Impact of Noise Inside Server Room

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Abstract

Hearing loss is a major health issue in the work environment. Exposing humans to excessive sound levels or frequencies can adversely impact the ability of workers to communicate or hear. Noisy environments inside data centers present a unique occupational safety exposure to staff and operators which spend a considerable amount of time in the rooms to perform daily tasks. The specific sound frequency emitted by servers may also have a negative impact on worker performance and well-being which has not been analyzed in the past as this is an emerging technology. Specific opportunities may exist by analyzing the characteristics of the sound signal produced from servers in the server rack partially cancel the sound waves through similarity, time-delay and the correlation for the produced signals.

Keywords

Noise, Server Room, OSHA, NIOSH.

1. Introduction

Occupational Noise. The assessment of hearing loss is performed by audiologists and is a function of the shifting of the hearing threshold as defined by audiometry. The degradation of hearing associated with excessive noise is irreversible (NIOSH, 1998). Many other relative risks that can be developed from noise induced hearing loss are impaired communication with family and coworkers, social isolation, irritability, anxiety, decreasing of self-esteem and loss of productivity.

Noise Inside Server Rooms. Network engineering technicians and other workers access server rooms to install, fix and configure devices on a regular basis. Noisy environments inside data centers represent an occupational exposure tostaff, especially those which spend a considerable amount of time in the rooms to perform daily tasks. This noise may also cause discomfort for operators even if the noise inside the rooms is below the OSHA mandated threshold.

Sound is measured in Decibels (dBA) (A-Scale more closely represents hearing exposures for humans) which is a unit of sound pressure in Pascal (Pa) (Carstenpxi, 2010). On the other hand, Decibels dB represents the microphone sensitivity dB to the sound in Volt/Pascal (v/Pa). Noise in an average size data center ranges from 70 - 80 dBA (Miljković, 2016). OSHA limits the sound level over an eight-hour time period to not exceed 90 dBA with consideration provided by time weighting the data. That is, it is expected that the volume of sound may go above or below 90 dBA during the day, but the overall TWA (Time Weighted Average) shall not exceed 90 dBA. TWA analysis inside a server room is therefore more appropriately performed by equipment that can tabulate the data in a format where the average exposure over the entire day is evaluated. The evaluation of the noise exposure and the method of analysis is standardized over the United States, and it representative of the maximum exposure over a workers' lifetime. This standard was developed in 1970 and is therefore dated based upon what we understand today. Engineering professionals typically adopt the more stringent noise levels defined by NIOSH (National Institute for Occupational Safety and Health). NIOSH has defined the REL (Recommended Exposure Limit) noise limit and the values are compared in Table 1. (Johnson, 2014). Although Table 1 shows that the limit for noise exposure for eight-hour time shift is 85 and 90 dBA for NIOSH and OSHA sound level respectively, prolonged exposure to noise at specific hearing

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frequencies might also cause hearing loss gradually after a lifetime even when sound level does not exceed the regulatory (OSHA) and recommended standards (NIOSH) (Pinosova, et al., 2015).

Table 1.

OSHA and NIOSH noise limit

Duration (hr)	OSHA Noise Level (dBA)	NIOSH Noise Level (dBA)
8	90	85
4	95	88
2	100	91
1	105	94
0.5	110	97
0.25	115	100

For example, it is theorized that working in a data center noise may cause tinnitus, which is an unpleasant ringing in a person's ears) due to the frequency of the sound and not the overall sound power. (Sharma & Vig, 2014).

Alternative Solutions for Server Room Noise. There are several approaches for mitigating the impact of server room noise on the employees evaluated. It is important to note that the sound pressure values did not exceed federal mandates requirement. However, this requirement is based upon the OSHA regulations which are over 40 years old (OSHA) (OSHA, 2014), but are over the NIOSH recommended values which was updated in 1998.

