

AC/DCIM

Acoustic Channels for Data Center Infrastructure Monitoring

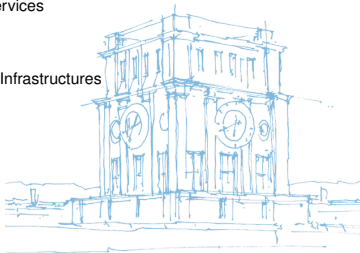
NOMS 2022

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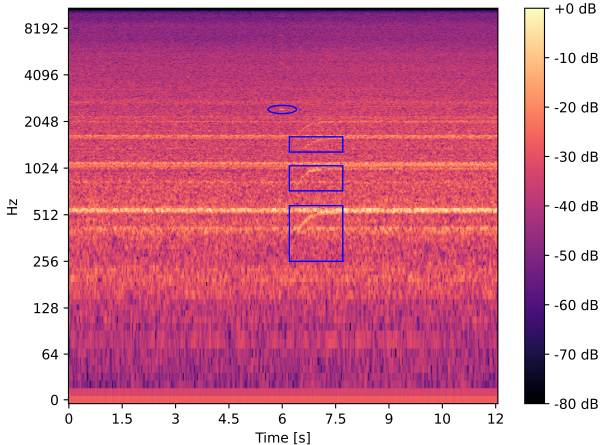
- Data Centers (DCs) power our lives
- DC monitoring includes [6]
 - Device states
 - Network monitoring
 - Infrastructure monitoring
- Introduction of a novel method for monitoring DC devices
- Based on acoustic side channels
- Enables
 - Activity Detection
 - Error Detection



- For infrastructure monitoring, various side-channels are monitored

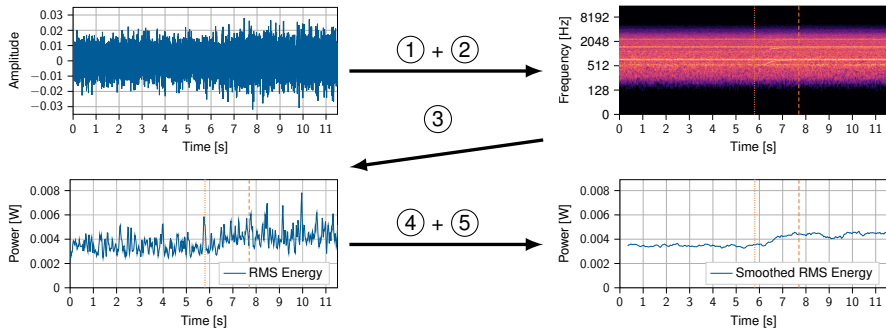
Feature	RW
Power consumption	[2, 6, 3]
Heat	[5, 4, 7, 6]
Airflow	[1, 6]
Humidity	[8, 6]
Vibration, water/air pressure	[6]
Sound	None

- Sound
 - is well researched
 - can be captured with a high resolution and sample rate
 - is easy and cheap to capture

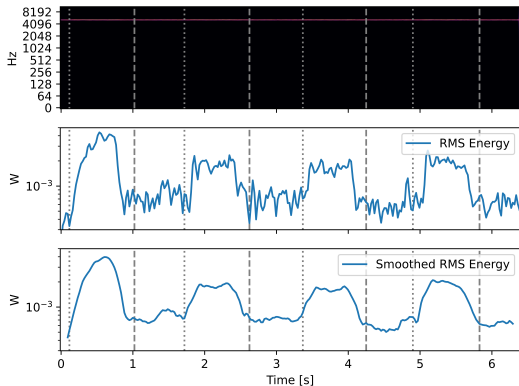


- Static background noise
- Little human interaction due to remote management
- Many devices in close proximity
- Sound only affects a part of the complete frequency band
- Devices have characteristic frequencies depending on hardware

Root Mean Square Energy for Activity Detection



- ① Perform Short Term Fourier Transform
- ② Limit the spectrum to relevant frequencies
- ③ Calculate the Root Mean Square (RMS) Energy for each time frame
- ④ Smooth the RMS Energy to identify trends
- ⑤ Identify activities
 - threshold based method
 - extract time-frame and identify activity



- Narrow frequency band for detecting events on specific frequencies
- Step ④ requires less smoothing – fewer frequencies carry noise

- Acoustic side-channels are suitable to identify device behavior in a mixed signal
- In various experiments in a real world DC we identified
 - activity spanning many frequencies, and
 - error beep codes on single frequencies.

- Exploration of robustness
 - simultaneous activity
 - noise
- Device identification via error code frequency analysis
- Correlation of side-channel information with network traffic
- Use of multiple microphones for device identification

AC/DCIM

Acoustic Channels for Data Center Infrastructure Monitoring

Motivation

- Data Centers (DCs) power our lives
- DC monitoring includes [6]
 - Device status
 - Network monitoring
 - Infrastructure monitoring
- Introduction of a novel method for monitoring DC devices
- Based on acoustic side channels
- Enables
 - Activity Detection
 - Error Detection

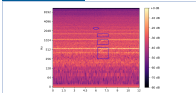


Related Work

- For infrastructure monitoring, various side-channels are monitored

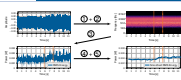
Feature	R/W
Power consumption	[2, 6, 8]
Heat	[5, 4, 7, 6]
Airflow	[1, 4]
Humidity	[8, 6]
Vibration, water/air pressure	[6]
Sound	None
- Sound
 - is well researched
 - can be captured with a high resolution and sample rate
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Data Center Soundscapes



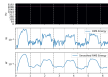
- Static background noise
- Little human interaction due to remote management
- Many devices in close proximity
- Sound only affects a part of the complete frequency band
- Devices have characteristic frequencies depending on hardware

Root Mean Square Energy for Activity Detection



- Perform Short Term Fourier Transform
- Limit the spectrum to relevant frequencies
- Calculate the Root Mean Square (RMS) Energy for each time frame
- Smooth the RMS Energy to identify trends
- Identify activities
 - threshold based method
 - extract time-frame and identify activity

Single Frequency Event Detection



- Narrow frequency band for detecting events on specific frequencies
- Step 4 requires less smoothing – fewer frequencies carry noise

Conclusion and Future Work

- Acoustic side-channels are suitable to identify device behavior in a mixed signal
- In various experiments in a real world DC we identified
 - activity appearing many frequencies, and
 - error beep codes on single frequencies.
- Exploration of robustness
 - simultaneous activity
 - noise
- Device identification via error code frequency analysis
 - Correlation of side-channel information with network traffic
- Use of multiple microphones for device identification

[1] N. Ahuja et al. Real Time Monitoring and Auditability of Server Activity to Efficient Data Center Cooling. In *IEEE 28th INMIC 2013*.

[2] A. Baghel et al. Online Anomaly Detection in HPC Systems. In *IEEE ACMS 2016*.

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[4] S. Lee et al. Model Based Thermal Anomaly Detection in Cloud Datacenters Using Thermal Imaging. *IEEE Trans. Cloud Comput.*, 4(6):2016.

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[8] M. G. Rodriguez et al. Wireless Sensor Network for Data Center Environmental Monitoring. In *2010. ICSIT 2010*.

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