Android smart platform kernel malware

Touchpad based Key logger

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- Android smart platform kernel malware
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  - Technical Description I
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Introduction

Android smart platform sandbox

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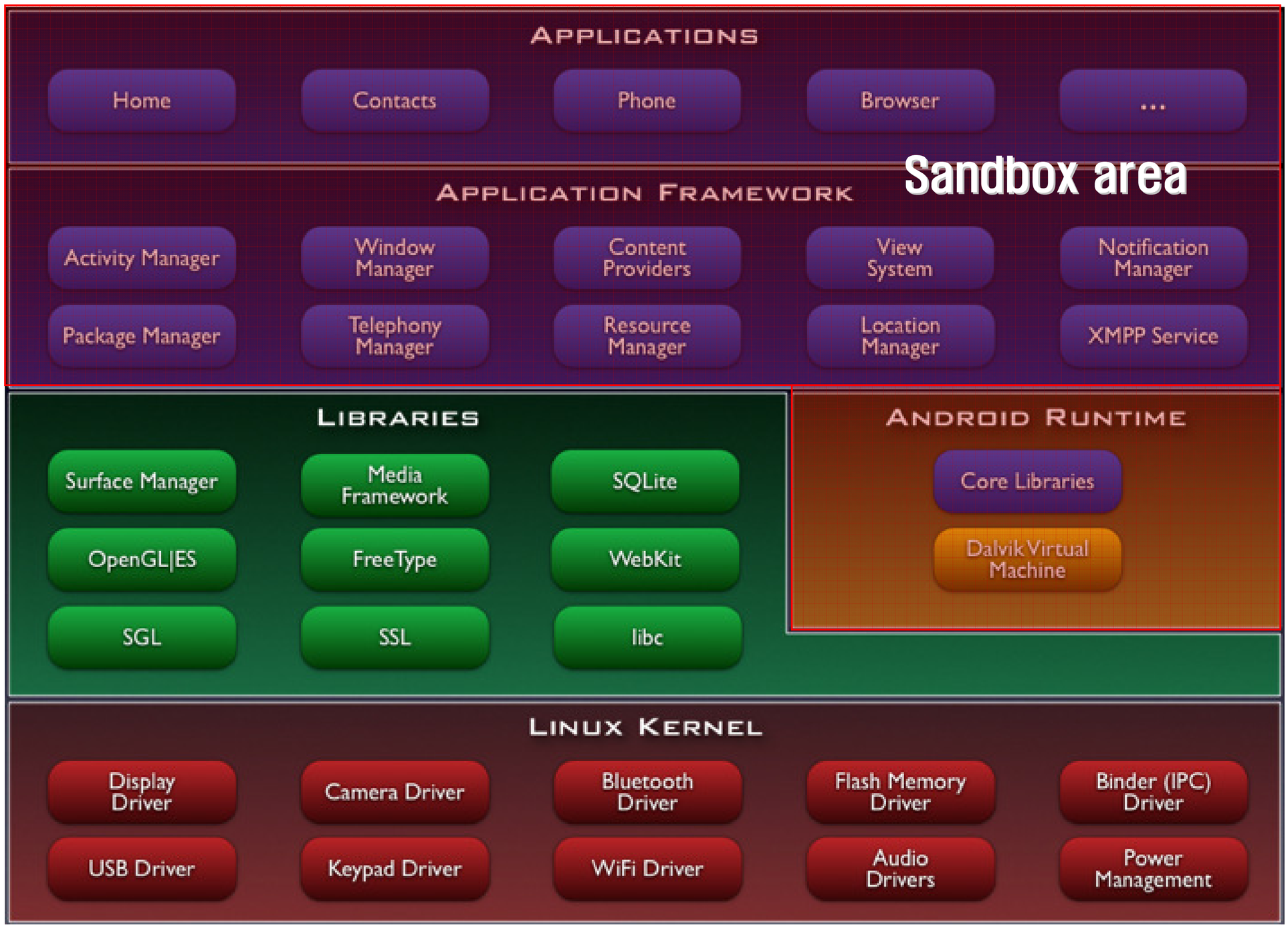
Android sandbox 1/5

The purpose of Sandbox

The ideal operating of a sandbox

Android sandbox 2/5

- **Android smart platform sandbox**



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Android sandbox 3/5

Reality of sandbox security

However, the reality is a battlefield

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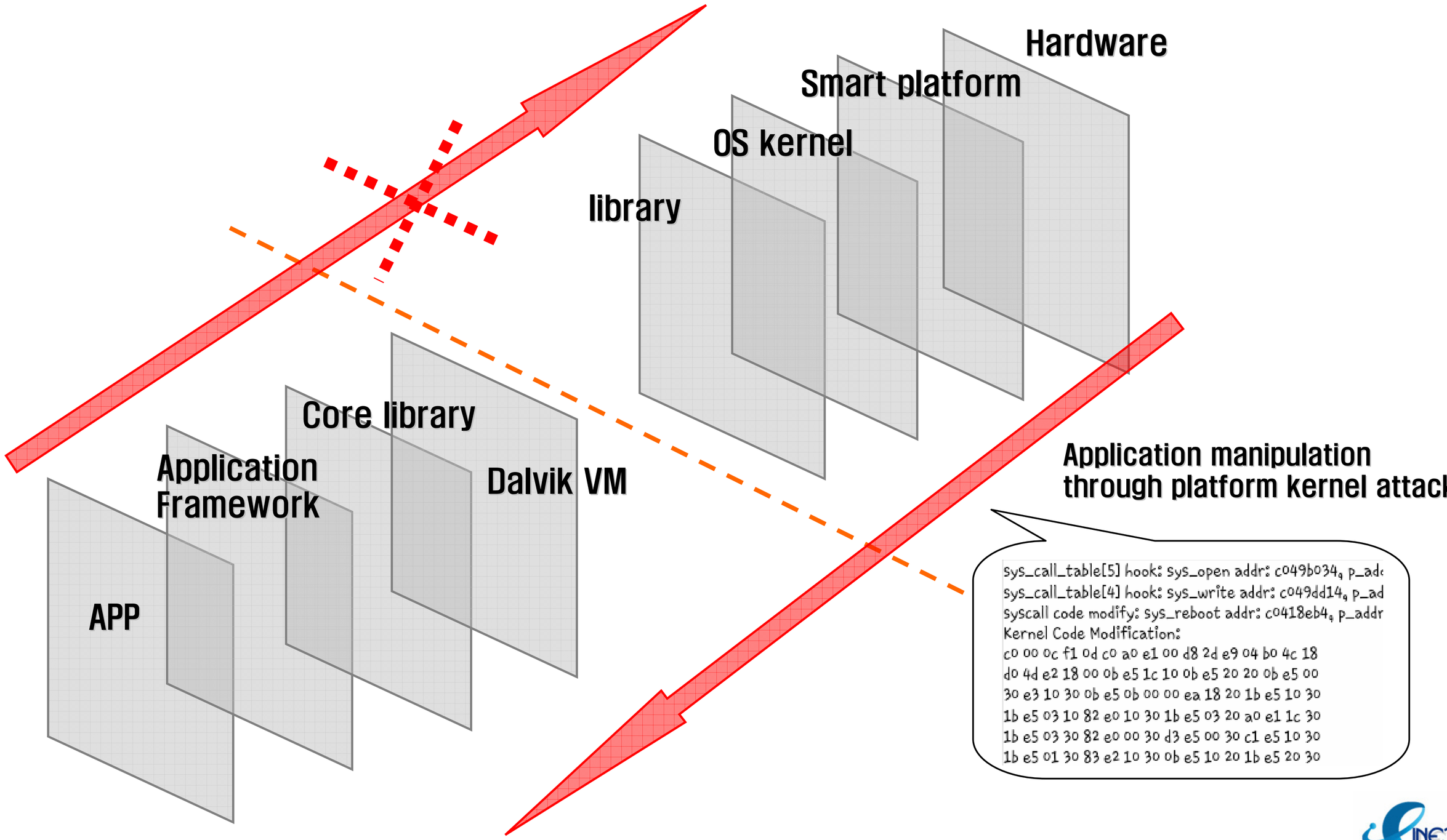
Android sandbox 4/5

- **Security Technology Issue**



Android sandbox 5/5

- **Security threat caused by malware inside of Sandbox**
  - various Backdoor, Trojan S/W and malwares with a form of app
  - Overcharged fee, personal information leak, eavesdropping etc.
  - H/W device meltdown, sending spam SMS, DDoS botnet attack
  - Can be handled by verifying app integrity and a vaccine

- **Security threat caused by vulnerabilities out side of Sandbox**
  - Android 3rd party application and web browser remote attack, 2010
  - Local rooting exploit code using kernel vulnerability, Aug 2009
  - LKM type kernel rootkit (Defcon 18) , June, 2010
  - Hard to apply a security update on a smart platform

