Music-Defined Networking

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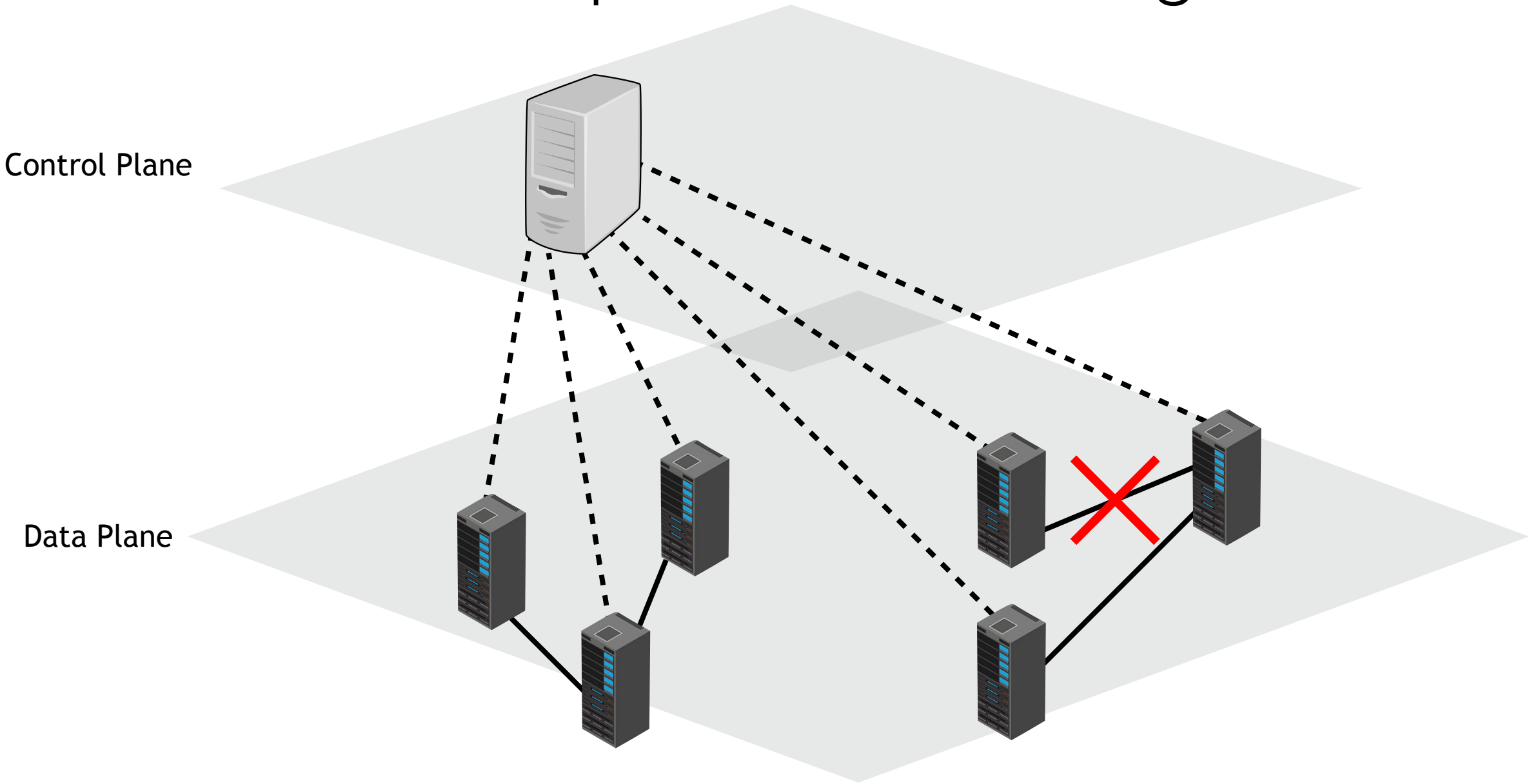
Data and control plane fate sharing



Control Plane Tasks

Forwarding table updates

Networking monitoring

Device configuration

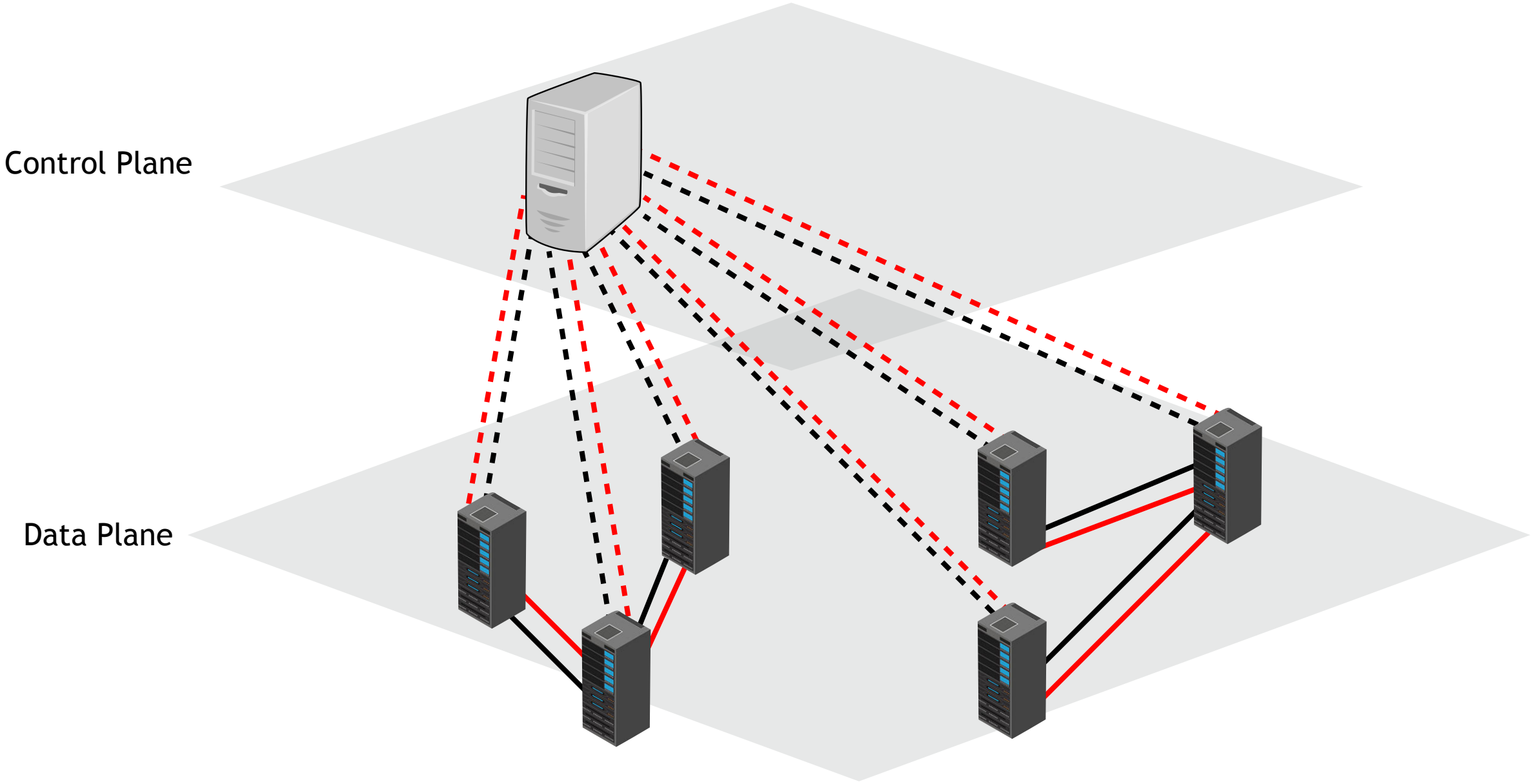
Control networks have different characteristics than the data plane

