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Android Anti-Forensics Through a Local Paradigm

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INTRODUCTION

- Mobile phones, are among the most common and diffused current technologies:
  - 2.6 billion of subscribers in the world

- Class of Mobile Phones (NIST):
  1. Basic.
  2. Advanced.
  3. Smart.

- Regarding the forensic environment, a very large amount of personal information is stored into advanced/smartphones

STATE OF THE ART

- Mobile Forensics is still experiencing a number of difficulties and problems (mainly due to models ethereogeneity jungle and to the unremovable internal memory).

- Anti-Forensics (AF)
  - *"Any attempts to compromise the availability or usefulness of evidence in the forensic process"* (R. Harris – 2004)

- By the study of the AF techniques, a number of useful conclusions and guidelines can be drawn, in order to improve and harden the currently used forensic tools and techniques

KINDS OF ANTI-FORENSICS

1. Destroying Evidence
   - It involves the destruction of evidence, in order to make it unusable during the investigative process.
2. Hiding Evidence
   - It is the act of administrate the evidence in order to decrease, or even nullify, its visibility during the forensics analysis.
3. Eliminating Evidence Sources
   - It is the neutralization of the evidentiary sources.
4. Counterfeiting Evidence
   - It is the creation of a fake version of the evidence (Poisoning).

MOBILE ANTI-FORENSICS

- Classical forensic guidelines and tools, often, are not suitable for Mobile Devices as well.

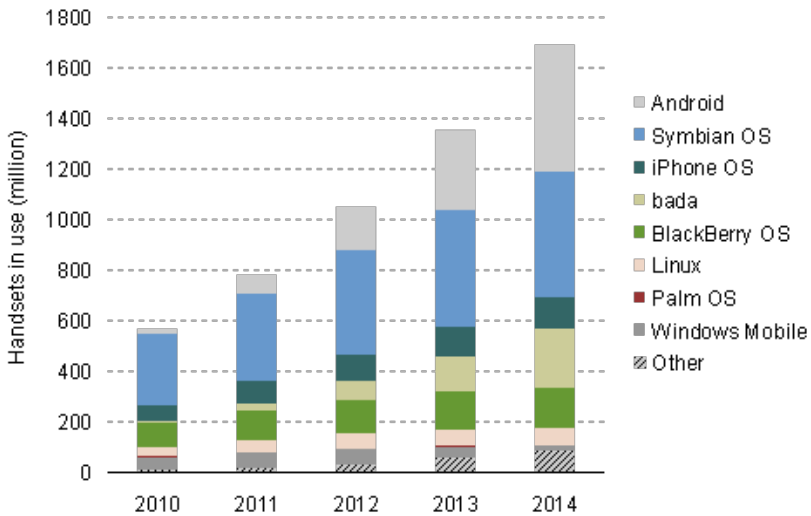
- **Problem**: unavailability of a direct access to the internal memory:
  - In fact, if the removable storage volumes (e.g., memory cards, SIM cards) can be isolated from the device and analyzed with standard procedures, the internal memory volume cannot.
  - The internal memory seems to be an ideal candidate in order to apply some AF techniques.

- However, as for any other commercial forensic tool, concerns on the tool behavior arise

ANDROID OS

- Android is a set of open source software elements specifically designed for Mobile Devices, it includes:
  1. Operating System (OS).
  2. Middleware.
  3. Set of native application.

Smartphone handsets in use, by OS, 2010–2014 [Source: Analysys Mason, 2010]



Top Smartphone Platforms 3 Month Avg. Ending May 2010 vs. 3 Month Avg. Ending Feb. 2010 Total U.S. Age 13+ Source: comScore MobiLens			
	Share (%) of Smartphone Subscribers		
	Feb-10	May-10	Point Change
Total Smartphone Subscribers	*100.0%*	*100.0%*	*N/A*
RIM	42.1%	41.7%	-0.4
Apple*	25.4%	24.4%	-1.0
Microsoft	15.1%	13.2%	-1.9
Google	9.0%	13.0%	4.0
Palm	5.4%	4.8%	-0.6

• Analysis Mason Forecasts confirms that the 2014 market share taken by Android will be approximately of 1.7 billion devices

ANDROID OS: OVERVIEW

- Android Architecture is composed by five major components:
  1. Applications.
  2. Application Framework.
  3. Libraries.
  4. Android Runtime.
  5. Linux Kernel.