* Reference: http://www.exploit-db.com

Technical Description I

Kernel Level Hooking Techniques

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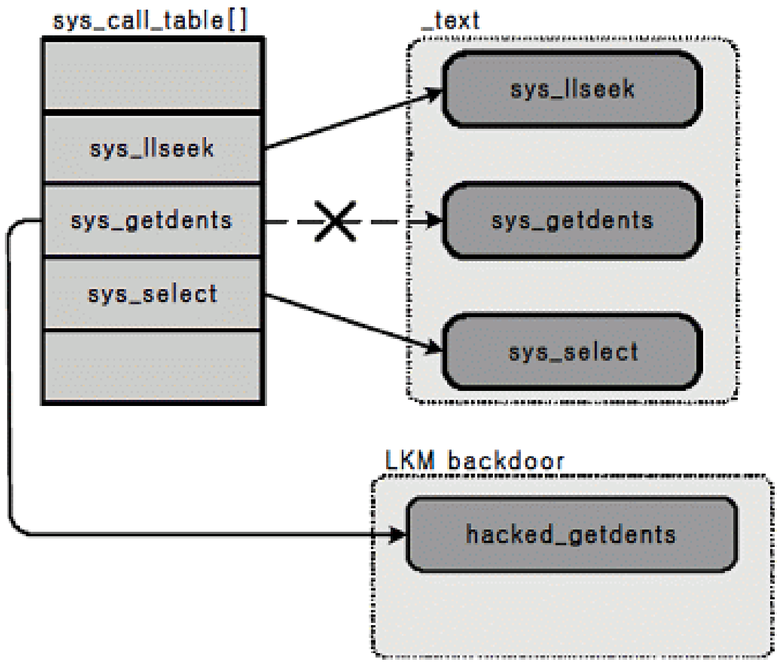
Android Kernel Rootkit 1/3

- **LKM (Loadable kernel module) access technic**
  - Can both add or remove a new code without a kernel compile or reboot
  - Change function addr in sys_call_table into hacker's function and hook it
- **KMEM device access technic**
  - Silvio Cesare's "RUNTIME KMEM PATCHING" / sd's Phrack 58-7
  - Access via /dev/mem(physical), /dev/kmem(virtual) memory mapping files




```
$ export PATH=/data/local/bin:$PATH
$ lsmod
pcnet32 28744 0 - Live 0xd0cb9000
btusb 10316 0 - Live 0xd0c48000
sco 8948 0 - Live 0xd0c21000
rfcomm 29876 0 - Live 0xd0a71000
bnep 10976 0 - Live 0xd0a27000
l2cap 19444 4 rfcomm,bnep, Live 0xd09f6000
bluetooth 47784 5 btusb,sco,rfcomm,bnep,l2cap, Live 0xd086f000
rfkill 9776 1 bluetooth, Live 0xd0844000
$ insmod
usage: insmod <module.o>
$ ls -l /dev/mem
crw------- root     root       1,   1 2011-01-03 22:52 mem
$ ls -l /dev/kmem
crw------- root     root       1,   2 2011-01-03 22:52 kmem
$
```

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Android Kernel Rootkit 2/3

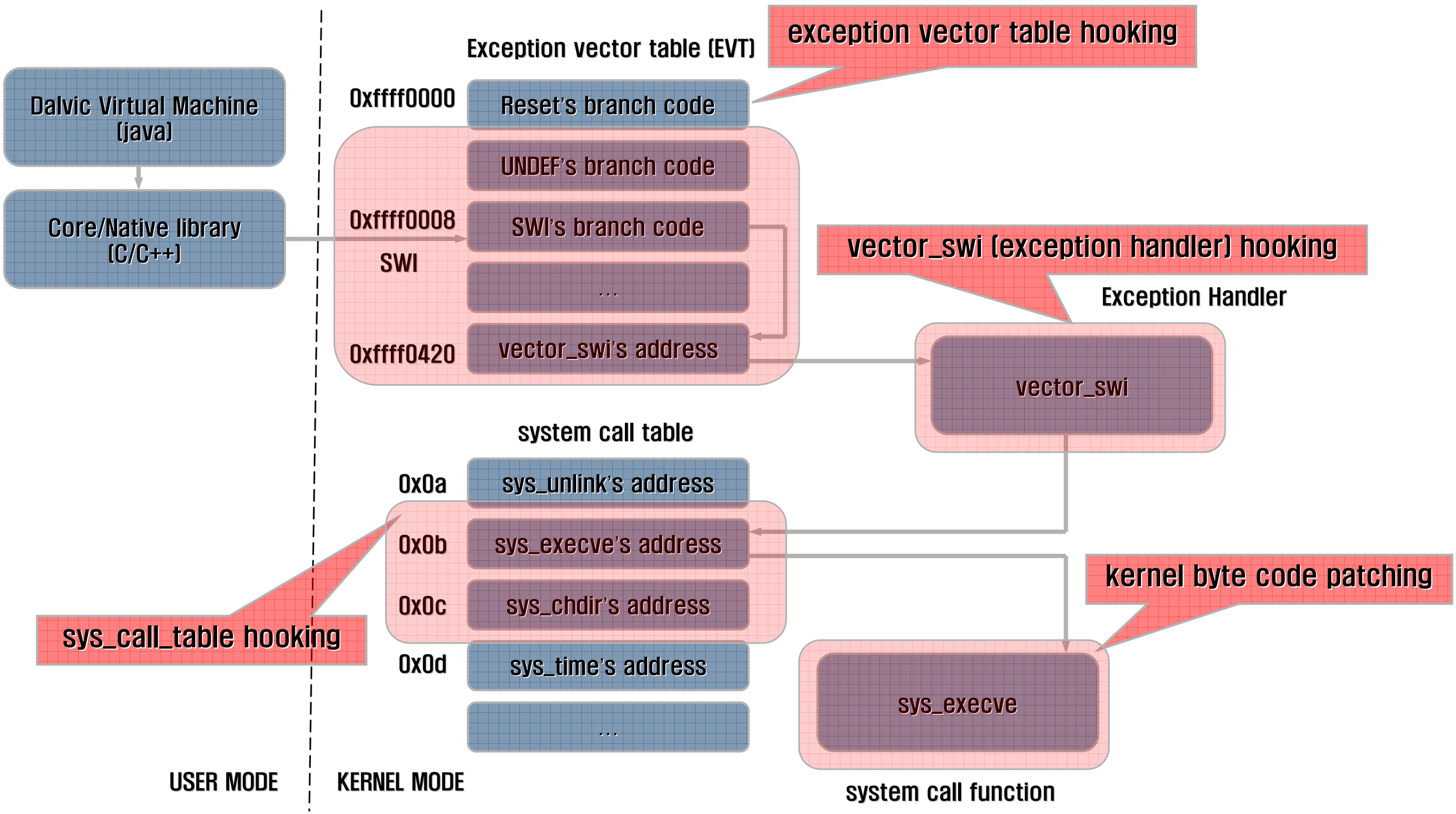
- **Searching sys_call_table**
  - Getting sys_call_table address in vector_swi handler
  - Finding sys_call_table address through sys_close address searching
- **Treating version magic**
  - Modification of UTS_RELEASE value in utsrelease.h header
  - Modification of __module_depends value in the kernel module
  - Direct overwrite of vermagic value in a compiled kernel modile binary

```
fs/open.c:
EXPORT_SYMBOL(sys_close);
...
call.S:
/* 0 */                 CALL(sys_restart_syscall)
                        CALL(sys_exit)
                        CALL(sys_fork_wrapper)
                        CALL(sys_read)
                        CALL(sys_write)
/* 5 */                 CALL(sys_open)
                        CALL(sys_close)
```

```
# insmod sys_call_table.ko
insmod: init_module 'sys_call_table.ko' failed (Exec format error)
# dmesg -c
<3>[10605.267272] sys_call_table: version magic '2.6.29-omap1 preempt mod_unload ARMv5 ' should be '2.6.29-omap1 preempt mod_unload ARMv7 '
#
```