Isolated from data plane failures

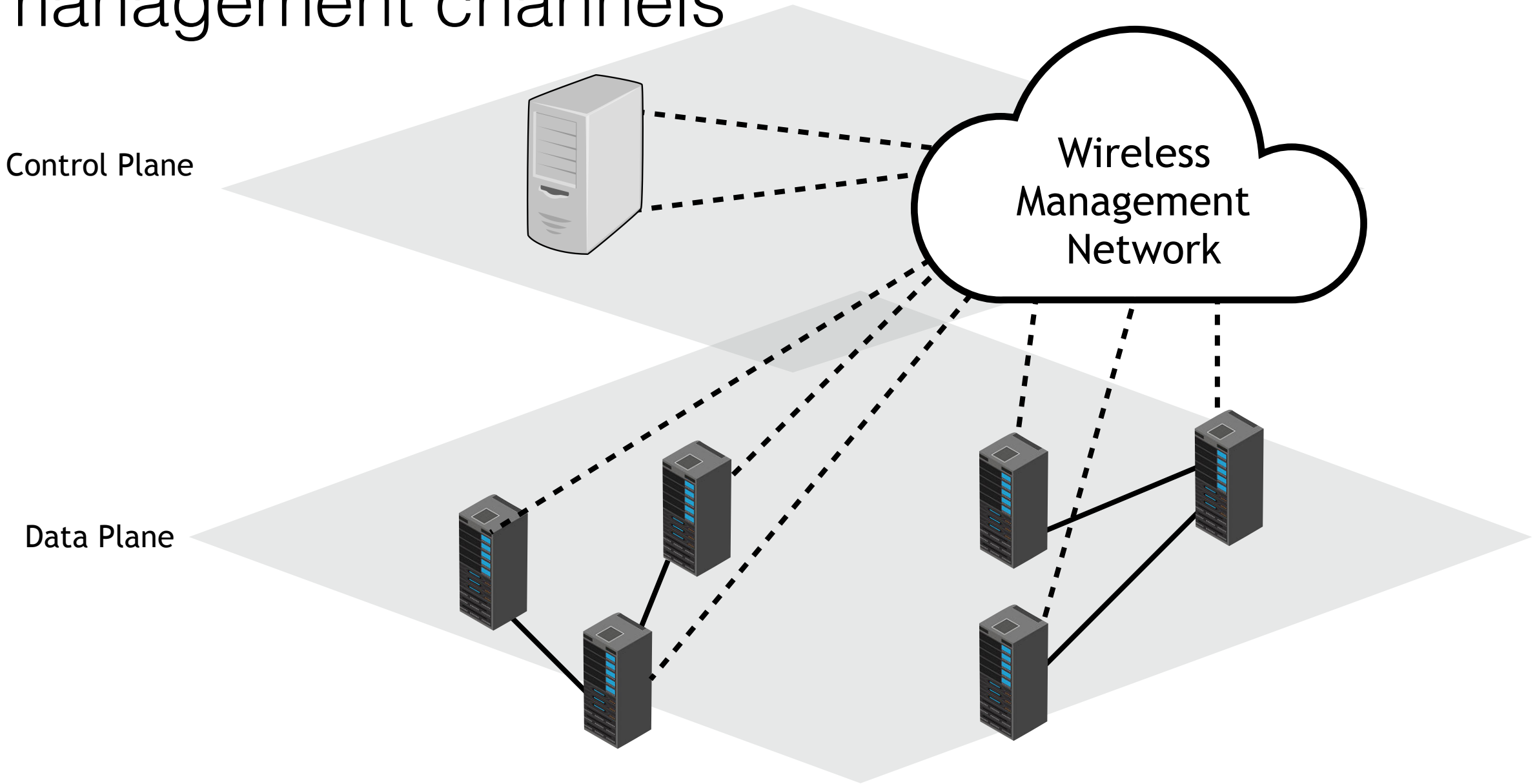
Scalable to reach all devices

Lower bandwidth than data plane

Parallel networks are often infeasible



Wireless networks are scalable management channels



Sound is an effective and low-cost out-of-band management channel

Reliable
Sound survives data plane failures

Low-cost
MDN only requires inexpensive microphones and speakers

Easily implemented
Sound doesn’t require changes to existing physical infrastructure

