Covert Channels Using Mobile Device's Magnetic Field Sensors

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Covert channels: scenario

A target computer

- protected by firewalls, IDS etc.
- or even isolated into an **air-gap**
- infected by the attacker

An attacker

- has no network access
- may have no physical access
- wants to exfiltrate data from the target

➡ The attacker needs a **covert channel** to transmit data

Covert channels: examples

- **Electromagnetic**
  - CPU emissions and a dedicated receiver [1]
  - CPU-RAM emissions and a mobile phone with patched firmware [2]
- **Acoustic**
  - transmission using ultrasonic sounds [3,4]
- **Thermal**
  - using built-in thermal sensors [5]

Covert channels: requirements

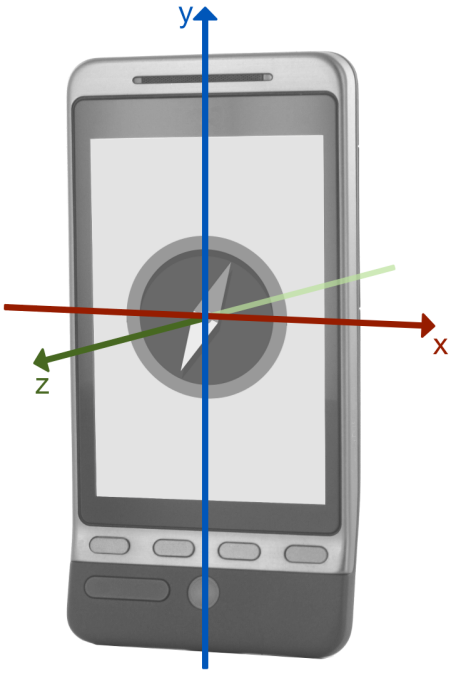
Use of hardware is restricted in air-gapped networks	→	Covert channel should not require dedicated hardware
Physical access is limited	→	Covert channel should be easily deployed to victim's device

Our motivation: a new covert channel, applicable to any commonly used hardware

Covert channels: a new approach

Idea: Use of smartphone's magnetic sensors

- installed in every modern smartphone
- used to measure magnetic field along 3 axes
- available through OS API

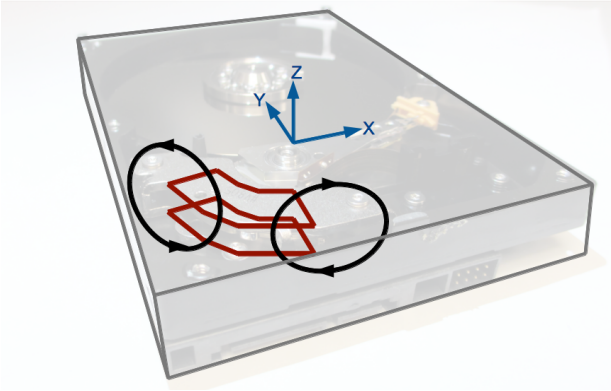


Basic use case: track phone orientation in space

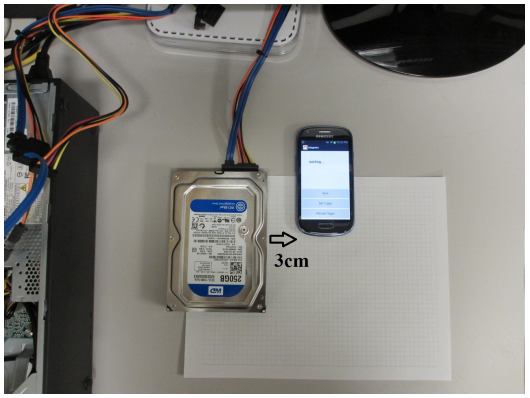
Our approach: measure magnetic signals emanated from a target device

Hard drive side-channel attack

Previous results: side-channel attack on hard drives (FC'2015)



