Security Risks posed by Temperature Measurements in Mobile Platforms

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ETHZ

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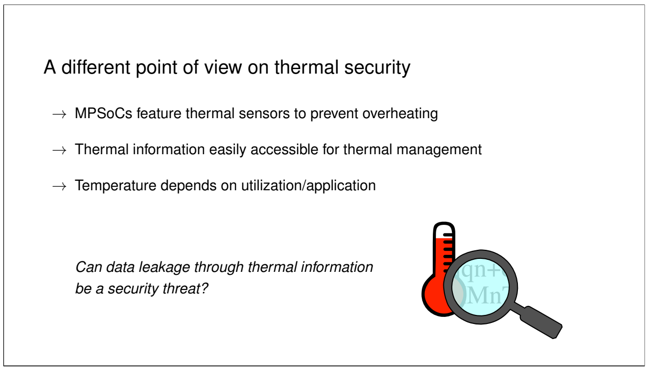
SAFURE

SAFety and secURity by dEsign for interconnected mixed-critical cyber-physical systems



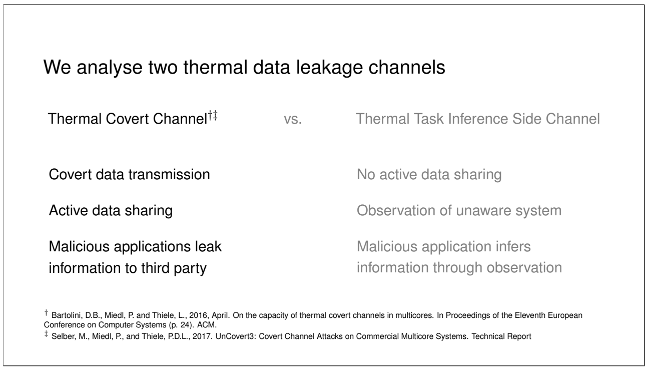
A different point of view on thermal security

→ MPSoCs feature thermal sensors to prevent overheating

→ Thermal information easily accessible for thermal management

→ Temperature depends on utilization/application

Can data leakage through thermal information be a security threat?



We analyse two thermal data leakage channels

Thermal Covert Channel[†‡]	vs.	Thermal Task Inference Side Channel
Covert data transmission		No active data sharing
Active data sharing		Observation of unaware system
Malicious applications leak information to third party		Malicious application infers information through observation

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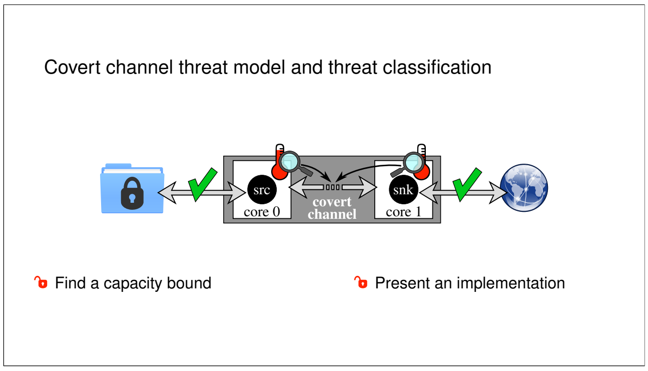
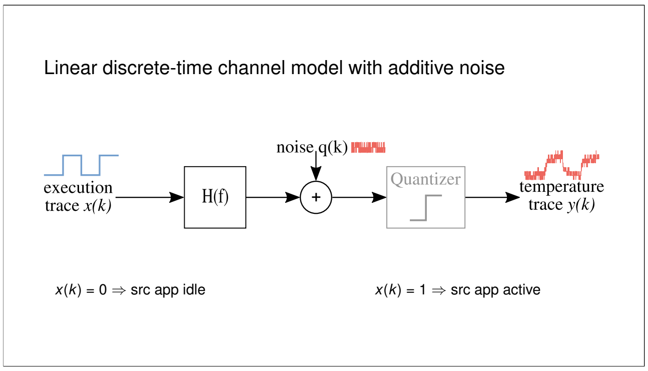


