River Cooling System" an extremely compelling solution for any Data Centre.

ICE

Eaton Corporation estimates that 50% of the Data Centre utility bill goes towards cooling the servers. They also proclaim that if this seems too high, it is. They recommend redirecting and concentrating the available airflow to the servers.

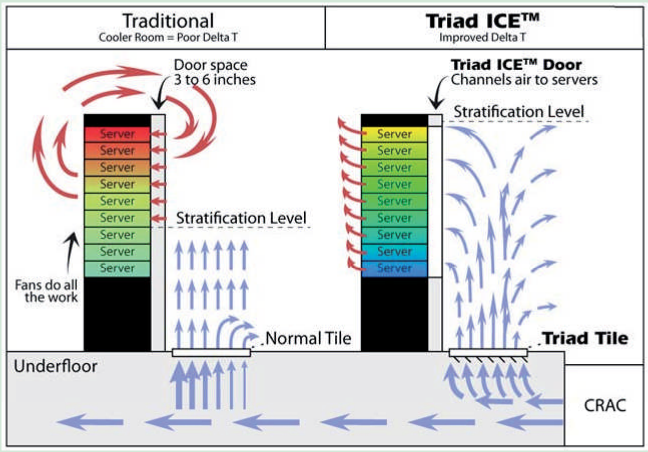
For years the traditional Data Centre cooling systems have presented air to the cold aisle through the perforated tile. Air flowed by the bottom of the tile causing short cycles, while also flowing by the front of the cabinet door as well. This causes the Data Centre manager to add CRAC units to the Data Centre while lowering set points to cool the room. The costs of this inefficiency add 40% to the costs of CRAC units and 40% to the electrical bill.

Triad vs. Traditional

1. The tile should be constructed in a way that it ensures positive flow out of every part of the tile (no short cycling).

2. It should divert the air to the servers so it can penetrate the boundary layer of heat on the front side of the cabinet or rack.

3. It should be able to "stratify" the air to the top of the cold aisle. Servers need a constant flow of air to keep them cool.



Redirecting and concentrating the air to the server can improve the efficiency of the cooling system. Triad Floors has created ICE – Inter-Connected Cooling Efficiency™ to address this problem. ICE is a system designed to redirect and concentrate the air to the server. It takes advantage of the Triad High-Plume Fin. The Triad High-Plume Fin has four, patented airflow components to it. The effect of the fin causes the air to bend into the front of the cabinet. This improves the cooling capabilities of the available air.

ICE takes this one step further by channeling the air into the front of the server by using the same, patented effects of the tile within the cabinet door. By using the High-Plume Fin on the tile you are able to create a dispersed airflow to the front of the cabinet, and by adding a fin to the front of the door you take the flow of air and concentrate it to the front of the server. This creates a "River" flow of air directly into the server fan by redirecting and concentrating the air to the server. In the end, it is not how much air you have but how effective you are with the air you have. By connecting the tile airflow with the front of the server cabinet, you can improve AUE by several points.

Tile Efficiency

The tile is the entity that delivers the air to the servers, but it is only one part of the system. We have broken the airflow ecosystem into four components. These all play a part in the efficiency of the airflow system. Each of these components supports the flow of air while minimising waste and loss of thermal integrity. Each and every molecule of cool, moving air, should go through or across a server.

These four components are:
1. The under floor space
2. The perforated tile
3. The cabinet / rack
4. The return air system

For this example, we will be focussing primarily on one part of the system; the perforated tile as an airflow delivery device. Through a detailed analysis of perforated tile performance, in an open plenum environment, we have found the need for three distinct performance characteristics.

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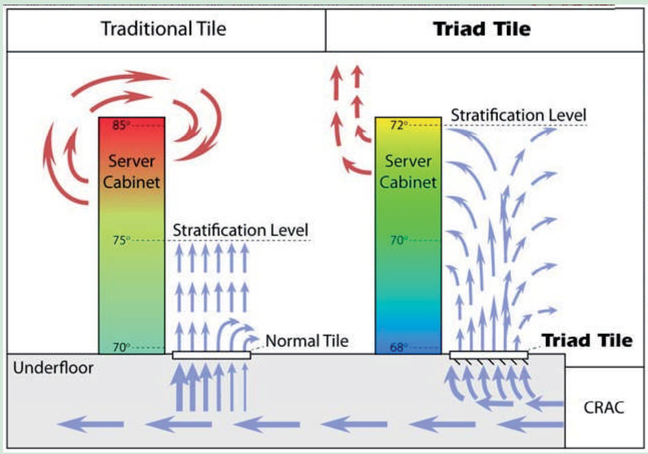