- Android File System:
  - Natively supported YAFFS2.
  - Designed for NAND Flash chips.

ANDROID SECURITY ARCHITECTURE

- Multi-process platform which relies on the standard Linux facilities:
  - Security between applications is enforced at process level.

- Application & Sandboxes:
  - Android denies to any application the capability to perform operations with the objective to hamper any other application, the OS or the end-user.

- User Ids & Permissions:
  - Android manages every installed application as a different Linux user.
  - The applications have to export their service to the Manifest files,
    It's the only way to guarantee the communication between us.

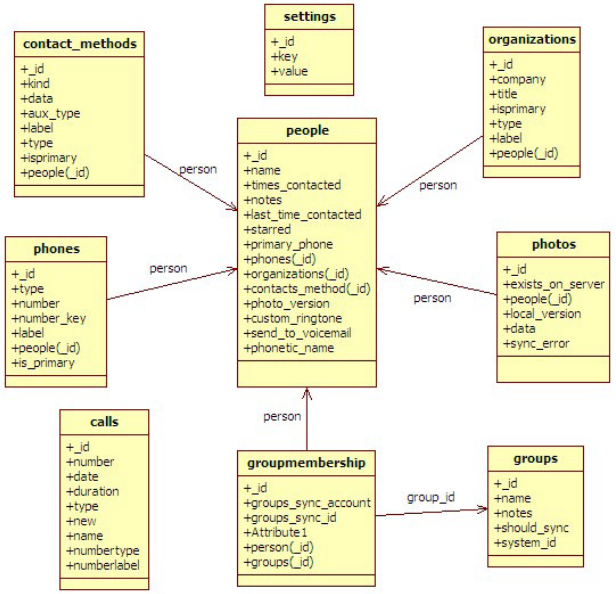
ANDROID ANTI-FORENSICS

- Three main concepts behind the work:
  1. Exploting Android Features.
  2. A Private Folder.
  3. Anti-Forensics by a Common Application.

- Thanks to the standard Android security features, for a given application it is possible to create a directory that is inaccessible for any other applications:
  - It used to store any kind of information (e.g., text files, multimedia).
  - It's created at install time and remove when the owning application is uninstalled.
  - Easy to figure out how this kind of folders can be exploited in order to perform AF Techniques.
  - Inaccessibility ensure the protection of the stored data.

ANDROID DATABASES

- Android OS store any kind of informations in sqlite3 databases within own application private folder, for example:
  - Contacts are in */data/data/com.android.providers.contacts/databases/contacts.db*
  - *SMS/MMS are in /data/data/com.android.providers.telephony/databases/mmssms.db*
  - *Media Files are in /data/data/com.android.providers.media/databases/external.db*



CONTACT DATABASE

- Any sqlite3 file has a restriction access, to provide application ownership these data;

- To read/write data into databases the applications must specify correct permission in **AndroidManifest.xml**, for example:
  - *android.permission.READ_SMS*
  - *android.permission.WRITE_SMS*

