QEMU emulation detection

thuxnder

Chaos Computer Club Cologne e.V.
http://koeln.ccc.de

Köln
29.01.2015

Content

- QEMU
- Emulator detection
- Emulation detection
  - Binary translation engine
  - Cache behavior

QEMU

"QEMU is a generic and open source machine emulator and virtualizer."

- several architectures (x86, ARM, ppc, ...)
- different backends (binary translation, KVM)
- used for dynamic analysis systems

- Android emulator included in SDK
- dynamic Android app analysis

Motivation

Why do we want to detect ...

- malware wants to hide malicious behavior
- defeat dynamic analysis (hide IP, ...)
- academic research
- fun to look under the hood

context

We will focus on the **Android**/**ARM** use case,
but it is also applicable to other use cases and architectures.

Emulator detection

Use your favorite search engine :-/
We are not going into details, because most do simple pattern matching.

- Hardware specific values (CPU, graphic card, ...)
- OS specific values

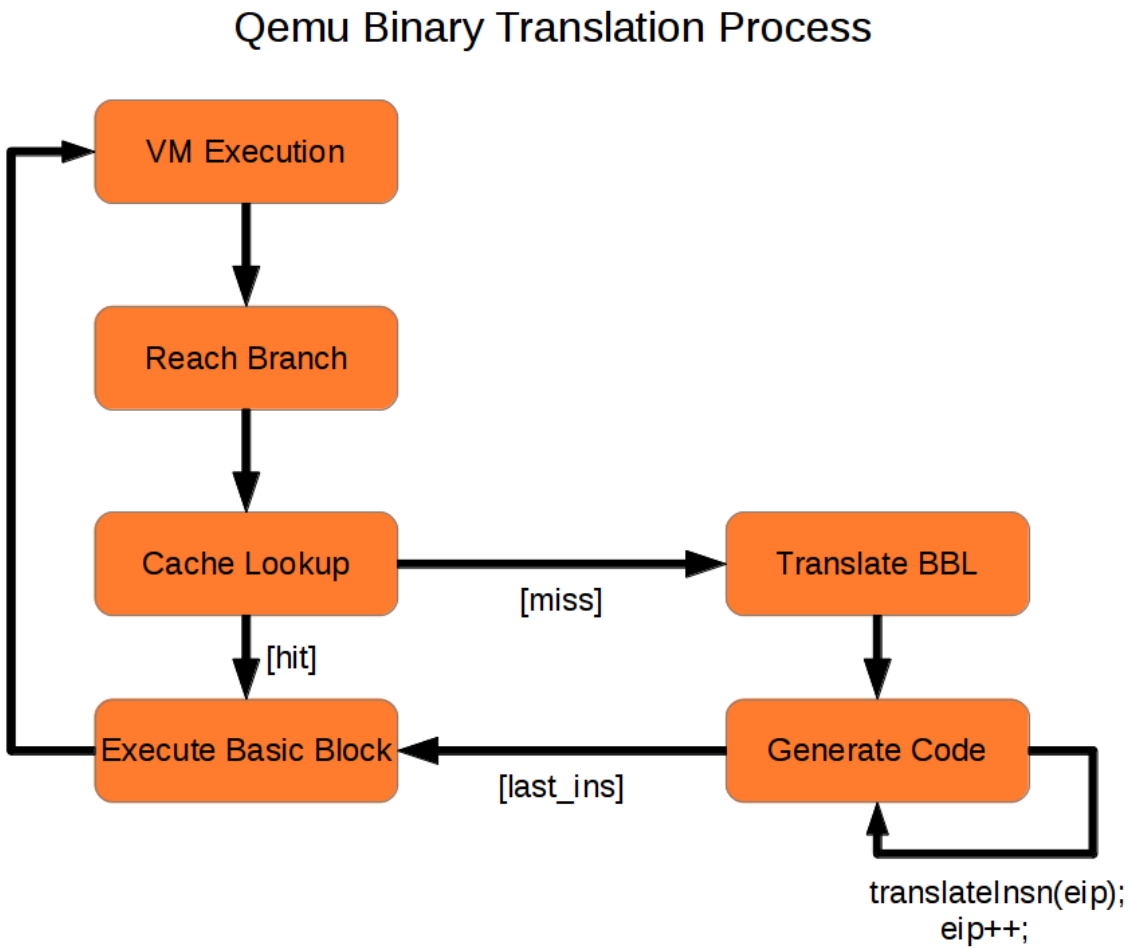
Emulation detection

With the following methods we are going for a more **generic approach** by **not** detecting the **emulator** itself but side effects of the **emulation** engine that is used.

