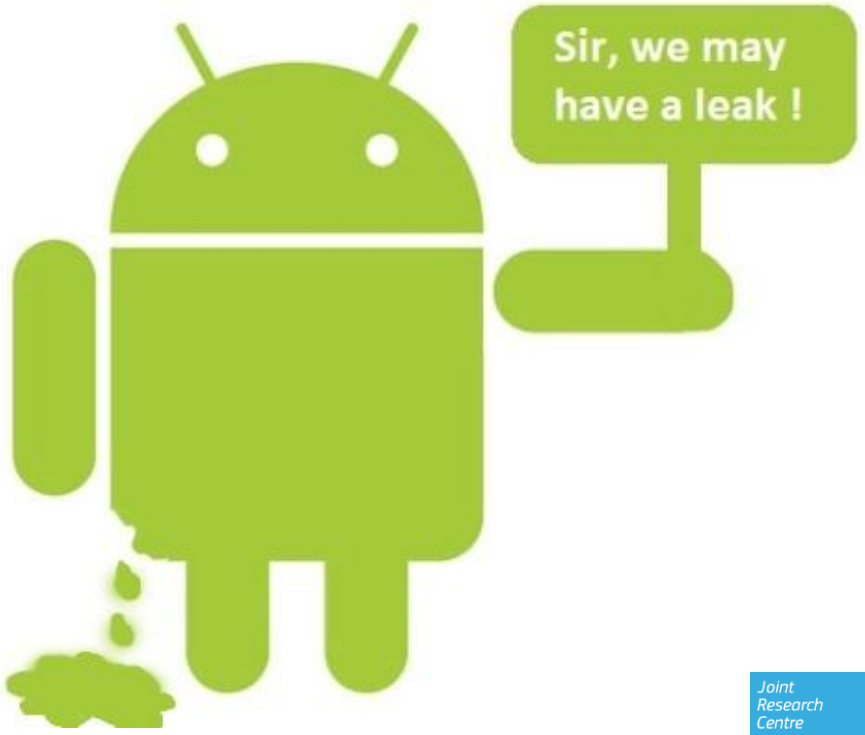
European Commission

Applications' Credentials Harvesting from Android Memory

Pasquale Stirparo



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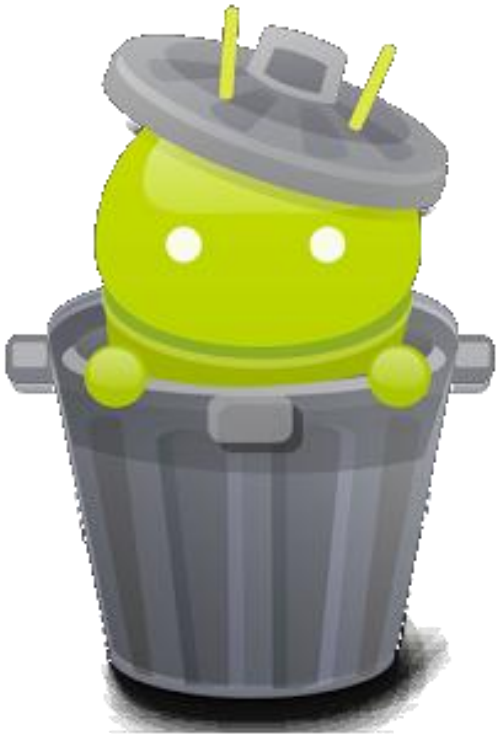
- **Pasquale Stirparo**
  - Digital Forensics and Mobile Security Researcher at Joint Research Centre (JRC) – European Commission
  - Ph.D. candidate at KTH – Royal Institute of Technology, Stockholm

- Research Interests
  - Security and Privacy issues of **mobile communication protocols**
  - **Mobile Malware/Botnets**
  - **Digital Forensics**

- Background and previous experiences
  - Certified GCFA, OPST, OWSE, ECCE
  - Previously working as Pen-Tester and Digital Forensics Engineer

Android Memory Management

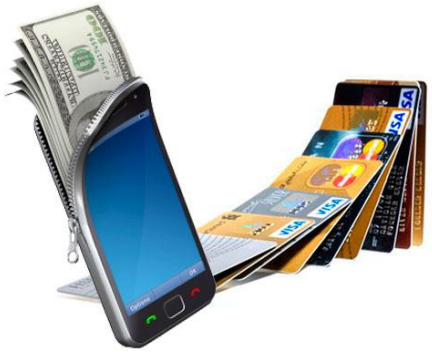
- Every app runs within a separate process, which has its own instance of the Dalvik-VM;
- When app is launched, the "*Zygote*" process is forked and Dalvik heap is preloaded with classes and data by *Zygote*
- Dalvik-VM implements Garbage Collection (GC) on the heap



Apps Analysed

Two Apps categories analysed

- Top downloaded apps
  - 11 of the most popular Android applications
- Mobile Banking apps
  - 15 mobile banking applications



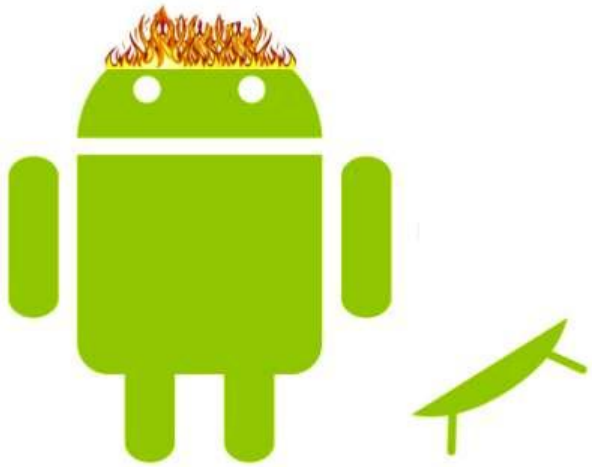
Memory Acquisition...