Frequency-Based Applications

Program devices to play sine waves

Learn information by identifying the frequencies in audio signal

Duration of sound is arbitrary

MDN works with the in-band control plane

Packets sent over in-band control network

Some monitoring tasks offloaded with sound

MDN reduces load in traditional control channel

Out-of-band Channels

	60 GHz Radios	Power Line	Music-Defined Networking
No infrastructure changes	✗	✓	✓
Inexpensive hardware	✓	✗	✓
Robust to failures	✗	✓	✓

Outline

Practical Implementation

MDN Applications

- State Processing
- Network Telemetry
- Traffic Engineering

Limitations & Future Work

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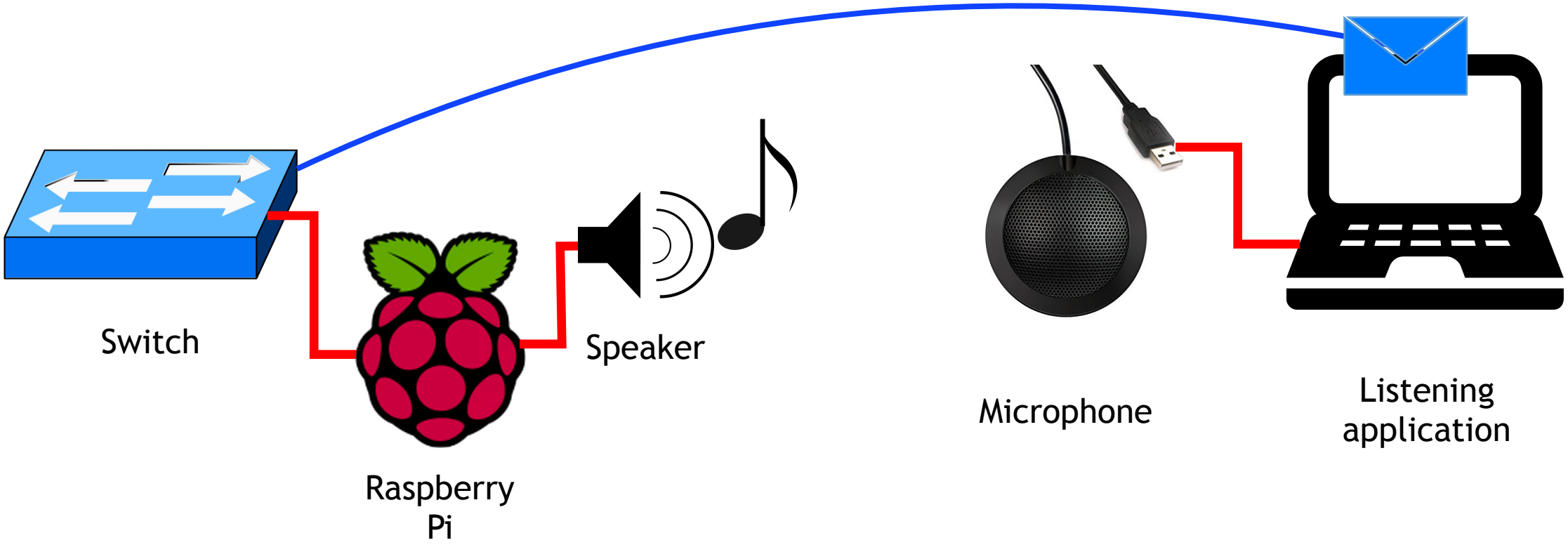
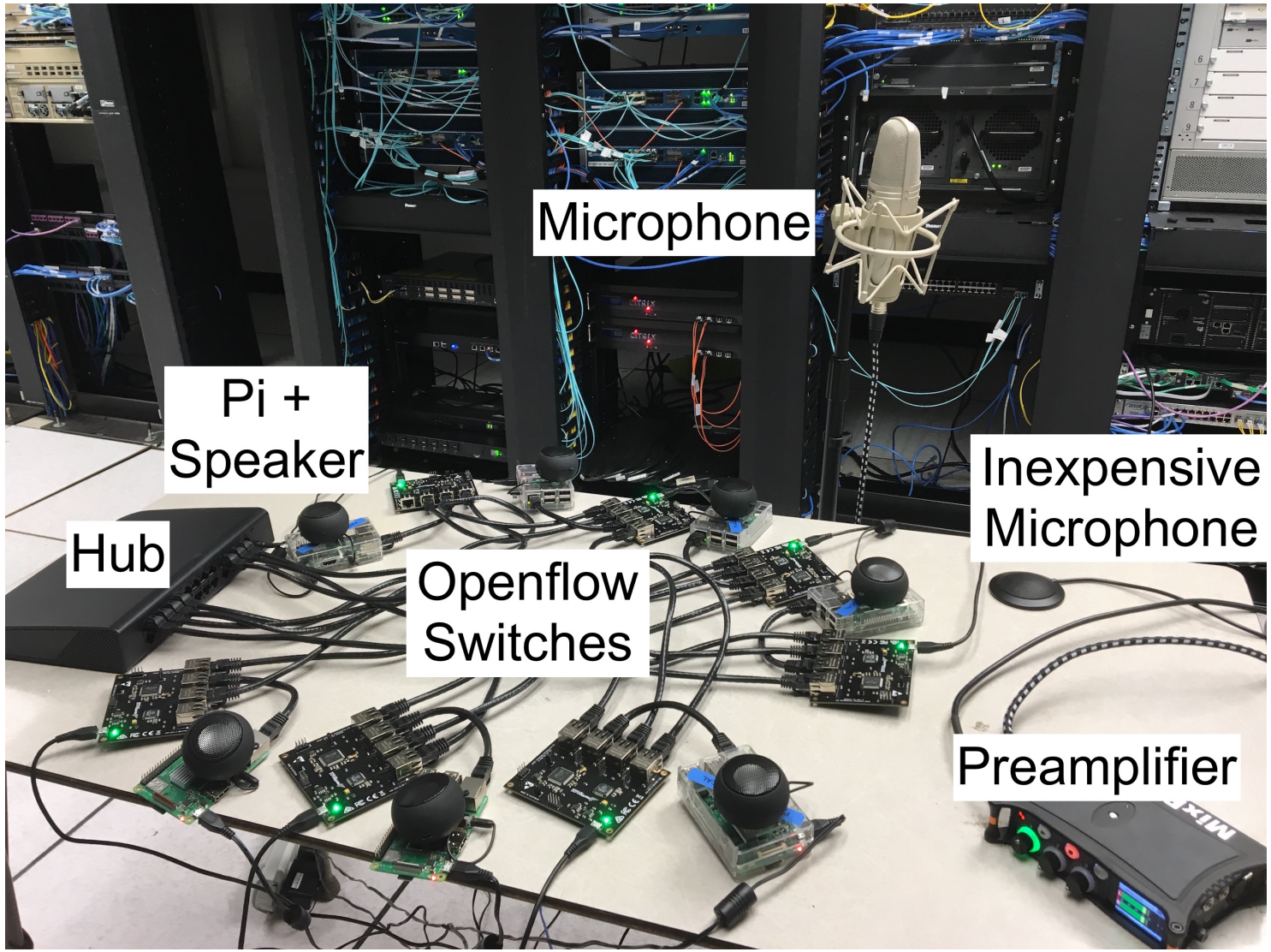
Sound Testbed