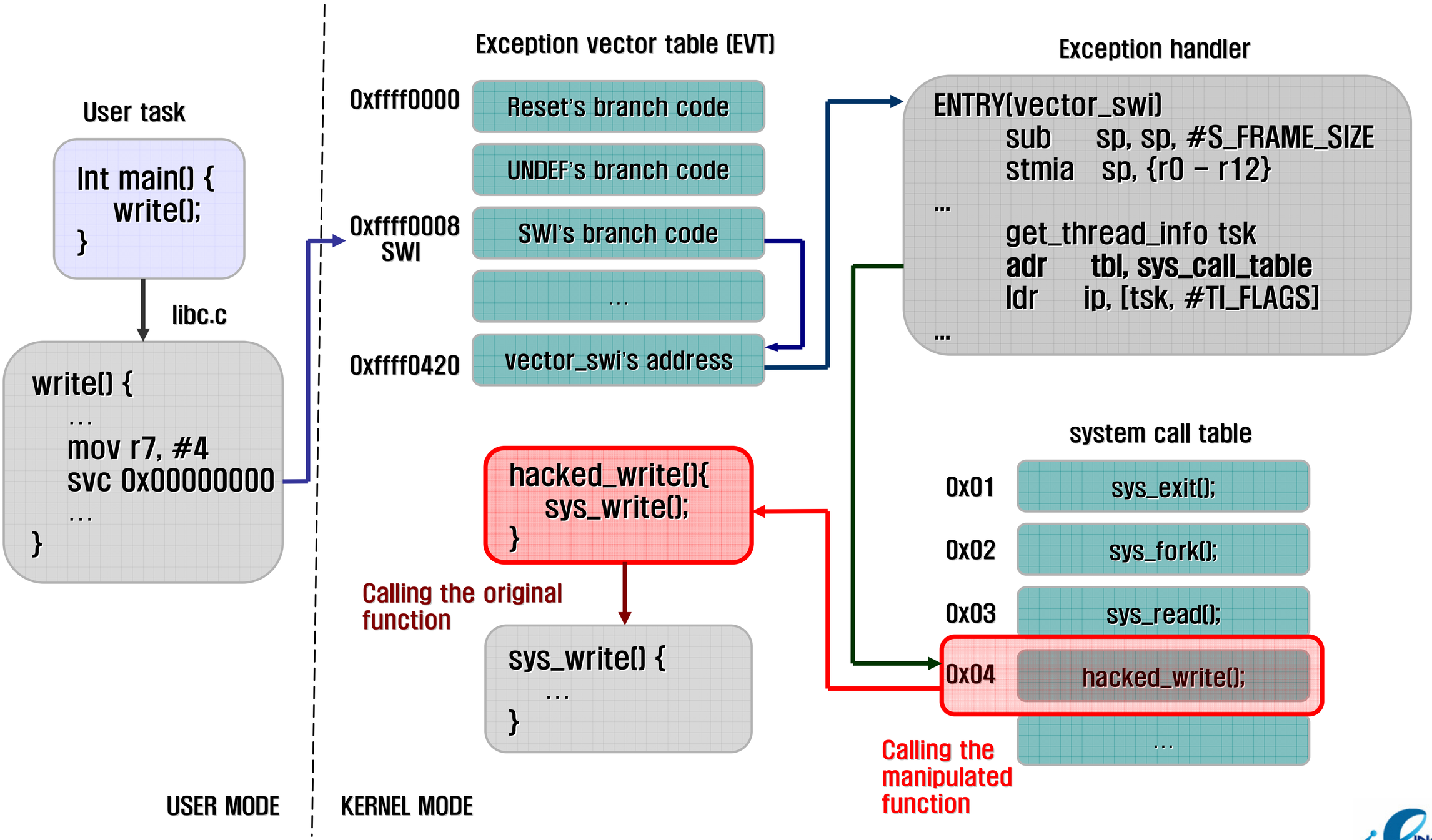
Android Kernel Rootkit 3/3

- Branches of Android platform kernel hooking



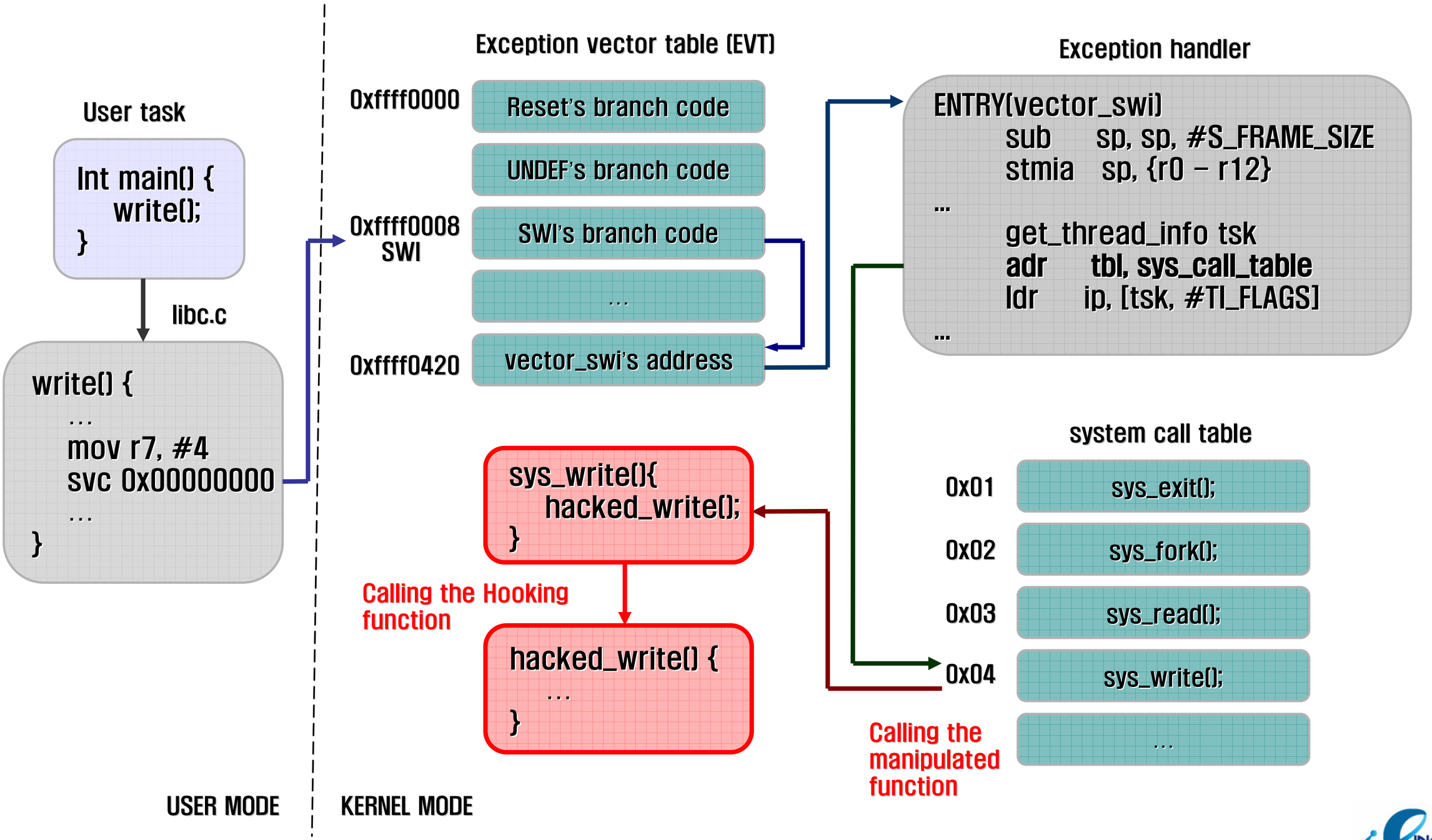
Hooking Techniques 1/5

- **Basic techniques for sys_call_table hooking #1**



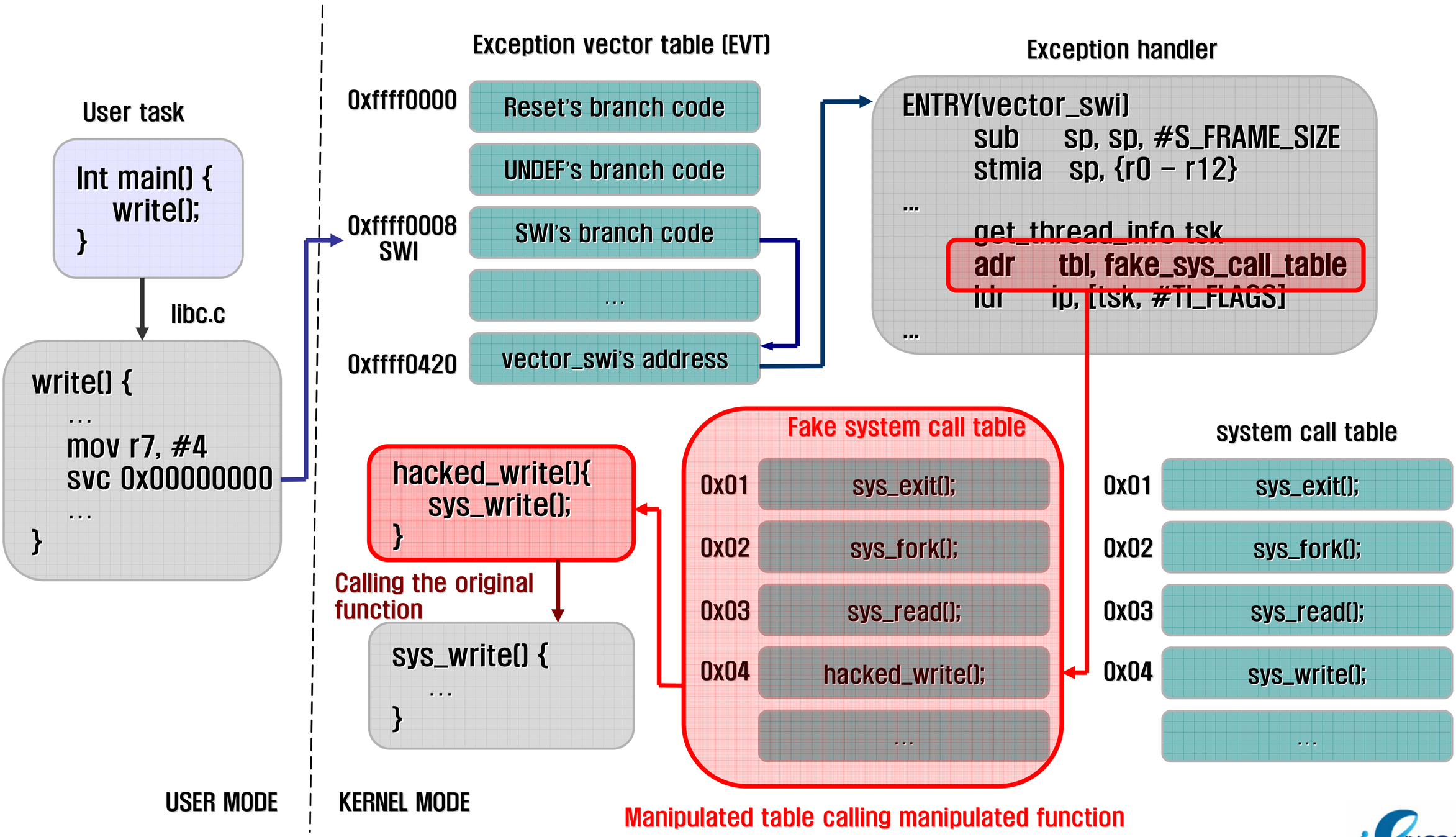
Hooking Techniques 2/5