Covert channel threat model and threat classification

Find a capacity bound

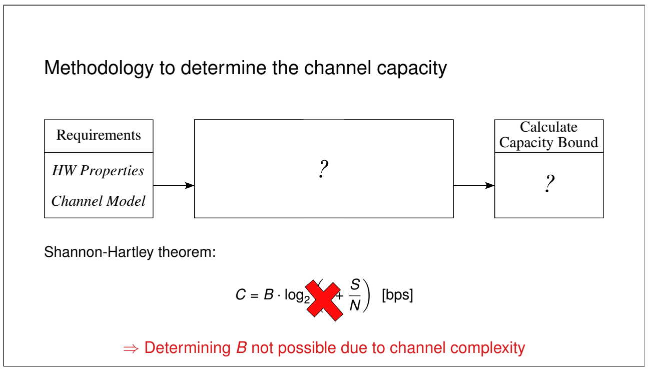
Present an implementation



Linear discrete-time channel model with additive noise

$x(k) = 0 \Rightarrow$ src app idle

$x(k) = 1 \Rightarrow$ src app active

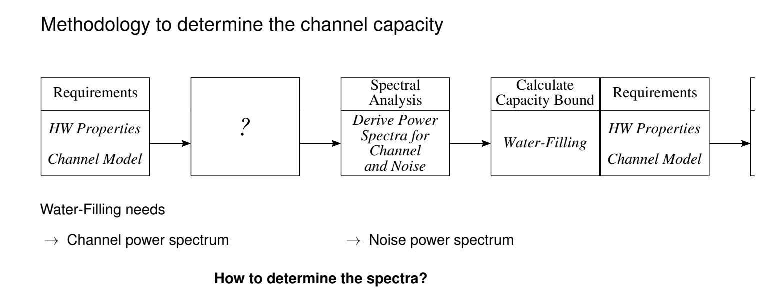


Methodology to determine the channel capacity

Shannon-Hartley theorem:

$$C = B \cdot \log_2 \cancel{\Big(1 +} \frac{S}{N}\Big) \text{ [bps]}$$

⇒ Determining *B* not possible due to channel complexity



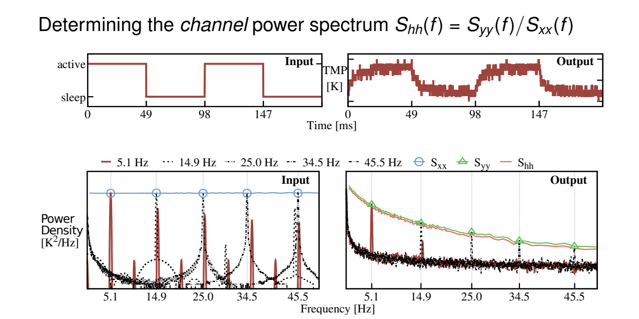
Methodology to determine the channel capacity

Water-Filling needs

→ Channel power spectrum

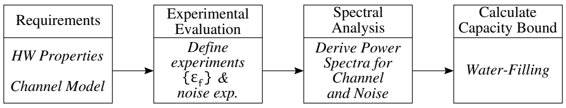
→ Noise power spectrum

How to determine the spectra?



Determining the *channel* power spectrum $S_{hh}(f) = S_{yy}(f)/S_{xx}(f)$

Methodology to determine the channel capacity



Estimation of the noise power spectrum

- Only needs one experiment
- Is not input dependent

Ability to determine capacity of complex covert channel

Experimental evaluation on two distinct platforms...

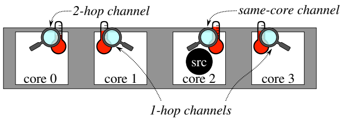
→ Odroid XU-3 representative of smartphones

→ Lenovo T440s representative of business laptops

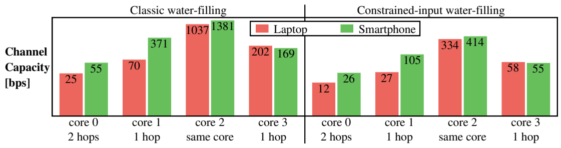
...under controlled conditions

- ✓ Core pinning
- ✓ Real time scheduling
- ✓ Limited wakeup latency
- ✓ Maximum fan speed
- ✓ Fixed operating frequency
- ✓ Ambient temperature ≈ 23 °C

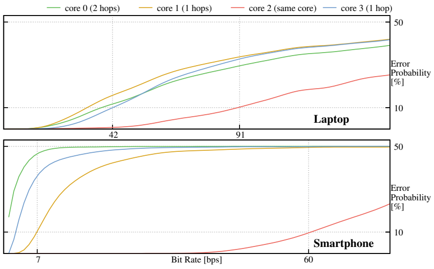
Assumption of linear core-alignment



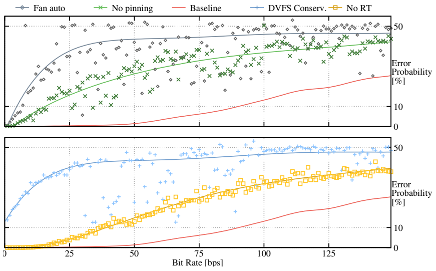
Capacity estimation ⇒ Thermal covert channel is security threat



