Volafox

Finding treasure in your memory

Who Am I

- Kyeongsik Lee, nick: n0fate
- Digital Forensic Research Center, CIST
- research: FreeBSD, Solaris, Mac OS X

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- Memory Analysis Process
- Physical Memory Analysis
  - Physical Memory Acquisition
  - symbol acquisition
  - Virtual Address Translation
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Introduction

- DFRWS 2005 Memory Forensic Challenge
- rootkit
- many operating system

Target System

Target System

Target System

- Intel 32bit
- Intel 64bit
- PowerPC

Target System

Intel 32bit

Intel 64bit

PowerPC

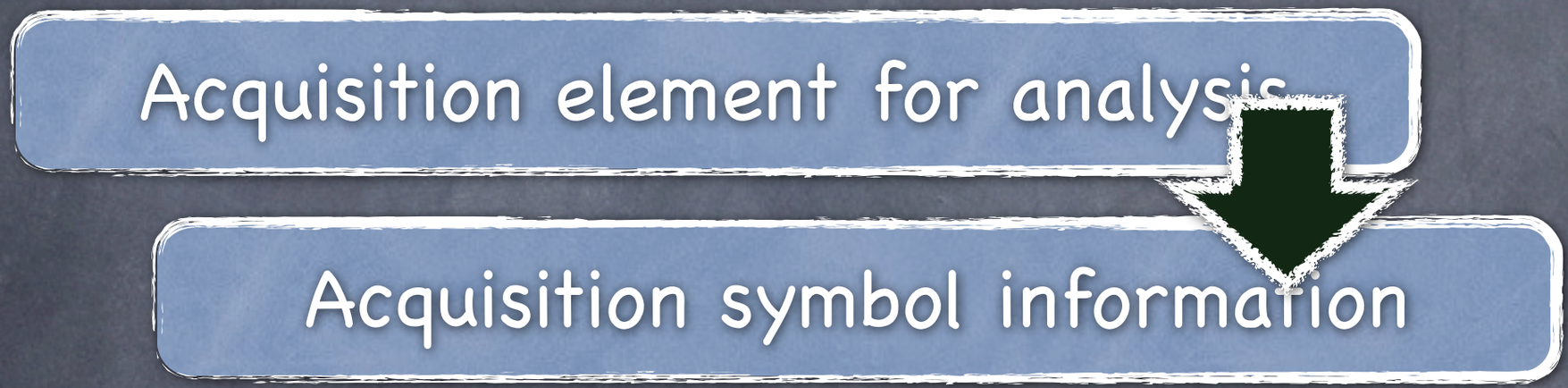
Process

Acquisition element for analysis

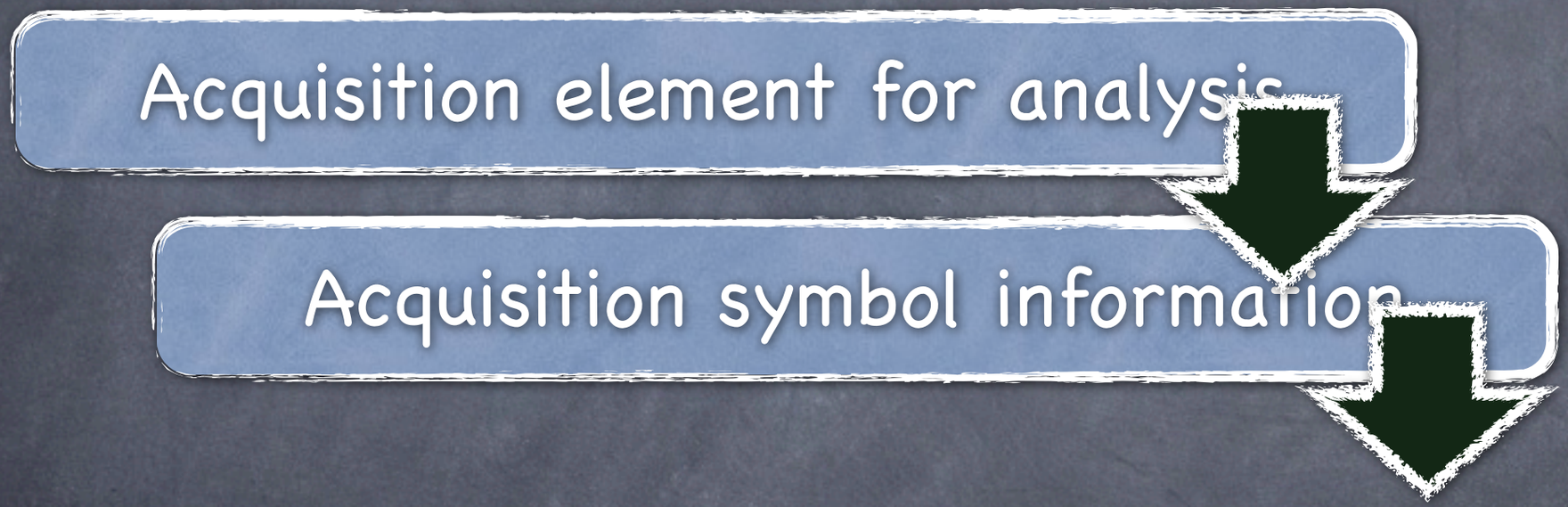
Process

Acquisition element for analysis

Process


Acquisition element for analysis
Acquisition symbol information

Process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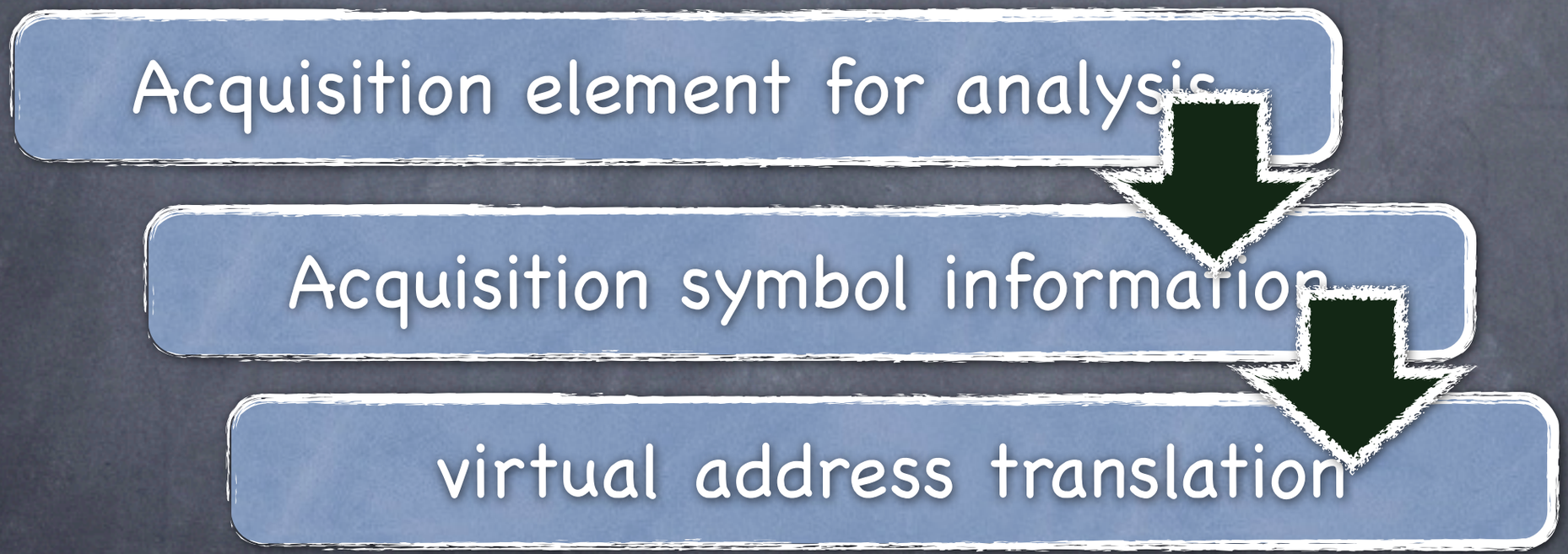
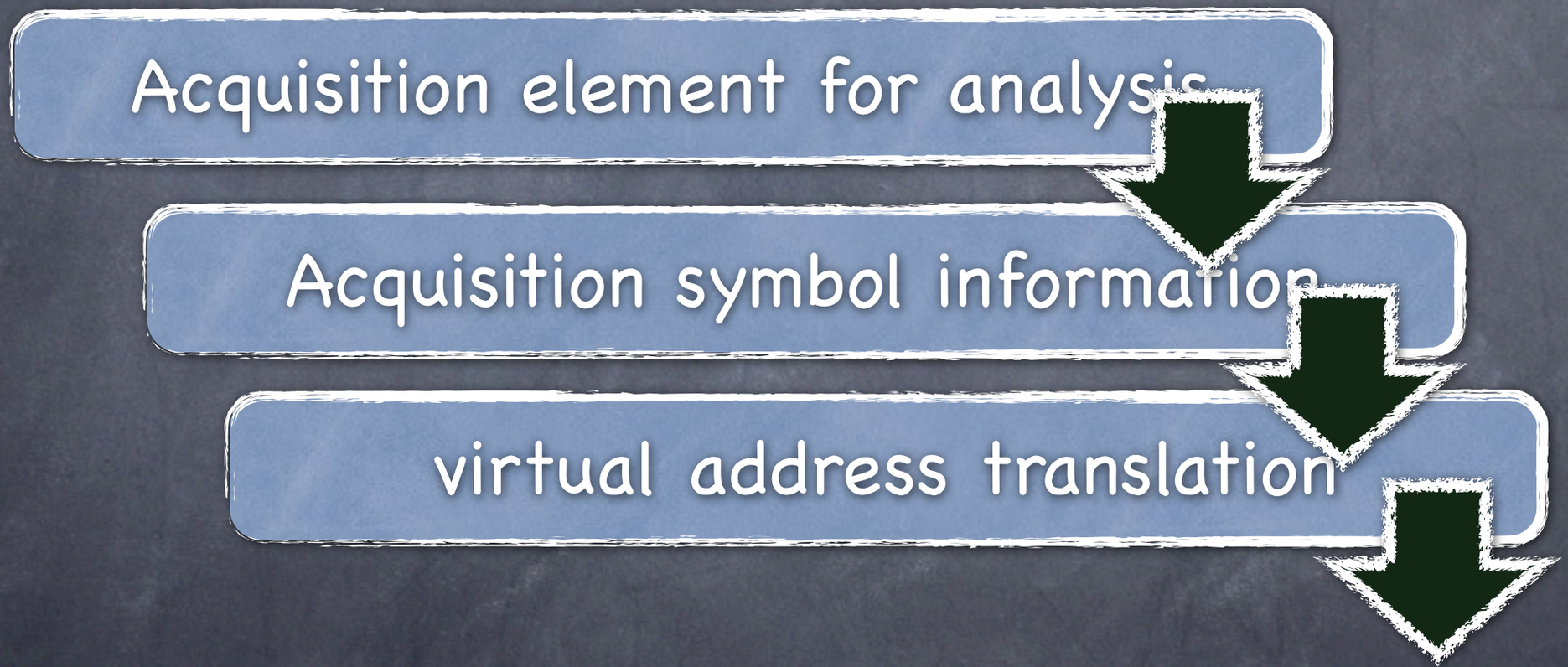

Acquisition element for analysis
Acquisition symbol information
virtual address translation

Process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virtual address translation

