Hewlett Packard Enterprise

Technical white paper

Factors influencing acoustics

HPE's approach to acoustical design of HPE ProLiant servers

Contents

Introduction

Server acoustics historically has taken a back seat to power and performance. However, in recent years, servers have become dense enough that high-powered fans are being considered to air cool their components. This document outlines how Hewlett Packard Enterprise addresses server acoustics by explaining the factors that influence noise levels and the potential options to reduce server noise.

Server size

Main server source of noise comes from system fans. Server size, component density, and component power determines fan size and required speed. Typically, fan noise level is in proportion of fan dimensions, fan speed, and the number of blades. A taller server has the luxury to select larger fans. Larger fans can provide same airflow at lower fan speeds, which has the potential of consuming less power and creating lower acoustics, making the system more efficient. An example of this can be seen between 1U and 2U servers. The 2U 60 mm fan is 50% larger and has one less fan than its 1U counterpart. If one assume negligible sound difference between the sixth and seventh fan, then Table 1 shows that the smaller fans are more than double the sound power level[1] than the larger 2U fans (The next section verifies the acoustic assumption.).

Table 1. 1U versus 2U server acoustics for both idle and operating conditions

Chassis state of operation	1U chassis 40 mm fan (x 7)	2U chassis 60 mm fan (x 6)
Idle	5.2 belA	4.6 belA
Exercised	5.9 belA	4.6 belA

[1] Sound power is cut in half when it reduces by 0.3 belA. This is not to be confused with sound pressure, which sees its acoustics cut in half when 6.0 dBA reduction occurs.

Fan quantity

Adding more fans will increase server noise, but not in a way one would expect. As Figure 1 illustrates, the first two fans added net the largest overall sound increase. However, as one adds additional fans, the relative overall system acoustics increases at a decreasing rate. From three fans to four, the overall increase is 1.3 dBA while four to five fans is just 1 dBA. To the point that by the time one adds a tenth fan, its contribution to the overall server acoustics is less than 0.5 dBA. The human ear cannot detect a difference less than 2 dBA. Thus, the first couple of fans net the largest system acoustical increase.

