Server Fan Over-drive in Fan assisted Cold Air Containment Systems

Server Racks Australia

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Executive Summary

The increased cooling requirements of high density rack-mount equipment has necessitated managed air supplies in addition to the airflows provided by in-built server fans. There has been concern that increased air velocities in a fan assisted cold air contained server rack over-drives the server fans, leading to lower MTBF caused by premature fan failure. This is not the case; in a fan assisted cold air contained system the differential pressure (△P) across the server fans is negative while the server is on and fans cannot be driven while in a negative pressure environment. Furthermore, △P is small when the server is off, resulting in only a small driving force. This paper provides a deeper explanation of this and justifies these claims with experimental evidence.

1 Introduction

The fans located in rack-mount IT equipment provide airflows that cool the equipment components. For low power density equipment (1-2kW), a hot/cold aisle Data Centre is capable of providing inlet air between 5 and 10°C above that supplied by the Computer Room Air Conditioning (CRAC) Unit, allowing for effective cooling of the equipment. For a well engineered Data Centre, this technique is sufficient to achieve the optimal operating temperature for medium power density equipment (3-6kW), reducing the problem of overheating. As rack-mount equipment increases in power density these techniques alone are insufficient to maintain optimal temperatures, especially in secure environments. As such, fan assisted cold air containment solutions, like the SRA produced Intelligent Plenum Air Management Module (iPAMM™), have been designed to provide the air necessary to cool this high density equipment (7kW+). The details of how this is achieved is not in the scope of this paper, although the basic techniques used are important[1].

Fan assisted cold air containment typically works by pressurising the front plenum of the rack. Traditional cooling solutions rely on underfloor pressure to manage airflows, while a fan assisted cold air contained solution generates the same airflows independent of the underfloor ΔP. In a Data Centre with fan assistance, a front plenum pressure of $\sim$62Pa is achieved[2]. A large ΔP such as this results from the movement of significant volumes of air, the effect of which on server fans must be considered.

The current myth is that large front plenum pressures drive excessive amounts of air through the server, resulting in a forced rotation of the server fans. It is believed that the volumes of air

[1] For more details on these solutions and the conditions in which they are viable, refer to

[2] Pressures are measured in a 42RU iPAMM rack with a single 2RU server and the unused vertical space covered with blanking panels

are sufficiently large to drive the fans at well above their rated speed. This increases the wear of the bearing in the fan (although it results in a smaller current draw within the fan) reducing its effective life and thus degrading MTBF. An alternative effect of an increased pressure is the slowing of the fan rotation. The increased pressure is effectively an increase in air density, rendering the air 'thicker' and thus more difficult to rotate through. This will cause the fan to spin slower, resulting in reduced wear, but have the counter effect of increasing the current drawn, raising thermal issues. This will also reduce the life of the fan and thus the server life.

This paper explores the real environment in which server fans are exposed for a range of rack types, while also detailing the fan behaviour under these conditions.

2 Server Equipment

The design of the server, including the location of the fans in it, is important for understanding the environment in which a fan operates. A typical server layout is shown in Figure 1.

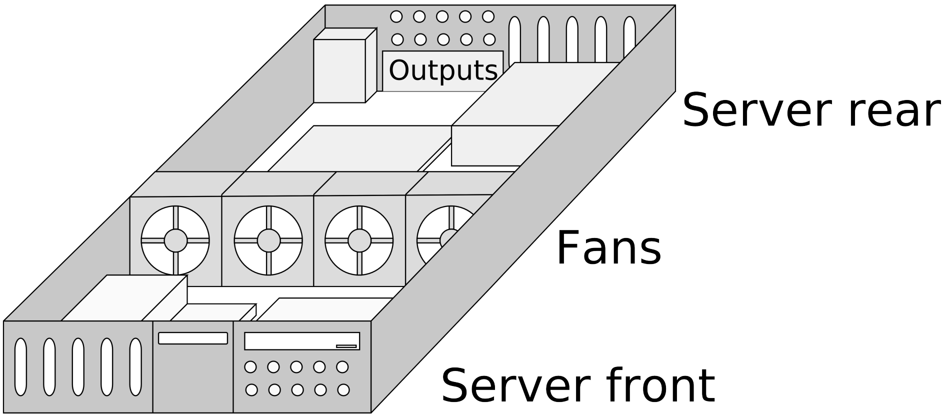

Figure 1: Typical server layout.