Sound Testbed

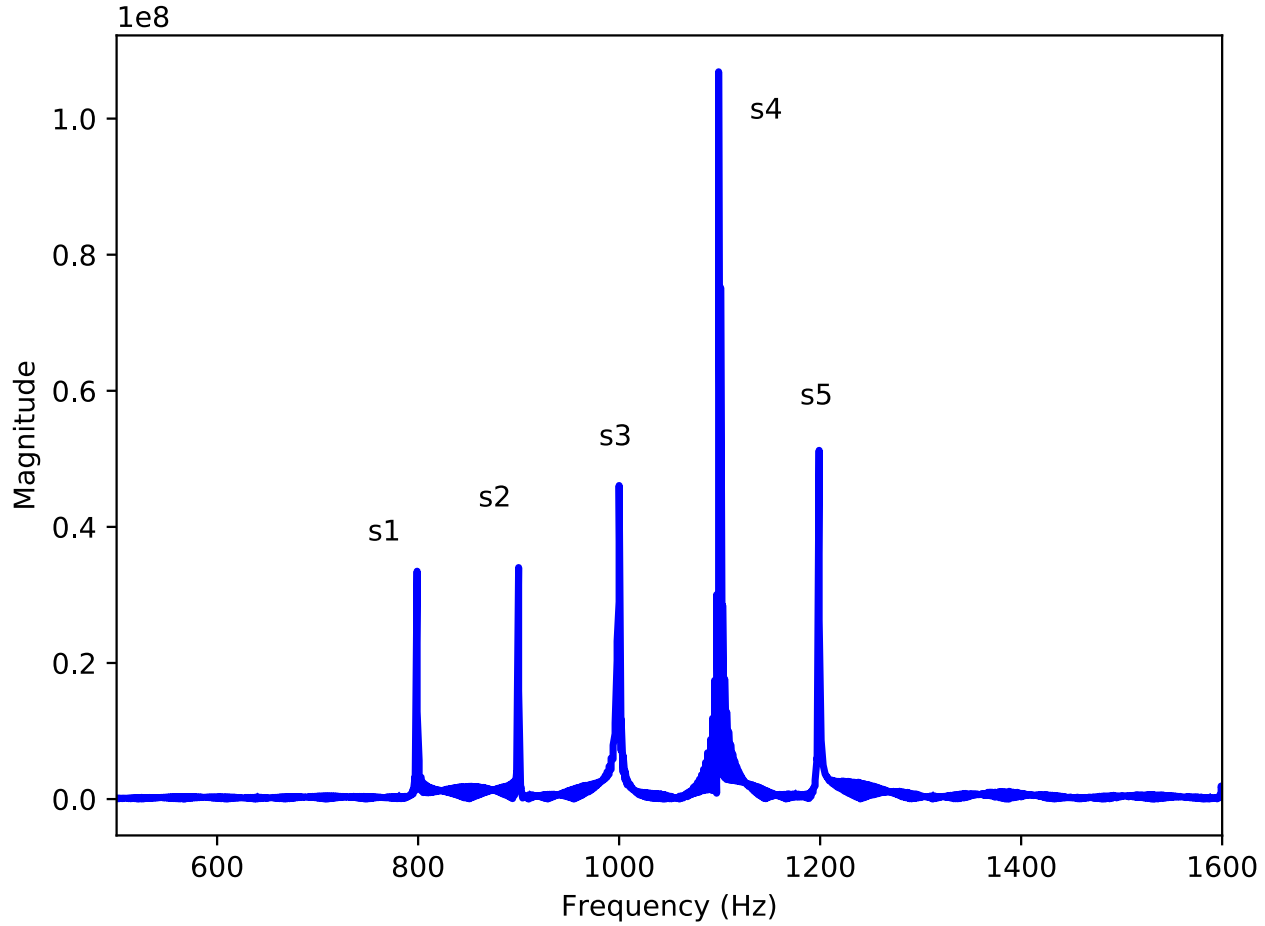


Processing MDN Signals

Record small chunks of audio

Extract frequencies with fast Fourier transform (FFT)