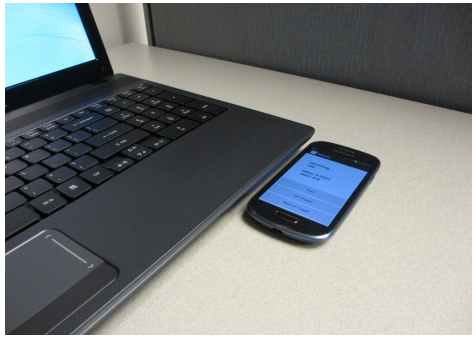
Head movements lead to EM fluctuations

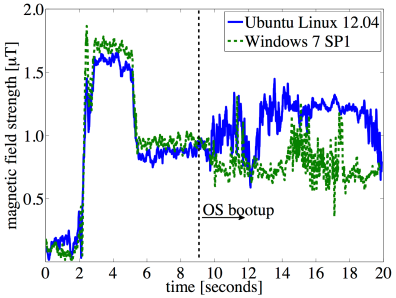


Magnetic sensors can detect hard drive activity

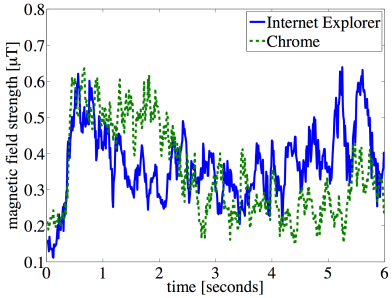
Hard drive side-channel attack (2)

1. Attacks against a laptop



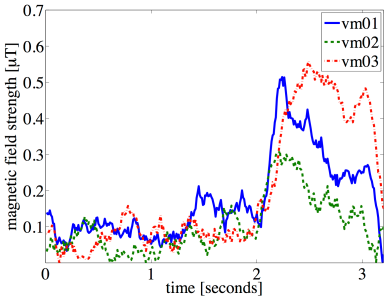


OS boot fingerprint

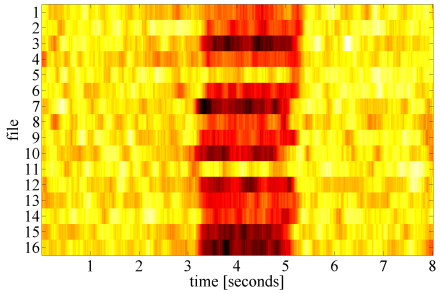


Application detection

2. Attacks against a server



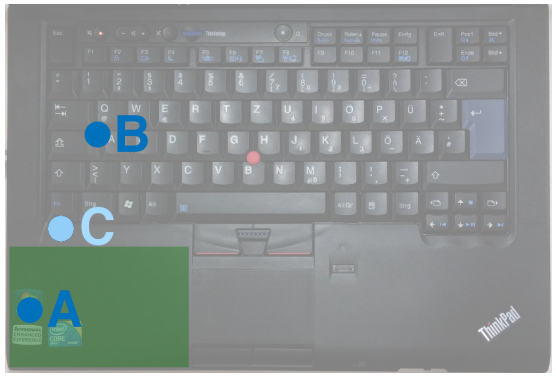
VM boot detection



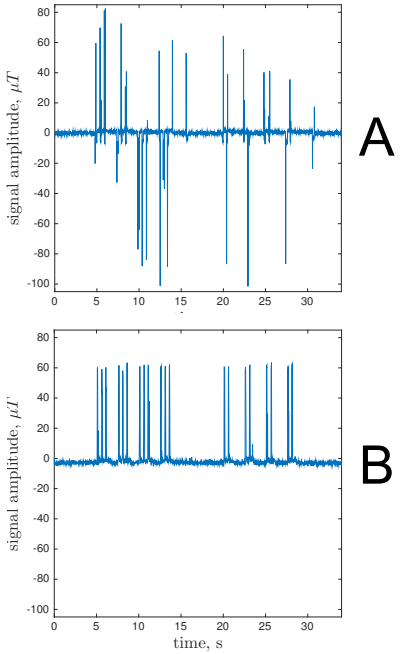
File caching detection

Electromagnetic covert channel

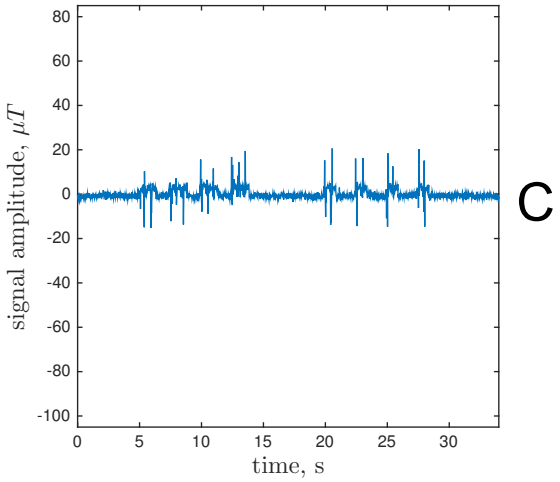
Basic operation: writing random data to the hard drive produces a single peak