- Acquisition with Linux Memory Extractor, a.k.a. LiME
  - Loadable Kernel Module
  - It allows full memory captures of linux-based devices, and so Android
  - Needs to be cross-compiled against device kernel source

```
$ adb push lime.ko /sdcard/lime.ko
$ adb forward tcp:4444 tcp:4444
$ adb shell
$ su
# insmod /sdcard/lime.ko "path=tcp:4444
   format=lime"
```

On the destination computer

```
$ nc localhost 4444 > ram-dump.lime
```



… and Analysis

Volatility Framework

- Identify process id (PID) of the target application
  - *linux_pslist*, which gathers active tasks by walking the task struct->task list
- Map the process in the memory to find the heap offset
  - *linux_proc_maps*, which gathers process maps for linux
- Dump the heap
  - *linux_dump_map*, which writes selected memory mappings to disk


```
$ python vol.py --profile=LinuxGolfish-2_6_29x86 -f ebay.lime linux_pslist
```

Offset	Name	Pid	Uid	Gid	DTB	Start Time
0xca969400	**com.ebay.mobile**	**379**	10067	10067	0x0aec8000	2013-03-29 09:22:08

```
$ python vol.py --profile=LinuxGolfish-2_6_29x86 -f ebay.lime linux_proc_maps
    -p 379 | grep heap
```

Pid	Start	End	Flags	Pgoff	Major	Minor	Inode	File Path
379	**0x0000b000**	0x003d1000	rw-	0x0	0	0	0	**[heap]**
379	**0x409b2000**	0x42124000	rw-	0x0	0	7	353	**/dev/ashmem/dalvik-heap**
379	0x42124000	0x449b2000	---	0x1772000	0	7	353	/dev/ashmem/dalvik-heap
379	0x46e02000	0x46e03000	r--	0x0	0	7	368	/dev/ashmem/SurfaceFlinger read-only heap

```
$ python vol.py --profile=LinuxGolfish-2_6_29x86 -f ebay.lime linux_dump_map
    -s 0x0000b000 --dump-dir  /memdump/ebay-heap/
```

Task	VM Start	VM End	Length	Path
379	**0x0000b000**	**0x003d1000**	**0x3c6000**	**/memdump/ebay-heap/task.379.0xb000.vma**

```
$ python vol.py --profile=LinuxGolfish-2_6_29x86 -f ebay.lime linux_dump_map
    -s 0x409b2000 --dump-dir  /memdump/ebay-heap/
```

Task	VM Start	VM End	Length	Path
379	**0x409b2000**	**0x42124000**	**0x1772000**	**/memdump/ebay-heap/task.379.0x409b2000.vma**

How do the findings look like?

Sample with identification labels

```
E3:1F40h: 61 74 61 3B 20 6E 61 6D 65 3D 22 75 73 65 72 6E  ata; name="usern
E3:1F50h: 61 6D 65 22 0D 0A 0D 0A 70 61 6F 6C 69 6E 6F 70  ame"....paolinop
E3:1F60h: 61 70 65 72 69 6E 6F 0D 0A 0D 0A 0D 0A 0D 0A 0D  aperino.........
[...]
E3:1FB0h: 61 3B 20 6E 61 6D 65 3D 22 70 61 73 73 77 6F 72  a; name="passwor
E3:1FC0h: 64 22 0D 0A 0D 0A 70 61 70 65 72 6F 70 6F 6C 69  d"....paperopoli
[...]
```

Data structure without identification labels

```
DD:B680h: 28 39 9B 40 00 00 00 00 1A 00 00 00 00 00 00 00  (9›@............
DD:B690h: 70 00 61 00 6F 00 6C 00 69 00 6E 00 6F 00 70 00  p.a.o.l.i.n.o.p.
DD:B6A0h: 61 00 70 00 65 00 72 00 69 00 6E 00 6F 00 3A 00  a.p.e.r.i.n.o.:.
DD:B6B0h: 70 00 61 00 70 00 65 00 72 00 6F 00 70 00 6F 00  p.a.p.e.r.o.p.o.
DD:B6C0h: 6C 00 69 00 23 00 00 00 B8 30 9B 40              l.i.#...¸0›@
```

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Forensics Implications

- Also **mobile memory analysis can be a goldmine** of useful information such as applications credentials
- Most applications save **credentials preceded by their identification label**
- **Processes still running after exiting the applications for 25 out of 26** applications analysed
- **LiME** it's a kernel module → **low memory footprint**
- **Technique not yet completely mature** from forensics perspective
  - Invasive, requires to root target phone, requires precise kernel source code of the device
- Need for kernel-agnostic module

References

Stirparo P., Nai-Fovino I., Kounelis I., "**Data-in-Use leakages from Android Memory - Test and Analysis**"; *9th IEEE International Conference on Wireless and Mobile Computing, Networking and Communications (WiMob)*, 2013.

J. Sylve, A. Case, L. Marziale, and G. G. Richard, "**Acquisition and analysis of volatile memory from android devices**," *Journal of Digital Investigation*, vol. 8, no. 3, pp. 175–184, 2012.

J. Sylve, "**Dalvik Inspector**", BlackHat USA Arsenal 2013.

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