- **Basic techniques for system call hooking #2**



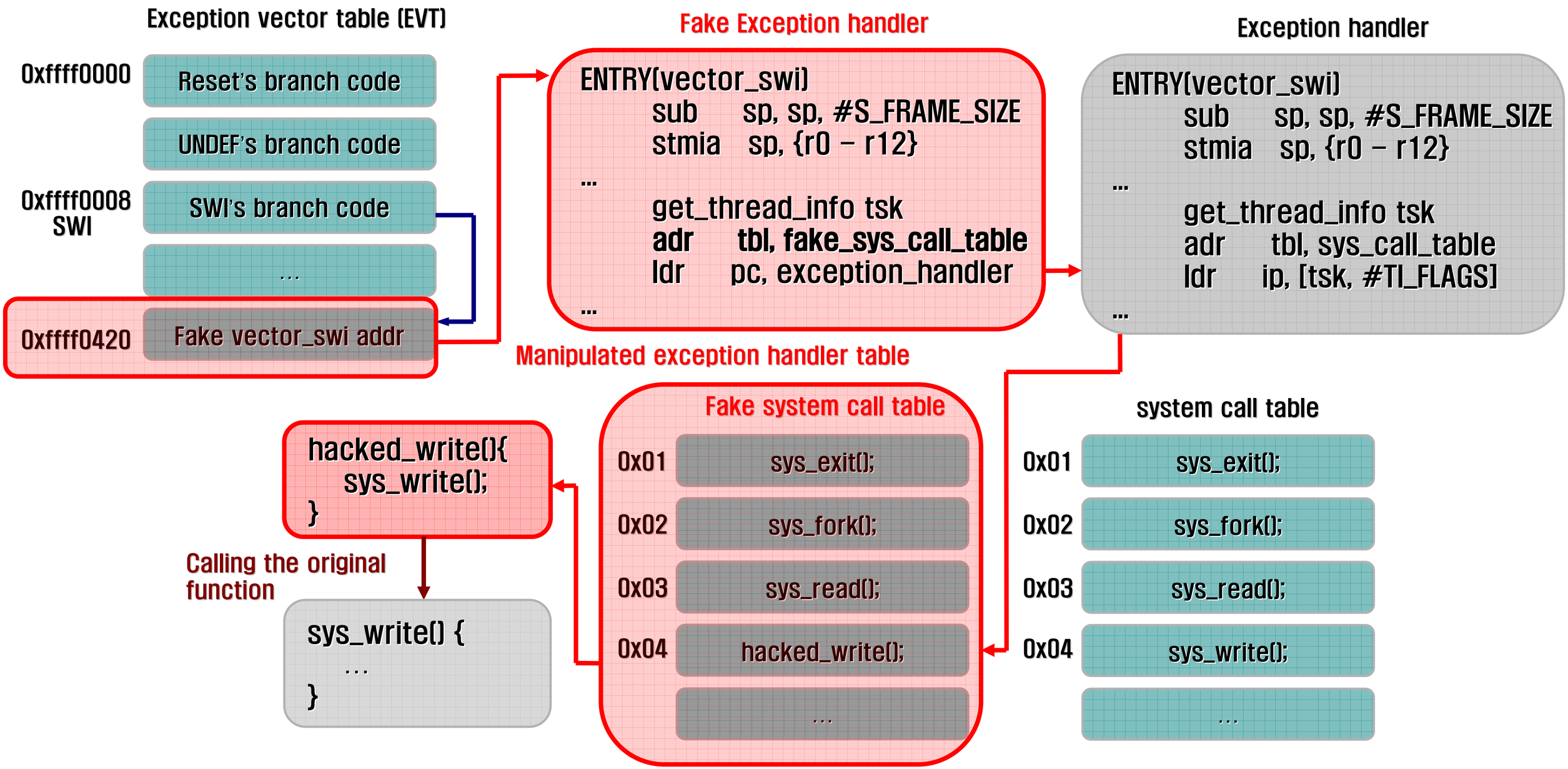
Hooking Techniques 3/5

- **Modifying vector_swi handler routine**



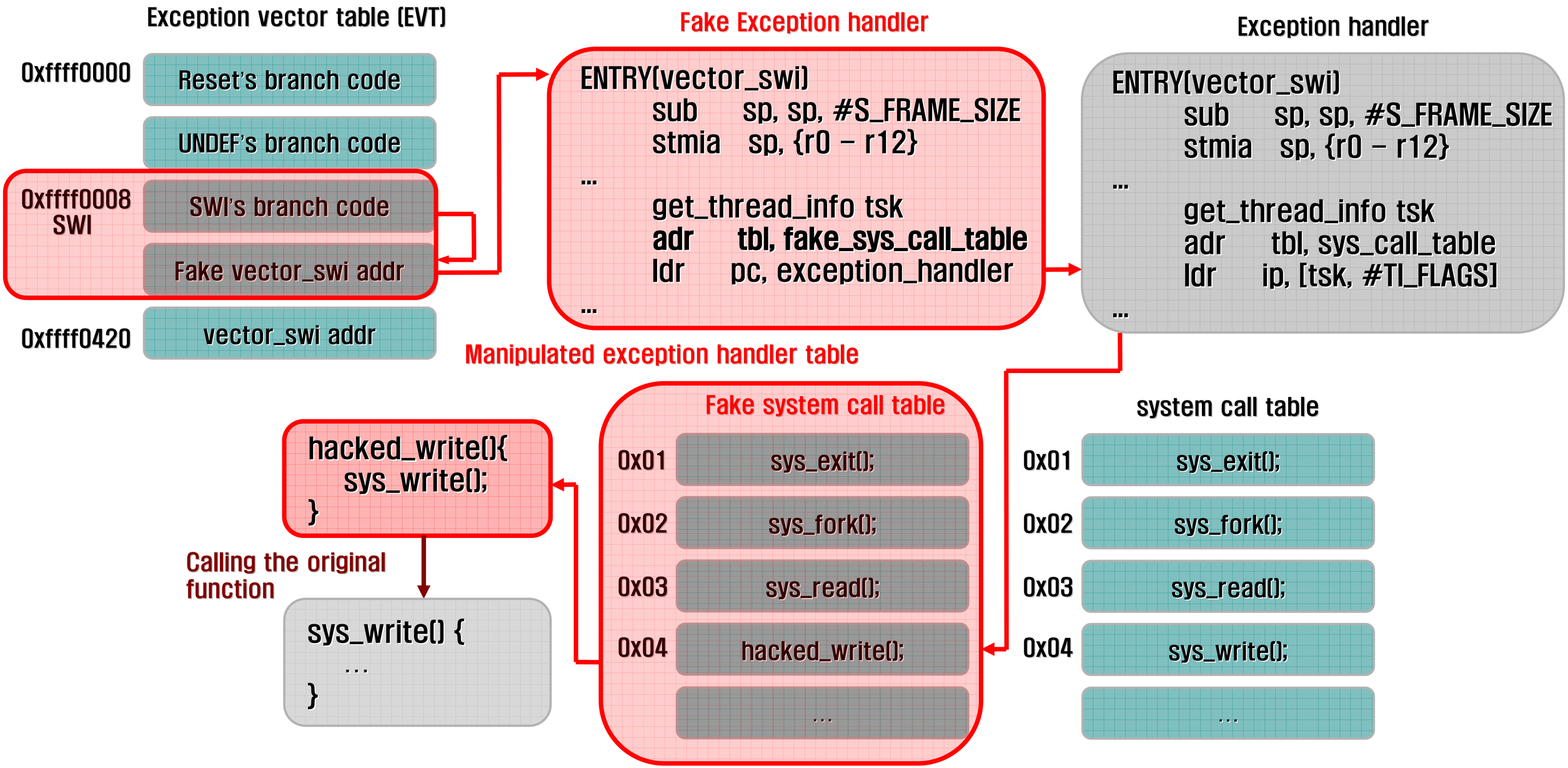
Hooking Techniques 4/5

- EVT modifying hooking techniques (vector_swi handler)



