R2CON 2020

# Codename: flip.re

Hypervisor-level debugging and beyond

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## The malware landscape

350 000 new malware threats per day *

The challenge: Understanding the threats that matter to you

- Discover the malware threats and actors that can hurt you
- Handle the malware threats that end up causing security incidents

* source: AV-TEST

## Malware analysis challenges

Even analyzing 1‱ (permyriad) of 350 000 would mean 35 per day!

A single threat can easily take 2 weeks to analyze

Sophisticated malware actively evade analysis

## Effective malware analysis

“For me, reverse engineering efficiently has always been about combining dynamic and static techniques”

Dynamic analysis is a lot faster, and almost always useful for deeper analysis

- Get an idea of what the code is doing
- Locate the code you want to analyze further

## Evasive Malware (anti-analysis techniques)

Designed to frustrate reverse engineers by actively making analysis challenging

- Code obfuscation / encryption
- VM/Sandbox detection
- Self-debugging
- Multi-stage code injection

## Current malware sandboxes for analysis use

Often used as an initial (dynamic) analysis

Reports can be useful, but is typically superficial

All fully automated analysis solutions will be vulnerable to evasive malware. Always. It is not possible to fix.

Anti-evasion problem = Halting problem

## The flip.re project

An interactive malware analysis system, combining dynamic and static analysis to

- Analyze advanced threats faster
- Triage threats faster

You need to understand how the malware works
before it’s too late.

And you need a human in the analysis loop.

## The plugin

## IO plugin for r2

Turns r2 into a hypervisor-level debugger

- Debug code running inside a Windows guest from a Linux host
- Enables debugging code in a very sneaky and stealthy way

Conceptually similar to the zdbg plugin (r2con 2017),
but written from scratch in Rust

## Rust

Pros:

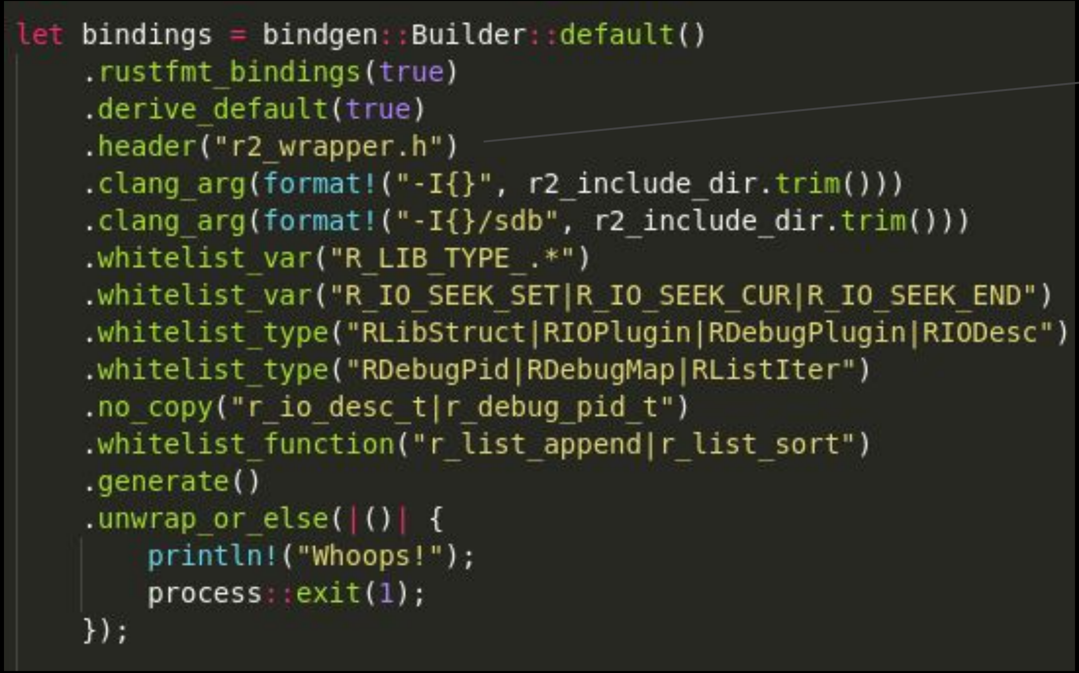
- Amazing language with an excellent modern toolchain
- Great replacement for C as a safer and more reliable systems programming language