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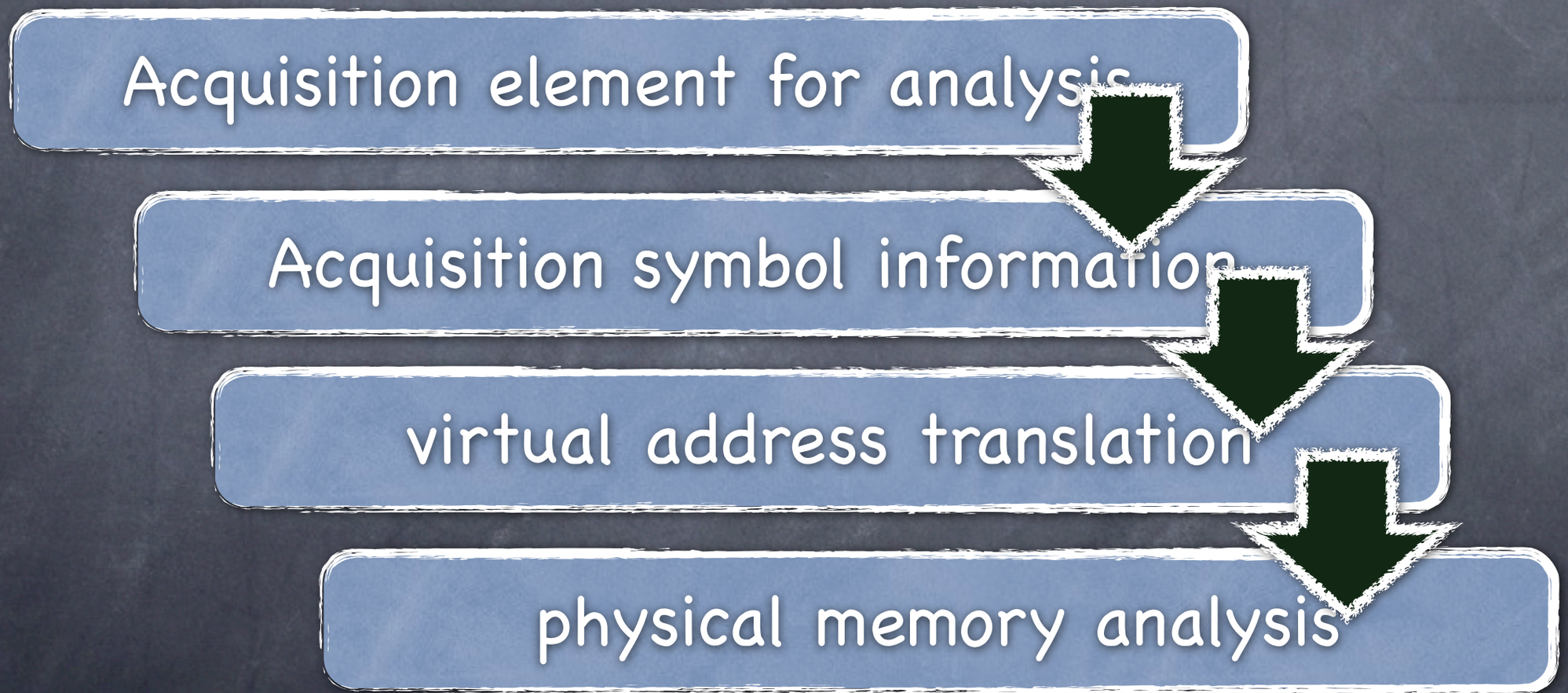
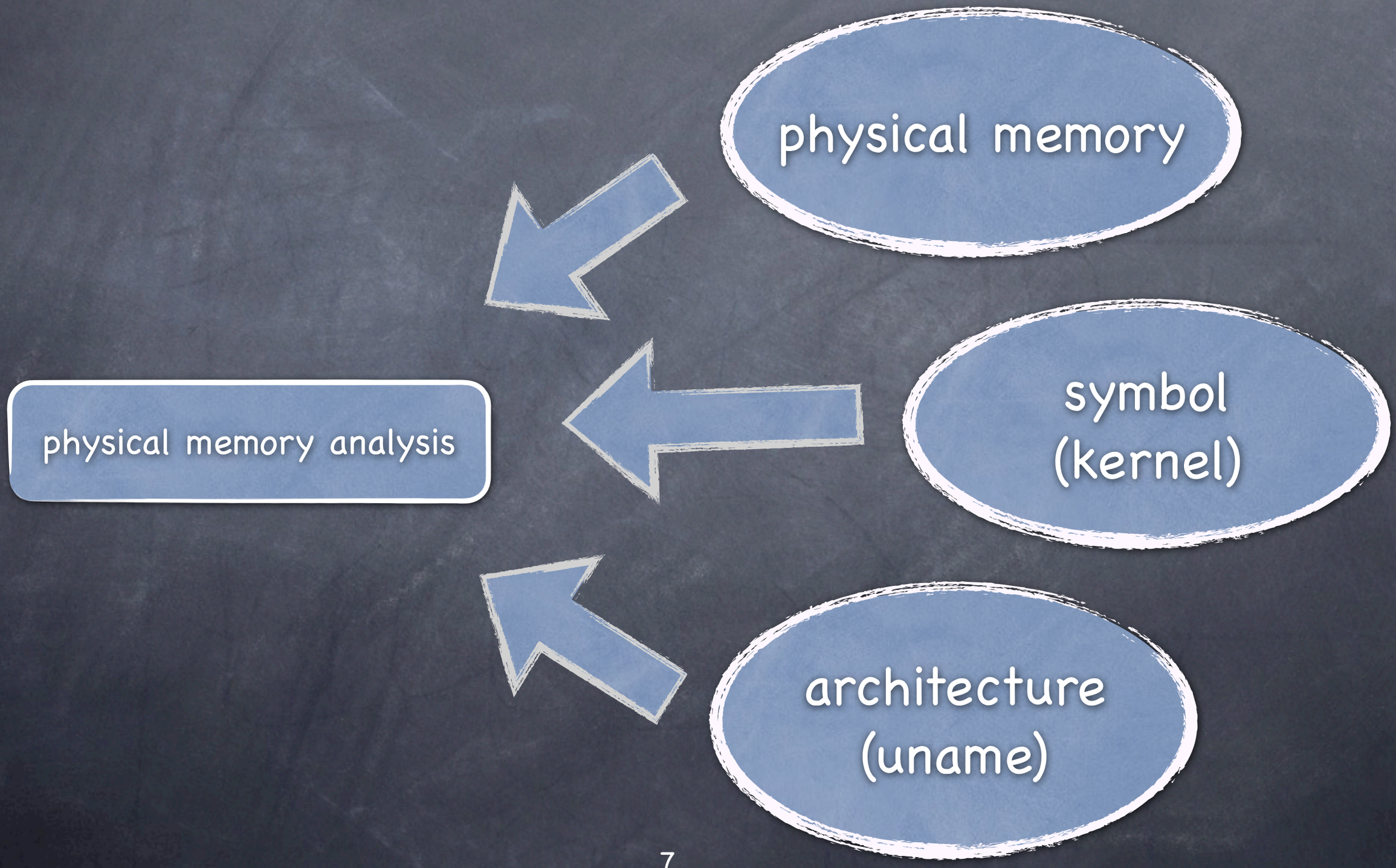

Acquisition element for analysis
Acquisition symbol information
virtual address translation
physical memory analysis

element for analysis



Physical Memory Acquisition

- Integrity(Physical Memory, HDD)
- Very Fast Speed
  - USB 2.0 - 480Mbit/s, FW800 - 800Mbit/s

Physical Memory Acquisition

```
import sys, time
import fw

BLOCKSIZE = 1024*1024*4
devices = fw.scanbus()

def format_guid(i):
    return ':'.join(["".join(x) for x in zip(("%016x" % i)[::2], ("%016x" % i)[1::2])])

start = 0x00000000L
end =   0x100000000L

for device in devices:
    print "Found device %s" % (format_guid(device.guid))
    fd = open("%016x-%08x-%08x.memdump" % (device.guid, start, end), "w")
    pos = start
    while pos < end:
        print "\r-> reading %08x ..." % (pos),
        fd.write(device.read(pos, BLOCKSIZE))
        print hex(device.lastResultCode*1L),
        pos += BLOCKSIZE
        sys.stdout.flush()
    fd.close()
```

Physical Memory Acquisition

- /dev/mem (dummy), /dev/kmem
- load KEXT --> disk, memory integrity (x)

Physical Memory Acquisition

Hibernation

- sleepimage
  - path: /var/vm/
- Encryption (Unknown)

Symbol Acquisition

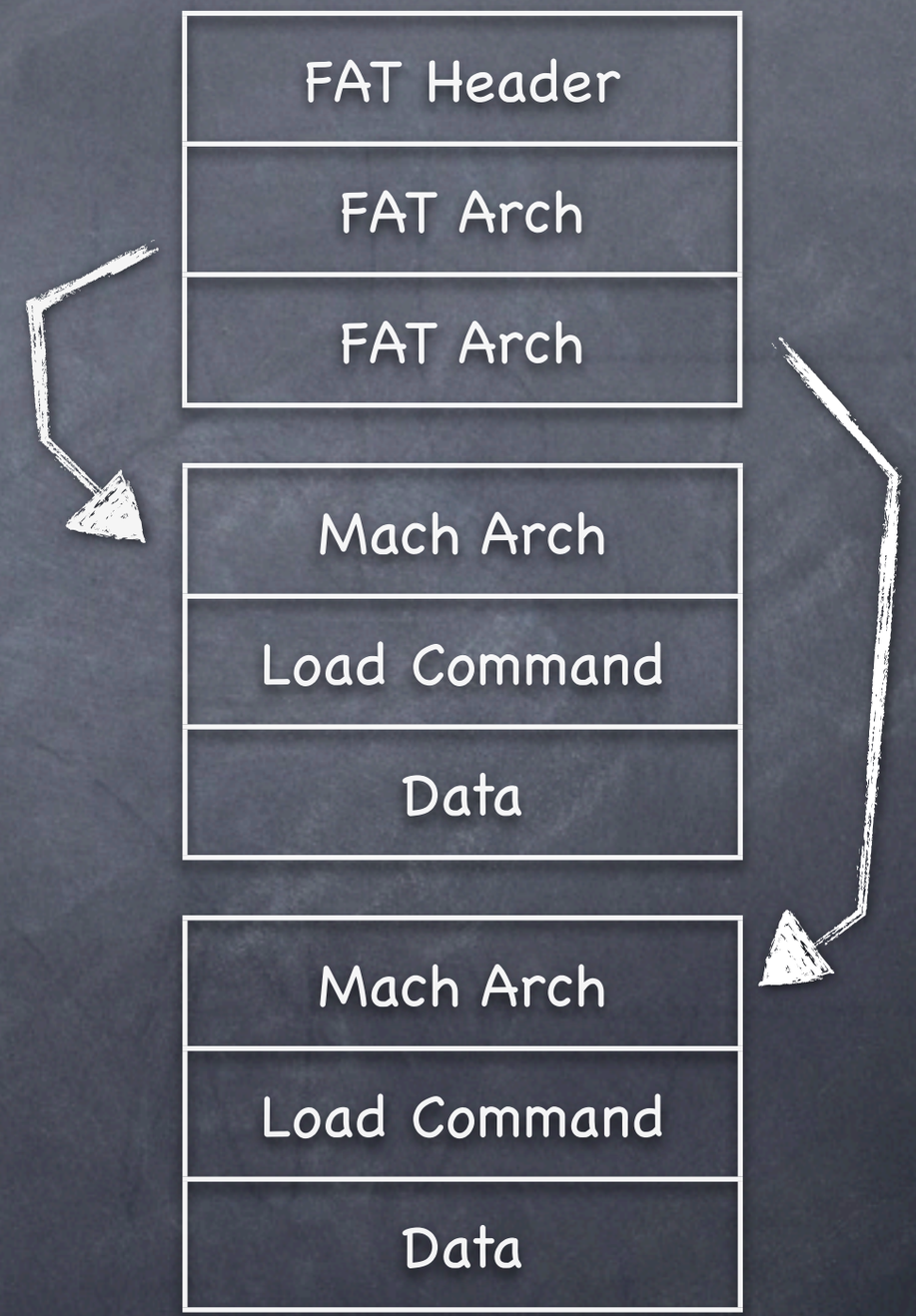
- kernel Image
  - Universal Binaries
  - Mach-O file format

```
In archive mach_kernel:

mach_kernel:i386:x86-64:     file format mach-o-le
mach_kernel:i386:x86-64


mach_kernel:i386:     file format mach-o-i386
mach_kernel:i386

mach_kernel:powerpc:common:     file format mach-o-be
mach_kernel:powerpc:common
```



Symbol Acquisition

Mach Header

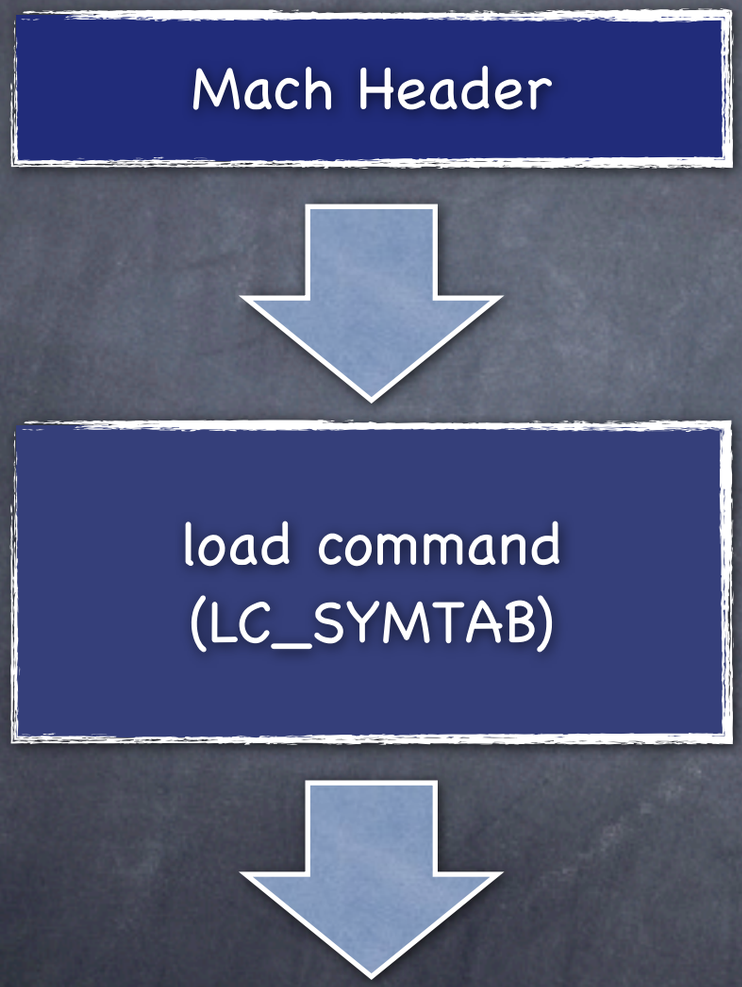
Symbol Acquisition

Symbol Acquisition

Mach Header

load command
(LC_SYMTAB)

Symbol Acquisition



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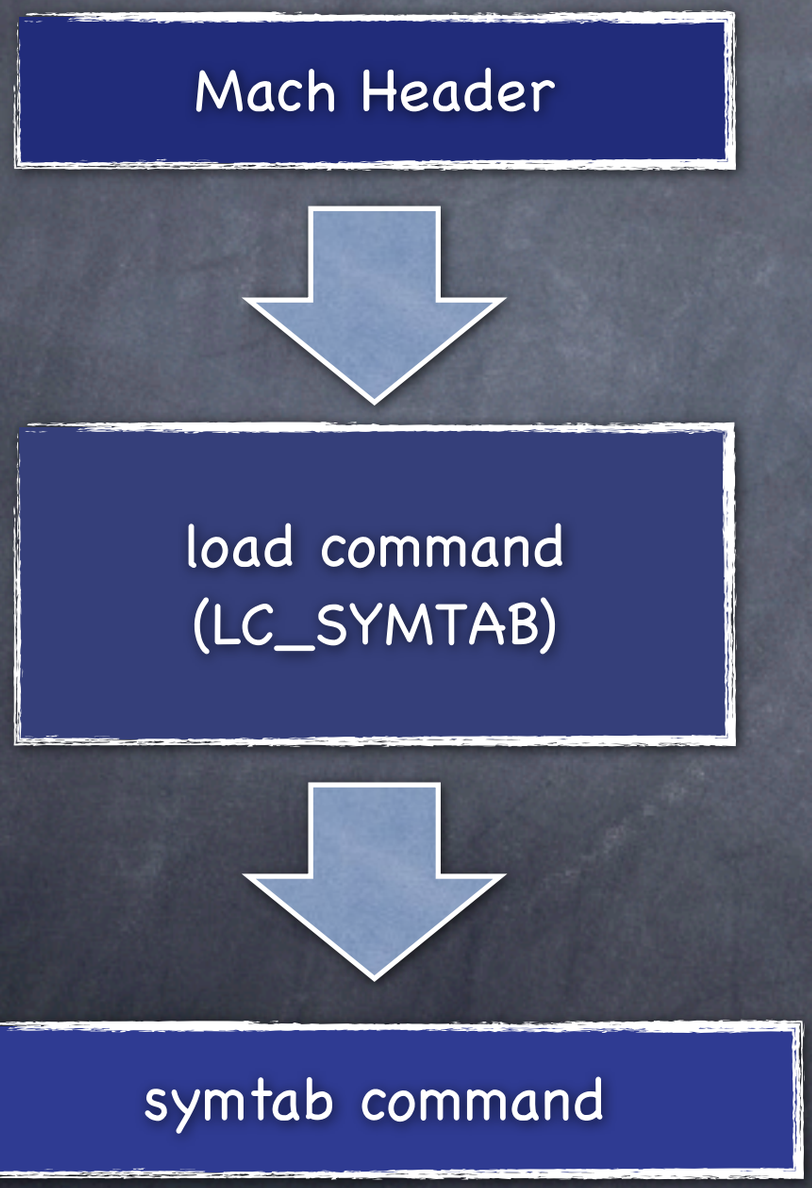