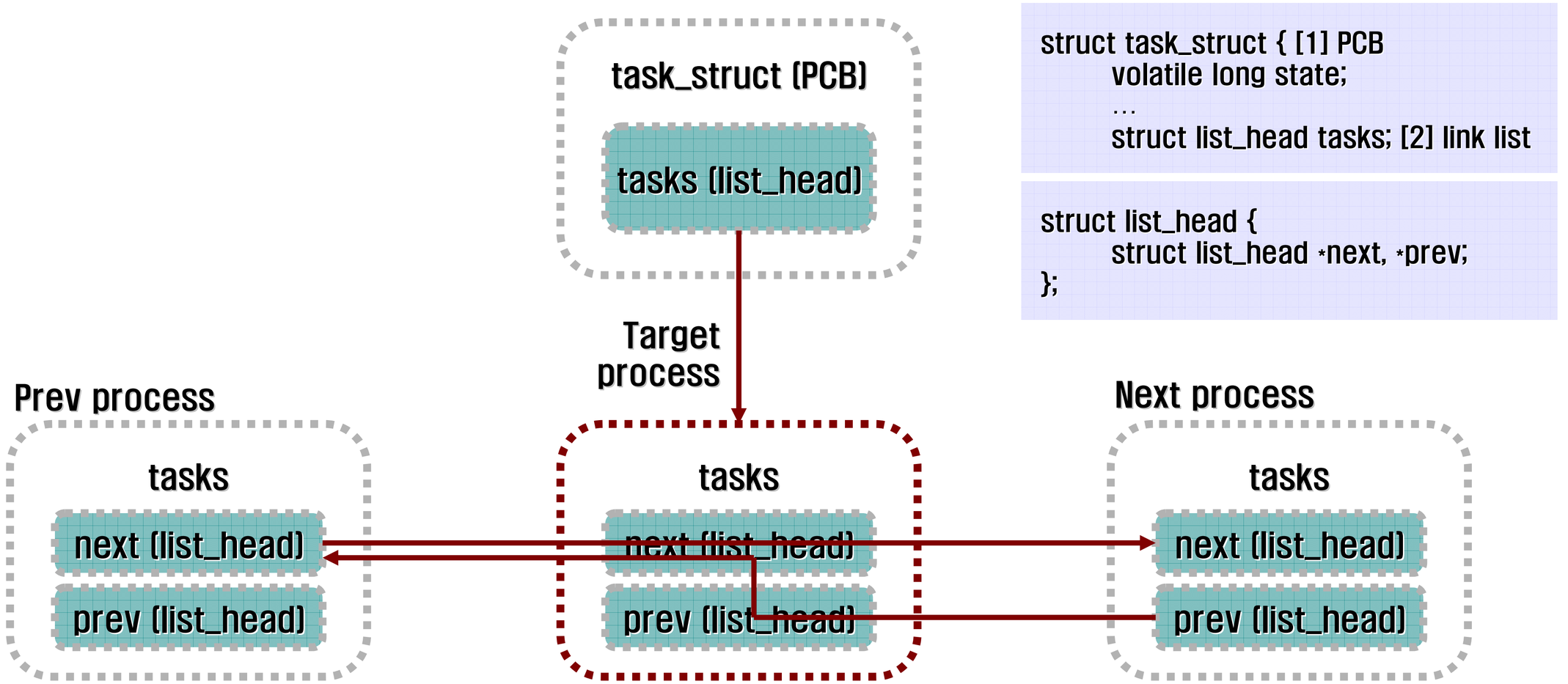
Hooking Techniques 5/5

- EVT modifying hooking techniques (branch instruction offset)



Basic of information hiding 1/3

- **How the Android kernel malwares hide their processes**
- **Basic of Process hiding**
  - Modifying list_head structure in PCB structure holding process info.
  - Combine prev(information of previous process) and next (next process)




```
struct task_struct { [1] PCB
        volatile long state;
        …
        struct list_head tasks; [2] link list
```

```
struct list_head {
        struct list_head *next, *prev;
};
```

Basic of information hiding 2/3

- **How Android kernel malwares hide their resources**
- **Basic of File & directory & Network status hiding**
  - Hook system calls by modifying EVT, vector_swi, sys_call_table
  - Delete object info in dirent64 structure after hooking getdents64
  - Delete or modify network info after hooking write, writev function

```
hacked_getdents64(
unsigned int fd,
struct linux_dirent64 *dirp,
unsigned int count);
```

```
struct linux_dirent64 {
    u64 d_ino;
    s64 d_off;
    unsigned short d_reclen;
    unsigned char d_type;
    char d_name[0];
};
```

```
hacked_write(int fd,
struct iovec *vector,
int count);
```

```
struct iovec {
    __ptr_t iov_base;
    size_t iov_len;
};
```

d_ino	d_off	d_reclen	d_type	d_name
6588…	271	16	4	net
6602…	272	16	4	kcore
7018…	273	16	4	10053
7020…	274	16	4	10054
…	…	…	…	…

Delete or modify object info inside of an entry

iov_base	iov_len
AAA BBB CCC DDD EEE	16
FFF GGG HHH	10

Delete or modify object info inside of an entry

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Basic of information hiding 3/3

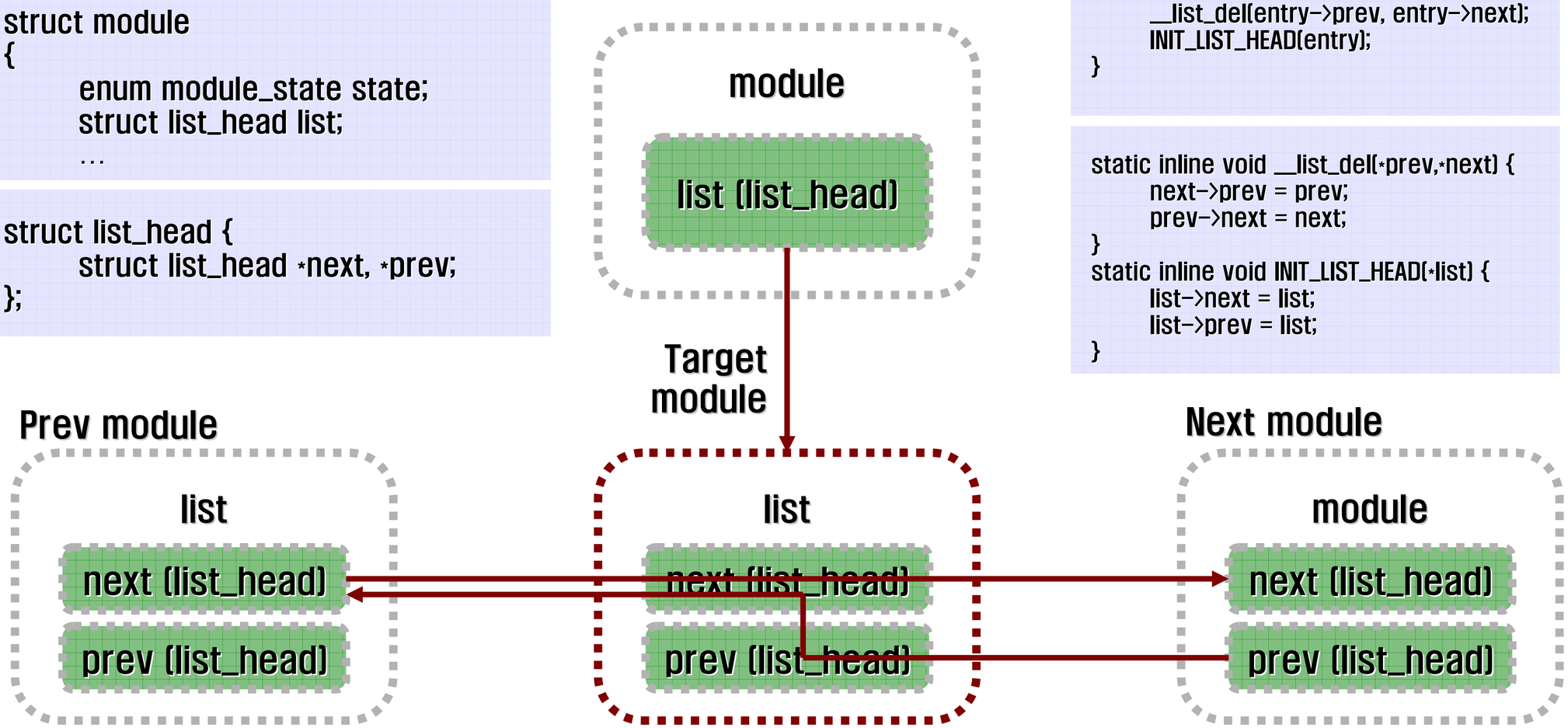
- **Basic information hiding method of Android kernel malwares**
- **Kernel module driver hiding**
  - Modifying list_head structure inside of module structure holding information about loaded module
  - Combine prev(information of previous process) and next (next process)

```
struct module
{
        enum module_state state;
        struct list_head list;
        ...
```

```
struct list_head {
        struct list_head *next, *prev;
};
```