As can be seen, the fans responsible for moving air, from the front end of the unit to the back end, typically form a partition midway along the server. Air is allowed to pass into the front of the server via the perforations located on the front server panel. The server front houses the CD Drive, Hard Drive etc. which receive ample air due to their location at the front. The fans draw air out of this front section and over the motherboard, RAM, CPUs, Power supply and expansion cards typically located in the back of the rack. There are often supplementary fans in the rack rear (that cool the processors) except these fans are often located in such a way that the effect of supplementary airflow is minimal. Finally, the back of the server is mainly comprised of output plugs, while a small fan is located at the rear to cool the power supply, and the rest of the area is perforated to allow hot air to pass out.

This layout is generic to the majority of servers, regardless of production date[3]. Although there may be small differences in the size of the front and back section, as well as the size of the fans, the majority of servers will have a row of fans partitioning these sections. As such, the behaviour of server fans within this layout is taken to be broadly representative of all server fan behaviour.

3 Server Equipment in a Rack

The effect of a large front plenum pressure on a rack-mounted server is not intuitively clear. It is dependant on two variables: ΔP between the front plenum and the rear of the rack, as well as the status of the server fans (off or on). A combination of these variables will produce different environments and each environment must be treated in isolation. However, there are factors that are common to all environments that will be considered initially.

The layout of the server plays an important role in the fan environment. The perforations in the front server panel are small and restrict airflow from the front plenum of the rack to the front of the server. As a result, large front plenum pressures are not translated into large pressures in the front of the server; ΔP between the two can be up to 40Pa. This large ΔP is indicative of the restricted airflows between the two plenums and is common to all of the distinct environments described below.

[3]The exception to this are blade servers, whose fans are located at the rear of the server and draw very large volumes of air. These two factors mean that they cannot be over-driven under typical circumstances.

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3.1 Active Server Equipment

When the server is on, there is an active process that moves air from the front of the server to the back. The volume of air located in the front of the server is small and the rate of air refill from the front plenum is slow, thus the fans move air from the front of the server faster than it can be replaced. This creates a negative ΔP across the fans, as shown in Figure 2.