Cons:

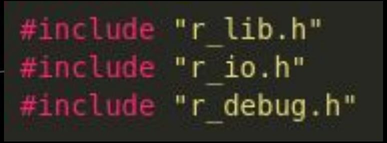
- Compiler can feel overly strict
- Unsafe Rust has a very similar feeling to C
  (type casting, memory management)

## build.rs

Using bindgen, you can generate Rust FFI bindings to use the radare2 C plugin API

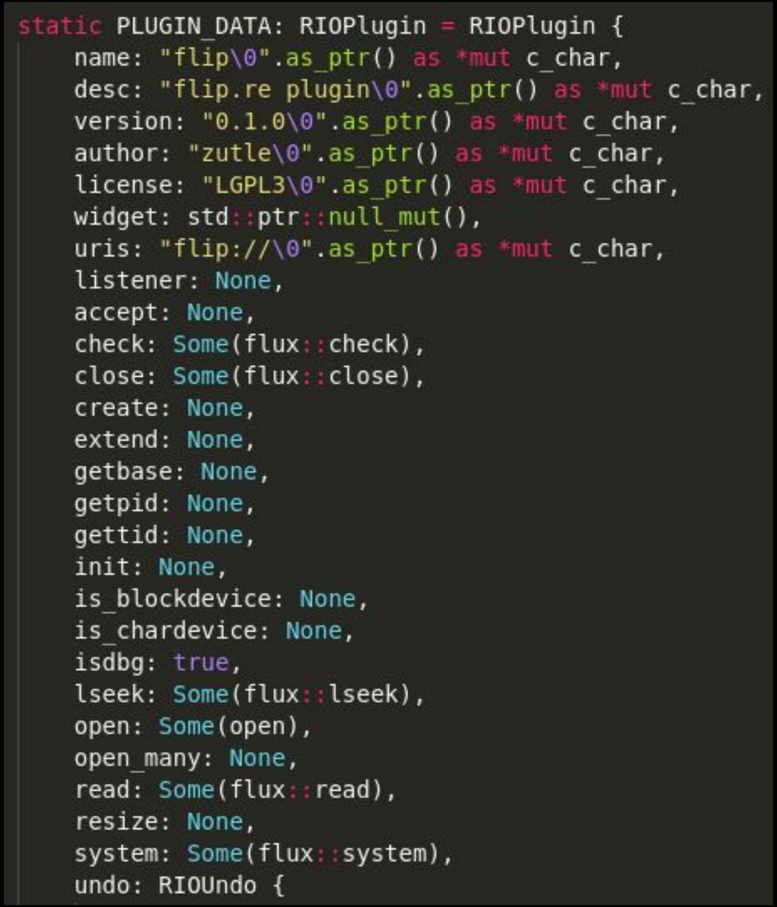


```rust
let bindings = bindgen::Builder::default()
    .rustfmt_bindings(true)
    .derive_default(true)
    .header("r2_wrapper.h")
    .clang_arg(format!("-I{}", r2_include_dir.trim()))
    .clang_arg(format!("-I{}/sdb", r2_include_dir.trim()))
    .whitelist_var("R_LIB_TYPE_.*")
    .whitelist_var("R_IO_SEEK_SET|R_IO_SEEK_CUR|R_IO_SEEK_END")
    .whitelist_type("RLibStruct|RIOPlugin|RDebugPlugin|RIODesc")
    .whitelist_type("RDebugPid|RDebugMap|RListIter")
    .no_copy("r_io_desc_t|r_debug_pid_t")
    .whitelist_function("r_list_append|r_list_sort")
    .generate()
    .unwrap_or_else(|()| {
        println!("Whoops!");
        process::exit(1);
    });
```



```c
#include "r_lib.h"
#include "r_io.h"
#include "r_debug.h"
```