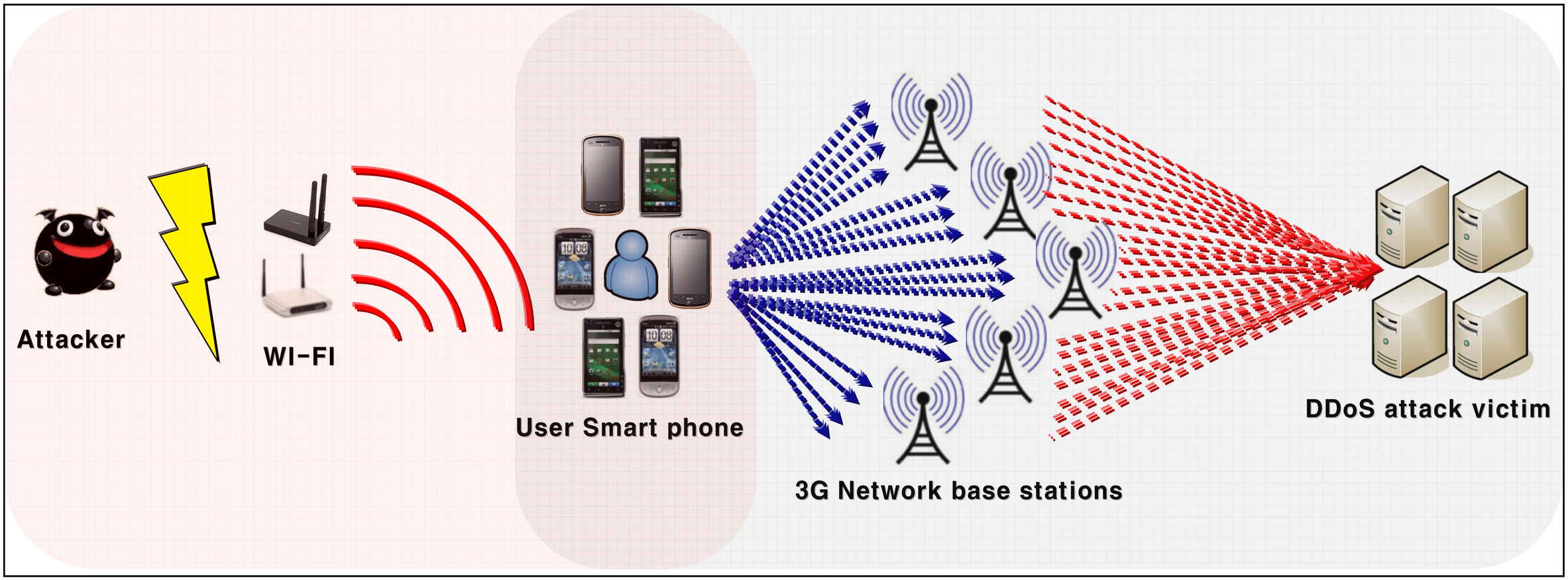
```
static inline void list_del_init(*entry) {
        __list_del(entry->prev, entry->next);
        INIT_LIST_HEAD(entry);
}
```

```
static inline void __list_del(*prev,*next) {
        next->prev = prev;
        prev->next = next;
}
static inline void INIT_LIST_HEAD(*list) {
        list->next = list;
        list->prev = list;
}
```



Effect of smart phone rootkit

- **Future threats for the Android platform**
  - Touchpad keylogging (interrupt hooking method)
  - Internet banking transaction manipulation
  - Advanced kernel based botnet (conceal C&C tools and connection channels)
  - Kernel rootkit that hides the malwares



Technical Description II

Input device Hooking Touchpad Key logger

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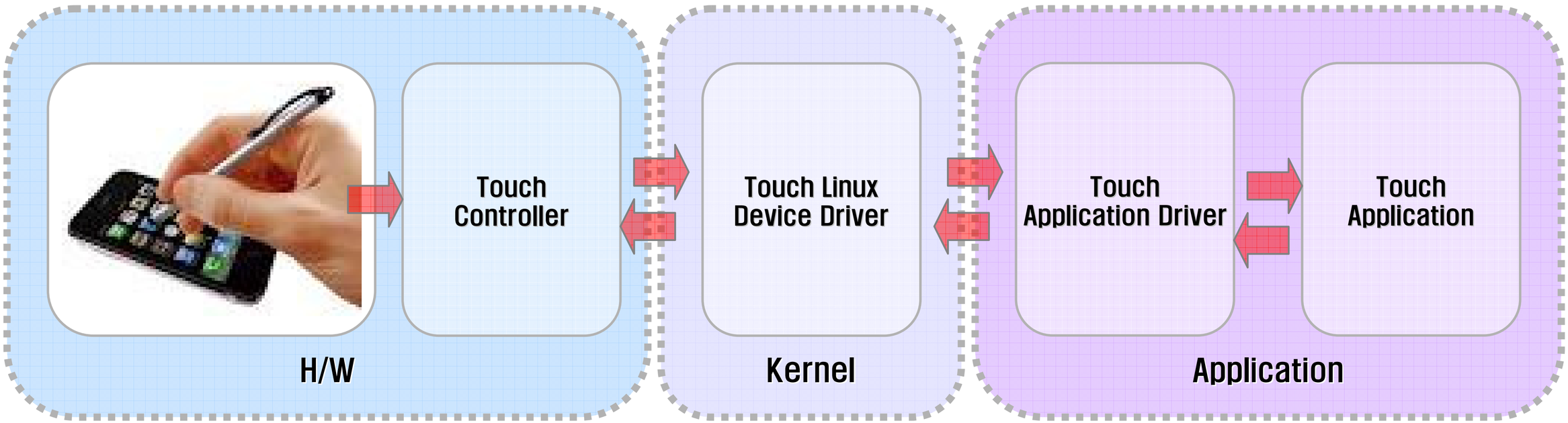
Input device driver 1/3

- System structure for input process
  - Hardware
    - touch pad controller
  - Kernel device controller
    - interpret user input and forward it to application
    - Since kernel 2.6, consolidated into a “input device controller”
  - Application
    - Consists of library modules and applications that use the libraries



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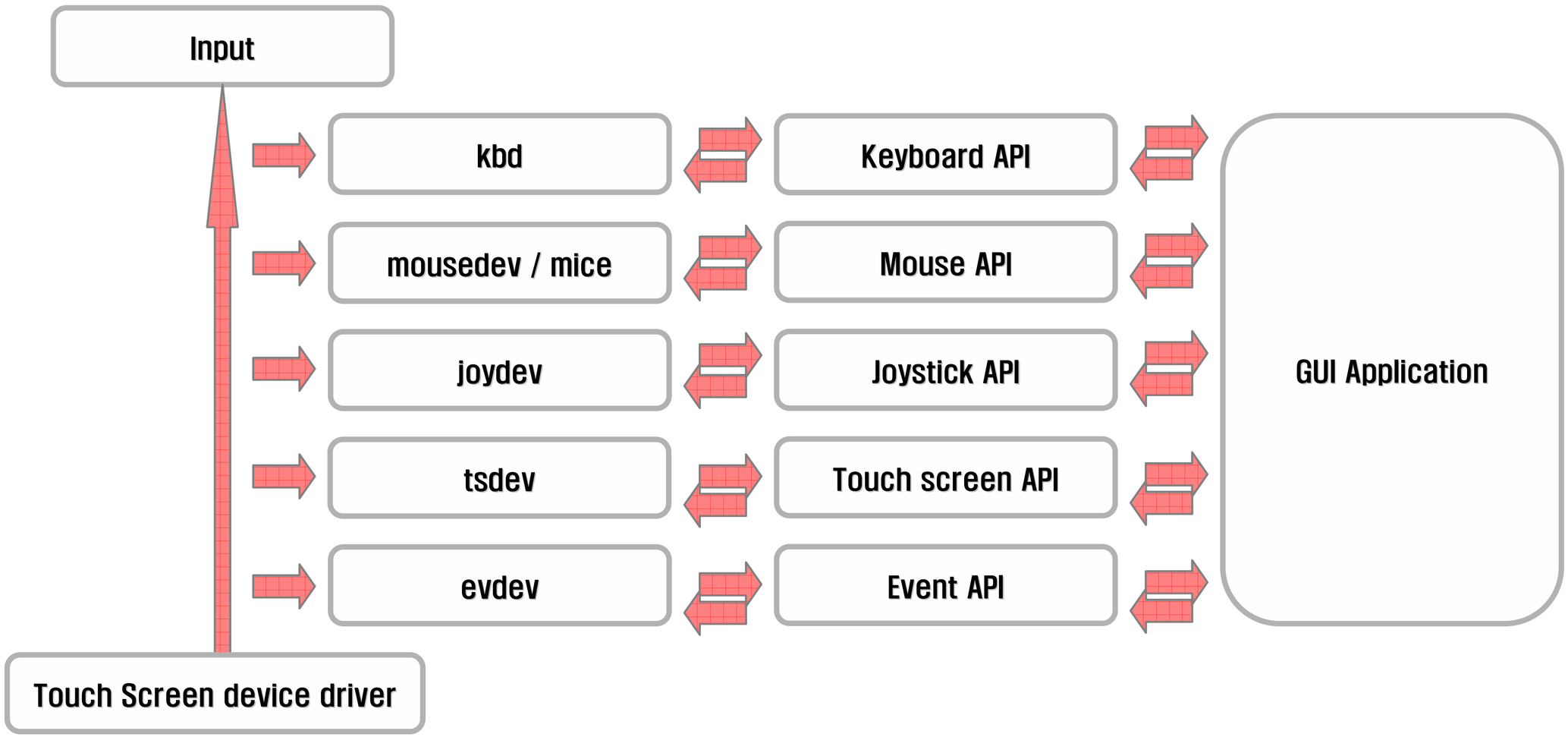
Input device driver 2/3

- **Input device driver**
  - Mouse, touch screen, joystick, keyboard and so on.
  - integrated input device driver for Linux to handle various devices
  - Read input information and make the applications react to the info.
  - Device driver handling method is standardized to handle various device



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Input device driver 3/3

- **Input device driver**
  - Provide registered event handler info and input device info
  - Connect input device driver and event handler device
  - Forward input to each event handler

```
ls -l /proc/bus/input
-r--r--r-- root     root            0 2011-10-19 15:05 handlers
-r--r--r-- root     root            0 2011-10-19 15:05 devices
# cat /proc/bus/input/handlers
cat /proc/bus/input/handlers
N: Number=0 Name=evdev Minor=64
```

```
I: Bus=0000 Vendor=0000 Product=0000 Version=0000
N: Name="qt602240_ts_input“
P: Phys=
S: Sysfs=/devices/virtual/input/input3
U: Uniq=
H: Handlers=mouse0 event3
B: EV=b
B: KEY=400 0 0 0 0 0 0 0 0 0 0
B: ABS=650000 11000003
```