Distinguishing simultaneous sounds requires frequency bands



MDN in a working environment

Human-hearable frequencies played at reasonable volumes

Loud sounds create uncomfortable conditions

MDN sounds must be different than background noises

MDN is robust to outside sounds

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MDN Application Feasibility

Management tasks may require complex solutions

MDN has limited granularity

Sound is better suited for longer timescales

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State Processing

Management plane states with sounds

Management states happen at longer timescales

Port knocking

Controller keeps track of the port numbers the switch has seen

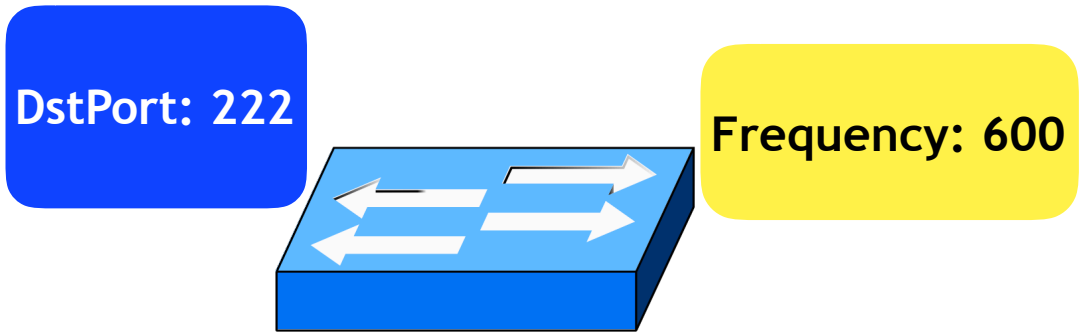
Port knocking opens ports on a firewall

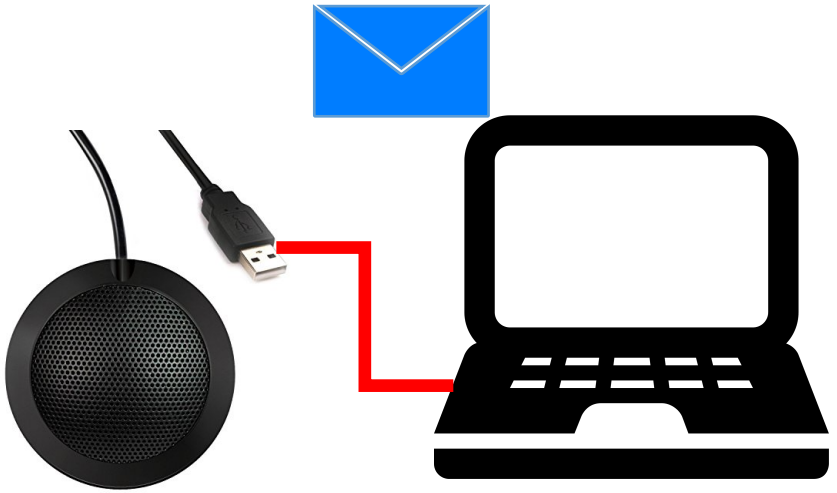
All packets dropped initially

Host sends sequence of packets to prespecified (closed) port numbers

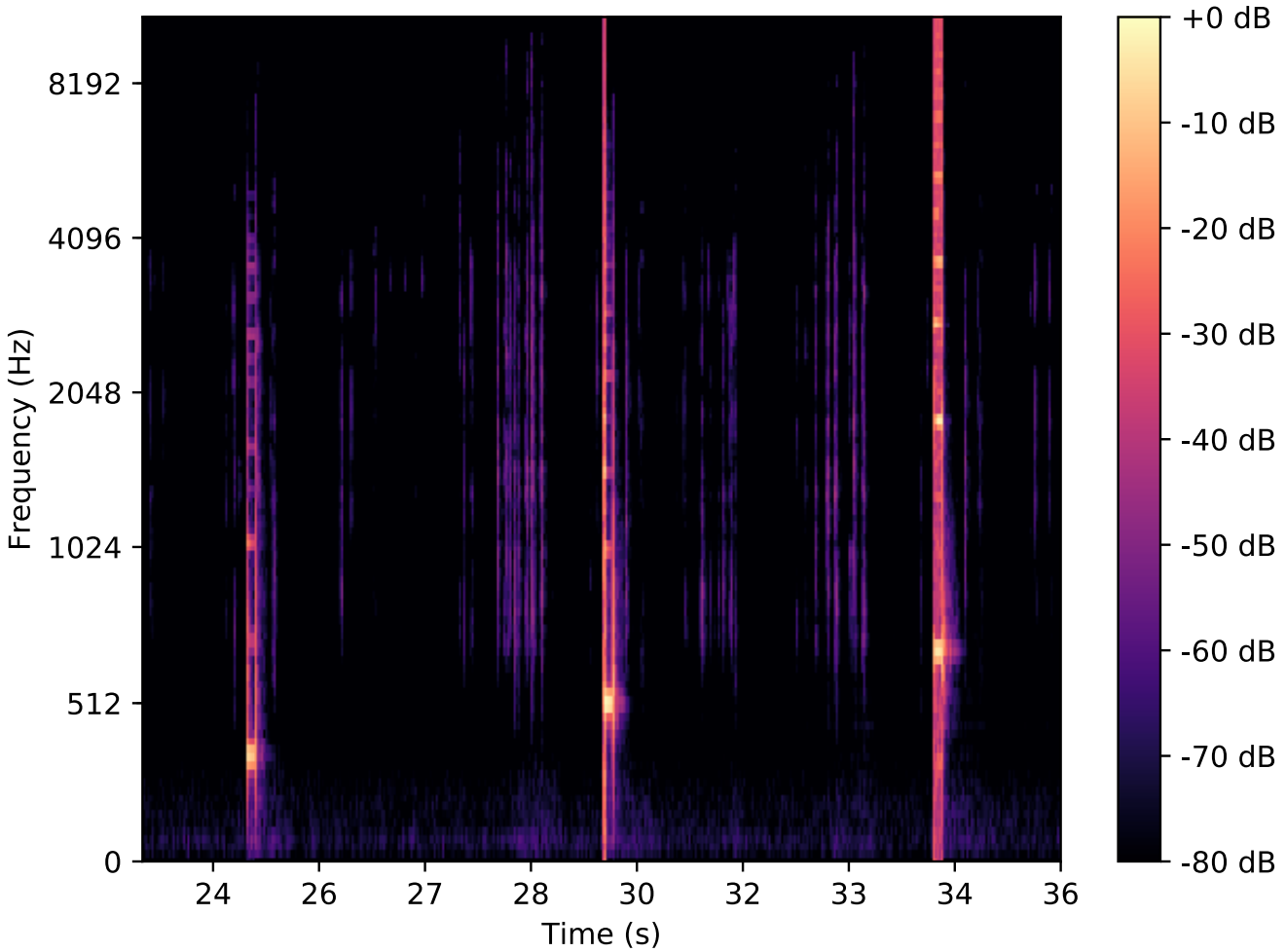
When the correct sequence is received, specific ports are opened