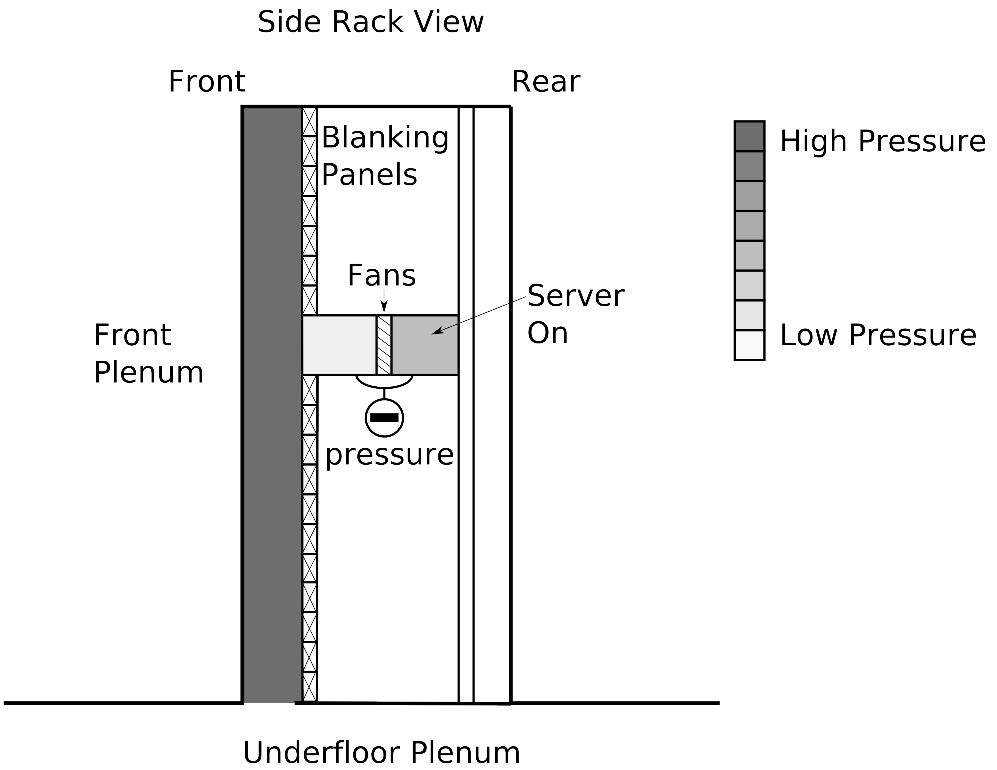

Figure 2: Rack-mounted server with shaded pressure differential and air flow.

The ΔP typically experienced across the fans inside the server, in a set-up identical to that shown in Figure 2, is shown in Table 1[4].

Table 1: ΔP across server fans while the server is on.

Server	Front Plenum to Rack rear ΔP (Pa)	ΔP across fans (Pa)
On	+62	-8

The information presented here represents the worst case scenario in which a server fan would be forced to operate[5]. Despite the fan assisted rack supplying the maximum volume of air possible, the server fans are still able to displace more air from the front of the server than can be replaced by the front plenum, thus there is a negative ΔP across the server fans. A much larger front plenum ΔP is required to create a positive ΔP across the fans, however the supplementary are volumes required to do this are well above that currently possible by the most powerful of rack air systems. Fans can only be driven while in a positive pressure environment, thus while in a negative pressure environment they will not be over-driven.

[4]The details of the experimental set-up used to obtain this data can be found in Appendix A

[5]A single server in a fully blanked server rack will experience the largest possible airflows. As blanking panels are replaced by servers, the front plenum ΔP will reduce, thus there is a smaller volume of air being forced through each individual server.

3.2 Dormant Server Equipment

When the server fans are off, there is no active process to equalise ΔP across the fans resulting in a positive ΔP. As such, air will move through the fans and can drive their rotation. This is shown in Figure 3.