The issue here is the frequency of the sound and not the sound pressure and addressing employee's concerns where science and epidemiology do not appear to be up-to-date on the impact of this kind of technology. The most common technique to reduce the occupational noise exposure is by reducing the sound volume by administrative procedures (i.e. reducing time of the operators in the server room), or through personal protective equipment like earplugs. The construction of the earplug with soft silicon or a wax pillow allows the user to insert this device into the ear canal to reduce the pressure of the noise on the inner part of the ear. The use of these plugs is effective in filtering the noise if the employee uses them correctly, but it impacts their ability to communicate with other workers inside the server room. Workers may stay for a prolonged duration inside the data center to conduct maintenance work and communication within parties especially during times of crisis is imperative. New technology that allows employees to communicate is evolving, but these solutions are expensive and require that the company purchase units for each employee that are over $1000 a unit and require potential fitting the employee's ear (Sensear, 2016). Therefore, the standard earplug is not the ideal approach for this kind of work environment (Sultan, et al., 2016).

Earmuffs are another solution for noise inside server rooms. Earmuffs cover the pinna (the external part of the ear) to reduce the energy of the noise that reach the inner ear of the human (Health and Safety Executive, 2014). Earmuffs are more effective in this manner due to encapsulation of the entire ear compared to earplugs. This solution has some drawbacks as it still impedes the conversation between the employees while they are wearing it during the work shift. In addition, earmuffs are more expensive than the earplugs and also cause the employee's head to feel compressed which is not desirable as well as heating up the ears as it covers the entire pinna. Some research also indicates that covering the pinna in this manner for extended periods of time can cause ear infections as no air movement takes place when the ear muffs are secured appropriately (YAF.NET, 2006).

OSHA requires the use of hearing protection such as earplugs and earmuffs only when there are no feasible cost-effective engineering or administrative solutions for the noise mitigation. OSHA will also recommend engineering over administrative controls since administrative controls require changes in the schedule or workplace to reduce or eliminate exposure of workers to source of noise (OSHA, 2014). Engineering controls are physical modification to the source noise or transferring the transmission path to reduce the level of noise.

Currently, many Human Factors Engineers are exploring the efficacy of active noise control that may serve for noise reduction in a data center. Active noise control methods have received some attention as they do not require any noise absorbing material (Sharma & Vig, 2014). The main principle for those methods is based on distractive interference. Those methods are similarly applied in industrial applications such as aircrafts, air conditioning systems and exhaust fans. The active noise control concept is based on the interference of two signals with opposite phase and equal amplitude. As a result, the subtractive of the two signals will decrease an overall amplitude. The amount of noise reduction depends upon the accuracy of the phase and amplitude anti-noise signal (KUO & MORGAN, 1999). Active noise controls are generally an adaptive filter that uses differing algorithms for modifying the parameters of the controller.

There are different algorithms that can be applied for the controller such as the least mean square (LMS) filter, the recursive least square (RLS) algorithm and the filtered reference least mean square (FxLMS). Active Noise Control methods are complicated and expensive to deploy in large server rooms, and therefore may not be cost-effective to reduce noise.

2. Research Methodology

Data Collection Tools. The noise volumes in the server room were collected twice in different manners. Firstly, the data were captured utilizing the Sound Pro Sound Level meter, which is manufactured by Quest Company (Model 2900/Type 2) and referenced in Fig. 1.

Figure 1: Quest technology model 2900/type 2

Sound level data were collected in 12 locations inside an actual server room that was evaluated (Fig. 2). It is worth to mention that size of the room 20 ft width, 15 ft length and 10 ft height with only two server's racks. The layout of the room and servers is depicted in the figure along with the twelve respective locations (A-13, M-15, W-13, I-19, M-18, R-19, A28, M-21, W-28, D6-2, D6-1, D6-4) where data were collected and annotated to distinguish sampling locations in the server room. The locations were selected based on the requirements of this research to make an initial measurement to the sound levels in dBA inside the server room.