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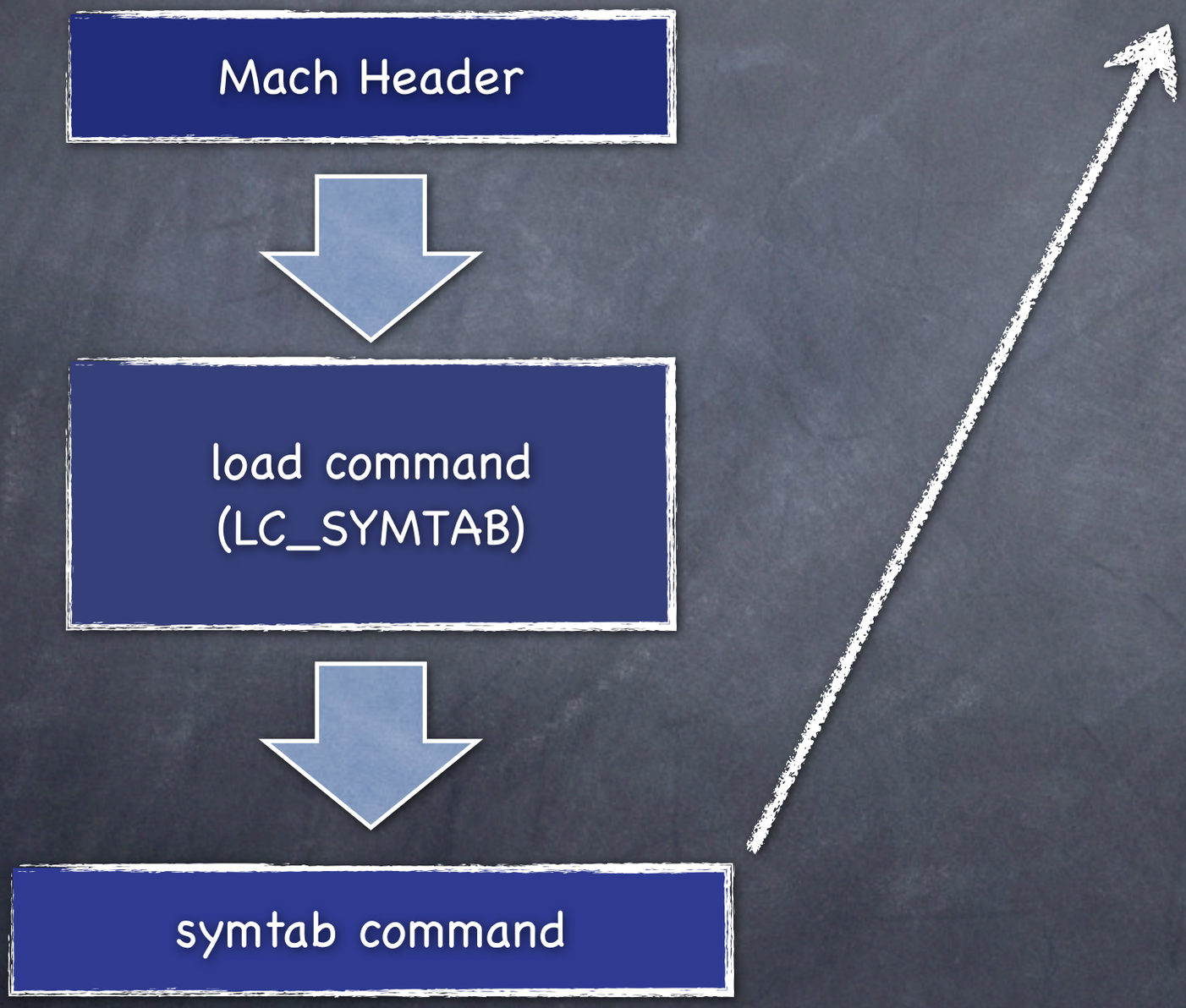
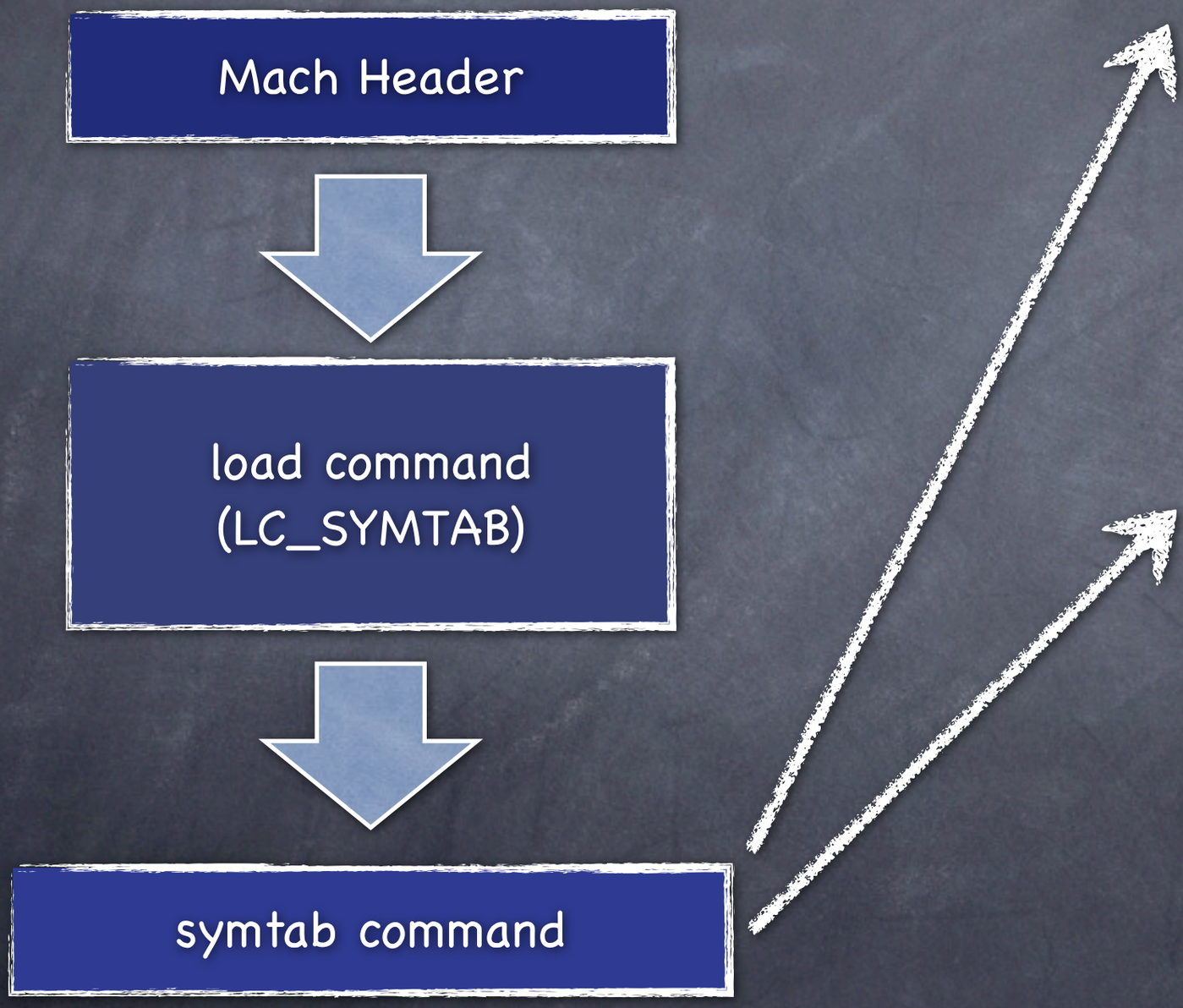


Symbol Acquisition



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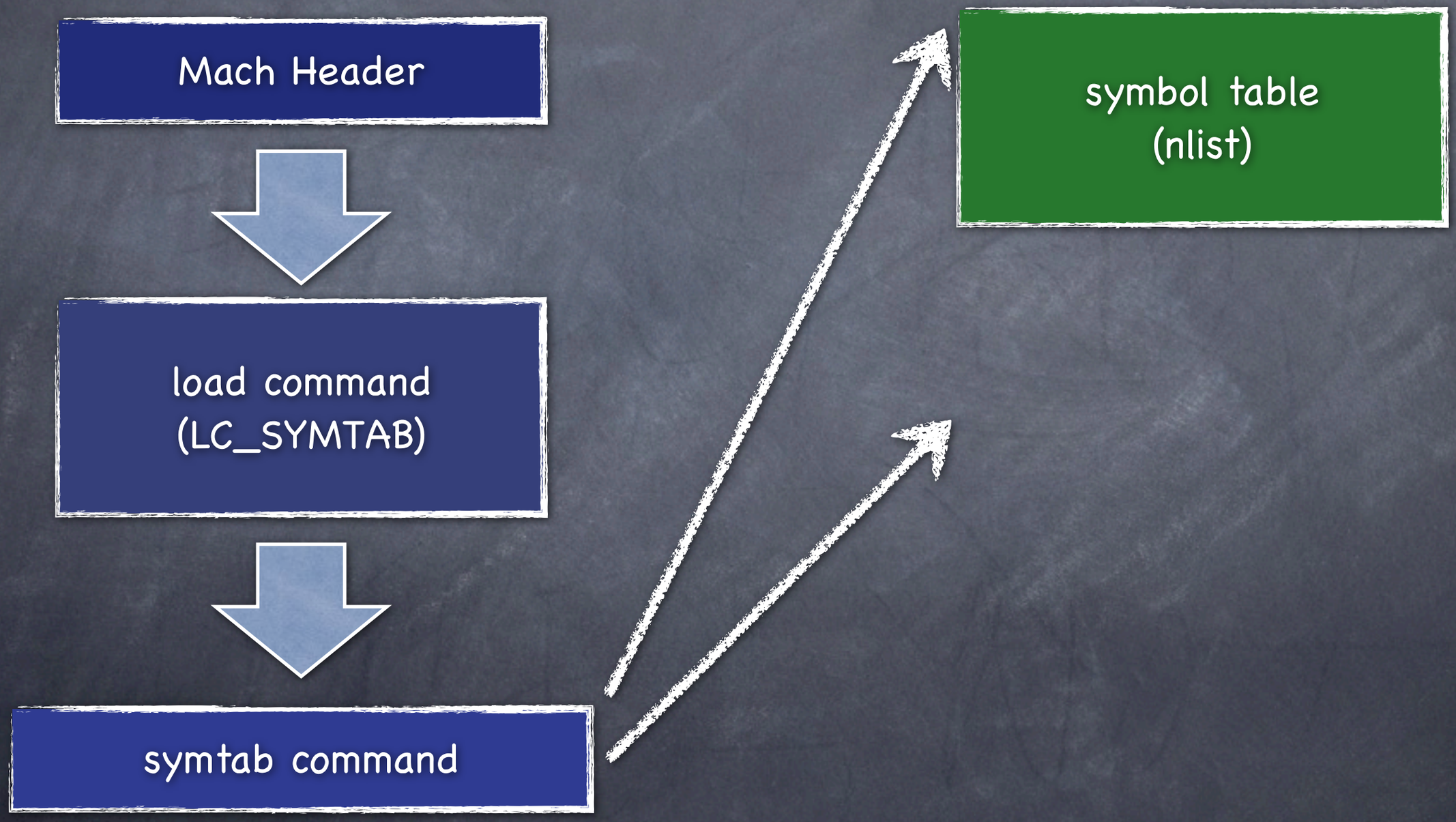
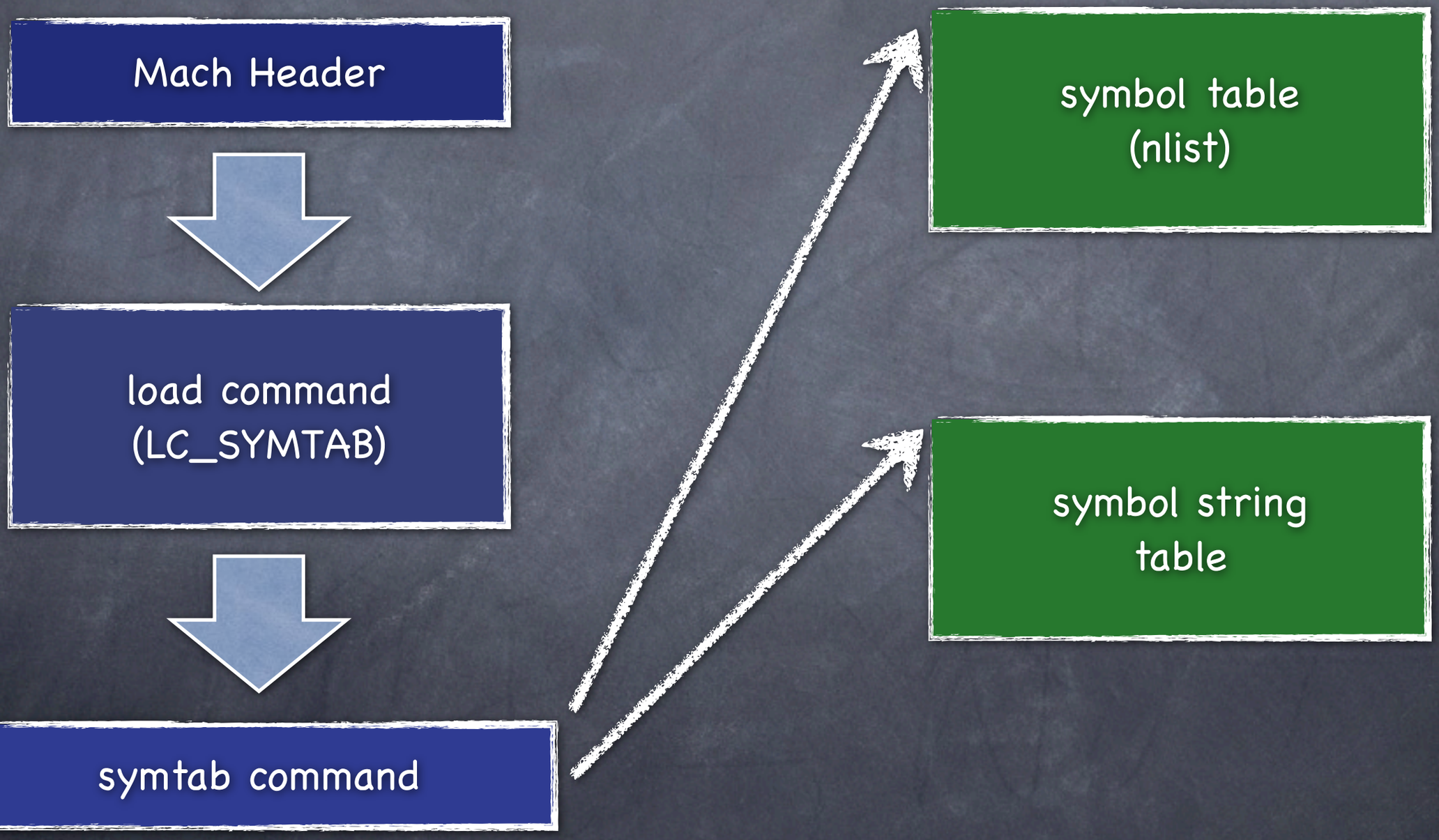


