Hiding Privacy Leaks in Android Applications Using Low-Attention Raising Covert Channels

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Introduction

Privacy protection is one of the hot topics for smartphones:

- Private data comprises:
  - phone identifiers (IMEI)
  - contacts, phone numbers (MSISDN)
  - sms content
  - files, passwords, ...
- Data leakages enable to:
  - Sell collected information
  - Blackmail a user
  - Attack other targets using the collected information
- Malware can use the phone's capabilities (e.g., send SMS)

Outline

Covert Channels

What about security if the malware exploits covert channels?

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Covert channels are channels that:

- are unforeseen by a system's design
- exploit application/OS/hardware capabilities
- ... in order to break a security policy
- escape classical detection solutions
- can be optimized to keep a low profile

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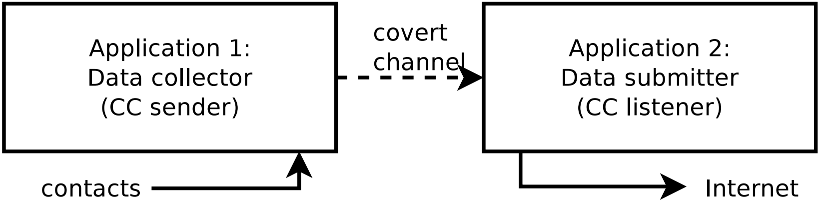
Our goal is to show that:

- covert channels can help to build an unnoticeable malware
- therefore, we improve the covert channel stealthiness

Malware Design

Our proposal, similar to Marforio et al. [?]:



- Data collector: accesses private data
- Data submitter: leaks collected data
- covert channel: local hidden communication path

Scenario: Multiple smart home apps, workout apps, ...

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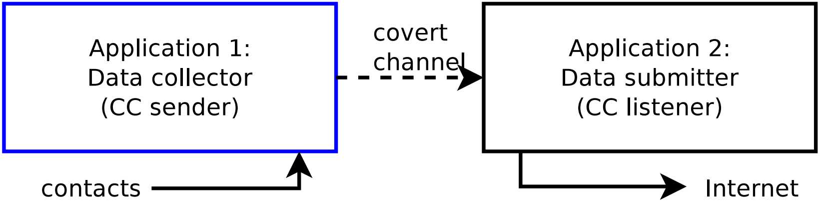

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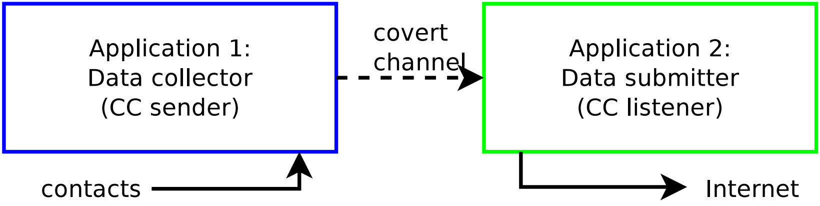

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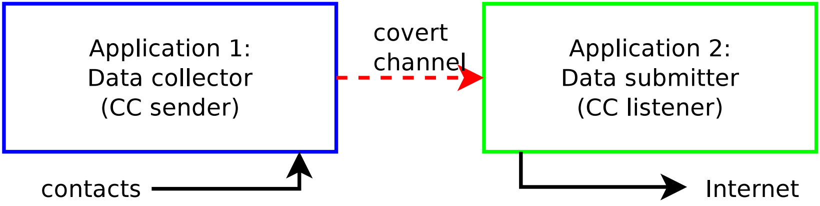

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Advanced Hiding Techniques for Covert Channels

The designed covert channel enables to leak private data and keeps a low profile by:

- minimizing and separating the required permissions
- leaking data correlated with the user interaction
- comprising a low energy footprint

Goal: User should not suspect presence of a malware.

Micro Protocols

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- MPs enable reliable covert channels
- MPs enable adaptive covert channels

We split the covert channel into a separate control channel (simple MP) and a data channel.