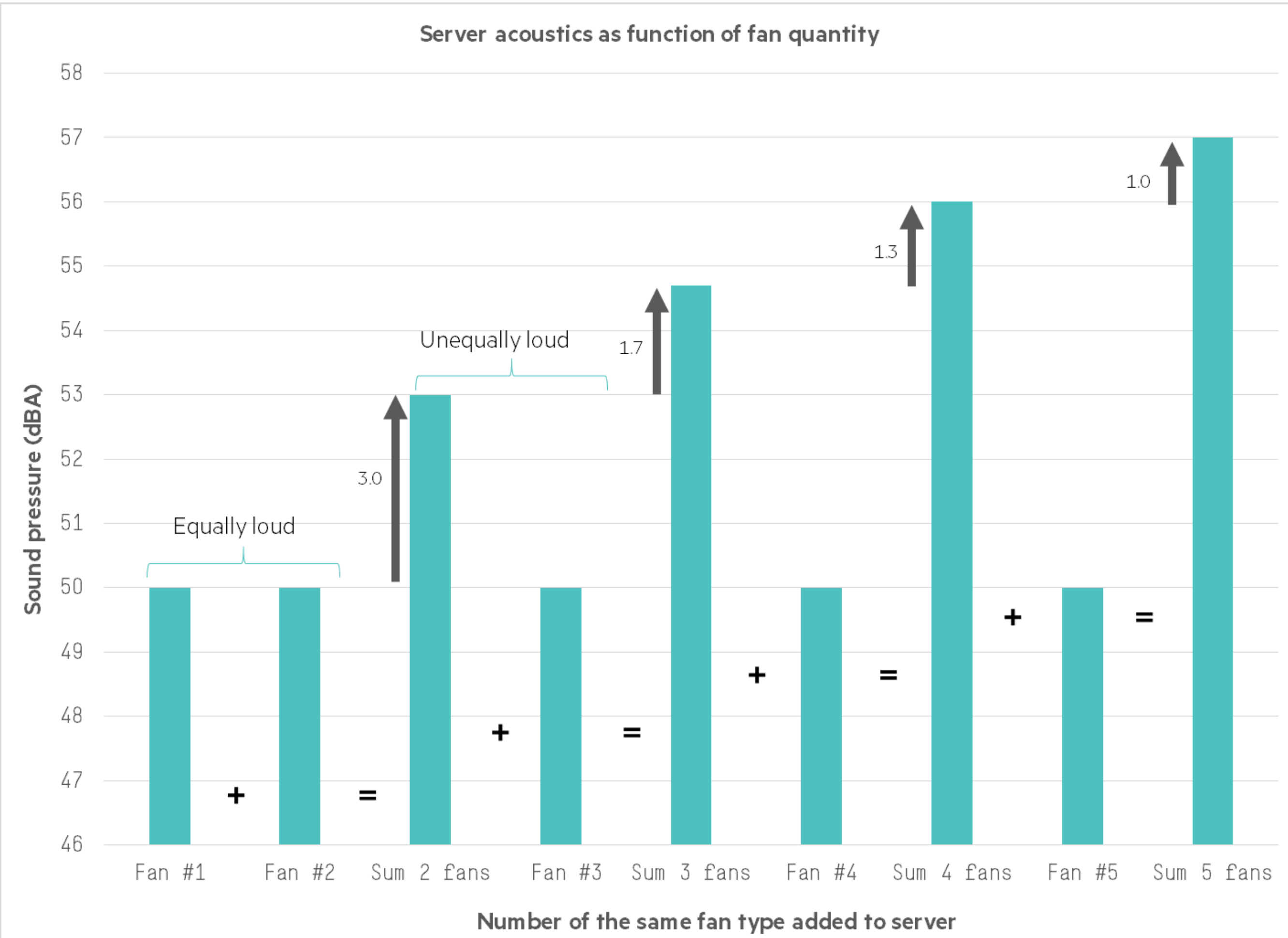

Figure 1. Overall sound increase when adding equally loud noise sources

Hardware options that increase acoustics

Several hardware options create challenges when installed in a server. Often, their presence increases system impedance resulting in reduced system airflow. To compound this problem, these added options generate varying levels of heat. This additional heat poses a threat to both itself and downstream components. A good example of this is server front storage. Both the quantity and power generation of either spinning disk (HDD) or solid-state drives (SSDs) can cause themselves to warm up heating downstream components. Also, these drives and their back planes impede system airflow. Together these factors lead to warmer component temperatures forcing fan speeds or acoustics to increase, as shown in Figure 2.