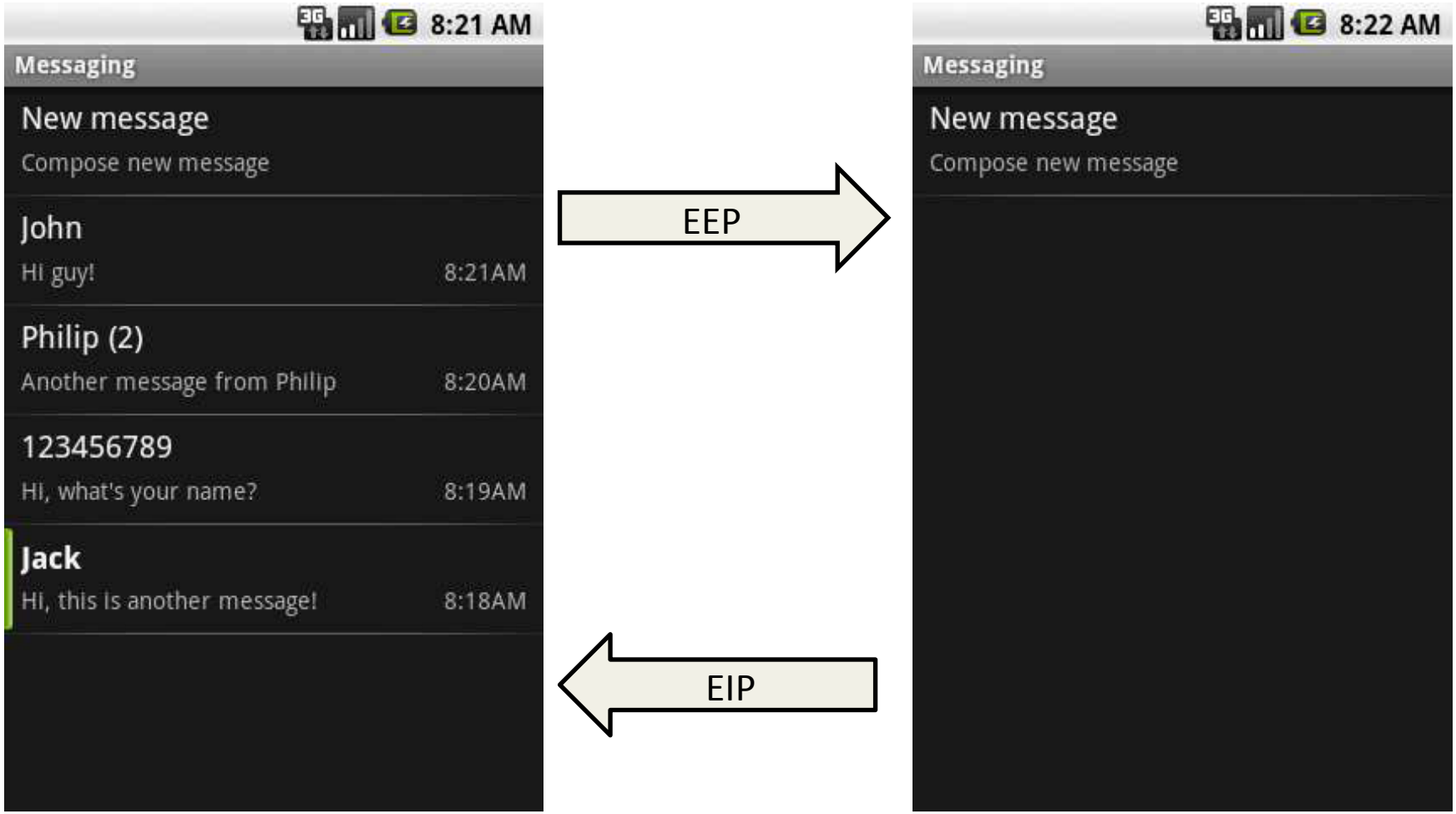
- Android AF analyzes the overall databases structure and execute some Update/Delete queries to apply AF Techniques

ANDROID ANTI-FORENSICS

- Private Folder features:
  - Data will be discovered only if the volume could be isolated.
  - Currently, isolation techniques and physical imaging are hard tasks.
  - It's impedes the cursory examination because infos are invisible to end-user.

- Implement AF as Android Application (AFDroid)
  - At install time, AFDroid creates private folder and it allows execution of two distinct processes:
    1. Evidence Export Process (EEP)
    2. Evidence Import Process (EIP)

ANDROID AF: EEP/EIP PROCESS



EEP: GOAL & FOCUS

- **Goal**: use the AF approach to delete/counterfeit evidence.