Four Different Covert Channels

We developed four covert channels linked to different required permissions:

Covert channel type	Control channel	Data channel	Required permission
CC#1: Task list / screen-based	screen state	task list	GET_TASK
CC#2: Process priorities / screen-based	screen state	process priority	
CC#3: Process priorities		process priority	
CC#4: Pure screen-based		screen based	WAKE_LOCK

Control and data channels of our covert channel techniques.

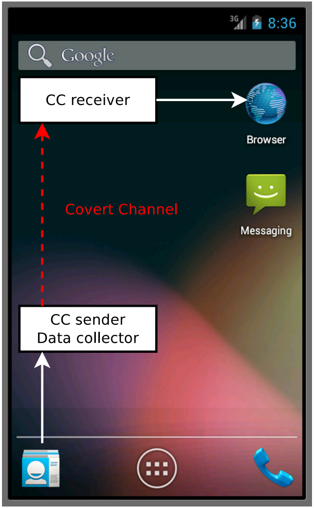
Required permissions (CC#1)

Required permissions

INTERNET

GET_TASKS

READ_CONTACTS

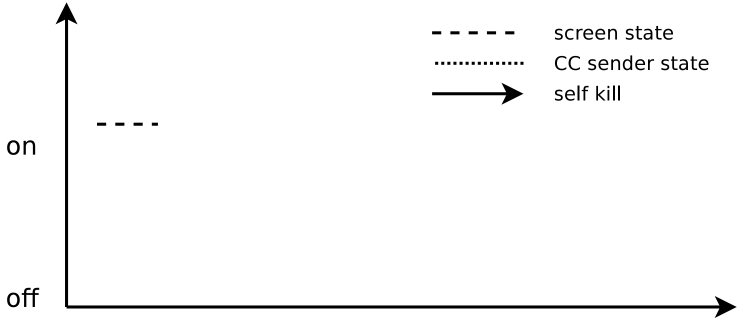


- The user will not suspect each app independently
- Automatic tools will miss the information flow
- How works the CC?

Why GET_TASKS permission is needed?

Example: CC#1 is based on observable screen and task events:

- The screen **turns off** ⇒ starting transmission
- CC sender **is killed**: ⇒ ending transmission (GET_TASKS)



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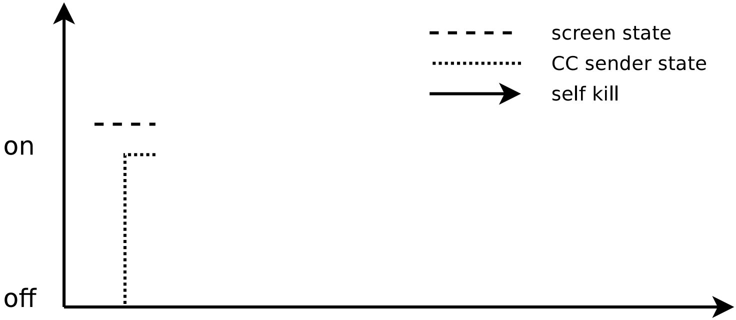

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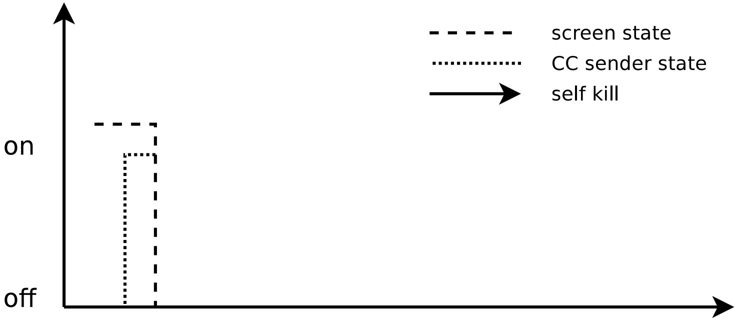

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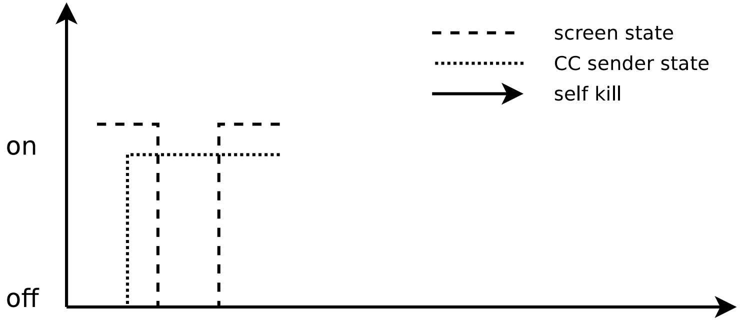