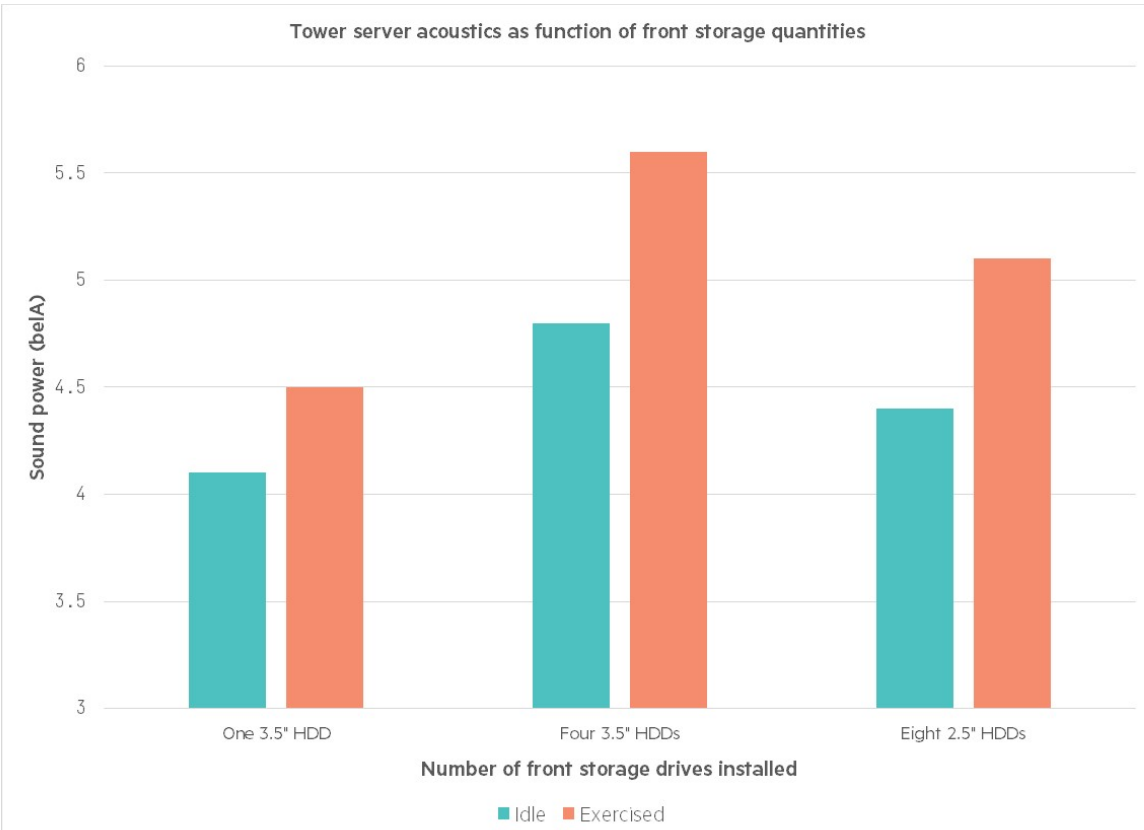

Figure 2. Tower server acoustics as function of number of front storage drives installed

On the other hand, GPUs are installed in the rear of the server. Their only challenge is being cooled with the preheated upstream air, again driving fan speeds or acoustics up. And NVDIMMs, that have both standard and persistent memory, will consume more power than regular DIMM in addition to having a lower thermal limit. These components will drive server acoustics up as well. Finally, Add-In Cards (AICs) that do not provide internal temperatures will force a less efficient cooling method using adjacent zone sensor, which will increase fan speed or acoustics.

Hardware options to decrease acoustics

If the customer is sensitive to acoustics, HPE offers options. Some servers have Acoustic Enablement Kit (AEK) that lowers acoustics. This kit contains larger quantity of performance grade fans as well as better heat sinks and baffling. This permits the components to be cooled with lower fan speed, which lowers system acoustics. The added benefit of this kit also permits cost savings to the customer over time since the fans will consume less power, for example, a standard configuration (2 fan) tower server compared with the same tower that has the AEK (6 fans). With the additional four fans, the same server airflow can be obtained by reducing the fan speeds, which cuts acoustics in half (idle mode) compared to the 2-fan solution, as shown in Figure 3.