Symbol Acquisition



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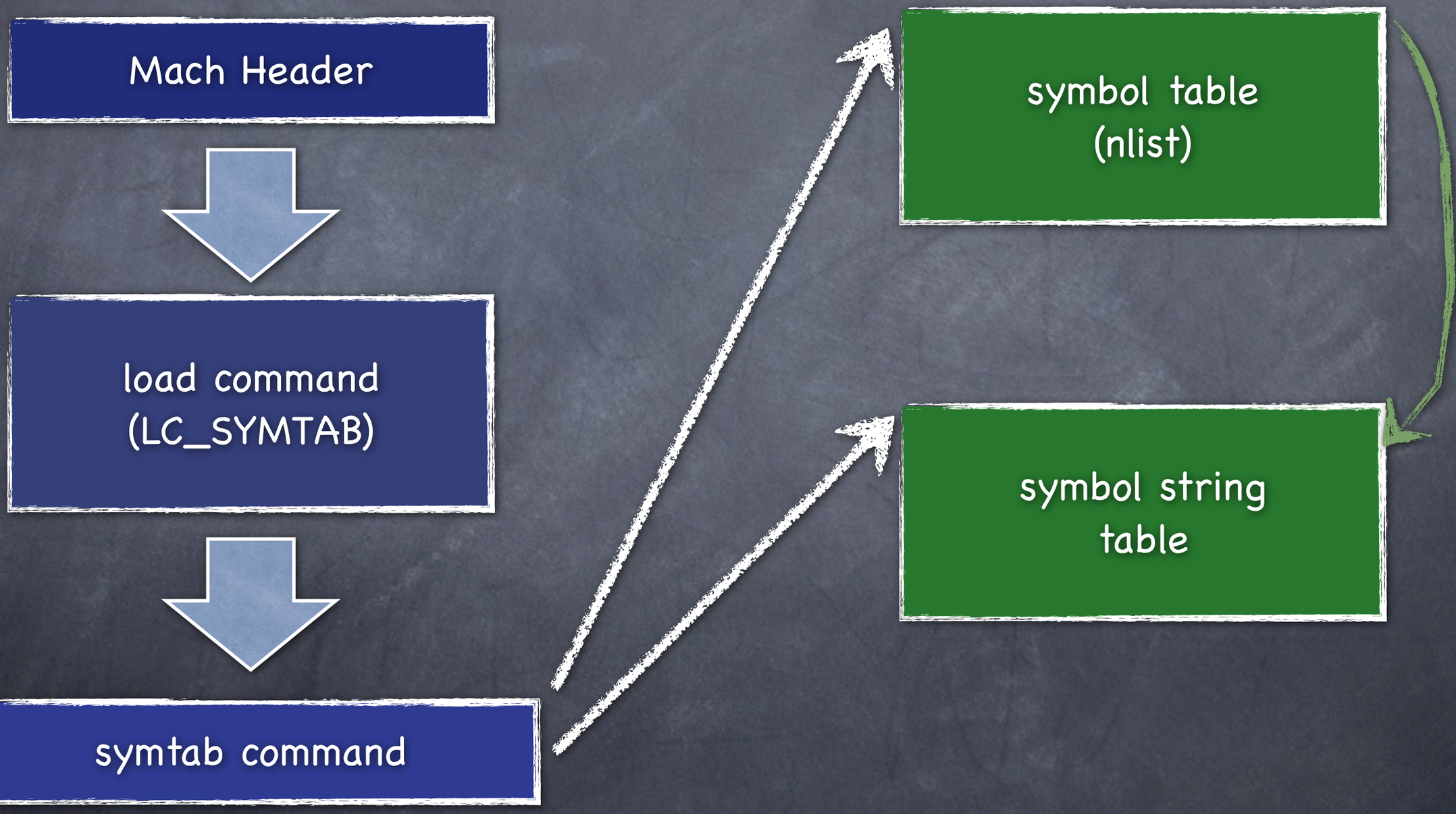

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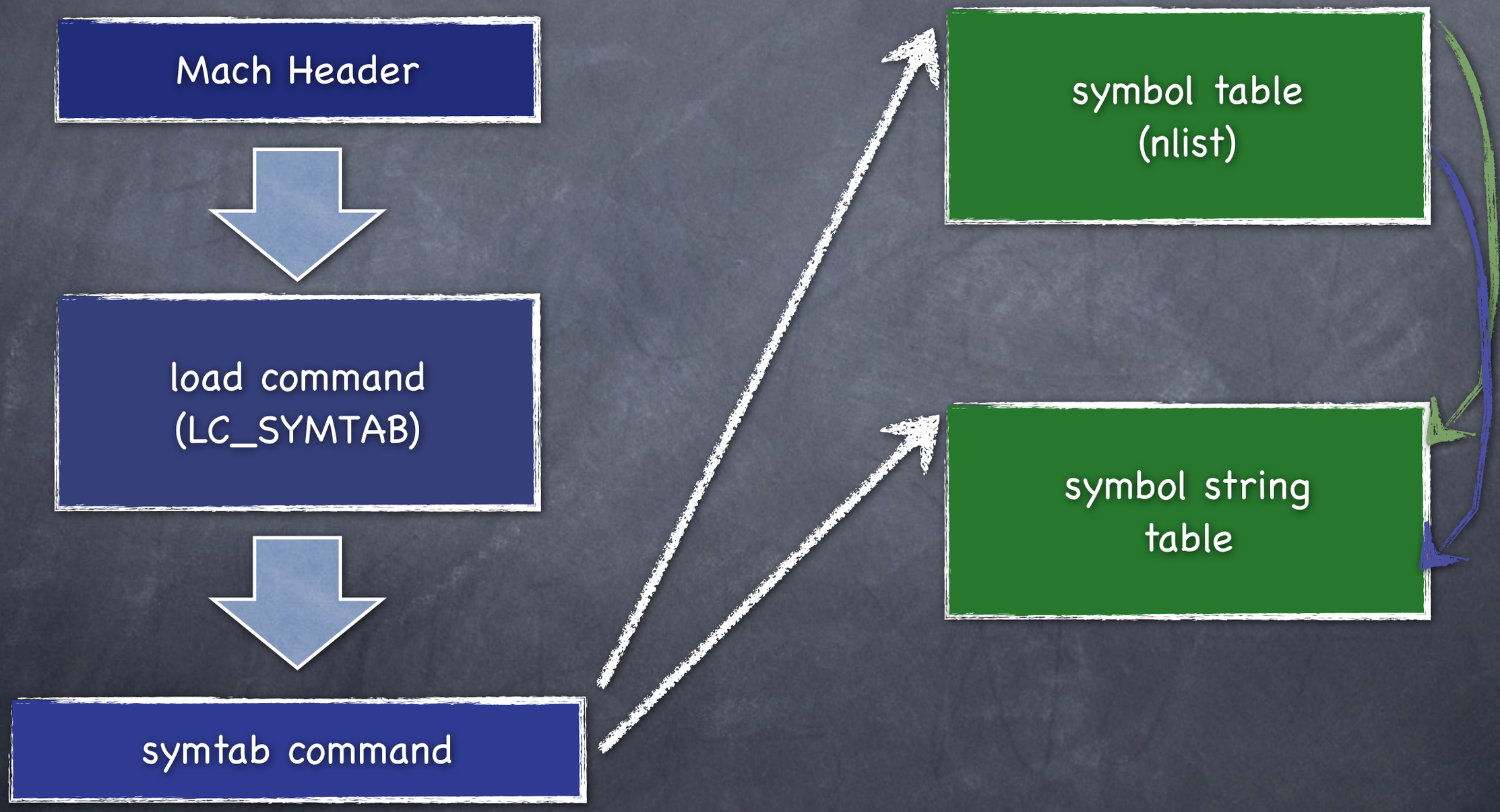

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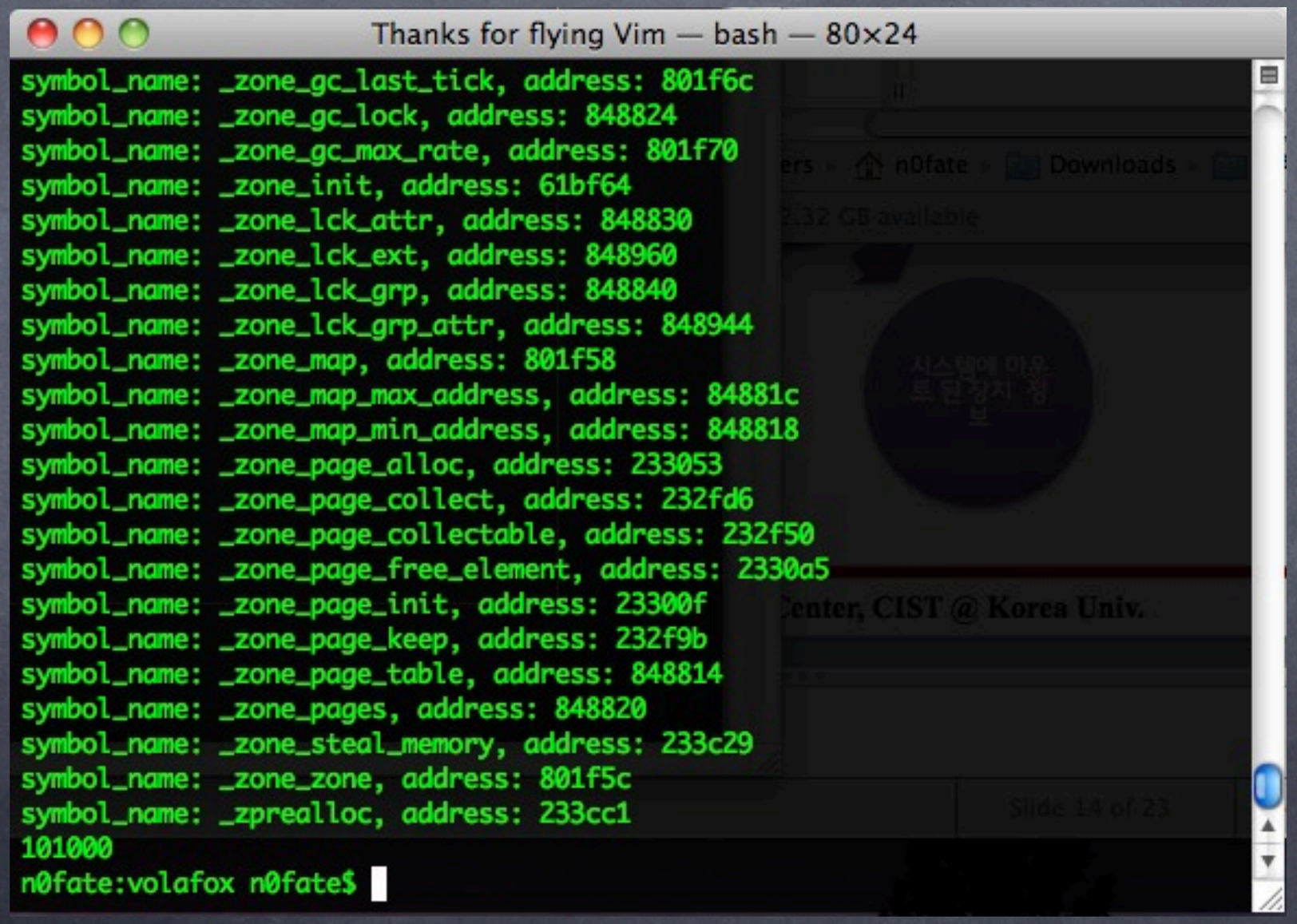
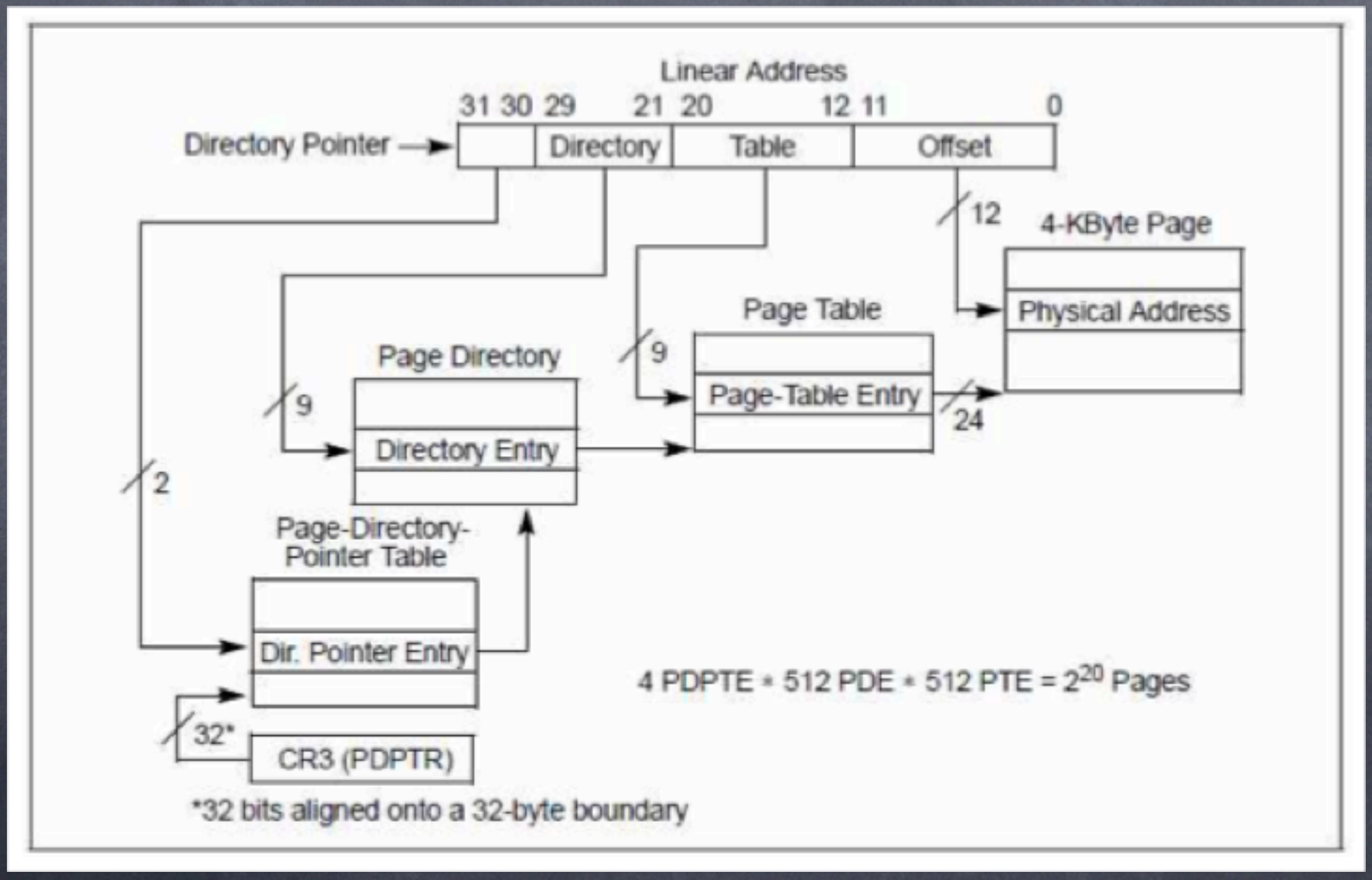