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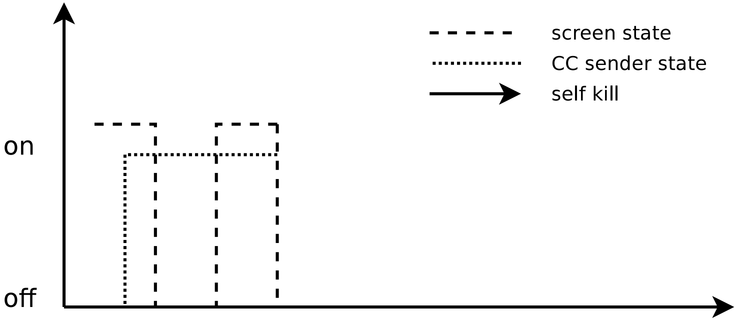

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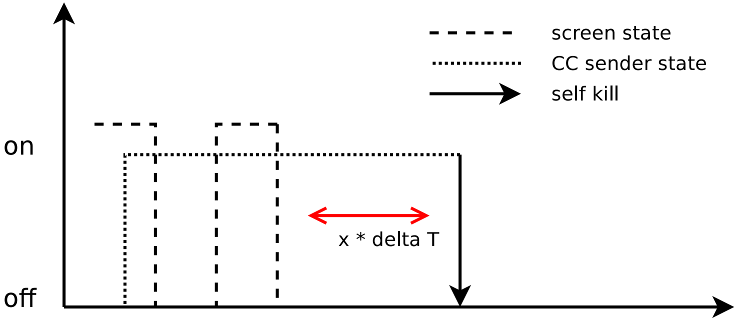

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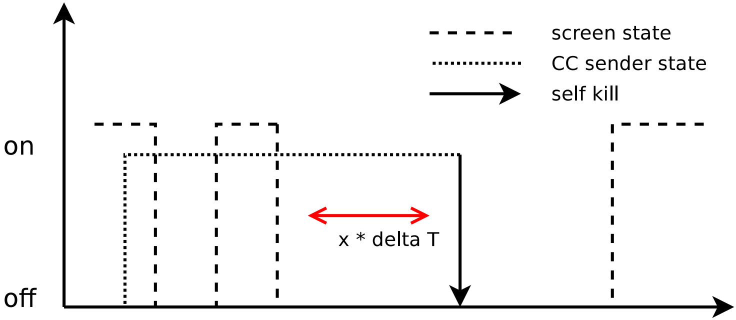


Eliminating the requirement for GET_TASKS

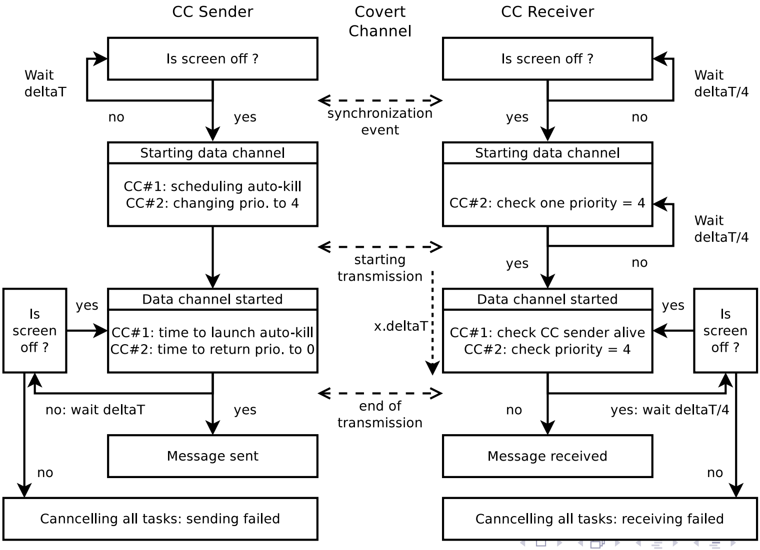
Synchronization realized like in case of CC#1 (screen state)

Data transfer based on process priority (receiver needs to scan for the priority) instead of process existence:

- Sender changes its priority to p known by sender and receiver
- Receiver iterates over all process IDs to determine the presence of a process with priority p (error-prone!)