- For each technique developed the related feature exploiting the Android Application Framework:
  - *SMS/Call Logs* vs. *Destroying Evidence.*
  - *Contact* vs. *Counterfeiting Evidence.*
  - *Media Files* vs. *Hiding Evidence.*
  - *MMS* vs. *Eliminating Evidence Sources.*

EEP Idea: Producing an `export.xml`
Containing the evidence gathered
by the target Android databases.
It's stored by private directory.

AF-TECHNIQUES ON EEP

- *Android Destroying Evidence:* deleting from the related databases any records which can carry sensitive information:
  - The investigator cannot find any information.

- *Android Hiding Evidence:* moving sensitive media files into the private folder:
  - The multimedia management applications cannot index the data.

- *Android Eliminating Evidence Sources:* it's enough to tamper the mechanism of conversation identifiers:
  - Any related MMS cannot be properly indexed by the system.

- *Android Counterfeiting Evidence: it's enough to change* a flag that states if the contact is among the preferred ones, and the related number of performed interactions:
  - This evidence can lead to a fast identification of strong relations between contacts.

EIP: GOAL & FOCUS

- **Goal**: restore the last state evidence stored inside the device before the EEP process

- Fully automated evidence reconstruction:
  - By Private Folder inspection.
  - XML File processing by SAX-XML Parser.
  - Other file processing.

- Evidence reconstruction and Forensic properties:
  - Automatic process for the reconstruction leverages on the capability of restoring both the generic files and databases contents.
  - EIP is reversible from the perspective of the end-user.

EIP: EXAMPLE

- Capability to restore the previous state of the device reading `export.xml` file

SMS Example

```
<database name='MMSSMS'>
<table name='sms'>
<row>
    <col name='_id'>977</col>
    <col name='thread_id'>15</col>
    <col name='address'>YYYYYYYYYYYY</col>
    <col name='person'>1148</col>
    <col name='date'>1265591133661</col>
    <col name='protocol'>0</col>
    <col name='read'>1</col>
    <col name='status'>-1</col>
    <col name='type'>1</col>
    <col name='reply_path_present'>0</col>
    <col name='subject'>null</col>
    <col name='body'>Text of the message</col>
    <col name='service_center'>XXXXXXXXXXXXX</col>
</row>
</table>
</database>
```

CONTACT Example

```
<database name='CONTACTS'>
<table name='calls'>
<row>
    <col name='_id'>2896</col>
    <col name='number'>YYYYYYYYYYYY</col>
    <col name='date'>1263580272900</col>
    <col name='duration'>288</col>
    <col name='type'>1</col>
    <col name='new'>1</col>
    <col name='name'>NameOfContact</col>
    <col name='numbertype'>2</col>
    <col name='numberlabel'>null</col>
</row>
</table>
</database>
```

EXPERIMENTS

- *Objectives:* test the strength of the selected processes in relation to the tools that are currently able to acquire a snapshot of the internal memory of the target device:
  - the strength of a given process that instantiates some AF techniques is inversely related to the capability to recover the processed evidence.

- *Used Devices:* experiments were performed on most recently smartphone:
  - Samsung Galaxy i7500, 1.6 SDK (*Kernel* 2.6.29, *Build* Donut.XEJC6)
  - HTC Magic 32b, 2.1-update1 SDK (*Kernel* 2.6.34, *Build* EPE54B)

- *Used Acquisition Tools:*
  - MIAT for Android (http://www.miaforensics.org)
  - Nandroid

EXPERIMENTS

- *Experimental Workflows:* formed by two main process
  - Evidence Export Process – EEP
  - Evidence Destruction Process – EDP