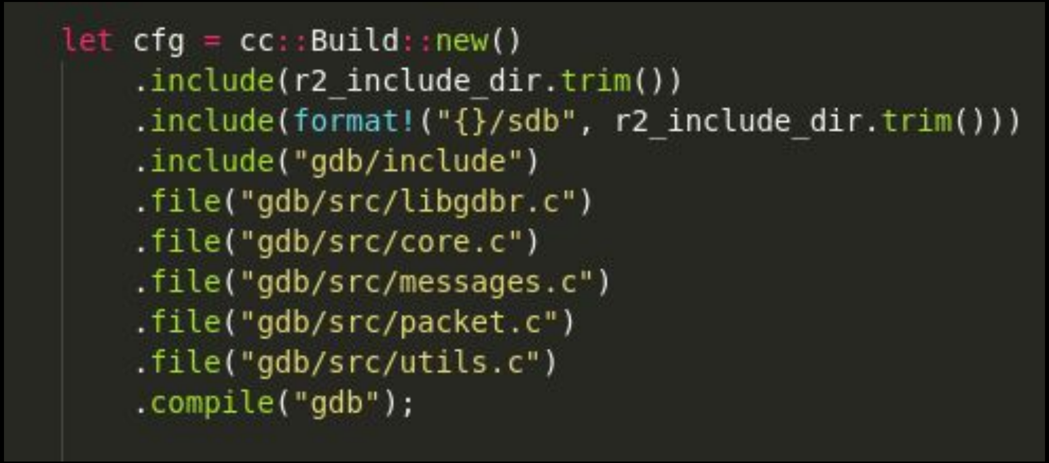
## Plugin



```rust
static PLUGIN_DATA: RIOPlugin = RIOPlugin {
    name: "flip\0".as_ptr() as *mut c_char,
    desc: "flip.re plugin\0".as_ptr() as *mut c_char,
    version: "0.1.0\0".as_ptr() as *mut c_char,
    author: "zutle\0".as_ptr() as *mut c_char,
    license: "LGPL3\0".as_ptr() as *mut c_char,
    widget: std::ptr::null_mut(),
    uris: "flip://\0".as_ptr() as *mut c_char,
    listener: None,
    accept: None,
    check: Some(flux::check),
    close: Some(flux::close),
    create: None,
    extend: None,
    getbase: None,
    getpid: None,
    gettid: None,
    init: None,
    is_blockdevice: None,
    is_chardevice: None,
    isdbg: true,
    lseek: Some(flux::lseek),
    open: Some(open),
    open_many: None,
    read: Some(flux::read),
    resize: None,
    system: Some(flux::system),
    undo: RIOUndo {
```

# build.rs

You can also compile C code with the Rust build system (cargo), and link it into your target executable (using the cc crate)



```rust
let cfg = cc::Build::new()
    .include(r2_include_dir.trim())
    .include(format!("{}/sdb", r2_include_dir.trim()))
    .include("gdb/include")
    .file("gdb/src/libgdbr.c")
    .file("gdb/src/core.c")
    .file("gdb/src/messages.c")
    .file("gdb/src/packet.c")
    .file("gdb/src/utils.c")
    .compile("gdb");
```

## Developing radare2 plugins in Rust

We are releasing an example Rust plugin for r2con 2020 for anyone interested in learning more about developing radare2 plugins in Rust