Virtual Address Translation

- Technique
  - PAE (Physical Address Extensions)
    - PML4 (Page Map Level 4)
- Store kernel symbol to translate VA
  - IdlePDPT, IdlePML4

Virtual Address Translation



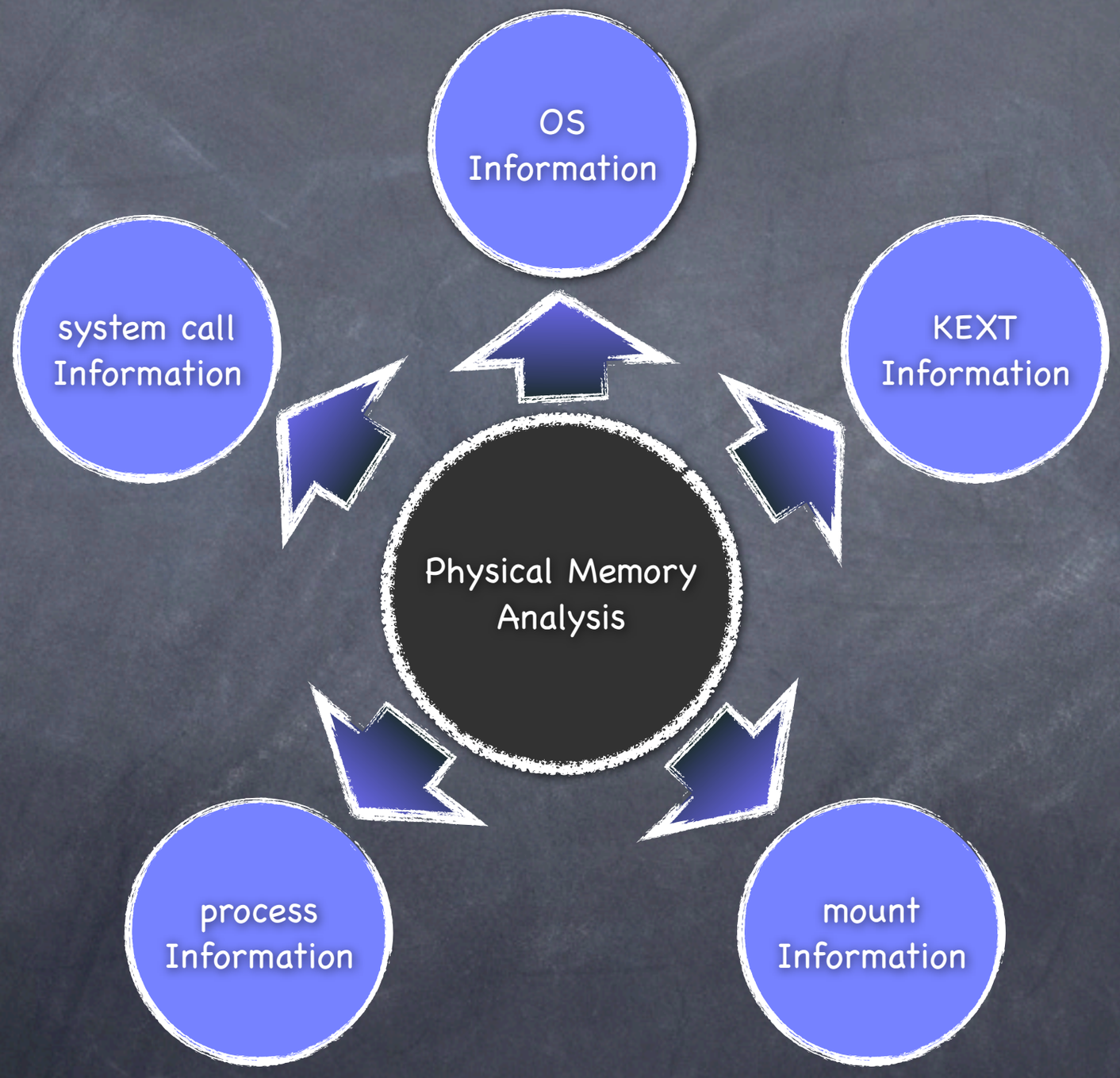
Physical Memory Analysis

- Symbol
  - select kernel symbol to analysis
- Structure
  - http://opensource.apple.com

volafox

- Memory Analyzer for OS X
  - Code: Python 2.5
  - Support OS: everything(?)
- Module
  - mach-o format analyzer
  - memory analyzer
  - Virtual Address Translation (Volatility Framework)

volafox


OS
Information
system call
Information
KEXT
Information
Physical Memory
Analysis
process
Information
mount
Information

Demo

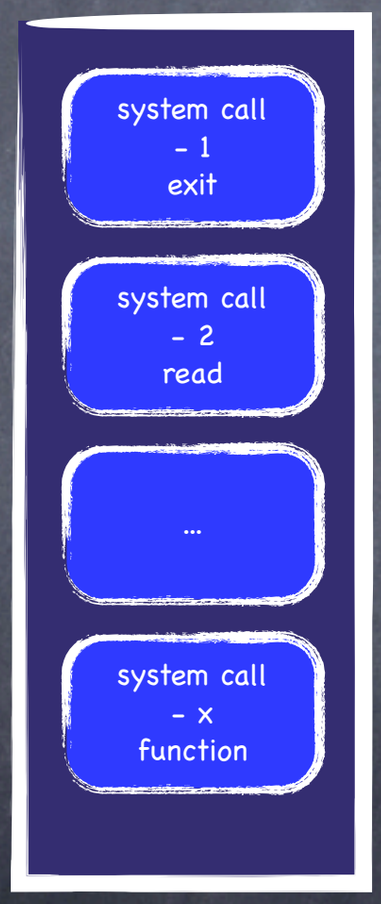
Terminal — bash — 80×24

```
n0fate:volafox n0fate$ python volafox.py
Memory analyzer for OS X 0.5 - n0fate
Contact: rapfer@gmail.com
usage: python volafox.py -i MEMORY_IMAGE -s KERNEL_IMAGE -o INFORMATION

-= CAUTION =-
this program need to physical memory image, kernel image(mach_kernel)
and it support to Intel x86 Architecture only :(

INFORMATION:
os_version          Dawin kernel detail version
machine_info        Kernel version, cpu, memory information
mount_info          Mount information
kern_kext_info      Kernel KEXT(Kernel Extensions) information
kext_info           KEXT(Kernel Extensions) information
proc_info           Process list
syscall_info        Kernel systemcall information
n0fate:volafox n0fate$
```

System Call Hooking



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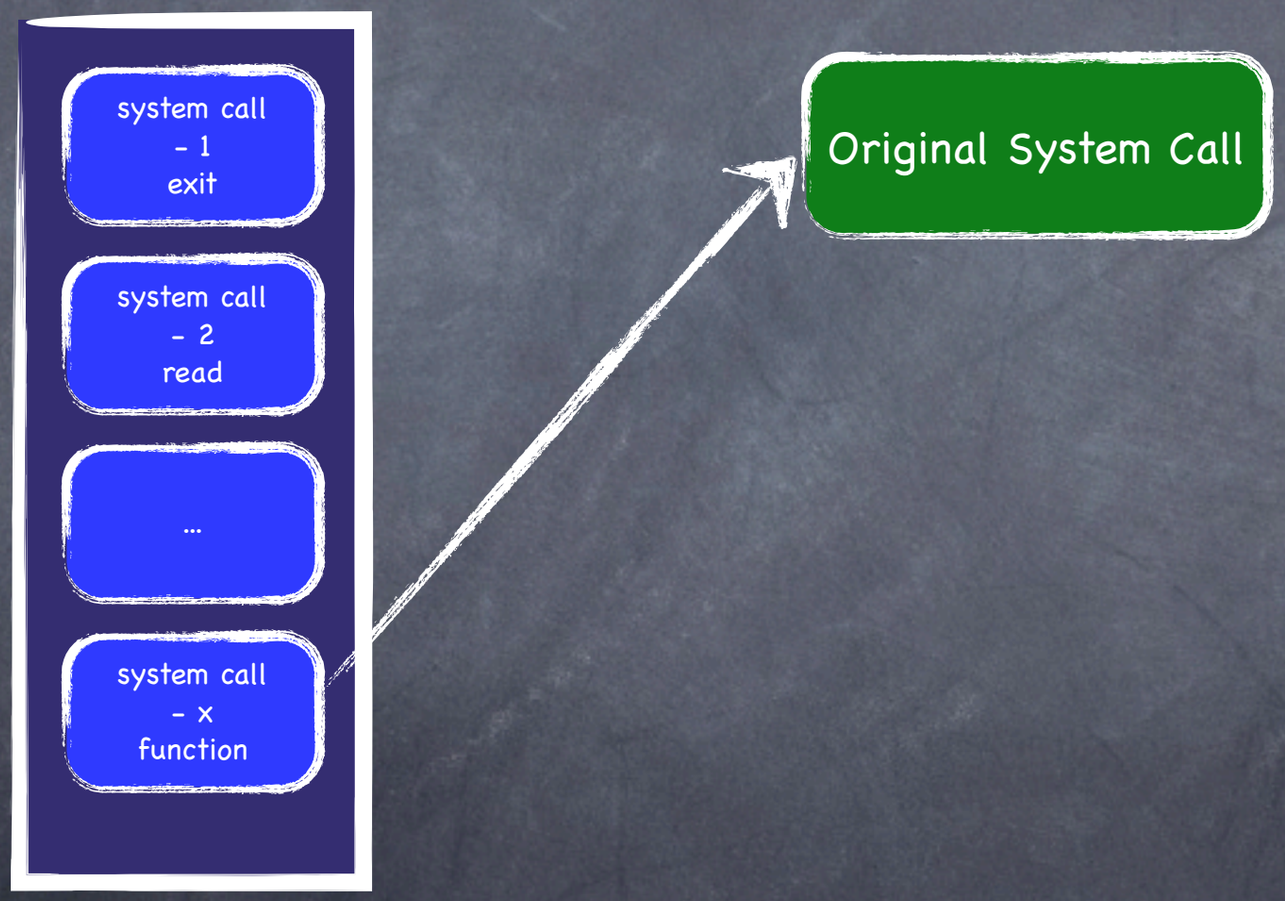

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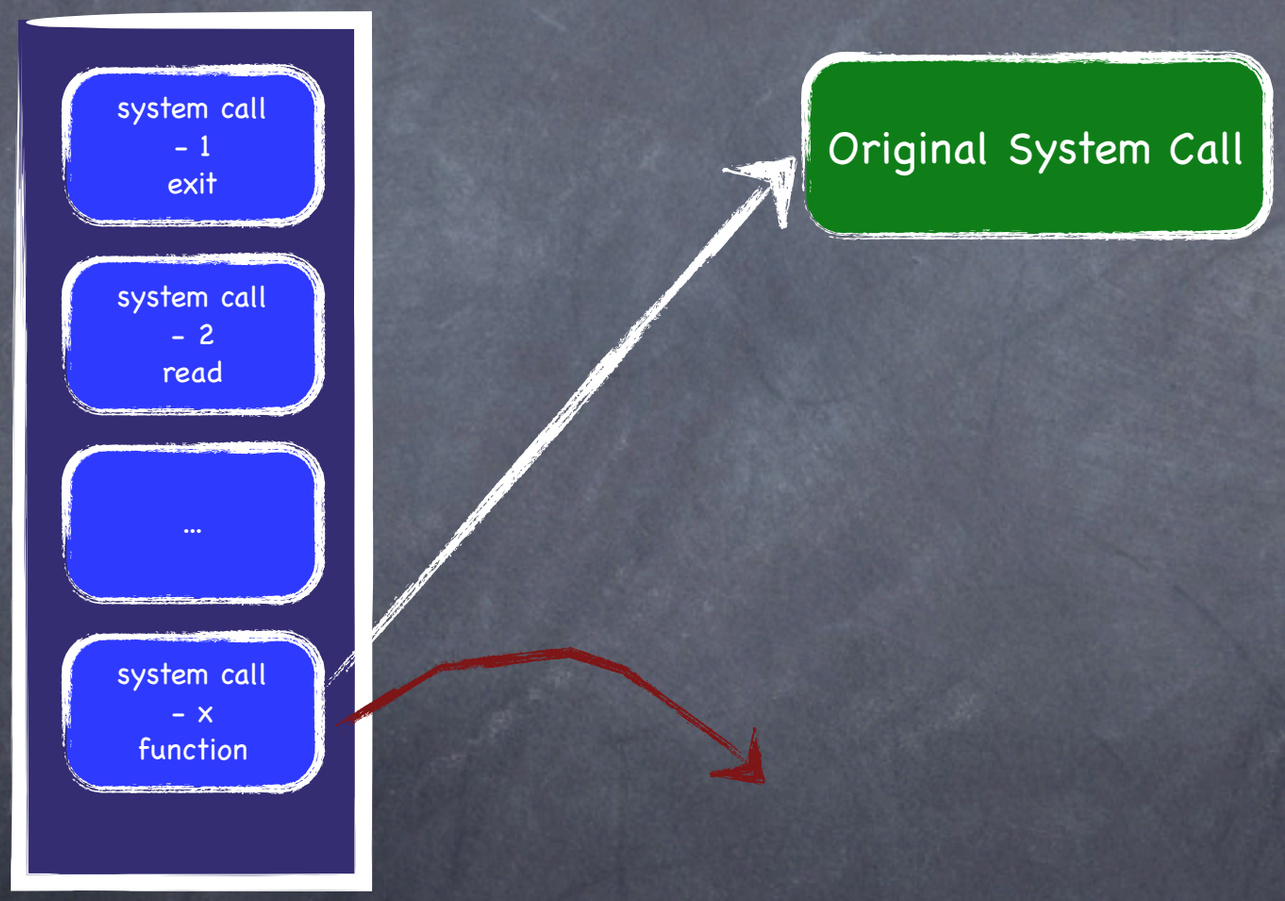