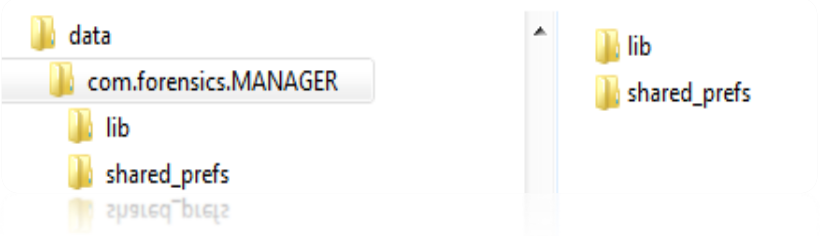
- *Experimental Results:* considered two different kinds of analysis of the target device:
  - *Cursory examination.*
  - *Acquisition & Analysis of the internal memory.*

File	Before	After
com.android.browser/databases/browser.db	58	5
com.android.providers.telephony/databases/mmssms.db	189	48

SIZE DIFFERENCES (KB) BETWEEN THAT FILES THAT STORE THE DATABASE AFFECTED BY THE EEP

EEP – EXPERIMENTS ANALYSIS

- After this task, any cursor examination of the device shows the following situation:
  - *Contacts:* no differences in terms of number of interactions.
  - *SMS/MMS/Call Log*: databases is empty.
  - *Multimedia Gallery*: empty folders.



BEFORE EEP

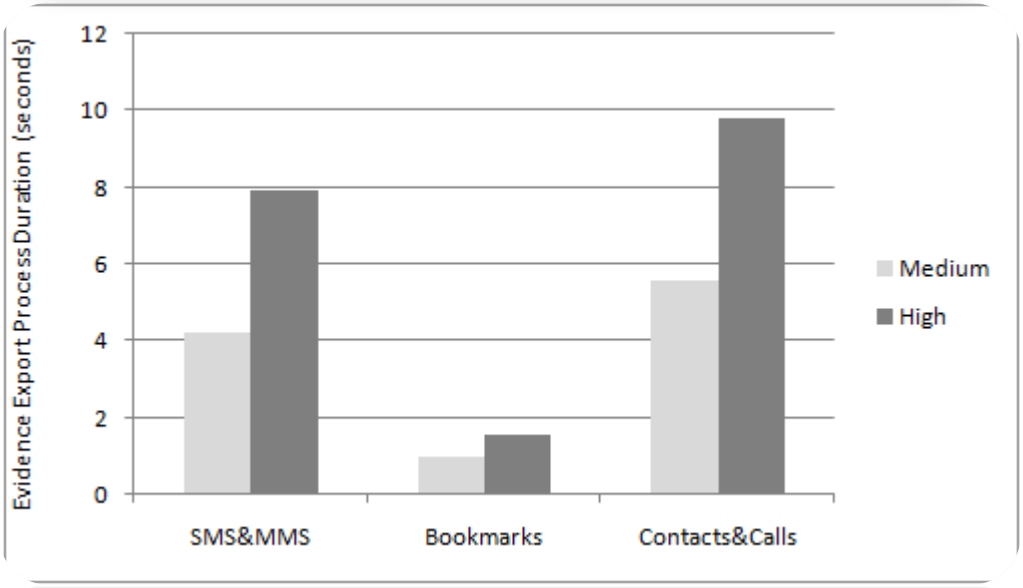
AFTER EEP

- NANDROID Tools: former data can be extracted only with the `unyaffs` tools

EEP – EXPERIMENTS ANALYSIS

- Duration of the process and load which was used.

Load	Contacts & Calls	SMS & MMS	Bookmarks
Medium	120	250	45
High	222	591	93



CONCLUSION

- Classification and application of the Anti-Forensics techniques to Mobile Environment
- Proposed some possible instances have been fully automated by AFDroid
- Designed and performed experiments proving the AFDroid features

FUTURE WORK

- Improving AFDroid application that has been developed:
  - …to notice the capability to selectively choose the target evidence.
- Instantiating Anti-Forensics to other operating systems:
  - Windows Mobile, Symbian, etc…