Port Knocking with Sound





Port Knocking



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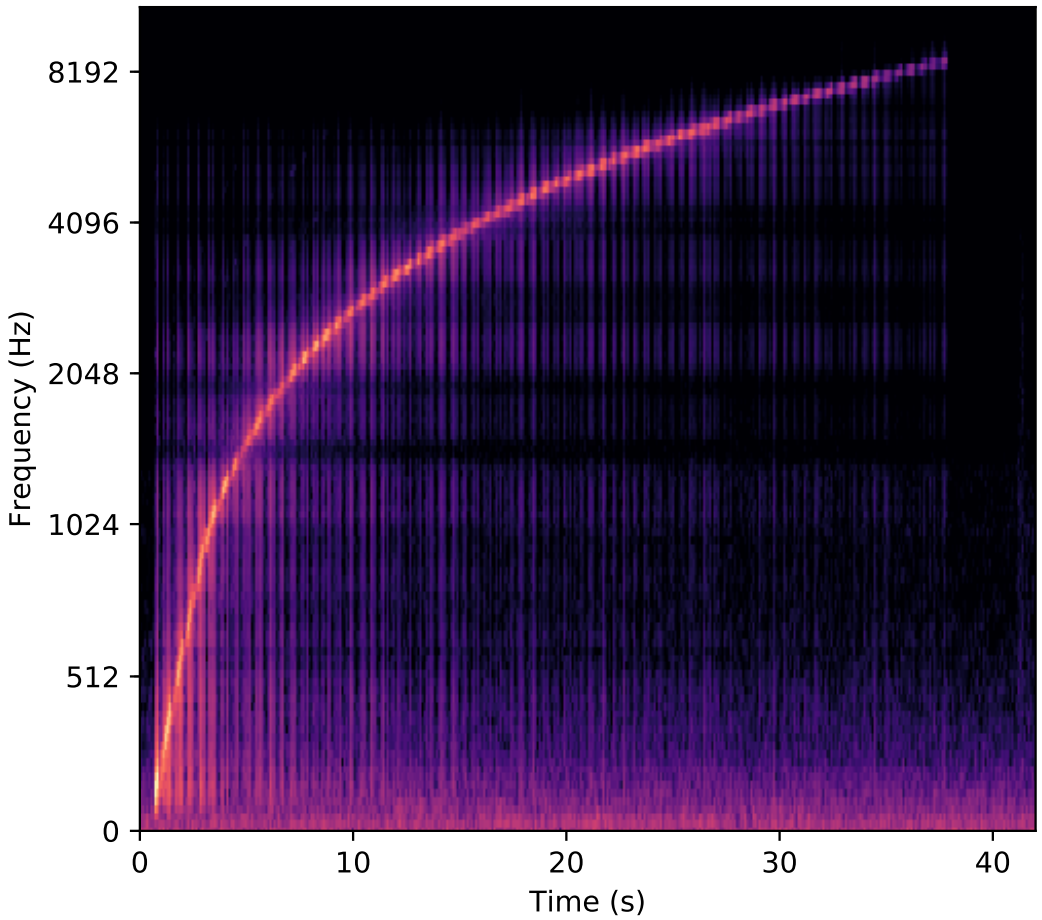
Network Telemetry with MDN