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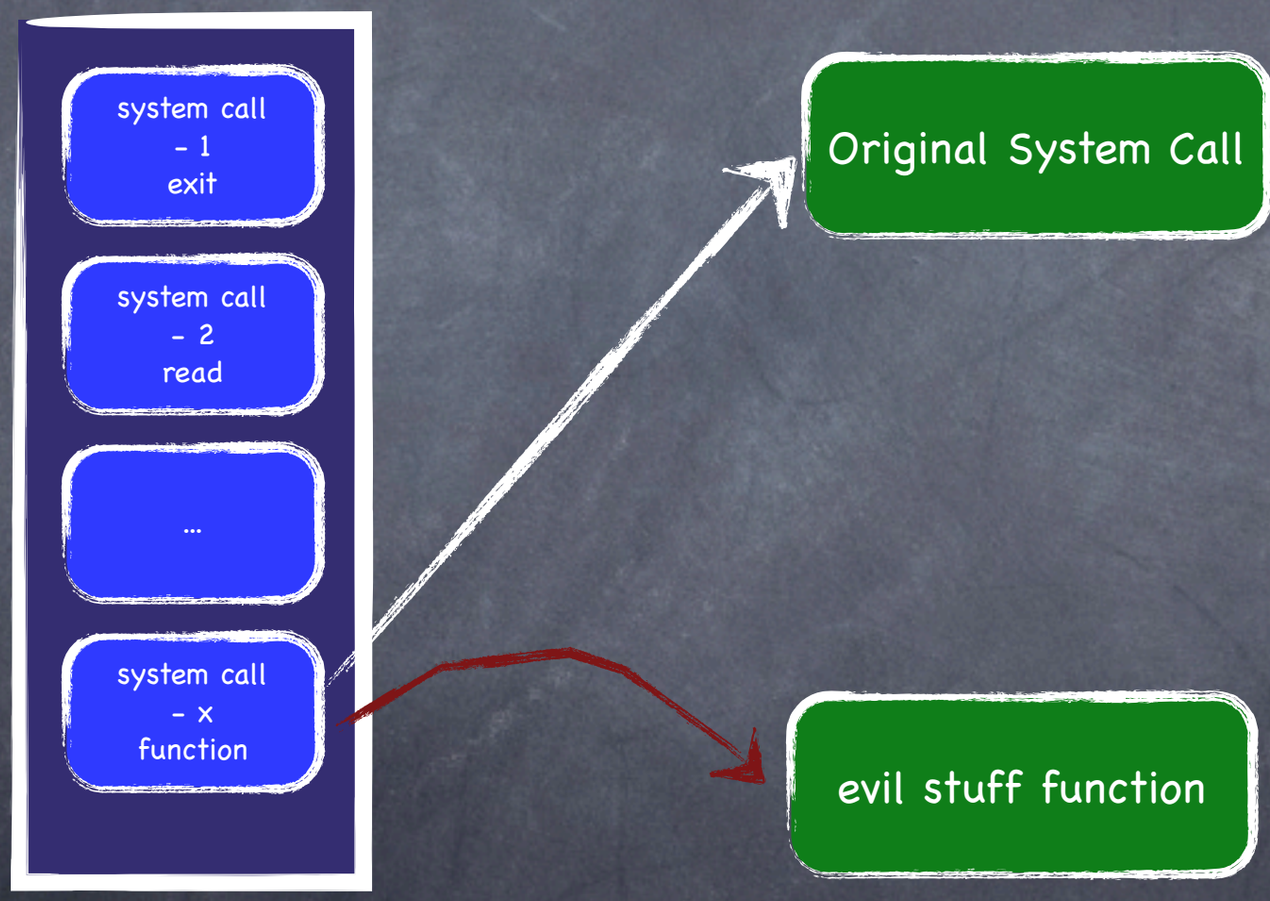

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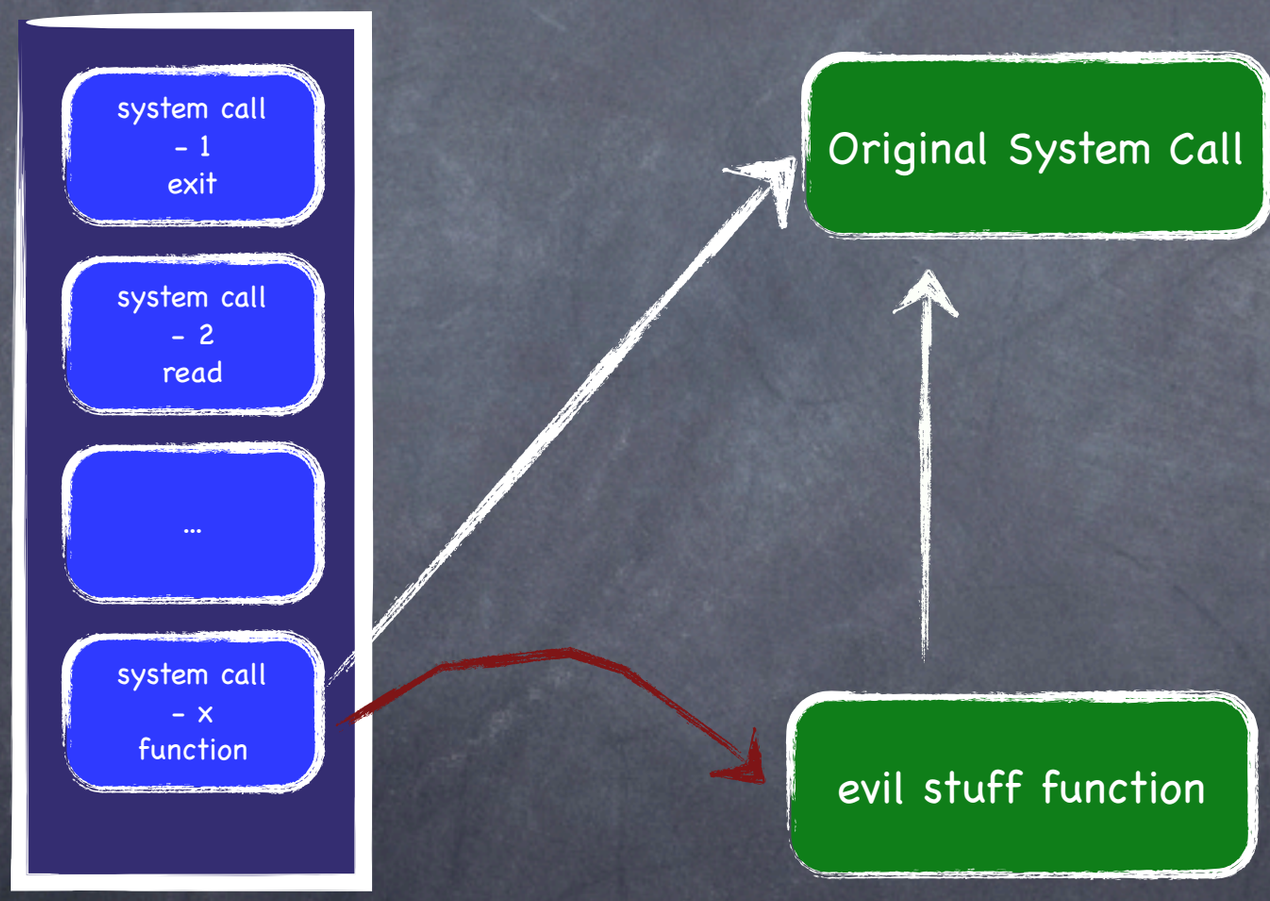
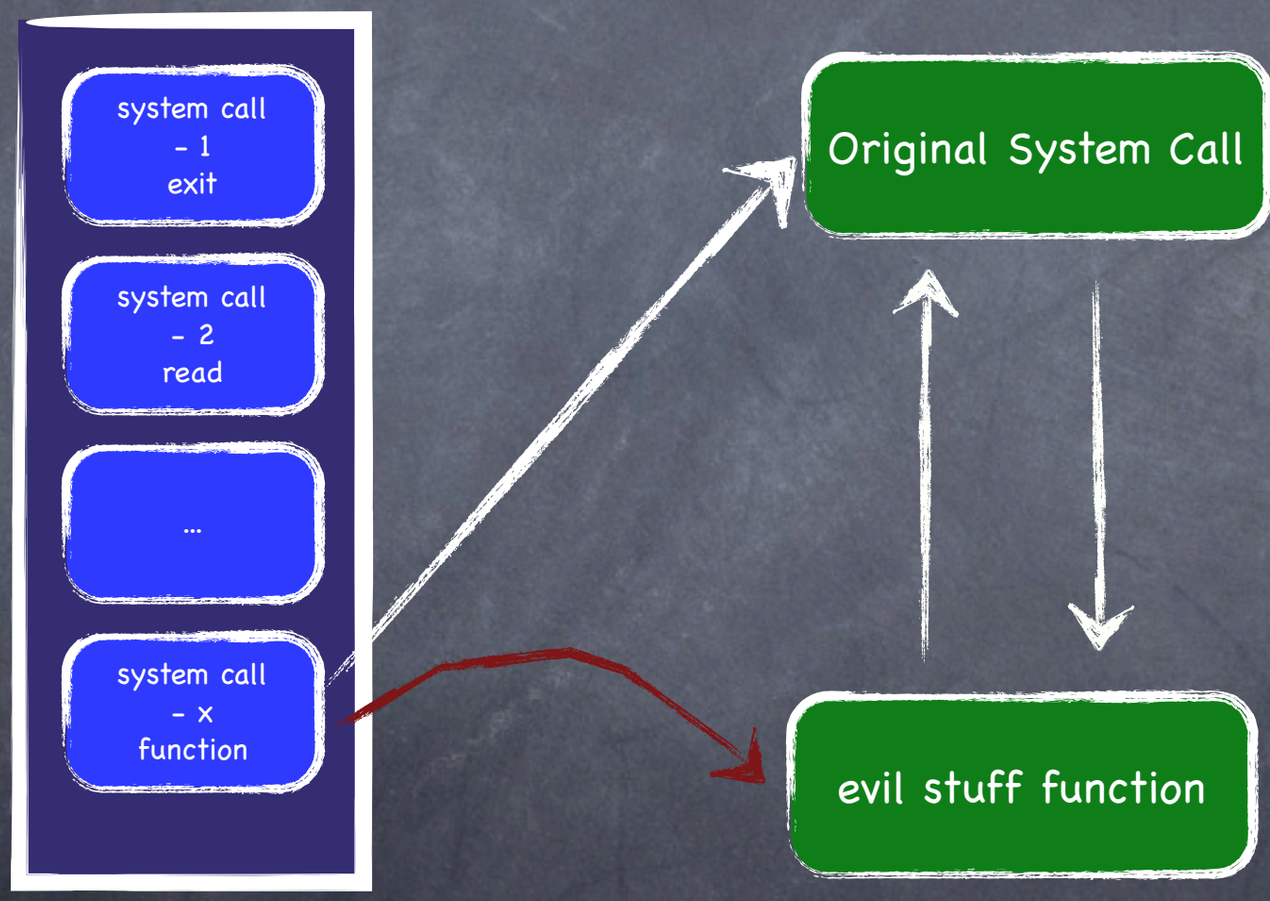


System Call Hooking



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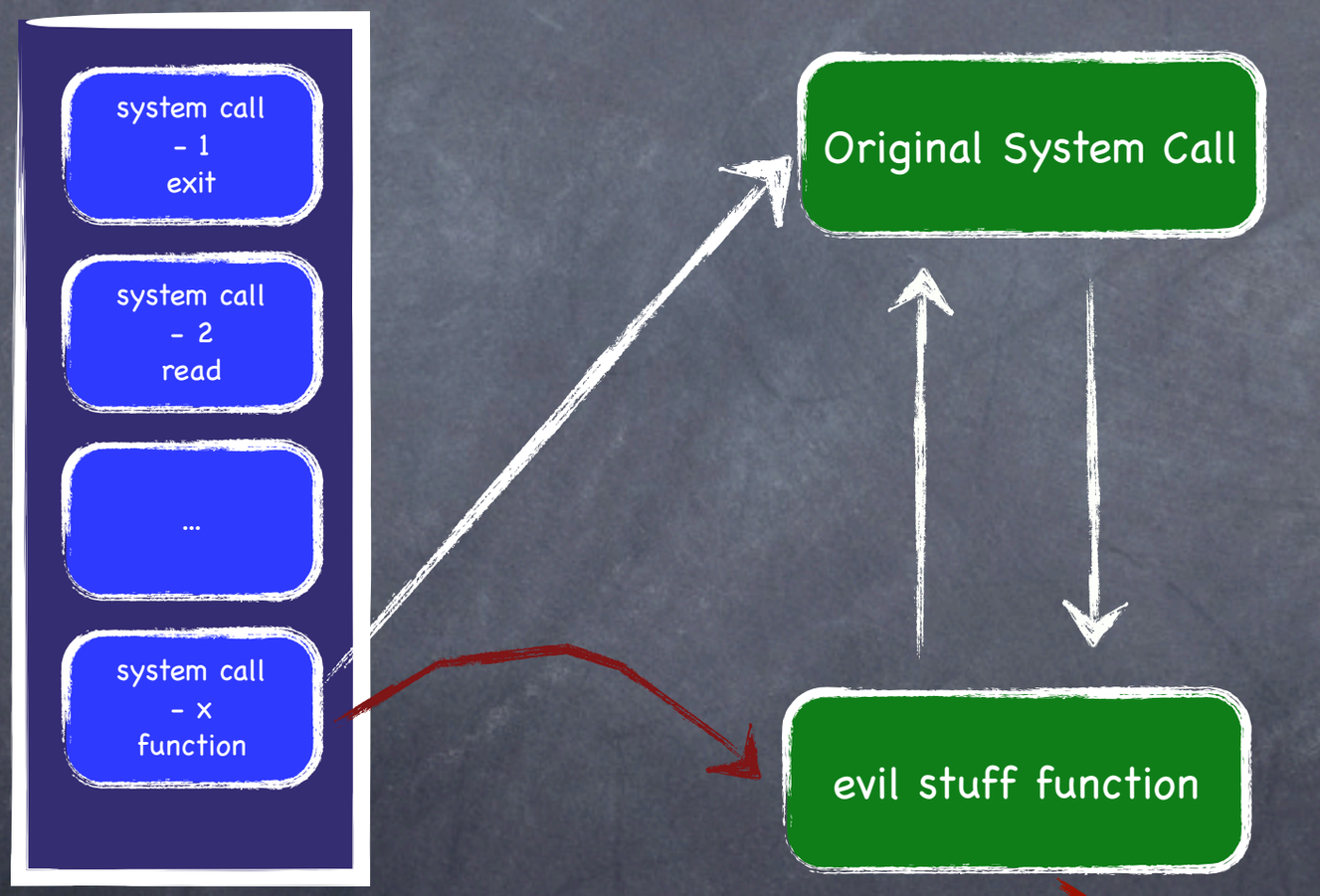
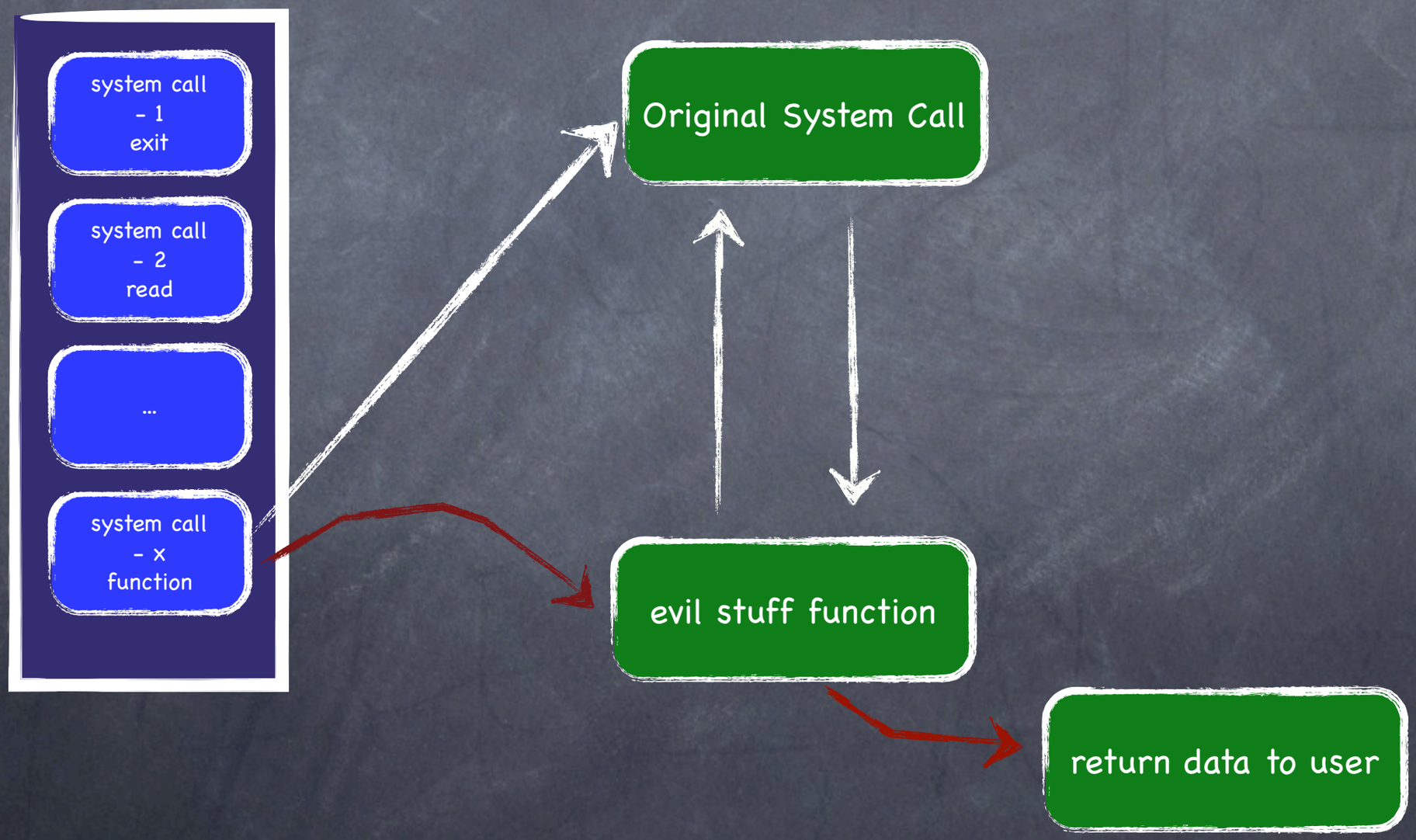