Input event device driver

- **Event handler device driver**
  - Actual device driver file to read input from input devices
  - Save input value into internal buffer after transform it properly
  - Make input value readable to application
- **evdev event handler device driver**
  - Device driver that reads in input value in general type
  - Each driver for each device, so it can read all the device values
  - All the drivers have same architecture, independent from H/W
  - Forward input events from kernel to application
  - Send time, type, key value in struct input_event structure type
  - Realized in linux/drivers/input/evdev.c
  - Exists as an char device type in path ‘/dev/input/event*’

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input_event structure 1/2

- Touch Keypad input_event structure type
  - time: when the input event occurs
  - type: the type of input device (ex: touch screen and mouse)
    - Touch pad uses absolute value (ABS_X, ABS_Y) for location
    - Mouse uses amount of change (REL_X, REL_Y) for location
  - code: Categorize input information
    - Member value to discern input information
  - value: input value for each code member
    - for touch screen and mouse, input location is stored

```
ls -l /dev/input/
crw-rw---- root     input     13,  71 2011-10-19 16:48 event7
crw-rw---- root     input     13,  70 2011-10-16 07:44 event6
crw-rw---- root     input     13,  69 2011-10-16 07:44 event5
crw-rw---- root     input     13,  68 2011-10-16 07:44 event4
crw-rw---- root     input     13,  67 2011-10-16 07:44 event3
crw-rw---- root     input     13,  66 2011-10-16 07:44 event2
crw-rw---- root     input     13,  65 2011-10-16 07:44 event1
crw-rw---- root     input     13,  64 2011-10-16 07:44 event0
```

```
struct input_event{
        struct timeval    time;
        unsigned short    type;
        unsigned short    code;
        unsigned int      value;
};
```

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input_event structure 2/2

- **Contents of Touch Keypad input_event structure**

```
# hexdump -C /dev/input/event3
...
00000060  2b 70 00 00 b2 97 04 00  03 00 35 00 9a 00 00 00  |+p........5.....|
00000070  2b 70 00 00 cb 97 04 00  03 00 36 00 cb 01 00 00  |+p........6.....|
00000080  2b 70 00 00 d2 97 04 00  03 00 30 00 00 00 00 00  |+p........0.....|
00000090  2b 70 00 00 d9 97 04 00  03 00 32 00 02 00 00 00  |+p........2.....|
000000a0  2b 70 00 00 e0 97 04 00  00 00 02 00 00 00 00 00  |+p..............|
000000b0  2b 70 00 00 eb 97 04 00  00 00 00 00 00 00 00 00  |+p..............|
```

```
linux/include/linux/input.h:
struct input_event {
        struct timeval time; // 2b 70 00 00 (tv_sec) cb 97 04 00 (tv_usec)
        unsigned short type; // 03 00
        unsigned short code; // 36 00
        unsigned int value;  // cb 01 00 00
};
```

```
defined in linux/include/linux/input.h
...
#define EV_SYN 0x00 // synchronize
#define EV_KEY 0x01 // key or button
#define EV_ABS 0x03 // Absolute
coordinate
...
```

type	code	value	Description
EV_KEY	BTN_TOUCH	0x0	Off from touch screen
EV_KEY	BTN_TOUCH	0x1	On the touch screen
EV_KEY	BTN_TOUCH	0x2	Consecutive touch
EV_ABS	ABS_X	X num	Absolute X coordinate
EV_ABS	ABS_Y	Y num	Absolute Y coordinate
EV_SYN	0x0	0x0	Event occurred

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input_event Hooking 1/2

- **Touch Keypad value logger**

input_event Hooking 2/2

- **Touch Keypad value Injection**
  - When a certain value is input, change it into other data
  - evdev event handler can inject an event
  - Using write function, write on event device file to inject event.
  - the information should be struct input_event strucutre type

```
unsigned char backspace[]={
  0x81, 0x01, 0x00, 0x00, 0x31, 0x74, 0x05, 0x00, 0x03, 0x00, 0x35, 0x00,
  0xae, 0x01, 0x00, 0x00, 0x81, 0x01, 0x00, 0x00, 0xb9, 0x74, 0x05, 0x00,
  0x03, 0x00, 0x36, 0x00, 0xcc,
  0xef, 0x74, 0x05, 0x00, 0x03,
  0x81, 0x01, 0x00, 0x00, 0x23,
  0x04, 0x00, 0x00, 0x00, 0x81,
  0x00, 0x00, 0x02, 0x00, 0x00,
  0x99, 0x75, 0x05, 0x00, 0x00,
  0x81, 0x01, 0x00, 0x00, 0x5f,
  0xae, 0x01, 0x00, 0x00, 0x81,
  0x03, 0x00, 0x36, 0x00, 0xcc,
  0x7e, 0x6f, 0x07, 0x00, 0x03,
  0x81, 0x01, 0x00, 0x00, 0x85,
  0x01, 0x00, 0x00, 0x00, 0x81,
  0x00, 0x00, 0x02, 0x00, 0x00,
  0x96, 0x6f, 0x07, 0x00, 0x00,
```

```
unsigned char h_code[]={
  0x8f, 0x34, 0x02, 0x00, 0x1f, 0xdd, 0x03, 0x00, 0x03, 0x00, 0x35, 0x00,
  0x2b, 0x01, 0x00, 0x00, 0x8f, 0x34, 0x02, 0x00, 0xaa, 0xdd, 0x03, 0x00,
  0x03, 0x00, 0x36, 0x00, 0x4b, 0x02, 0x00, 0x00, 0x8f, 0x34, 0x02, 0x00,
  0xe0, 0xdd, 0x03, 0x00, 0x03, 0x00, 0x30, 0x00, 0x28, 0x00, 0x00, 0x00,
  0x8f, 0x34, 0x02, 0x00, 0x14, 0xde, 0x03, 0x00, 0x03, 0x00, 0x32, 0x00,
  0x04, 0x00, 0x00, 0x00, 0x8f, 0x34, 0x02, 0x00, 0x48, 0xde, 0x03, 0x00,
  0x00, 0x00, 0x8f, 0x34, 0x02, 0x00,
  0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
  0x04, 0x00, 0x03, 0x00, 0x35, 0x00,
  0x02, 0x00, 0x91, 0x85, 0x04, 0x00,
  0x00, 0x00, 0x8f, 0x34, 0x02, 0x00,
  0x30, 0x00, 0x00, 0x00, 0x00, 0x00,
  0x04, 0x00, 0x03, 0x00, 0x32, 0x00,
  0x02, 0x00, 0xa3, 0x85, 0x04, 0x00,
  0x00, 0x00, 0x8f, 0x34, 0x02, 0x00,
  0x00, 0x00, 0x00, 0x00, 0x00, 0x00};
```

```
usleep(10000);
write(temp_fd,h_code,sizeof(h_code));
usleep(10000);
write(temp_fd,e_code,sizeof(e_code));
usleep(10000);
write(temp_fd,l_code,sizeof(l_code));
usleep(10000);
write(temp_fd,l_code,sizeof(l_code));
usleep(10000);
write(temp_fd,o_code,sizeof(o_code));
```

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Test result of Keyboard protectors (26/30)

- **Keyboard protectors are neutralized**
  - Most of the key values are revealed even if the arrangement of the key is randomized
  - Capture the screen when the key is pressed and compare the X,Y coordination

Demonstration

Android platform based kernel rootkit & Touchpad based Key logger

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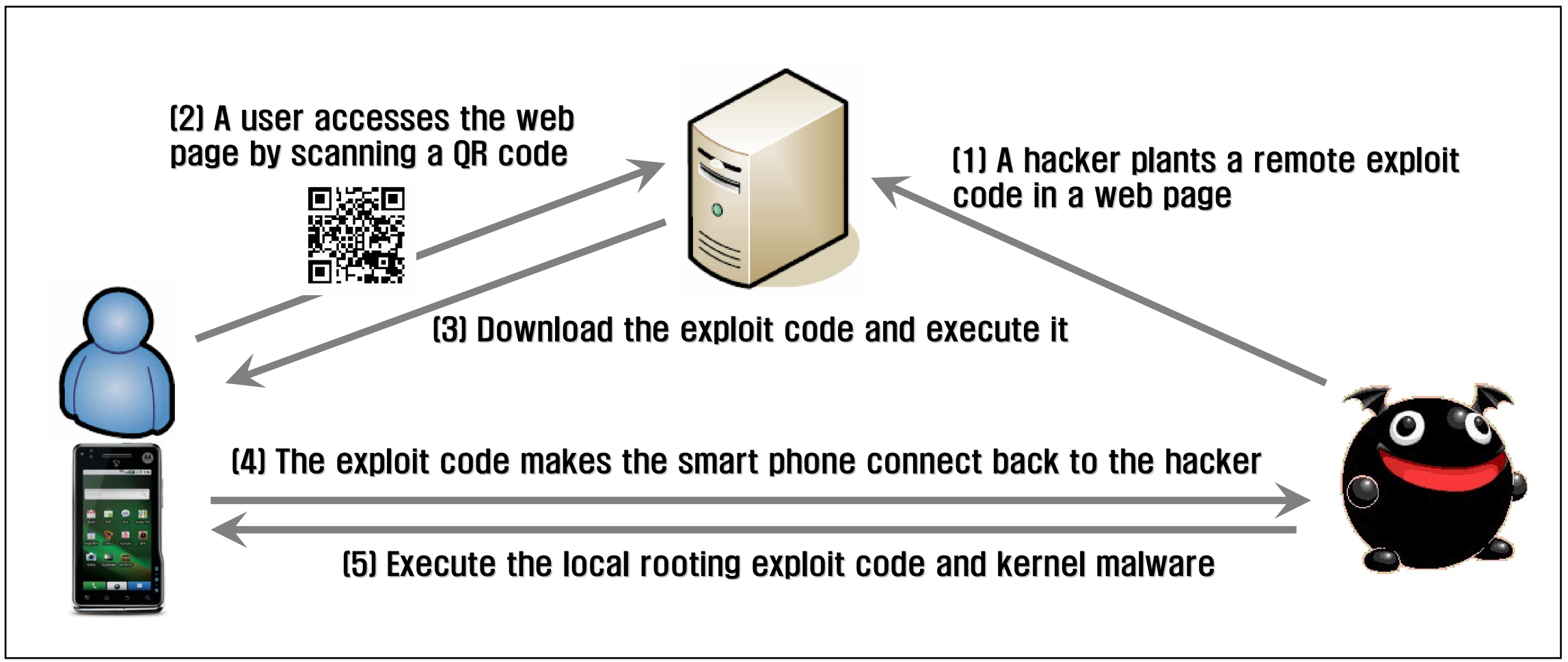
Demonstration 1/4