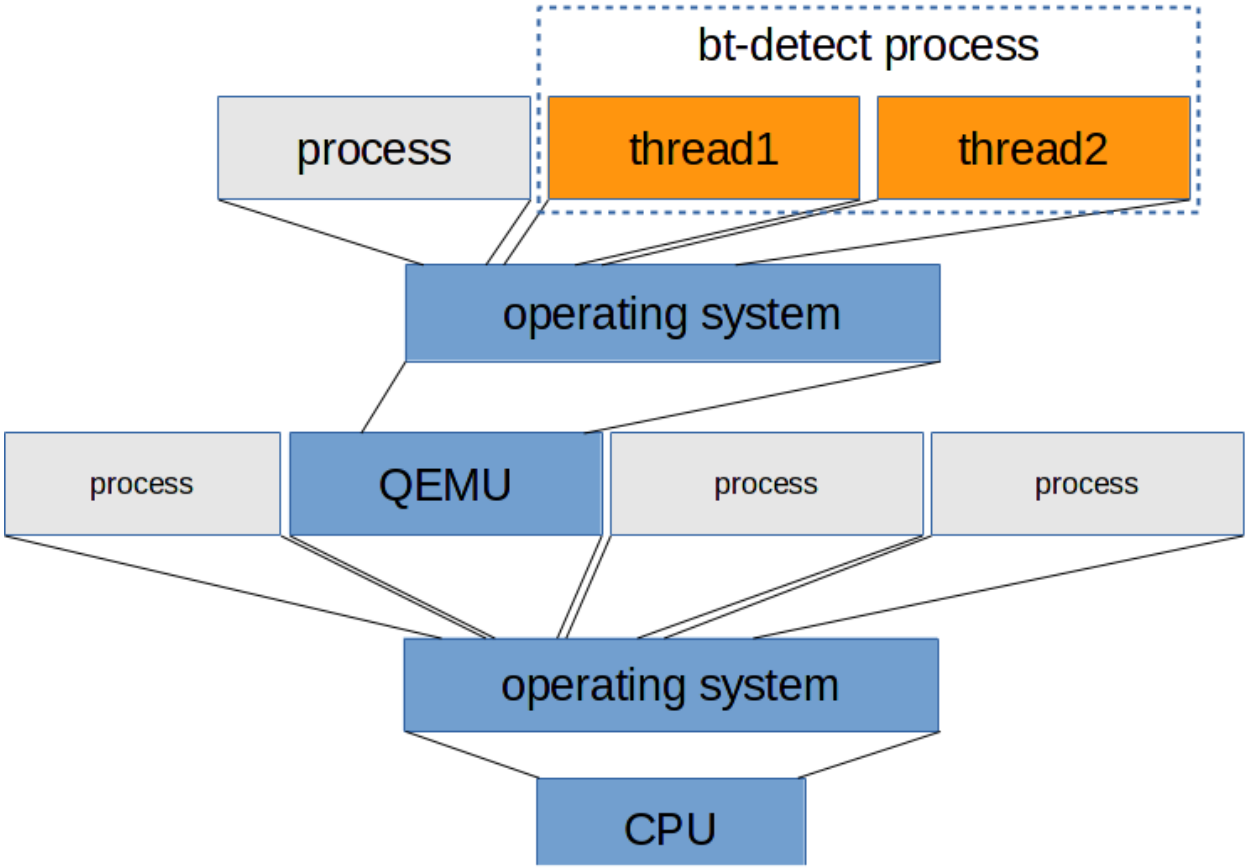
Emulation detection

Qemu uses (in most cases) a **binary tranlsation engine** to support archtitecturs other then the host system. This technique translates instructions to be executed into an equivalent instruction sequence on the host architecture and executes it, including memory address rewriting, etc...