All three of these performance parameters are necessary and lead to consistent temperatures and improved cooling. When analysing the performance of traditional perforated tiles by applying the stated requirements, we find meeting our performance criteria to be difficult. Traditional tiles have been tested in a duct and were never created to divert the air. When we measure the performance of the tile in an open plenum, we find the design of the tile to be flawed leading to mixing, no dispersion of the air into the servers and an inability to flow to the upper servers.

This flaw comes from the design of a "flat bottom" found on most perforated tiles. The best way to illustrate the impact of this design flaw is to show you how flat bottom tiles are like a car window when a car is moving down the road. When with your car windows open, you find inconsistent flow coming into the car. Air going by the window of the car passes by part of the "open area" of the window, providing some air into the car but pulling air out of the car as well. The only way to get the air to flow directly into the car is to angle the air into the area needing the air. This angling of the air towards the heated item creates wind chill on the surface of the item to be cooled and dissipates heat by letting the air pass by the item.

In other words, we need a vent window to divert the air to the servers. Flat bottom tiles are like a car window. Air passes by part of the tile, which leads to mixing, less directed flow and a low stratification line. These flaws have lead to design considerations that reduce the impact of the flaw found in the tile, but lead to a great deal of inefficient airflow utilisation. These airflow system designs have focused on pressure and open space instead of velocity and wind chill.

Consequently, the same study finds that we have 2.6 times more cooling capacity than is necessary.

Airflow Study

In a study on 'Airflow in the Data Centre', Dr. Bob F. Sullivan and Kenneth G. Brill estimate that only 28% of the air in the raised floor airflow system actually gets to the servers.

This means 72% of the air is wasted and is only present so as to guide the other 28%. We, in effect, use air to divert air.

Underfloor Efficiency

The under floor area of the Data Centre has been the storage area for the cold air of the airflow cooling system. The air is sent into this area and is pressurised. The goal of this system is to create enough pressure so as to force air through the perforated tiles. The hope is that the air coming out of the floor tiles will flow upward and be pulled through by the server fan.

This system has worked relatively well even though only 28% of the air in the system actually provided cooling, as the servers were not generating a significant amount of heat. With the emergence of virtualisation, more robust applications, video and IP applications, the server need for more air for cooling purposes has increased.

Lack of efficiency in these systems has lead Data Centre managers to add more cooling, lower the temperature of the room and increase static pressure to try to keep the servers from failing and to remove hot spots. This has lead facilities managers to provide 2.6 times more cooling than is necessary (see "Cooling Techniques that Meet "24 by Forever" demands of your Data Centre" by Dr. Bob Sullivan and Kenneth G. Brill). The Uptime institute believes that 72% of the air in the Data Centre is not getting to the servers. One of the major reasons for this is that a great deal of air is sitting in a pool under the floor. In effect, Data Centre managers are using air to create a wall to push the air through the tiles.

The cost of energy and the need for additional power has made the use of a system with this level of inefficiency so costly that the cooling of servers costs as much as powering the servers. Data Centre managers are learning that the use of pressure (using air to channel air) has more problems as the air coming out of the tile doesn't even get to the servers as there is not enough velocity coming out of the tile to get the air to the uppers servers.

Triad has created the River Cooling System as a way of reducing the air under the floor. There are three components to the River Cooling under floor system.

These consist of:

1. **Under floor walls**
2. **Floor height**
3. **River bank design**

By using under floor walls from companies like GapHOG, PlenaForm and Sub Zero, you can reduce the need for chilled air by as much as 50%. By creating "River" banks under the floor, you can redirect air to perforated tiles. This enables you to reduce the number of CRAC units needed and while positively impacting the thermal integrity of the cold air generated by the CRAC units.

Under floor walls can also be supplemented by lowering the height of the raised floor. Many floor systems are as high as 4'. By lowering the height of the floor you can reduce the cost of the floor system while reducing the amount of wasted air under the floor.