- **Android platform based kernel rootkit test environment**
  - H/W: Motoroi XT720, S/W version: Android 2.1 (Eclair)
    Linux version 2.6.29-omap1 (w21679@zkr30mdb05) (gcc version 4.4.0 (GCC))
  - H/W: Galaxy S, Galaxy tab, S/W version: Android 2.2 (Froyo)
    Linux version 2.6.32.9 (root@SEI-27) (gcc version 4.4.1 (Sourcery G++ Lite 2009q3-67))
  - H/W: Optimus one, S/W version: Android 2.2 (Froyo)
    Linux version 2.6.32.9 (mclab1@s-ibm06-desktop) (gcc version 4.4.0 (GCC))

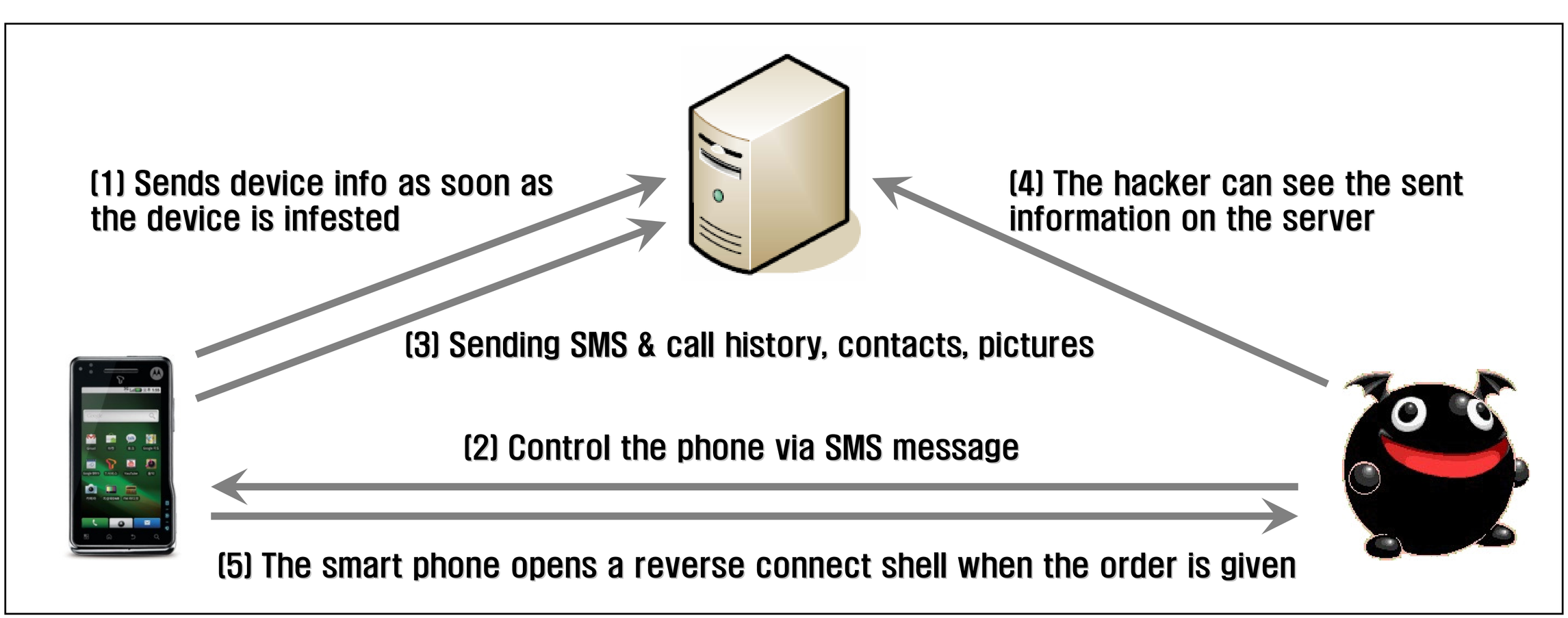
Demonstration 2/4

- **Android Remote / Local exploitation**
  - Acquiring a shellcode and rooting via QR code scanning
  - Webkit library use-after-free vulns (drive-by download)
  - CVE-2009-3547 linux kernel local pipe vulnerability



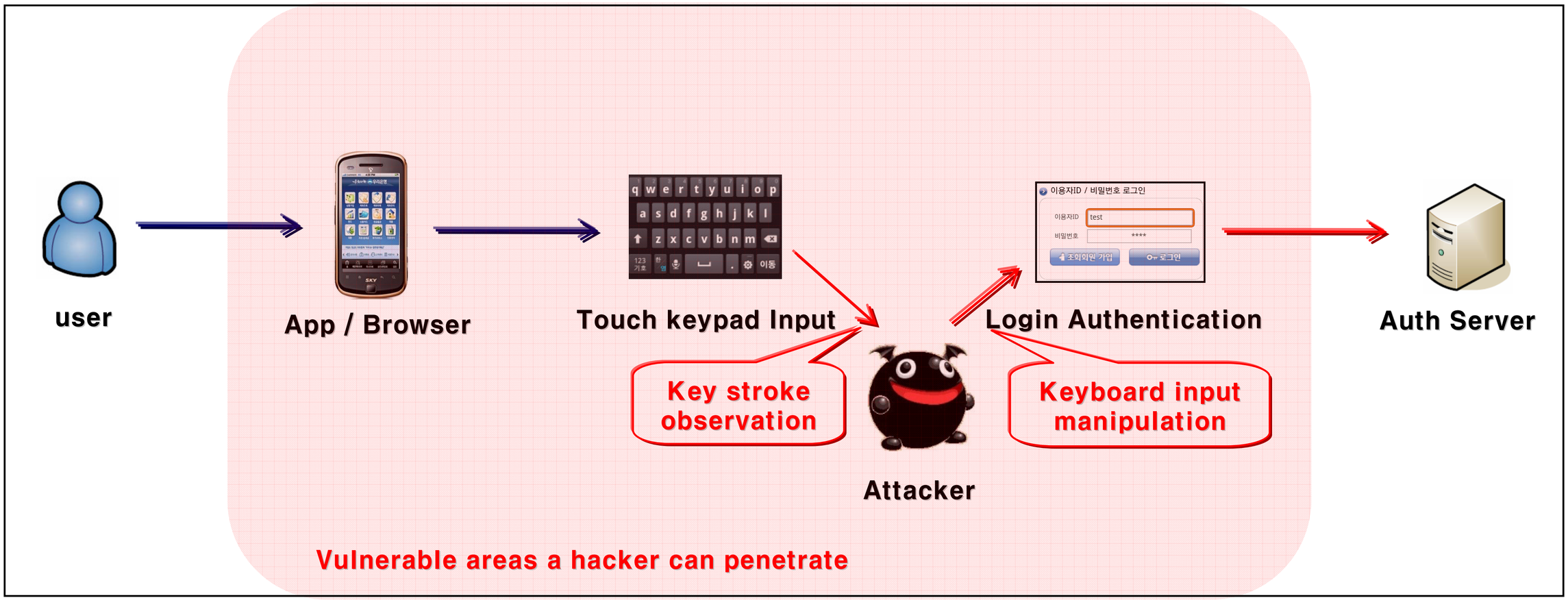
Demonstration 3/4

- **Android kernel rootkit**
  - Enabling kernel malwares and acquiring critical information (device info, history of SMS and calls, contacts, pictures, GPS info)
  - Hiding file & directory, process, LKM module driver
  - remote reverse shell connection



Demonstration 4/4

- **Demonstration of key logger**
  - Emulator/ Bluetooth keyboard logging
  - Touch pad key logging
  - Touch pad key injection
  - Neutralization of keyboard protector using screen capture



Demonstration of Android Kernel Rootkit & Touchpad based Key logger

Q & A

Thank you !

By "dong-hoon yoU" (Xpl017Elz), in INetCop(c).
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