System Call Hooking



System Call Hooking

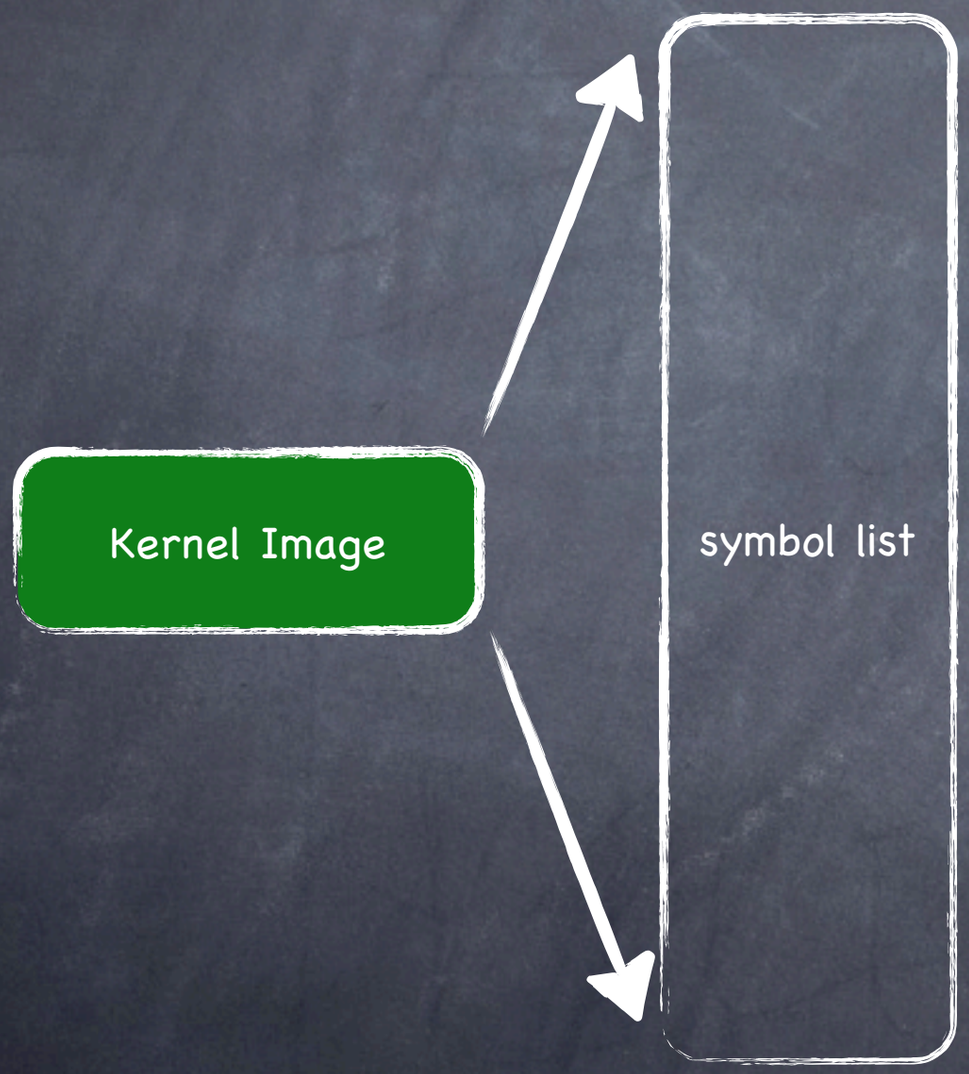
- Step
  - find `nsysent' symbol
  - Snow Leopard -> sysent = &nsysent - (nsysent * sizeof(sysent))
  - modifying system call function = sysent->sy_call = evil_stuff

```
struct sysent {
    int16_t sy_narg;
    int8_t reserved;
    int8_t sy_flags;
    sy_call_t *sy_call;
    sy_munge_t *sy_arg_munge32;
    sy_munge_t *sy_arg_munge64;
    int32_t sy_return_type;
    uint16_t sy_arg_bytes;
};
```

System Call Hooking

- Example) Hiding Files
- Hooking function
  - getdirentriesattr() - get file system attributes for multiple directory
  - getdirentries64() - read directory entries in a filesystem independent format

Detection



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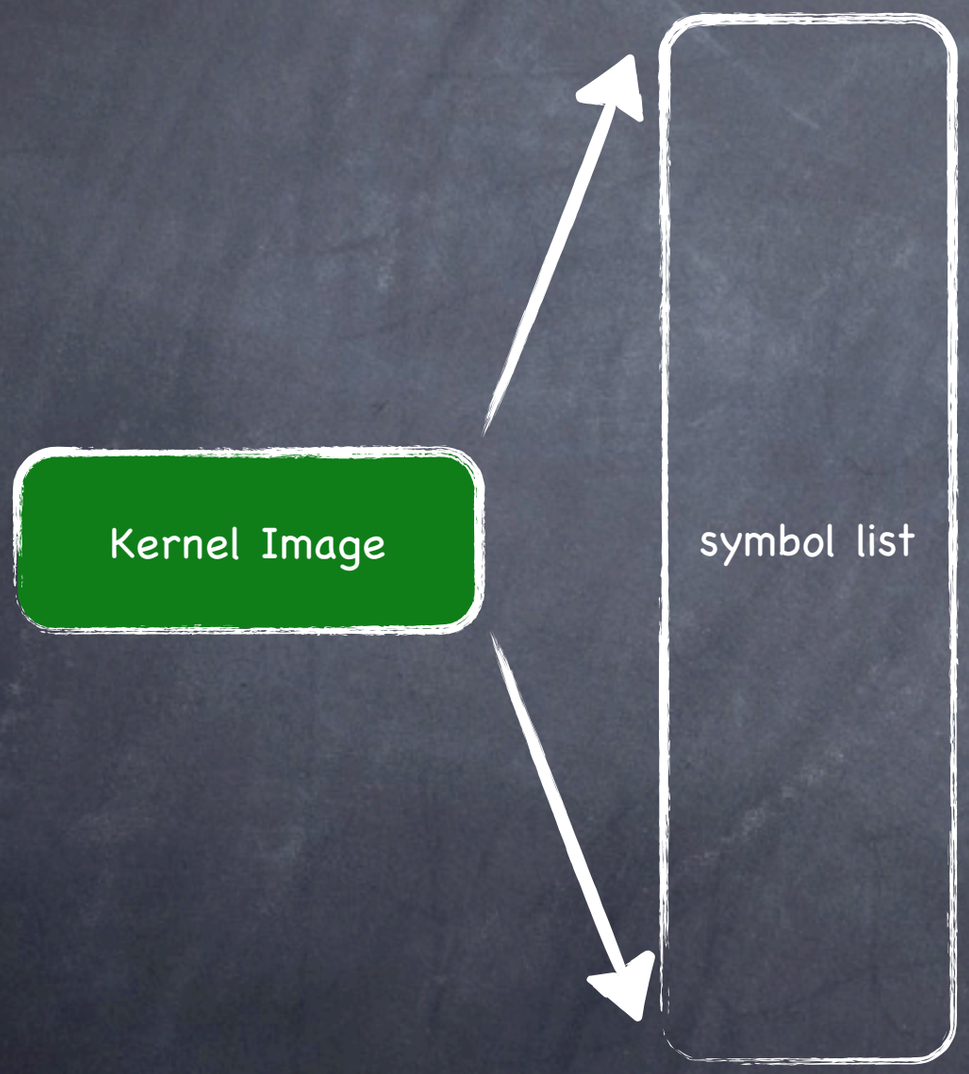
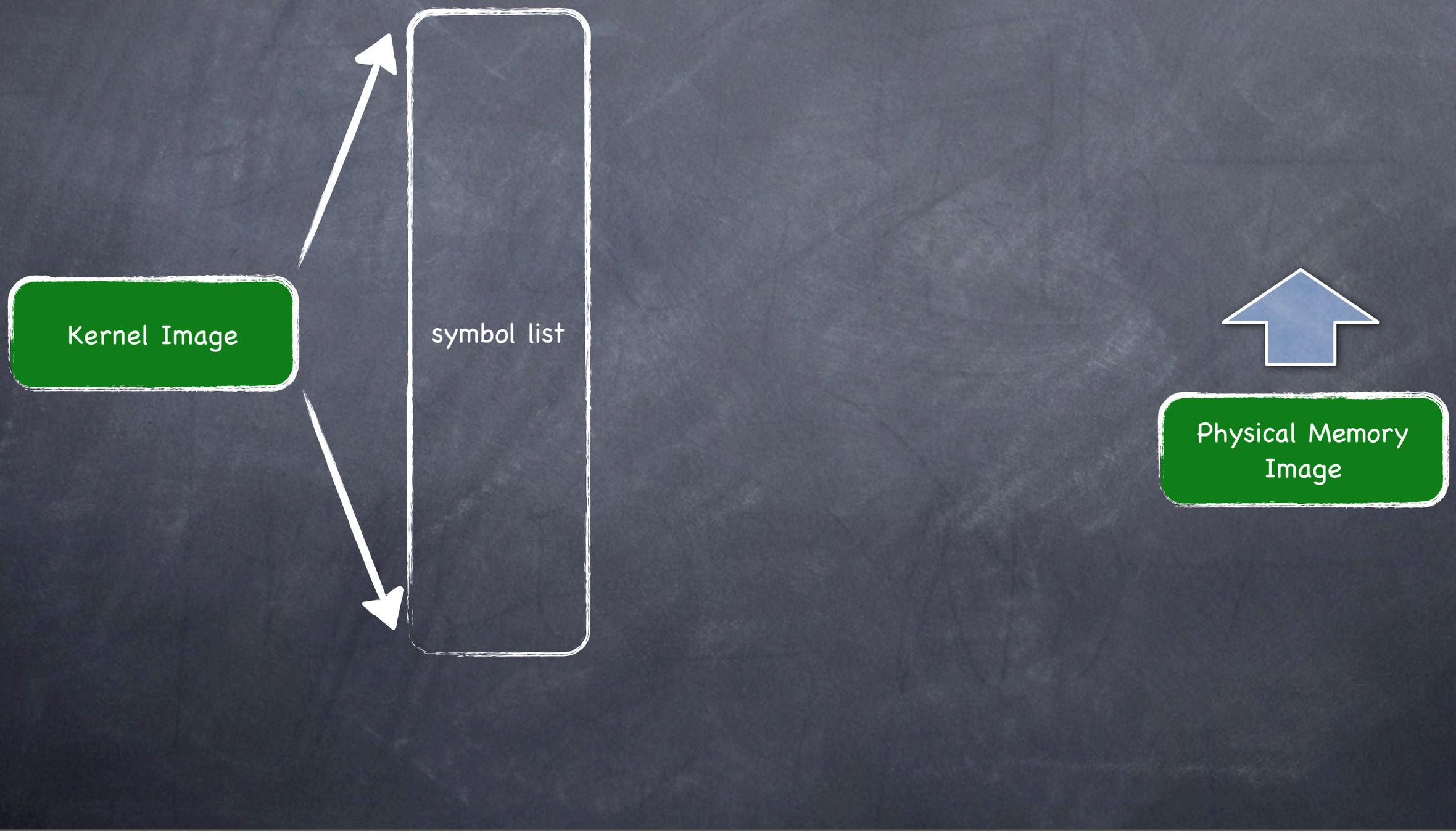