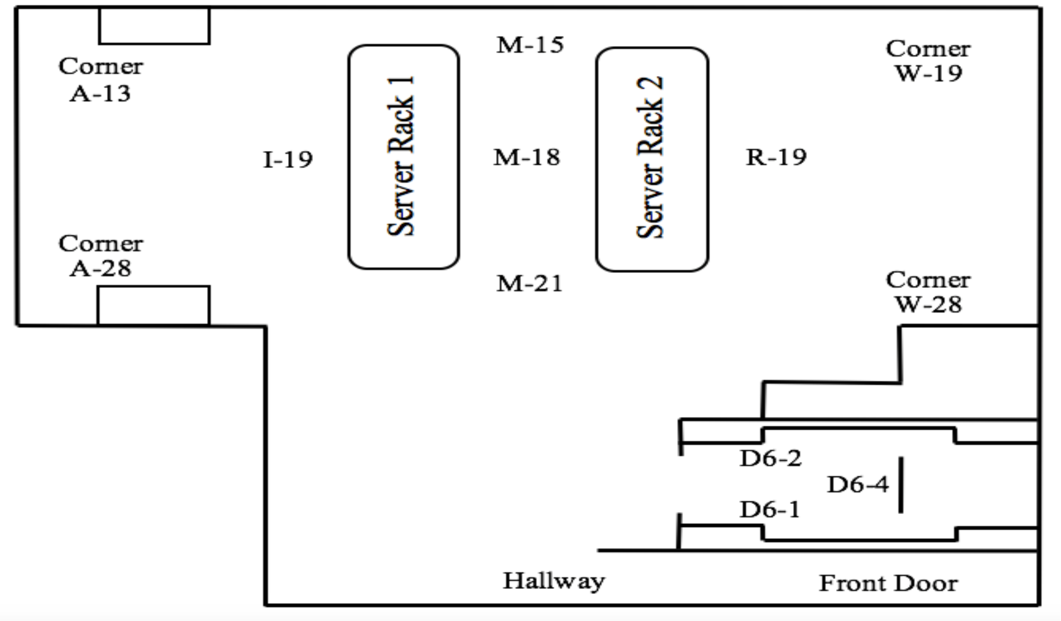

Figure 1: Server room layout

The Quest Sound Pro Sound Level meter measures the Sound Pressure Level (SPL) for the room associated with servers in the room computing sound pressure with algorithms at dBA, dBB, dBC, and linear slow scales respectively. Measuring sound on the dBA scale is of special interest to the investigator as sound for humans is primarily evaluated in a scale. This instrument is also able, however, to measure sound in dBB and dBC scales. The dBC scale is typically used for high sound pressure levels peaks and is virtually a linear scale as represented in Fig. 3, which includes the dBA, dBB, and dBC curves versus relative frequencies (Peter, 2015).

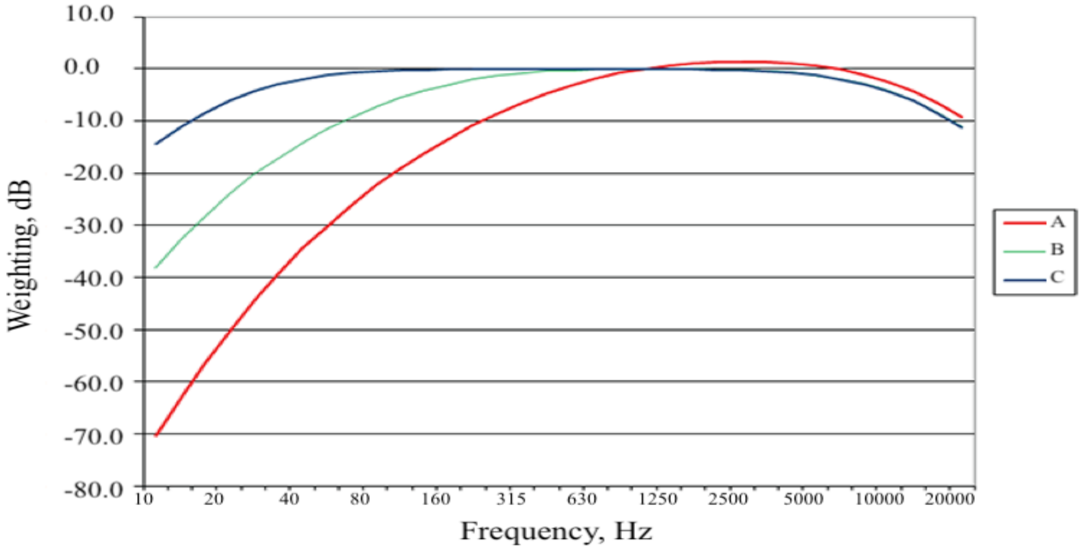

Figure 3: dBA, dBB, and dBC weighting curves (Peter, 2015)

Experimental Study. Upon conclusion of the data compilation phase inside an actual server room, the author then performed an experimental study to evaluate and compare results. In the lab study, the recorded sound of the noise signal was generated on a personal computer with multiple speakers to simulate the ambiance of the data center in a laboratory and measure the sound levels with a sound level meter (Quest/Model 2900).