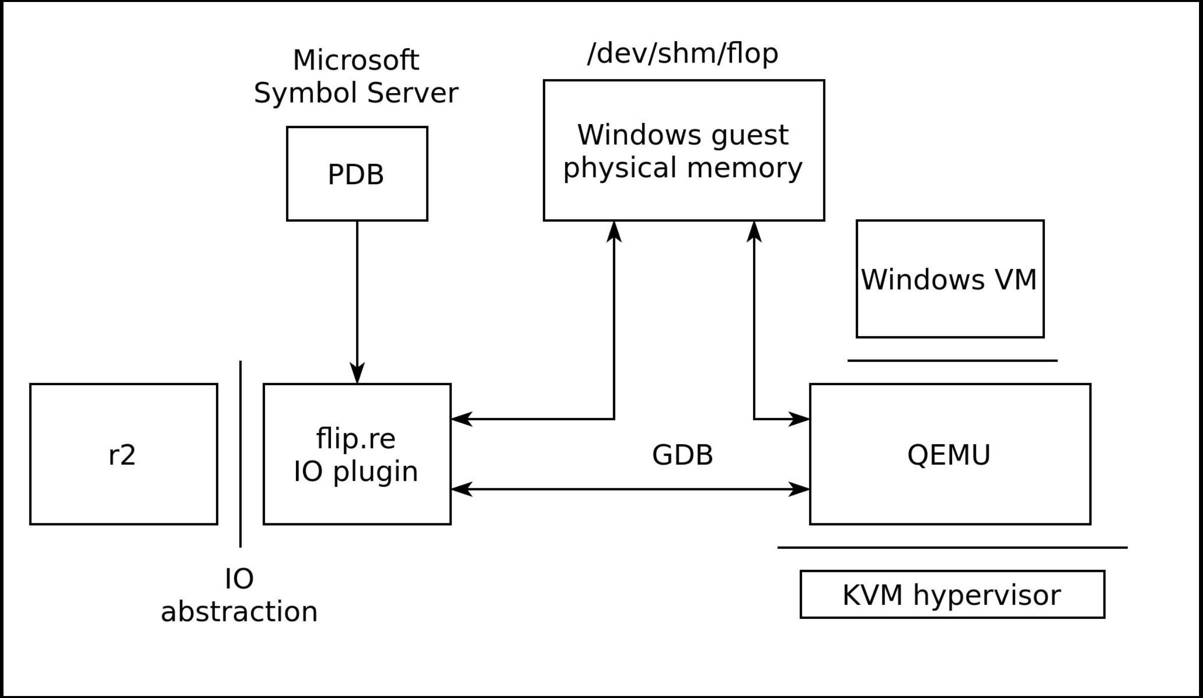
Available soon at:

https://github.com/flipreversing/r2con2020

Follow us on Twitter for updates:

@flipreversing

## Architecture



GDB provides registers and debug control

## GDB

‘-s’ param in QEMU enables gdbstub (GDB server) on localhost:1234

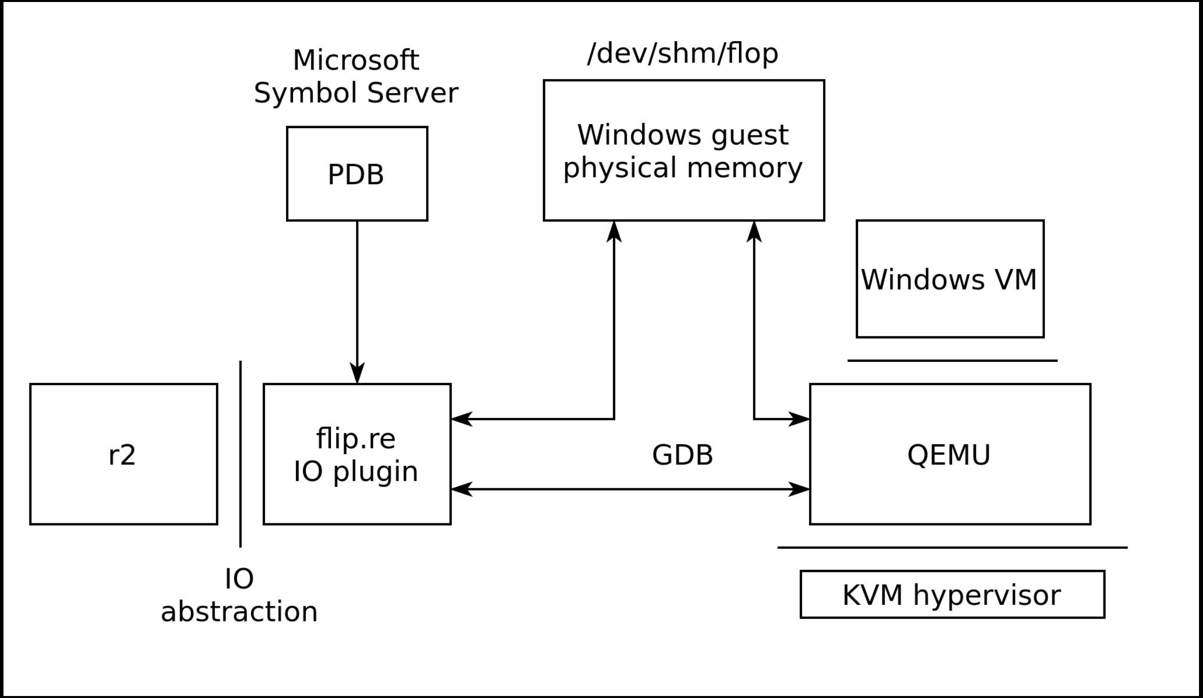
Effectively enables us to debug things that run inside the VM

