Chair of Network Architectures and Services
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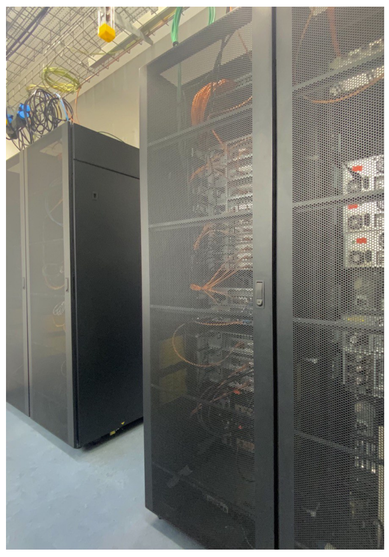
AC/DCIM

Acoustic **C**hannels for **D**ata **C**enter **I**nfrastructure **M**onitoring

Motivation

- 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



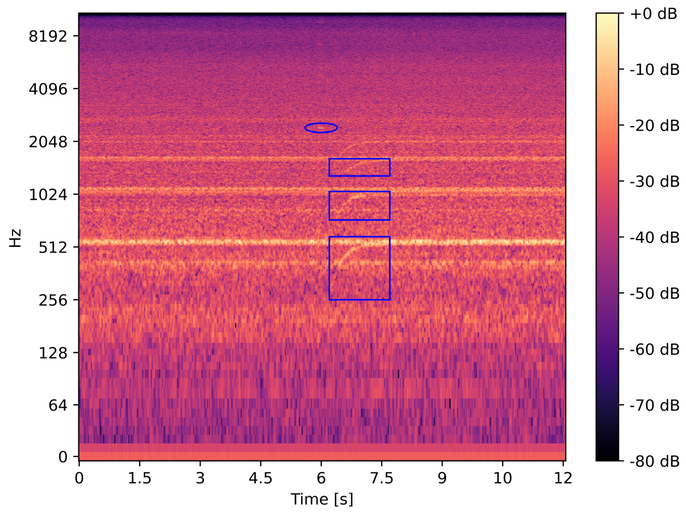
Related Work

- 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

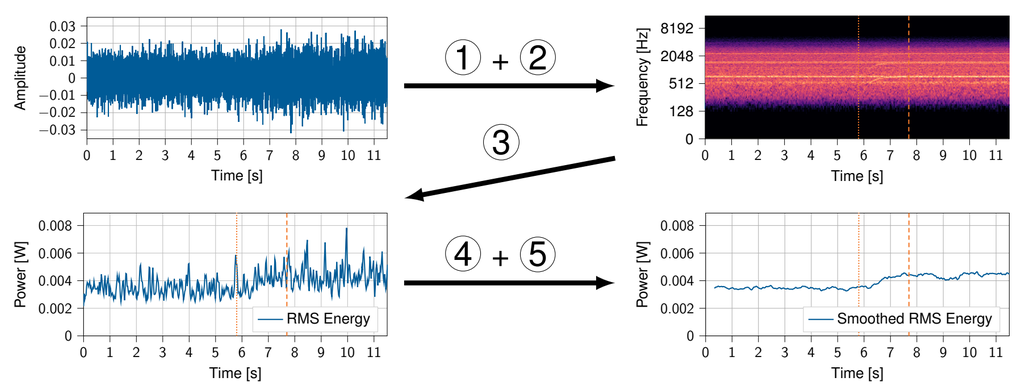
- Sound
  - is well researched
  - can be captured with a high resolution and sample rate
  - is easy and cheap to capture

Data Center Soundscape



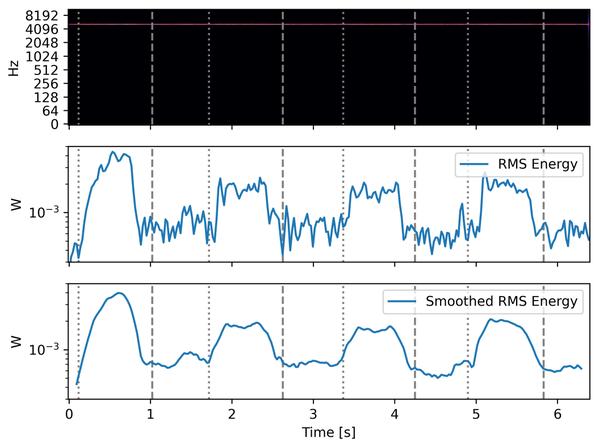
- Static background noise
- Little human interaction due to remote management
- Many devices in close proximity
- Sound only affects a part of the complete frequency band
- Devices have characteristic frequencies depending on hardware

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

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 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

[1] N. Ahuja et al. Real Time Monitoring and Availability of Server Airflow for Efficient Data Center Cooling. In *IEEE SEMI-THERM*, 2013.
[2] A. Borghesi et al. Online Anomaly Detection in HPC Systems. In *IEEE AICAS*, 2019.
[3] M. Dayarathna et al. Data Center Energy Consumption Modeling: A Survey. *IEEE Commun. Surv. Tutorials*, 18(1), 2016.
[4] E. Lee et al. Model-Based Thermal Anomaly Detection in Cloud Datacenters Using Thermal Imaging. *IEEE Trans. Cloud Comput.*, 6(2), 2018.
[5] E. K. Lee et al. Model-Based Thermal Anomaly Detection in Cloud Datacenters. In *IEEE DCOSS*, 2013.
[6] M. Levy and J. O. Hallstrom. A New Approach to Data Center Infrastructure Monitoring and Management (DCIMM). In *IEEE CCWC 2017*, 2017.
[7] M. Marwah et al. Thermal Anomaly Prediction in Data Centers. In *12th IEEE ITherm*, 2010.
[8] M. G. Rodriguez et al. Wireless Sensor Network for Data-Center Environmental Monitoring. In *5th ICST*, 2011.

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