The lab study provides more control and yet a flexible environment that assisted in further defining and measuring the noise as change parameters of the noise source (i.e. the density of the noise sources and the distance between those sources) were performed. As a result, the servers inside the data center's physical locations with different configurations could be simulated.

The lab portion of this study was performed at the St. Mary's University Electrical Engineering Laboratory. No effort was initiated to control reverberation of sound off the floor, ceiling or furniture/equipment in the room. Pieces of software and hardware were configured to create a small lab where sound levels could be captured, modified and, lastly, analyzed for the purpose of this experiment. A MacBook Pro computer was utilized and to capture and subsequently analyze the recorded noise files. The computer was connected to a Peavey XR8600D mixer amplifier (Fig. 4) to control the audio signal of six Peavey PR15 sound speakers (Fig. 5) that were connected to the mixer through 30 ft of speaker cable. The data extracted from the results of the lab study were compared to the data. The results of this study are presented in the following section.

Figure 4: Peavey XR8600D mixer amplifier

Figure 5: Peavey PR15 sound speakers

3. Results

Site Results. In Table 2 it was included the data captured over 60-minute intervals collected in several locations inside the server room. The data in Table 2 and Fig. 6 reveal that location I-19 has the highest level of sound with 82.7 dBA, and M-18 (the location in the middle of the two server racks) is the second highest sound level of 80 dBA which indicates that the noise level was reduced because part of the signal has canceled.

Table 2.
Sound level results

Location	dBA

Front Door	65.3
Hallway	69.4
Corner A-28	77.5
Corner A-13	77.1
Corner W-28	74.0
Corner W-19	73.3
R-19	75.1
M-15	76.1
M-18	80.0
M-21	75.5
I-19	82.7
D6-4 Office	65.5
D6-2 Office	65.0
D6-1 Office	66.4