Hash monitoring metric to frequencies

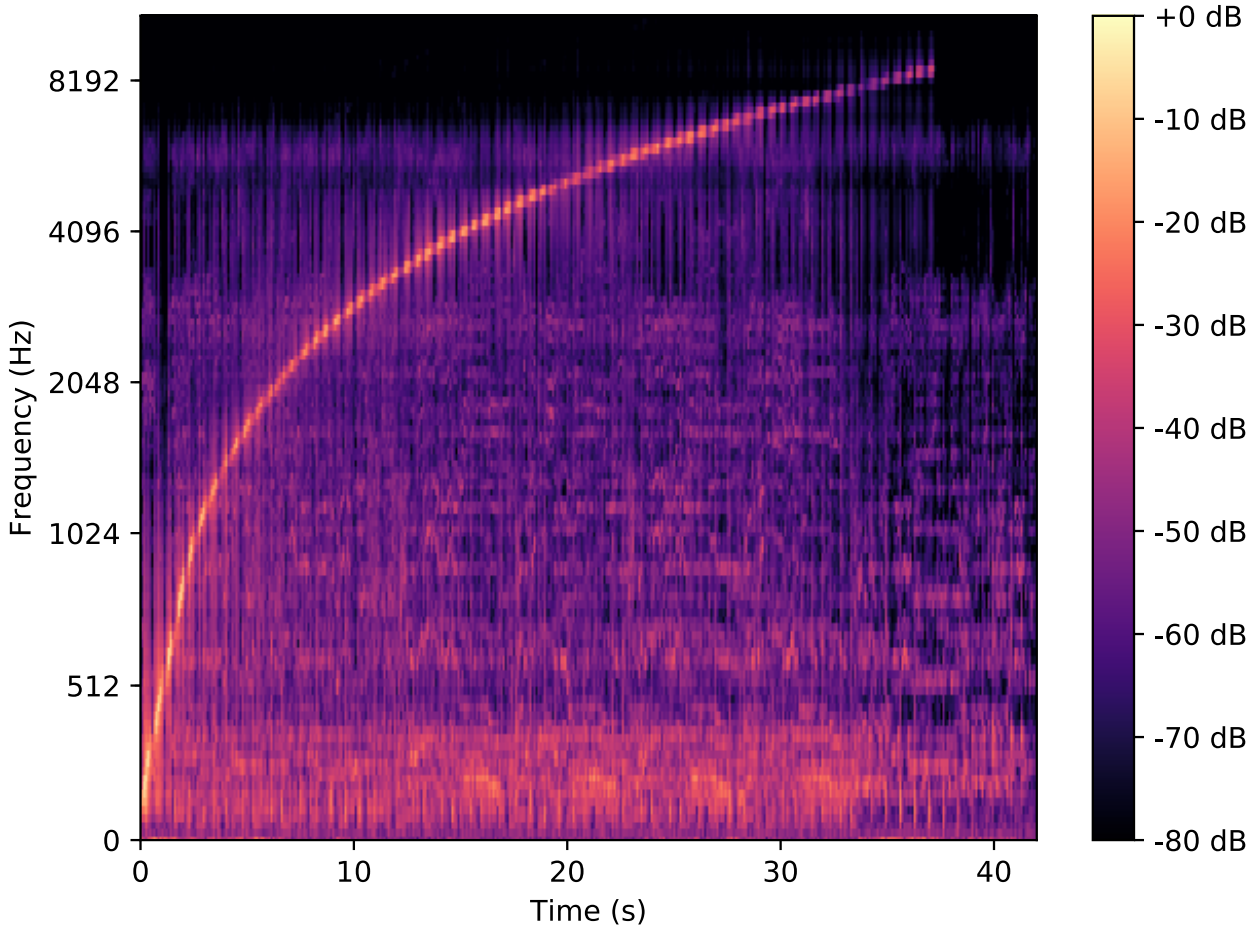
Play sounds for a sample of packets

Controller counts occurrences of each frequency

Port Scanning with Sound



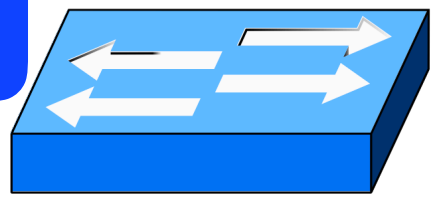
WITHOUT Background Noise



WITH Background Noise

MDN Heavy Hitter Detection

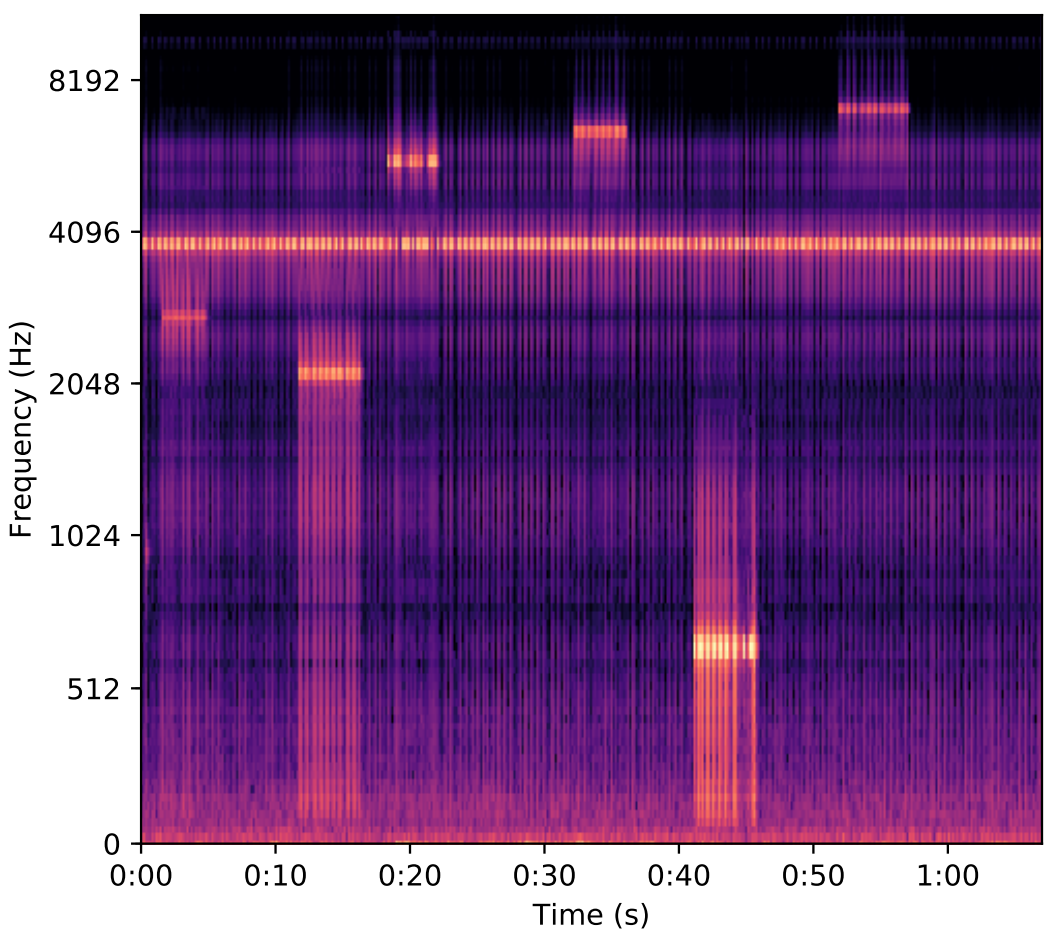
Flow ID: y



Frequency: 200

Frequency	Flow ID	Count
100	x	1
200	y	1

Heavy Hitters with Sound



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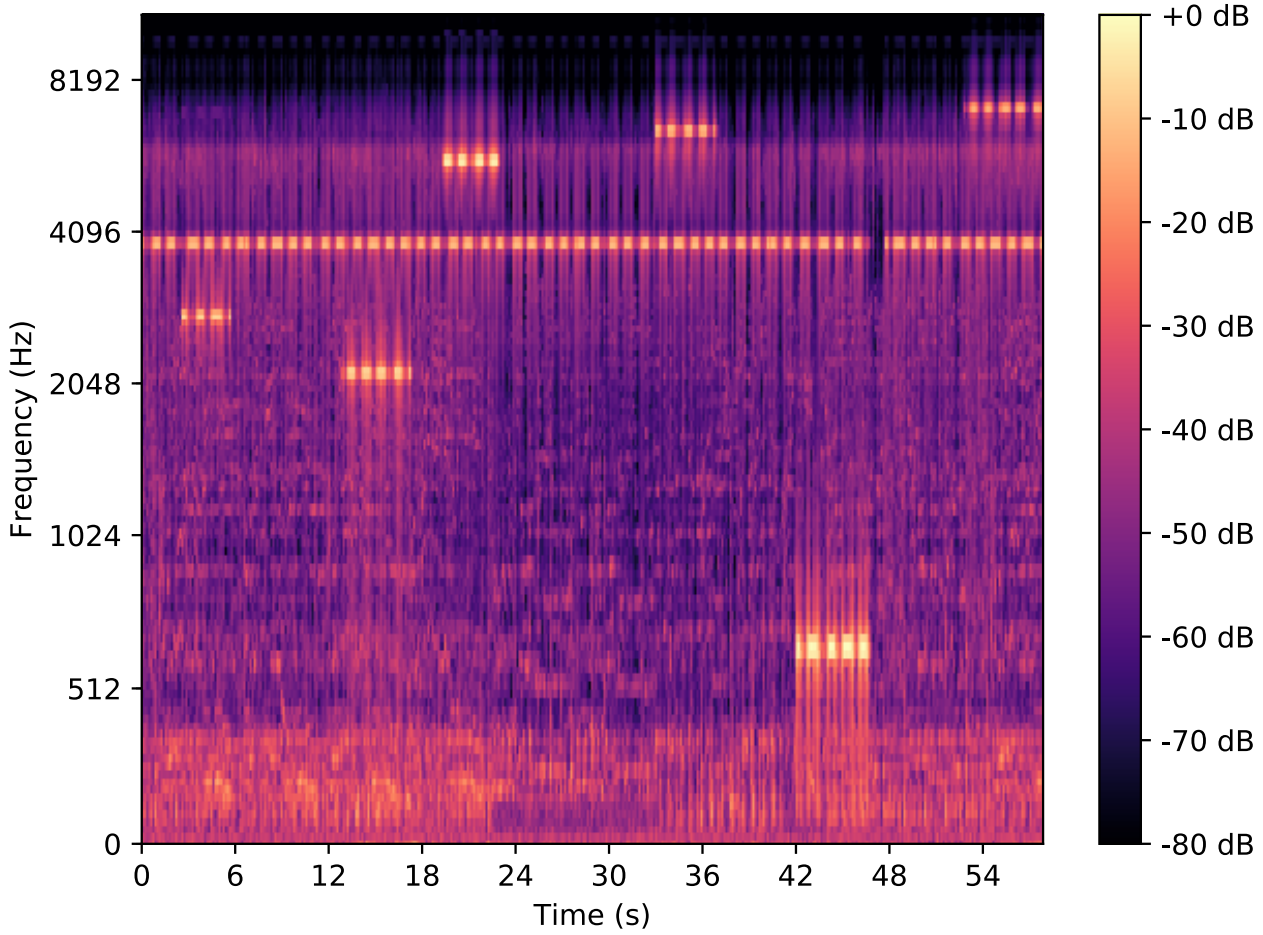

WITH Background Noise

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Sound as a signal to trigger traffic engineering decisions

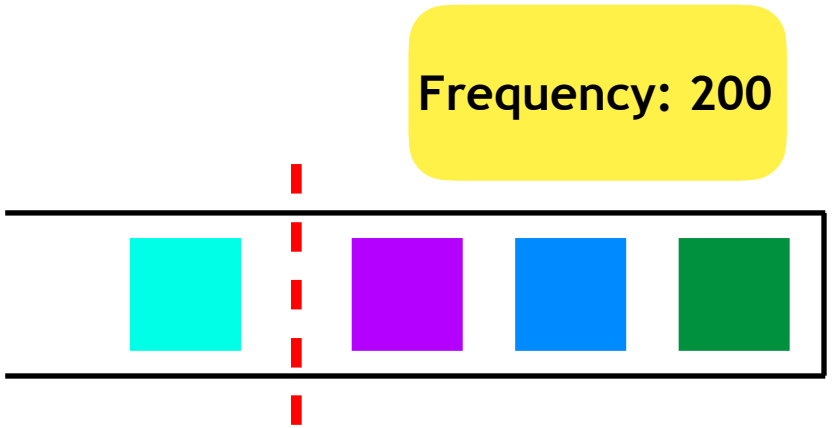
Sounds measure congestion in a switch

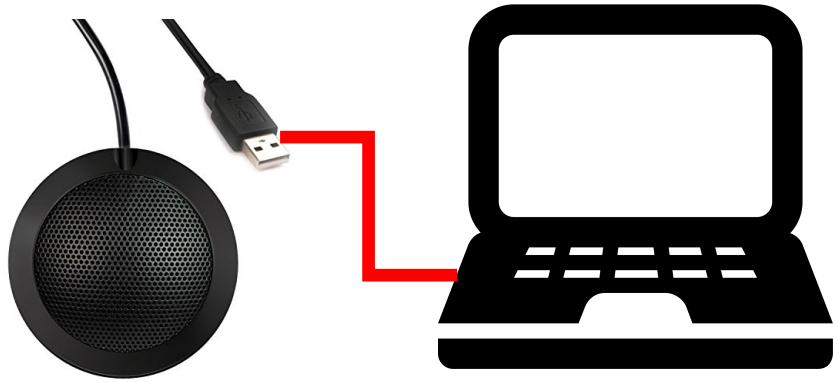
Frequencies map to queue size relative to a threshold

Estimated queue size can drive congestion control

Controller reacts to the frequencies it hears

Traffic Engineering with Sound





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Testbed Limitations

Single-hop sound transmission

Systems must have devices placed close together

Limited number of unique frequencies

MDN alone cannot support the number of tasks in a large network

MDN Security

MDN relies on existing physical security measures

Sound at low frequencies travels through materials

Open Questions

Infrasound and ultrasound frequencies

Multi-hop sound communication

Coordination of an array of microphones listening to different groups of switches

Bidirectional sound communication

Implement your MDN application

https://github.com/mhogan26/Music-Defined_Networking

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