- Kernel
- Any user-mode process

Features:

- Query CPU registers
- Single Step
- Trap on Breakpoints

## Architecture



Shared memory provides access to physical memory

## Physical memory access

QEMU can share the physical memory of the VM as a `memory-backend-file`

```
-object memory-backend-file,[...],mem-path=/dev/shm/flop,share=on
```

Essentially gives us access to guest physical RAM

- Enables accessing Windows’ (guest) memory from our Linux host
- Requires translating virtual to physical addresses to make sense

# Virtual memory access (Windows VM)

Each process has its own CR3 values

- contains directory base table (first lookup table)
- two values each (user/kernel) after Meltdown/Spectre

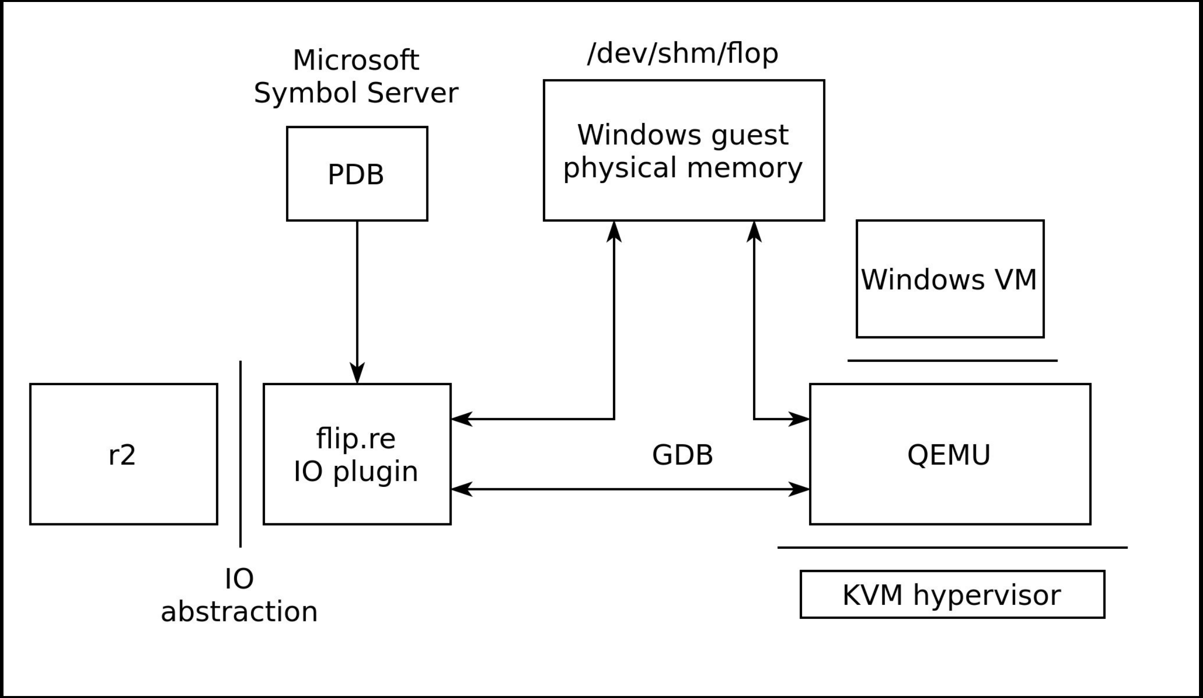
x86 architecture defines address translation logic