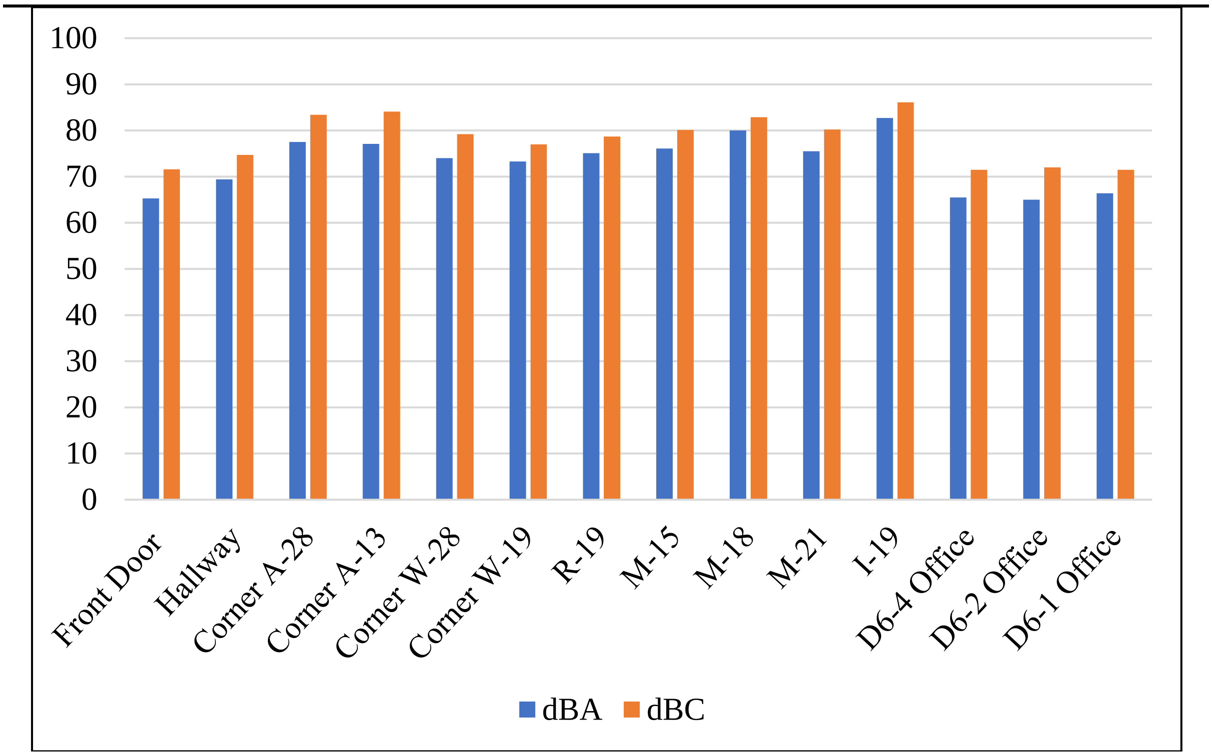

Figure 6: Sound level in dBA and dBC

Experimantal Results. Fig. 7 shows a bar-chart for the average values of the sound level for the two speakers at different distances. In addition, Fig. 8 shows the real-time reading for the noise level from the two speakers. It is obvious that the level of the sound is easily can exceed the level of 90 dBA as the speakers are getting closer to each other.