Experimental evaluation shows feasibility of channel



High influence of external factors on channel performance



Leaked data 13′432 bits from a virtual machine under realistic conditions

Laptop with native Ubuntu and Ubuntu in a VirtualBox

System idle but no controlled environment

Advanced data encoding

Leaked information included a private SSH Key

Application Level Throughput (Goodput) of 1.358 bps

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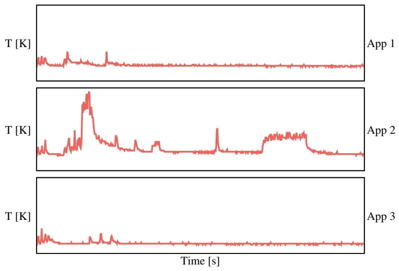
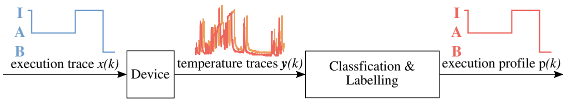
Different applications cause different thermal patterns



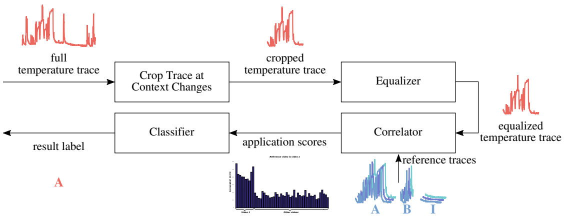
Basic concept thermal task inference side channel


I
A
B
execution trace $x(k)$
Device
temperature traces $y(k)$
Classfication & Labelling
I
A
B
execution profile $p(k)$

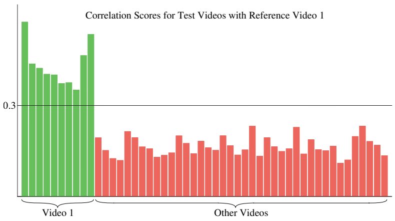
Possible outcomes:

- Allow advanced platform/user profiling
- New attack vector for side channel attacks

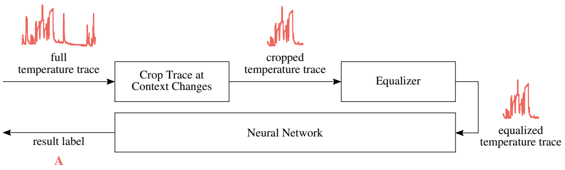
Feasibility study for thermal task inference using correlation on a Dragonboard 810


full temperature trace
Crop Trace at Context Changes
cropped temperature trace
Equalizer
equalized temperature trace
Correlator
reference traces
A
B
I
application scores
Classifier
result label
A

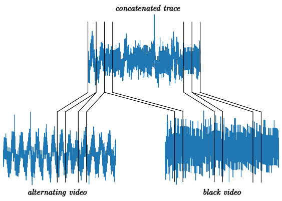
Thermal task inference using correlation with videos is feasible



Feasibility study for thermal task inference using neural networks


full temperature trace
Crop Trace at Context Changes
cropped temperature trace
Equalizer
equalized temperature trace
Neural Network
result label
A

Feasibility study using simple neural networks and augmented thermal data from Dragonboard 810



Simple neural networks work for augmented data but show weaknesses

Very simple dataset

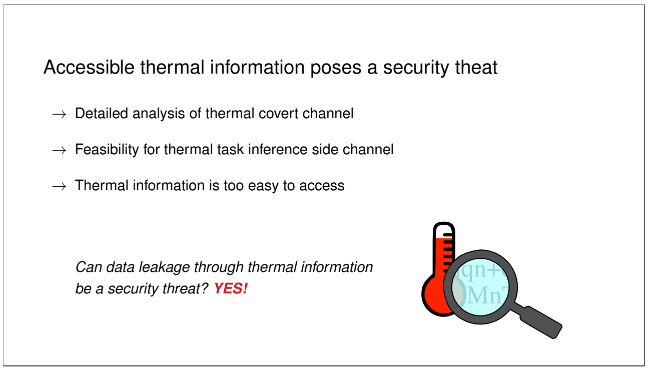
Very simple networks using LSTM (recurrent neural networks) or dense layers

Trace classification possible ⇒ Feasibility proven

Exponential growth for number of parameters & training time

Many open questions on thermal task inference

- Does it work for applications instead of videos?
- What are thermal features and thermal patterns?
- Are there relevant statistical measures?
- Can we use the temporal connection between features?
- Can we apply advanced machine learning techniques?



Accessible thermal information poses a security theat

→ Detailed analysis of thermal covert channel

→ Feasibility for thermal task inference side channel

→ Thermal information is too easy to access

Can data leakage through thermal information be a security threat? ***YES!***

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