Lastly, there are several designs that can improve the velocity of the air out of the tiles and keep pressures equal throughout the under floor system. These vary based on the length of the under floor River system and floor height.

Underfloor Walls

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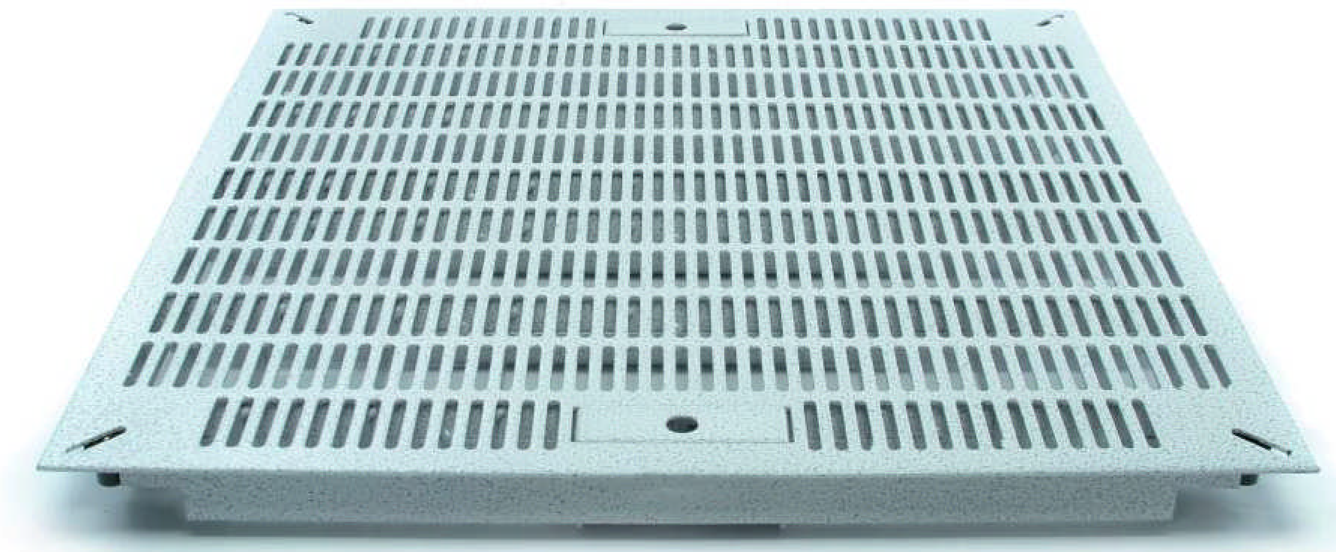

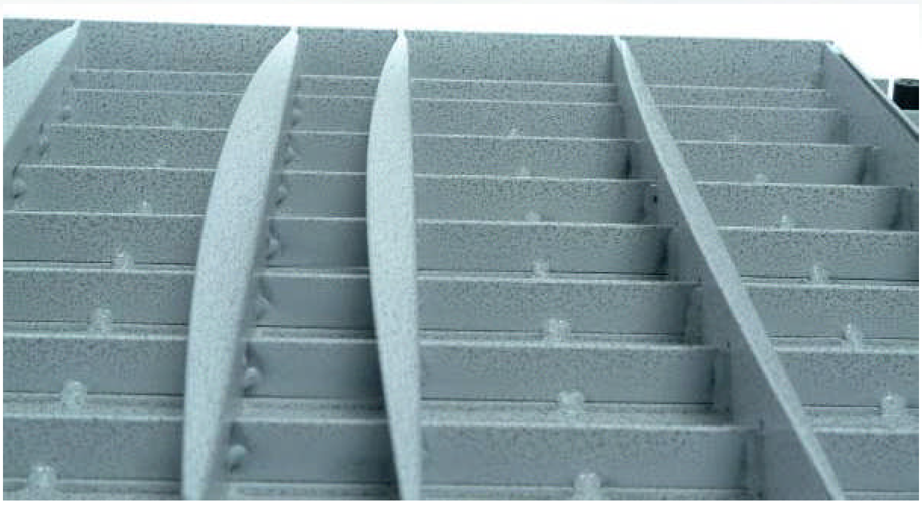

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