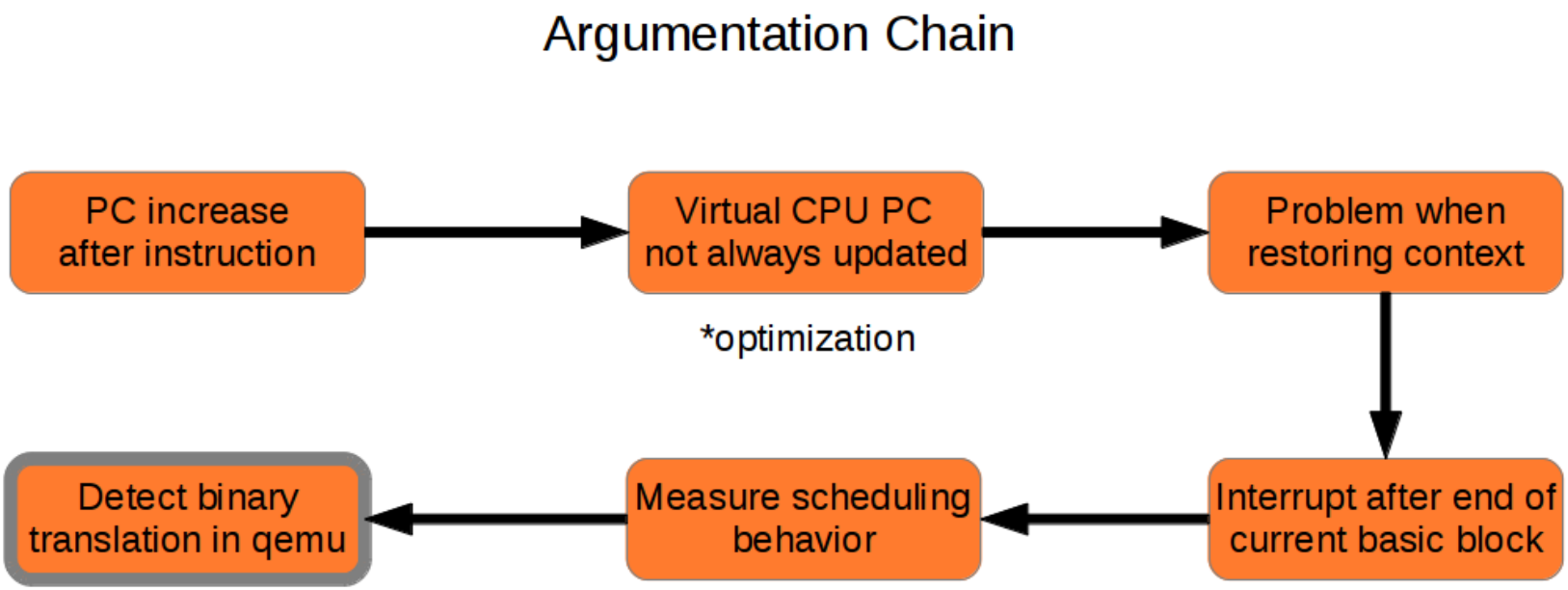
Emulation detection



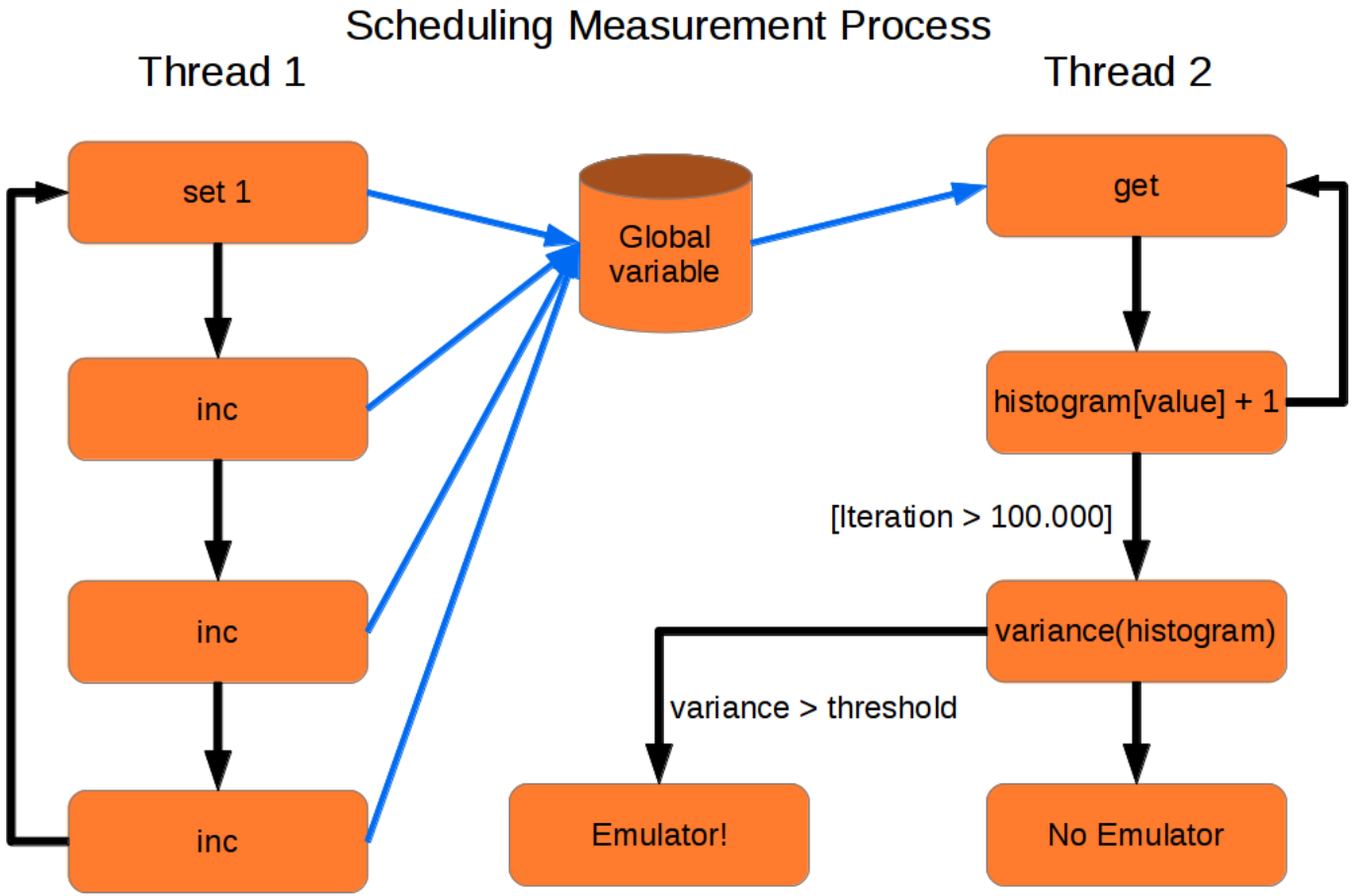
Emulation detection



Emulation detection



Emulation detection



Emulation detection

Source code:

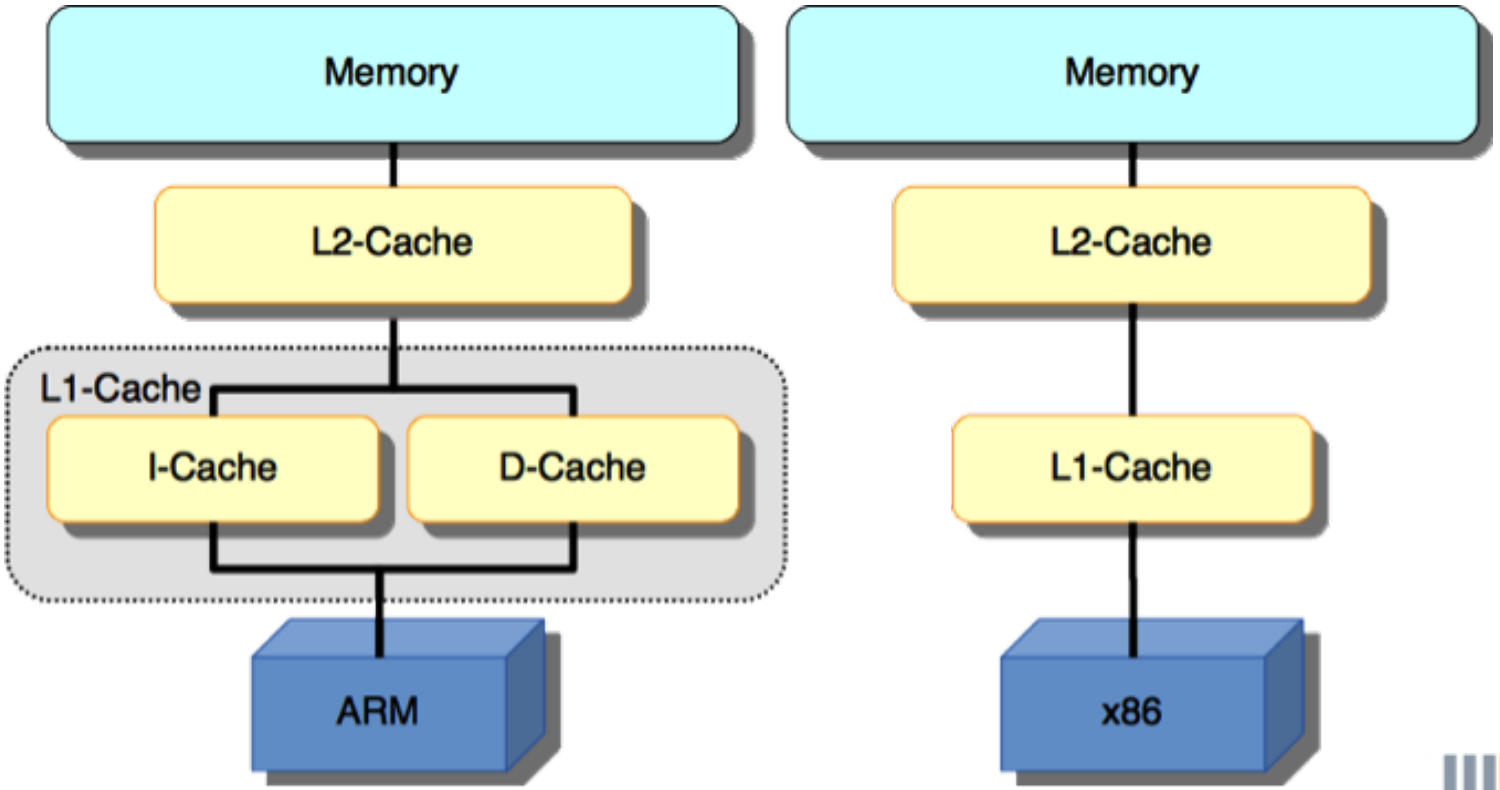
- http://dexlabs.org/files/detect_bt_x86.tar.gz
- http://dexlabs.org/files/detect_bt_amd64.c
- http://dexlabs.org/files/detect_bt_arm.c