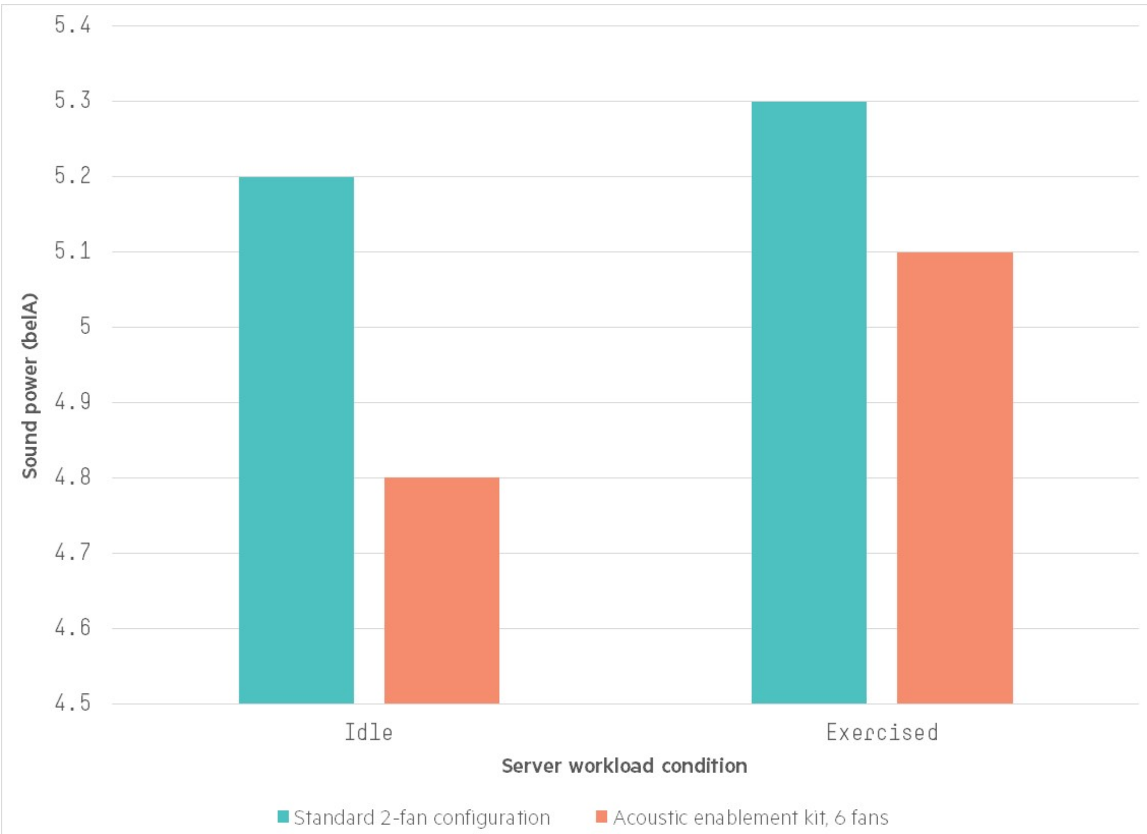

Figure 3. Tower server acoustics as function of number of fans

Cooling algorithm

By default, the fan speed is determined by component temperature. There is a **sea of sensors** providing both component and nearby air temperature readings. These air sensors are a backup sensor in the event of a neighboring component temperature sensor reading is unavailable. If one fan fails, then the remaining fans will ramp to full speed. This serves two purposes: first, provide sufficient cooling; and two, provide a relatively high-acoustic level to reveal that this server needs servicing.

If the customer wants to lower server acoustics, they will want to ensure that the advanced cooling option is not selected. Advanced cooling option drives the fans to higher speeds in order to keep components at cooler temperatures compared to the default setting.

Environment

Room ambient temperature will determine the server's inlet air temperature. As inlet temperature increases, its server fan speed and acoustics also increase. Also, room overall acoustic level will determine if the newly added servers' acoustics will be noticed. Just like Figure 1 (but replace fan #1 and #2 with server and room noise), if the **server** and **room noise** are equal, then the two added will be 3 dBA higher. Otherwise, the noisier of the two will begin to dominate, drowning out the quieter noise source.

For example, a customer buys two HPE ML350 tower servers and places one in their data center on a desk and the other server in a quiet office environment at their other desk. These two servers generate the same sound pressure level of a 60 dBA when seated three feet away. In the data center room, the background noise from the same seated position is 70 dBA while in the quiet office environment its background noise is 50 dBA. When in the data center, technicians will not hear the tower server. However, when they sit at their office desk, the only thing they will hear is the running sound of the tower server.

Acoustics in server QuickSpecs

This document provides server sound power and sound pressure measurements per ISO 9296 standard. Sound power is the server's total energy, independent of distance from noise source while sound pressure is from a specified location from either the typical standing operator or seated operator position.

To distinguish sound power results from sound pressure, sound power units are in belA while sound pressure in decibels (dBA). The A represents a weighting scale that best reflects the human ear (emphasizes frequencies from 1 kHz to 5 kHz).

However, one aspect of acoustics not mentioned in any server QuickSpecs is sound quality or tones. A tone is a concentrated amount of energy at a specific frequency. If this tone exceeds 6 dBA higher than surrounding energy, then this tone becomes a prominent tone. Despite HPE not mentioning tones in QuickSpecs, they do track and follow to ensure minimal prominent tones are present in their servers.

Acoustic "references"

To the acoustic novice, acoustic noise levels are sometimes ambiguous. Figure 4 has some common sound examples and their corresponding sound pressure levels. Table 2 also provides some typical examples of sound power levels.

The difference between sound power and sound pressure is straightforward. All acoustical measurements taken are sound pressure. Sound pressure is the magnitude of sound across a wide range of frequencies at a specific distance away from the noise source. When one makes many sound pressure measurements from different positions around the noise source and sums, factoring out the distance variable, then it becomes sound power. The beauty of sound power is that it's the total energy of the noise source, independent of where you stand or is positioned. While sound power is a good way to compare different servers' acoustic levels, people often relate to sound pressure measurements because it's the sound level at the distance they are positioned. Remember if it's too loud, doubling your distance from the noise source will reduce sound pressure level in half (reduction of 6 dBA).