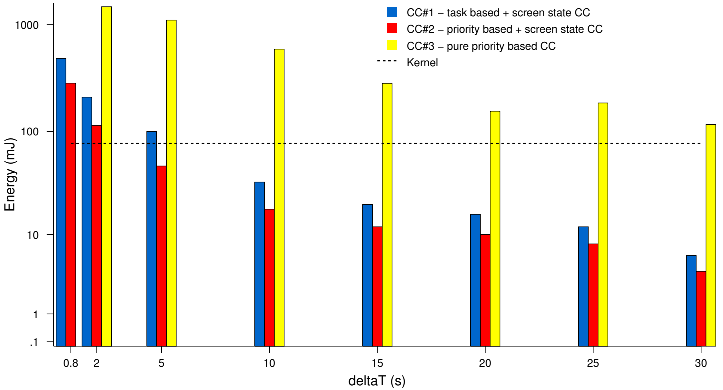
Two variants: With a data channel using the screen state (CC#2) and without data channel (CC#3)

Architecture of CC#1 and CC#2



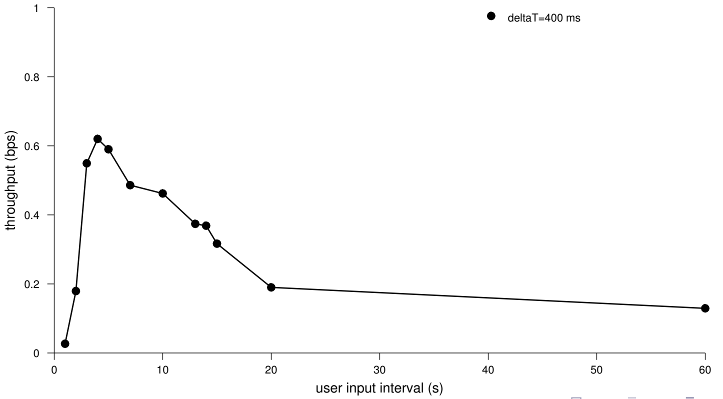
Energy Consumption

Energy consumption of CC#1 and CC#2 during 1 min of transmission (automatic fake user interactions) and of CC#3 during 1 min of runtime (measured using Power Tutor)



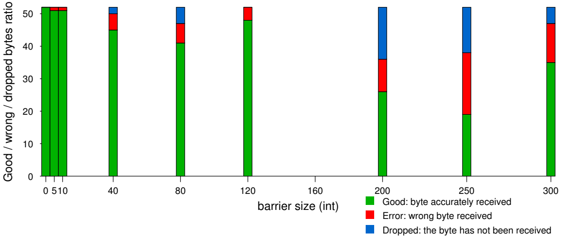
Throughput (Example CC#2)

Interruptions (screen interaction by the user after *n* sec). Low *n* interrupts CC transmission (the screen state changes), high *n* leads to long pause intervals between byte transmissions.



Countermeasures

- Applying the fuzzy time approach
- Applying machine learning
- Introducing barrier values, e.g. $\geq n$ process priority requests/sec
- Introduce errors for process priority requests (CC#3); Fig. shows results for introduced errors (barrier size) per 1000 API requests using solely the process priority:



Conclusion

- Introduced covert channels with a low throughput
- ... but with a high data transmission quality (control channel),
- ... the need for only few privileges,
- ... and a low energy footprint and a behavior correlated to the user's interaction (keeping a low profile)

Future Work

- Utilize multiple covert channels simultaneously
- Therefore: Introduce reliable covert channel protocols (sequence numbers and ARQ)
- Introduce adaptive covert channels (notice blocked communication means dynamically and switch to alternative channels on demand)

Questions

Demonstration Video: `http://www.dailymotion.com/video/x10lcyq_ectcm-2013-hiding-privacy-leaks-in-android-applications_tech`