Two sources of the signal



Peaks are different for sources A and B



Signals interfere in the intermediate position C

Amplitude modulation

Transmitter:

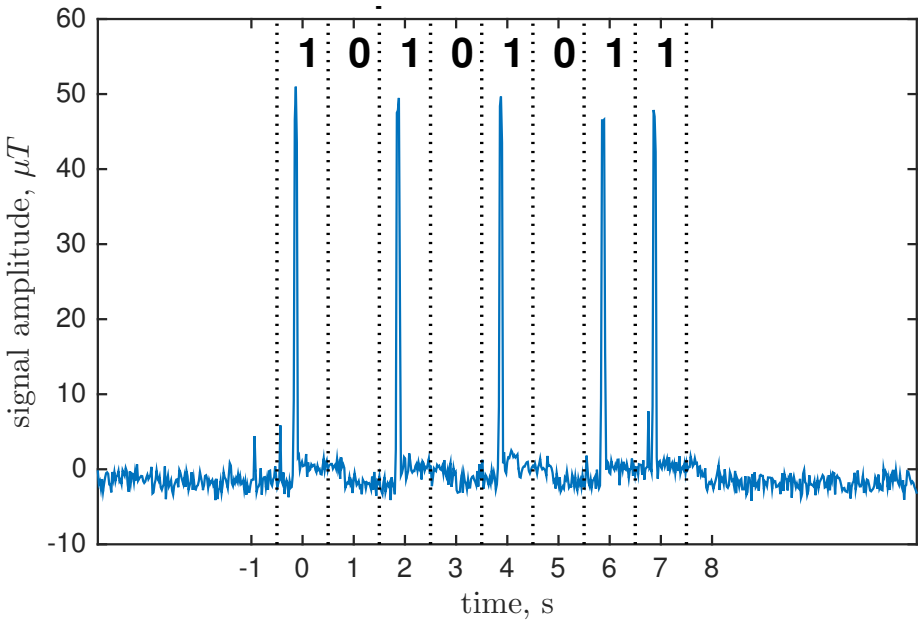
Emit a single peak for ‘1’,

no activity for ‘0’

Receiver:

Cross-correlation with

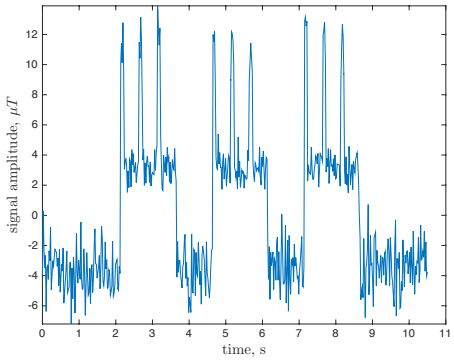
predefined patterns



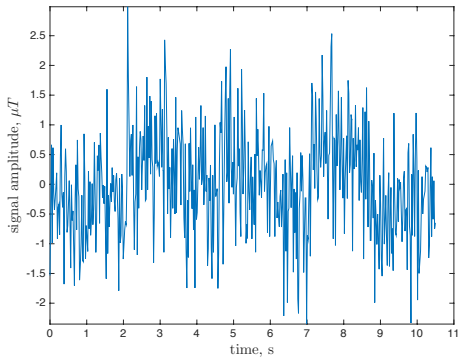
Amplitude modulation example

Amplitude modulation: limitations

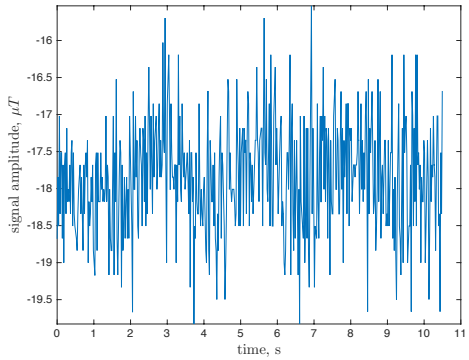
- **Signal fading** (theoretically $B \propto \frac{1}{d^2}$)



~3cm



~16cm



~20cm

- **Shape of peaks depends on**
  - hardware
  - distance → We still expect disturbance of the field
  - interference