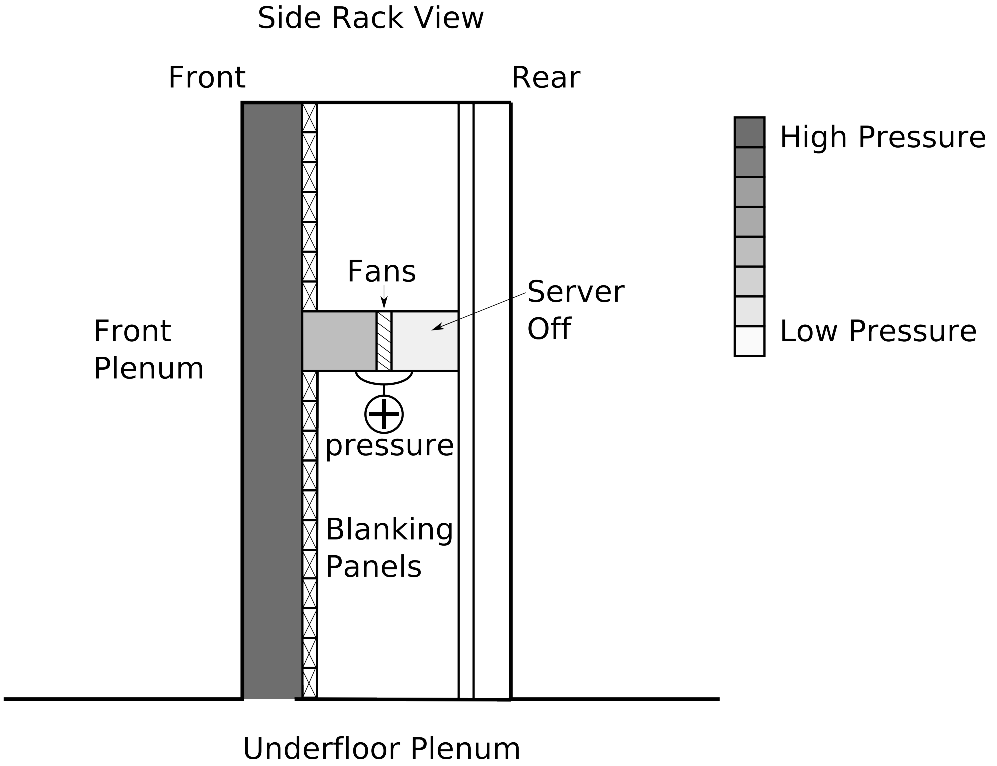

Figure 3: Rack-mounted server with shaded pressure differential and air flow.

The ΔP typically experienced across the fans inside the server, in a set-up identical to that

Table 2: ΔP across server fans while the server is off.

Server	Front Plenum to Rack rear ΔP (Pa)	ΔP across fans (Pa)
Off	+62	+4

Table 3: Server fan response to +ΔP.

Characteristic	Fan 1	Fan 2	Fan 3
Fan Dimensions (mm)	40 x 50 x 38	80 x 80 x 25	92 x 92 x 38
Rated Fan Speed (RPM)	10 000	2 500	4 800
Fan Speed at ΔP=5Pa (RPM)	0	1 875	0
Fan Speed at ΔP=10Pa (RPM)	0	3 000	1275
Fan Speed at ΔP=20Pa (RPM)	0	3 750	1875
Fan Speed at ΔP=30Pa (RPM)	0	4 300	3750
Fan Speed at ΔP=50Pa (RPM)	2 000	5 000	5 000

shown in Figure 3, is shown in Table 2[6].

A small ΔP between the front and back of the server, as is experienced by the server fans in the worst case scenario, will provide only a small air flow. Fans in this positive ΔP pressure environment will spin under the force of air moving across it. However, the air movement produced by ΔP=$\sim$4Pa is insufficient to spin the fan at speeds exceeding its rated maximum. The behaviour of three different sized fans in a range of pressure environments is shown in Table 3. Despite one of these fans being overdriven at high pressures, this information indicates that server fans will not be overdriven in the most extreme pressure conditions generated by a fan assisted cold air contained system, while the server is dormant.

[6]The details of the experimental set-up used to obtain this data can be found in Appendix A

4 Conclusion

The supplementary air supplied by a fan assisted cold air contained rack designed increases the volume of air available for cooling in a server, allowing for effective cooling of high power density equipment. This, however, is insufficient to over-drive the fans while they are dormant, whilst it is also insufficient to drive the fans while they are in operation. The myth that these air supplies will over-drive the server fans leading to reduced server life is therefore void.

5 Appendix A

All data used throughout this paper was obtained through rigorous testing conducted at Server Racks Australia in Queanbeyan, New South Wales. The testing environment consisted of a 300mm raised floor Data centre containing a 42RU iPAMM™ Rack. This rack contained a single 2RU AGI Argyle server located ∼1300mm from the ground; the unused vertical space contained blanking panels, for testing of the server fan pressure environment. The differential pressures were measured in the rack front plenum, the front of the server and the rear of the server, all referenced to a point outside of the rack.

In testing the fan behaviour in different pressure environments a purpose built 3RU blanking panel, with mounts for different fan types, was used. This replaced the server in the above mentioned set-up and the unused vertical space remained blanked. The pressure drop across the fan was varied using the iPAMM fan speed. The revolutions of the fan were obtained at each pressure with an Agilent U1604A Handheld Digital Oscilloscope.

All differential pressure measurements were made with a DPIA 2-Wire differential pressure transmitter, with a published error of ±2.5Pa. These were logged with a TREND Control Data Acquisition System and data was recorded only when the system was in steady state.