- Outside scope of this presentation (r2con 2017)

Our plugin takes care of memory translation we can:

- Select individual processes to inspect
- Effectively work with virtual addresses (both kernel and user-mode)

# Architecture



PDB is our key to navigate the Windows kernel

## PDB symbols

Our “API” to the Windows kernel
- Details on location and layout of structures (used internally by our plugin)
- Also useful to load as flags for the analyst

In the current alpha version:

- Copy ntoskrnl.exe from VM to host
- Plugin parses the kernel during initial attach

In the future we will parse the required information directly from the kernel loaded within the VM

# PDB symbols

We require the GUID: r2 -c “i~guid[1]” -q ntoskrnl.exe
and the pdb name: r2 -c “i~dbg_file[1]” -q ntoskrnl.exe

With this info, the plugin can download the correct PDB from Microsoft

We parse the PDB file using the Rust pdb crate

- https://crates.io/crates/pdb

## Live demo time!

- Attaching to a Windows VM
- Downloading PDB files from the Microsoft symbol server
- Load kernel symbols as flags in r2
- Load a program inside the Windows VM
  (from the host)
- Get ready to debug programs inside the VM

## Case Study: Anti-Anti analysis

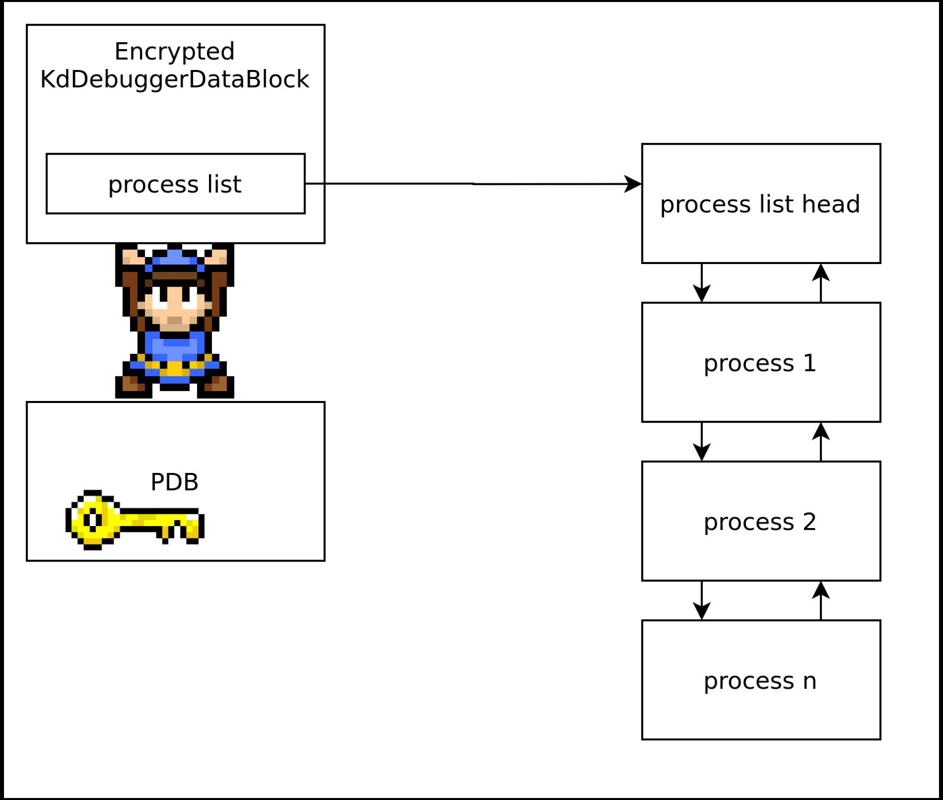
Tracing can be an effective technique to locate interesting code