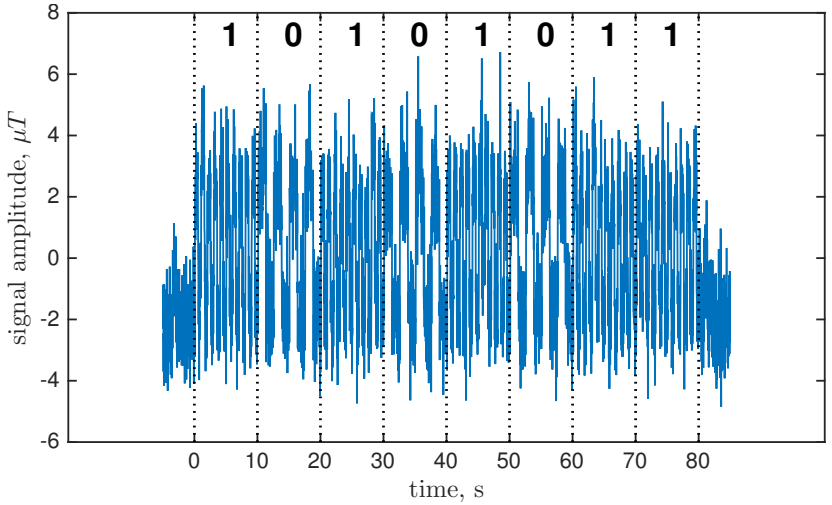
Periodic-based modulation

Transmitter:

Periodically emit consecutive peaks followed by pause, with two different frequencies

Receiver:

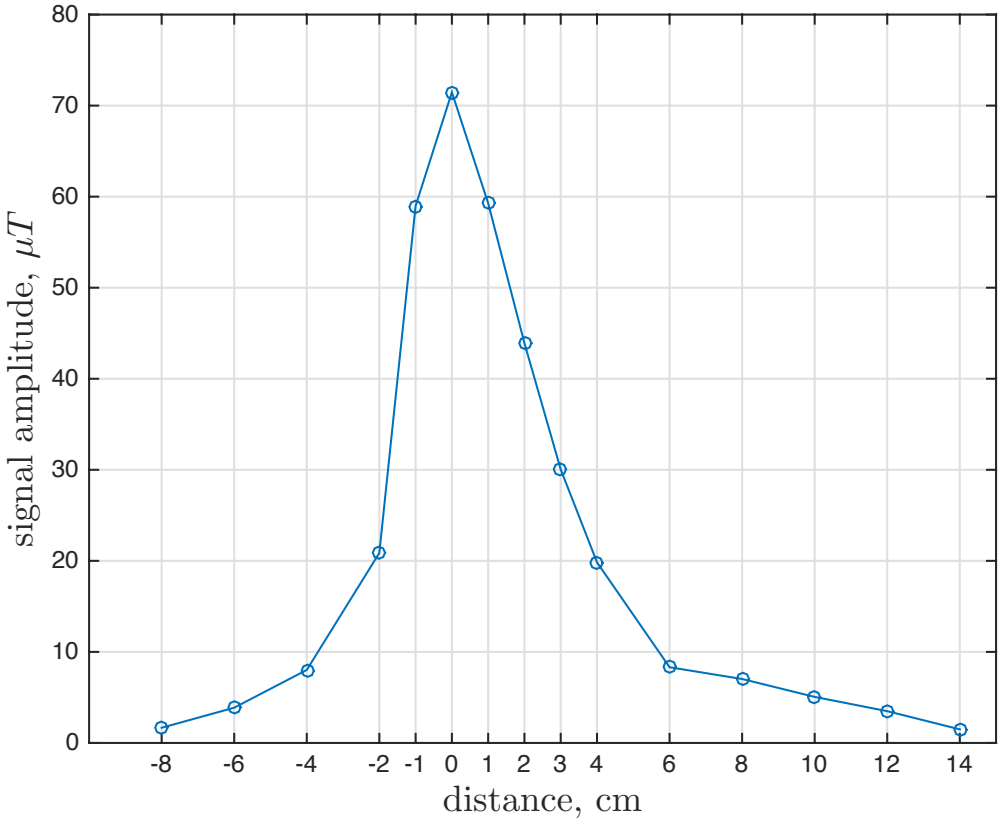
Perform the FFT, detect peaks and choose the corresponding peak frequency