An analogy of sound power versus sound can be made of a portable space heater positioned in the center of the kitchen. The heat generated from this heater can be measured in terms of power consumed by the heater. No matter where a person stands in the kitchen, the heater consumes the same amount of power. However, the closer they stand to the heater, the hotter they become—just like sound pressure. The closer you are to the noise source the louder it sounds.

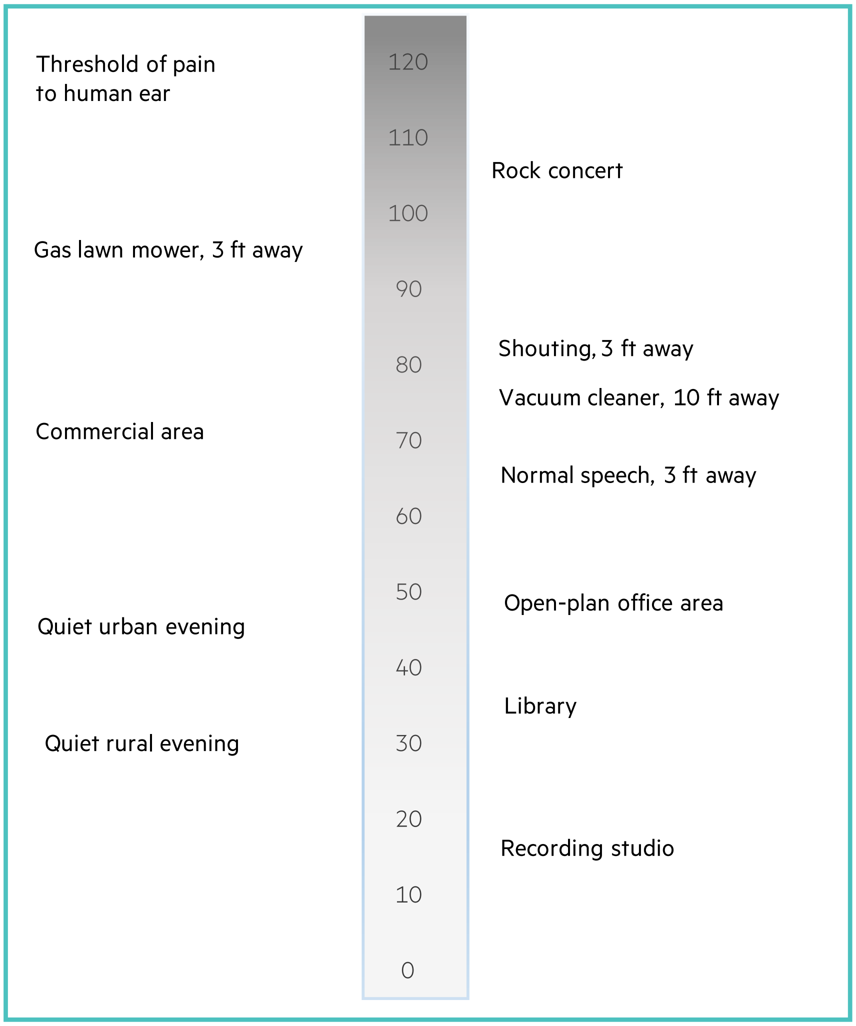

Figure 4. Common noise levels, sound pressure (dBA)

Table 2. Common sound power examples (sound power doubles every 0.3 belA increase)

Source	Sound power (belA)
Turbojet engine, 7k-lbf thrust	16
Loud radio	11
Person shouting	9
Normal conversation	7
Whisper	3

Summary

In this day and age of server technology, it's hard to grasp what factors most affect server acoustics. Yes, server acoustical noise is the result of fan speed, but what is driving the fan speed? It boils down to component power and its maximum thermal limit, ambient temperature, and chassis impedance. If more components are added, the higher the impedance and air temperature, the harder it is to cool. HPE has designed each of our tower and rack server to best reduce the acoustic level. This paper discusses the factors that influence fan speed, and we offer options and guidance customers can take to further reduce acoustics.

Learn more at

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