- Frida is a great tool for this

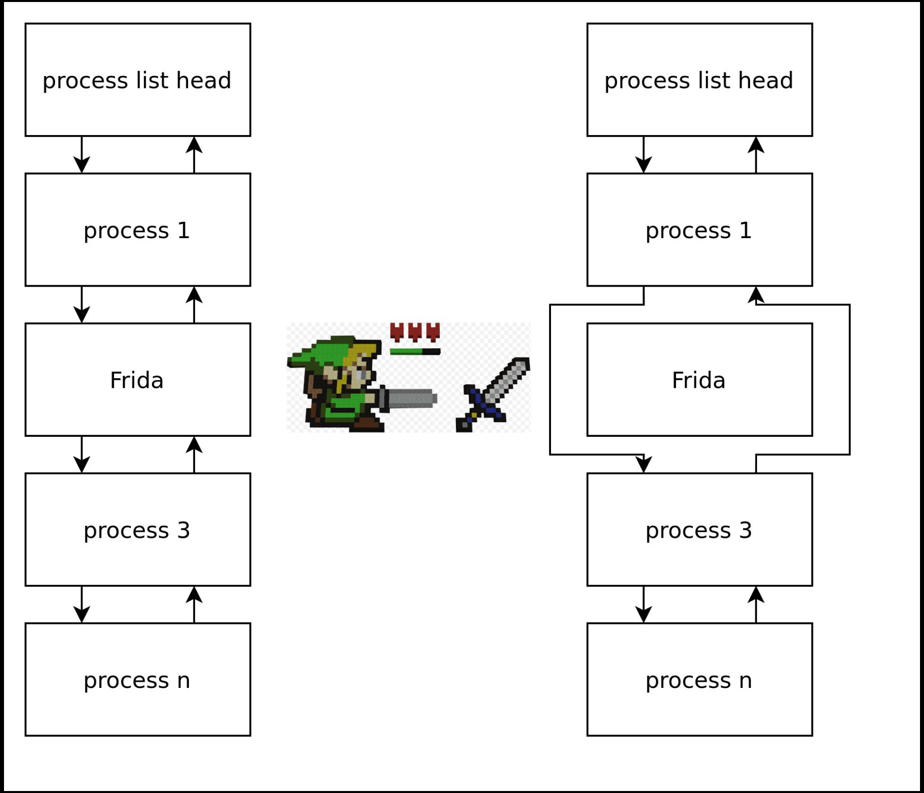
Malware can check for Frida’s processes on the system, and evade our analysis

- Our system can hide analysis components
- In this way we can fool the malware into running

## Retrieving the process list



## Hiding the Frida server process



## Live demo time!

- Using rootkit techniques to hide the Frida process
- Fooling grandma into revealing her true self
- Twice. And then a bonus trick

Disclaimer:
This is an early alpha version of the plugin,
and some features were coded during the con :D

## Participate!

We will soon be looking for alpha testers and early adopters!

Follow us on Twitter: @flipreversing

Join our Telegram: https://t.me/flipreversing

Send us an email: hello@flip.re

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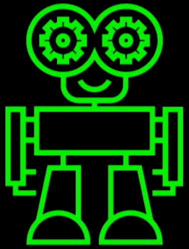
## Question time!



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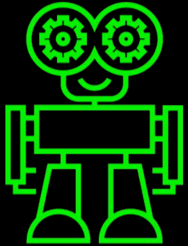
## Thank you, and enjoy chiptunes!



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