Cache behavior on ARM

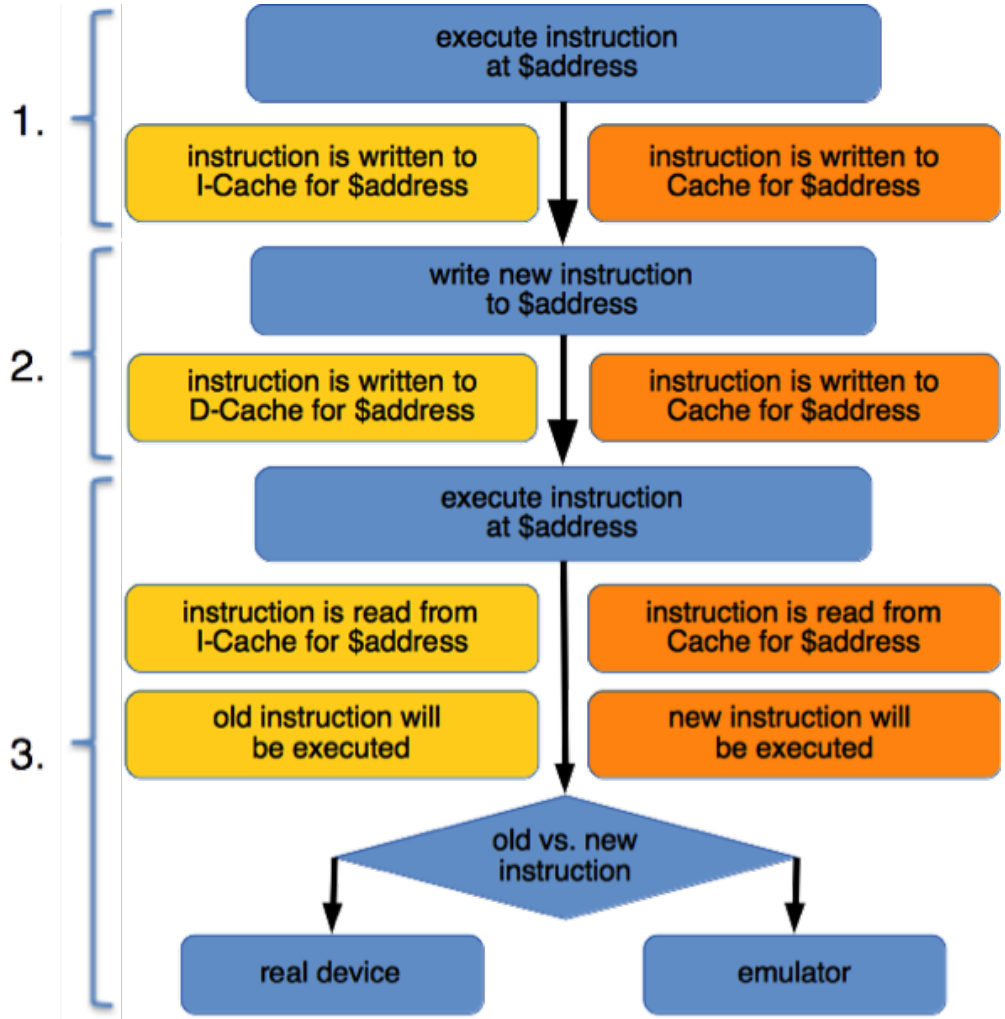
- different than x86
- I-Cache and D-Cache are not synchronized

QEMU does not implement two different caches for instructions and data. This leads to an anomaly that can be detected when comparing native execution and execution in QEMU.

Cache on ARM vs X86



Cache behavior on ARM



Cache behavior - POC

Perparation:

```
#define PROT PROT_EXEC|PROT_WRITE|PROT_READ
#define FLAGS MAP_ANONYMOUS|MAP_FIXED|MAP_SHARED

void *exec = mmap((void*)0x10000000, (size_t) 4096, PROT, FLAGS, -1,(off_t)0);
memcpy(exec, (&eval)-1, 2048);
```

Detection code:

```
mov r0, #0;
ldr r1, =0x467a3080;
code:
add r0, #1;
mov r2, PC;
add r2, #-6;
str r1, [r2];
cmp r0, #1;
BLE  code;
lsr r0,  r0, #7;
```

Questions ?!

References

- http://qemu.org
- http://dexlabs.org/blog/btdetect
- https://bluebox.com/technical/android-emulator-detection-by-observing-low-level-caching-behavior/