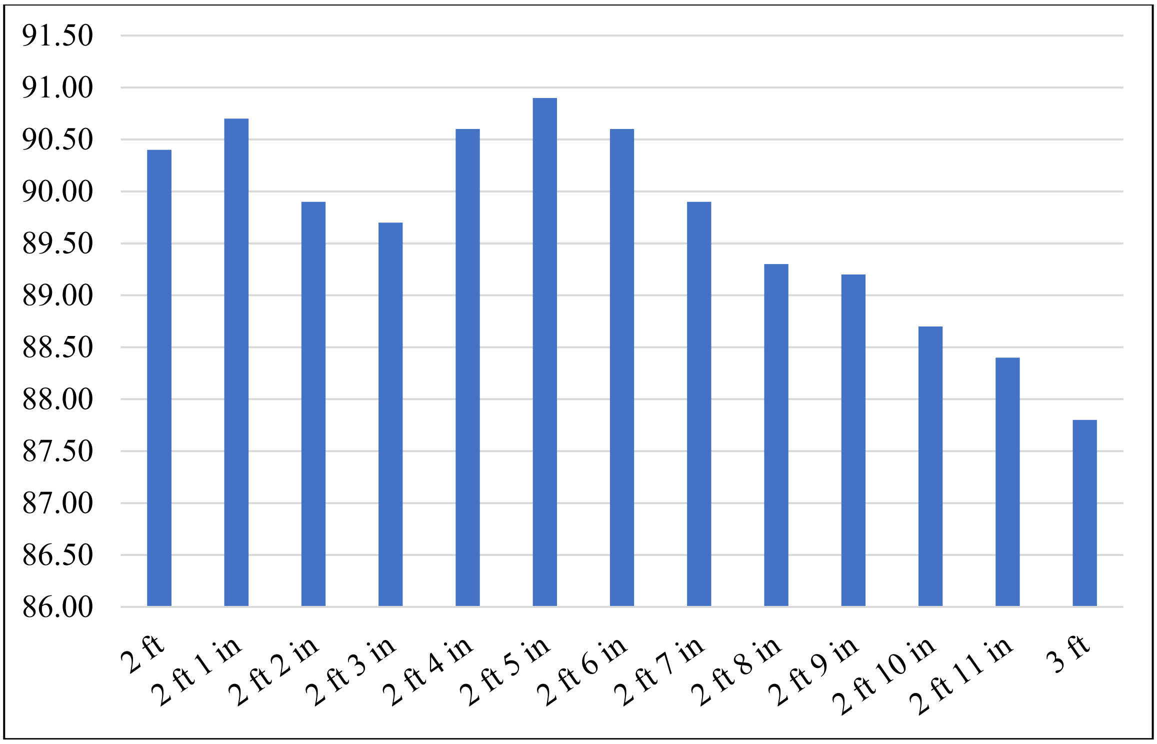

Figure 7: Average value of the noise level for two speakers

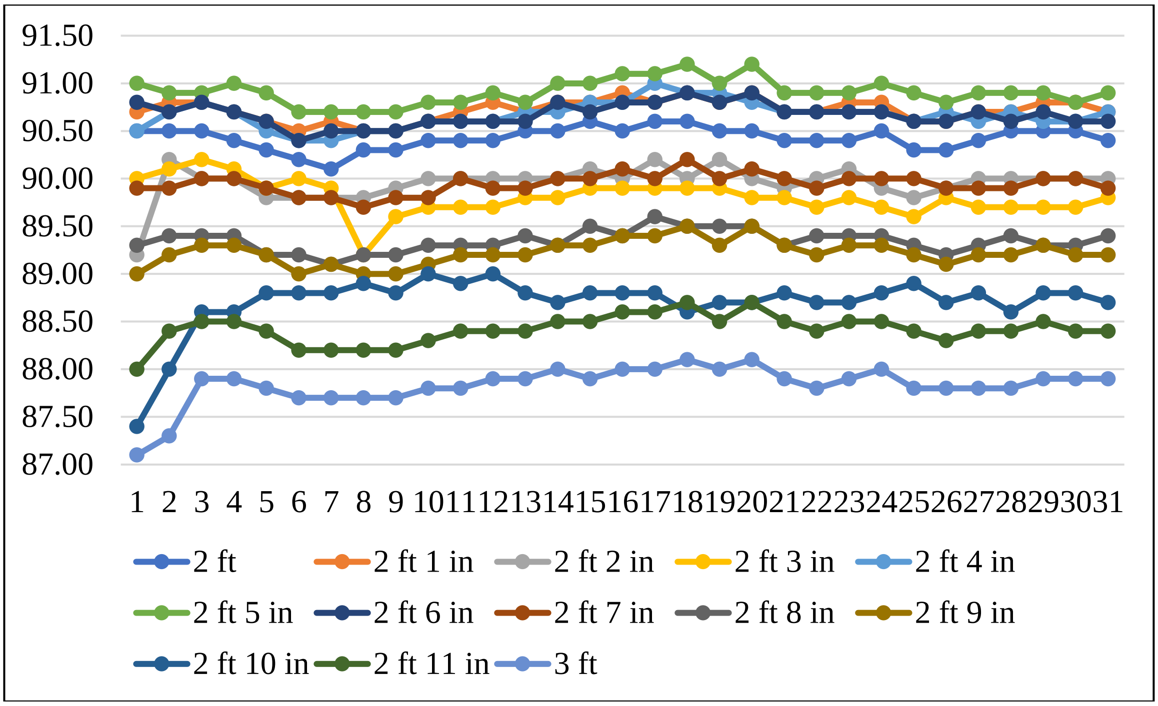

Figure 8: Real time reading for the noise level of two speakers

At the distance of 2.2 ft and 2.3 ft, the level of the sound is lower than the sound level for the distance range of 2.4 ft to 2.8 ft. This clarify that the noise losses part of its power because at those distances the noise signal has canceled each other at specific frequencies that can be calculated by:

$$f = \frac{speed\ of\ sound}{\lambda} \tag{1}$$

where f is the frequency (Hz) of the sound, λ is the wave length (ft) of the sound and sound speed is equal to 1125.3 ft/sec. Therefore, it can be concluded that a sound signal with the frequency of 490 Hz and its multipliers that is emitted from each speaker might cancel each other at a distance of 2.3 ft because of the correlation of the two sound waves. Other part of the signal can also be canceled for the same reason.

4. Conclusion

Based upon the additive law of sound, it is evident that the similarity of the noise that is generated from the servers can let to cancel part of the noise frequency as per the distance that separate between the server racks. This can help to reduce the level of the noise inside the server room by changing the distance between the server racks.

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