Periodic-based modulation example

Results: signal fading

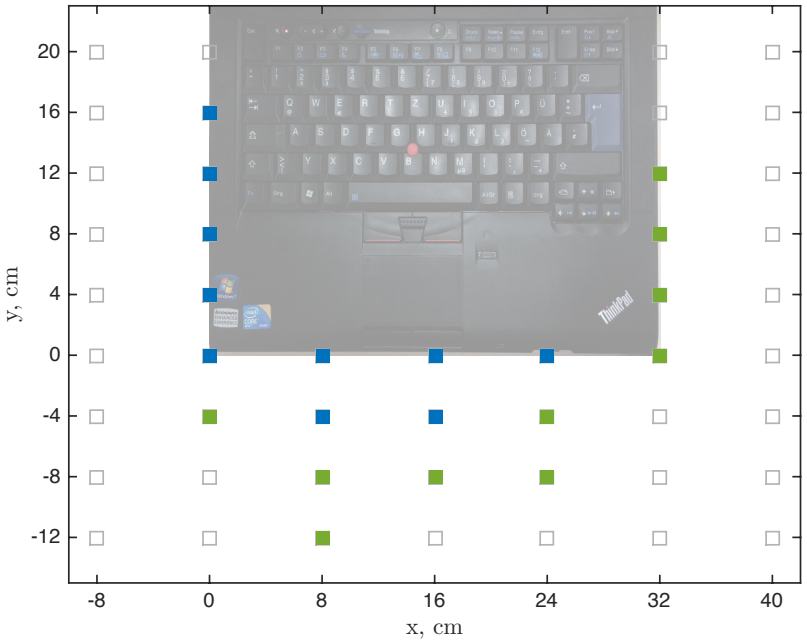
Amplitude of the signal depending on the distance from the source



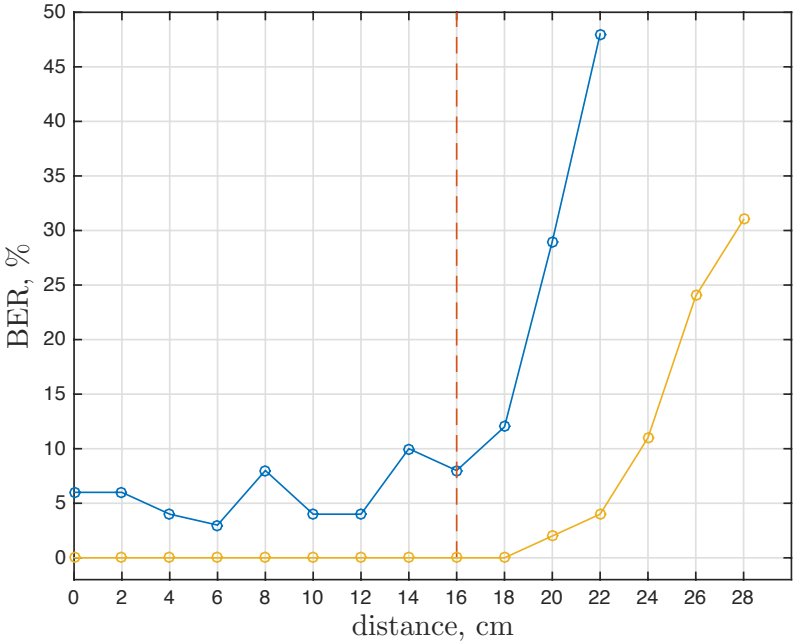
Signal fades conforming to $B \propto \frac{1}{d^2}$ and becomes comparable to noise at the distance of 14cm

Results: transmission distance

Presence of the signal



BER depending on the distance



Using periodic-based modulation, a signal is successfully decoded in the area up to 12cm in front of the laptop

Summary

- A new covert channel is presented
- Dedicated hardware or explicit permissions are not required
- Transmission distance is up to 12cm
- Protection against covert channels is necessary

Thank you!

Countermeasures

1. **Hardware level:** shield electronic components

2. **Software level:** limit access to magnetic sensors data

3. **OS level:** generate random I/O operations on a target system

References

[1] Callan, et al. "A practical methodology for measuring the side-channel signal available to the attacker for instruction-level events." *Proceedings of the 47th Annual IEEE/ACM International Symposium on Microarchitecture*. 2014.

[2] Guri, Mordechai, et al. "GSMem: data exfiltration from air-gapped computers over GSM frequencies." *24th USENIX Security Symposium*. 2015.

[3] M. Hanspach and M. Goetz. Recent developments in covert acoustical communications. In Sicherheit, pages 243–254, 2014.

[4] Deshotels, Luke. "Inaudible sound as a covert channel in mobile devices." *Proc. 8th USENIX Conf. Offensive Technologies*. 2014.

[5] Guri M. et al. BitWhisper: Covert Signalling Channel between Air-Gapped Computers using Thermal Manipulations //arXiv preprint arXiv:1503.07919. – 2015.