Physical Memory Image

Detection



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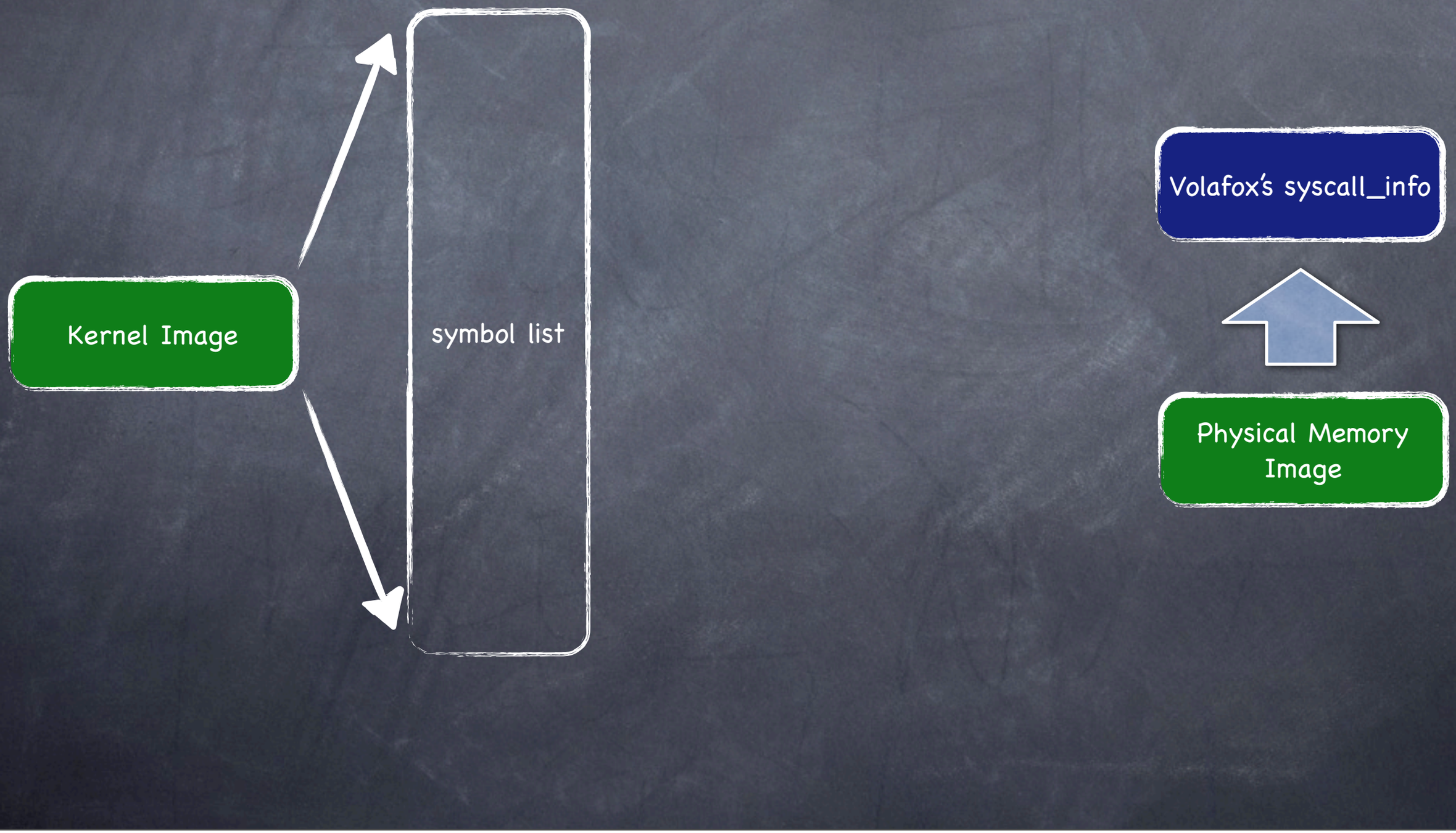
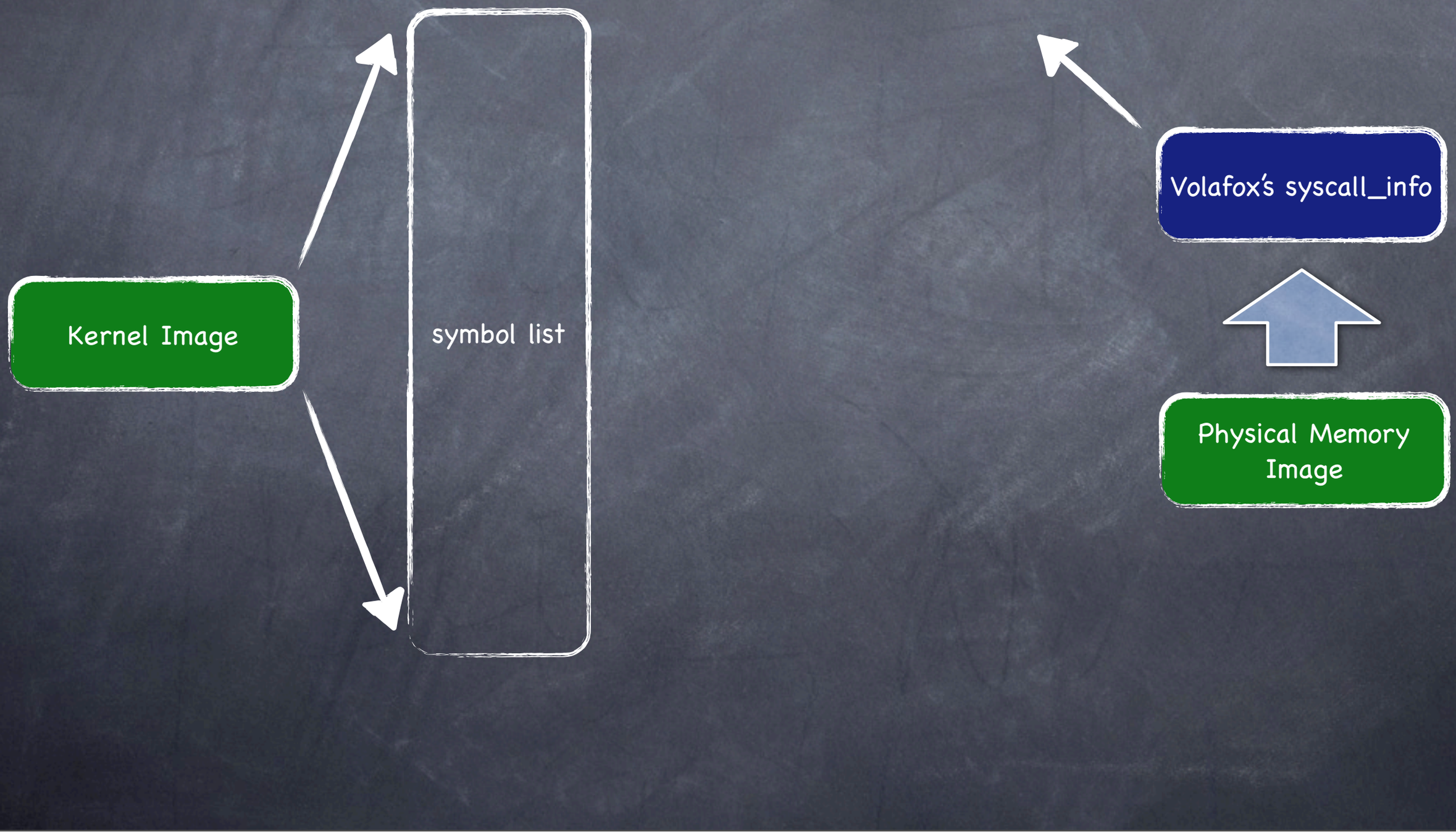

Kernel Image
symbol list
Volafox's syscall_info
Physical Memory Image

Detection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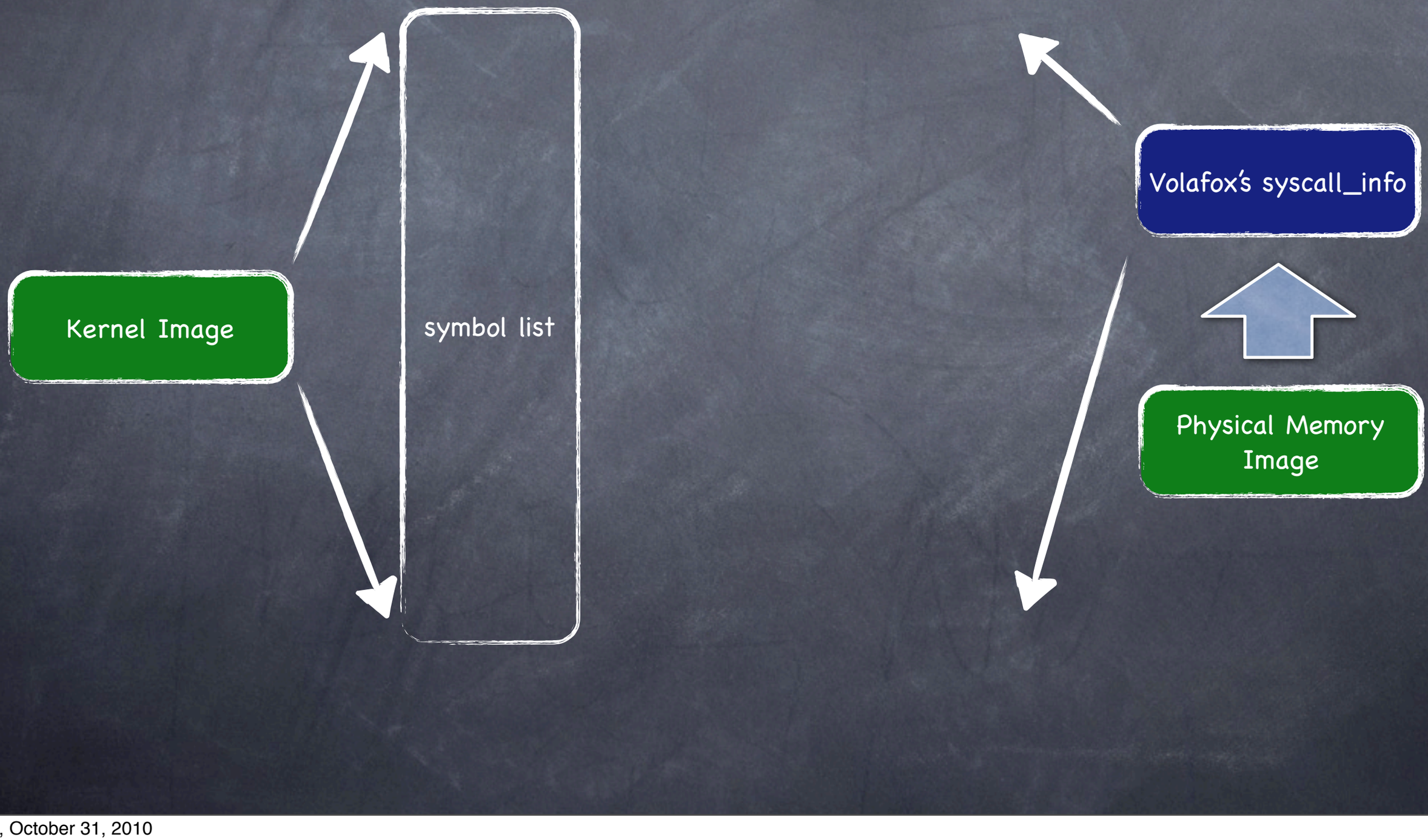
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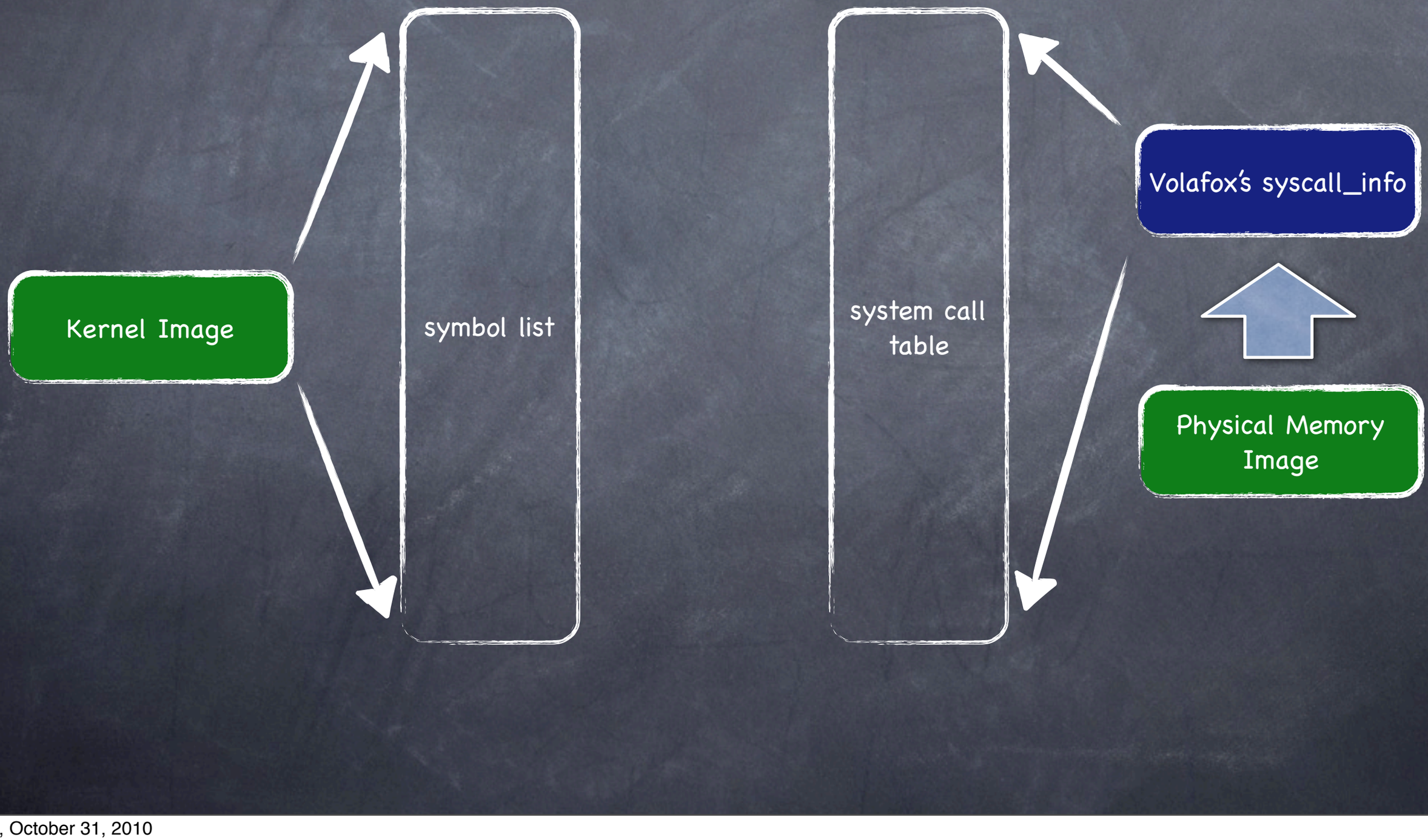
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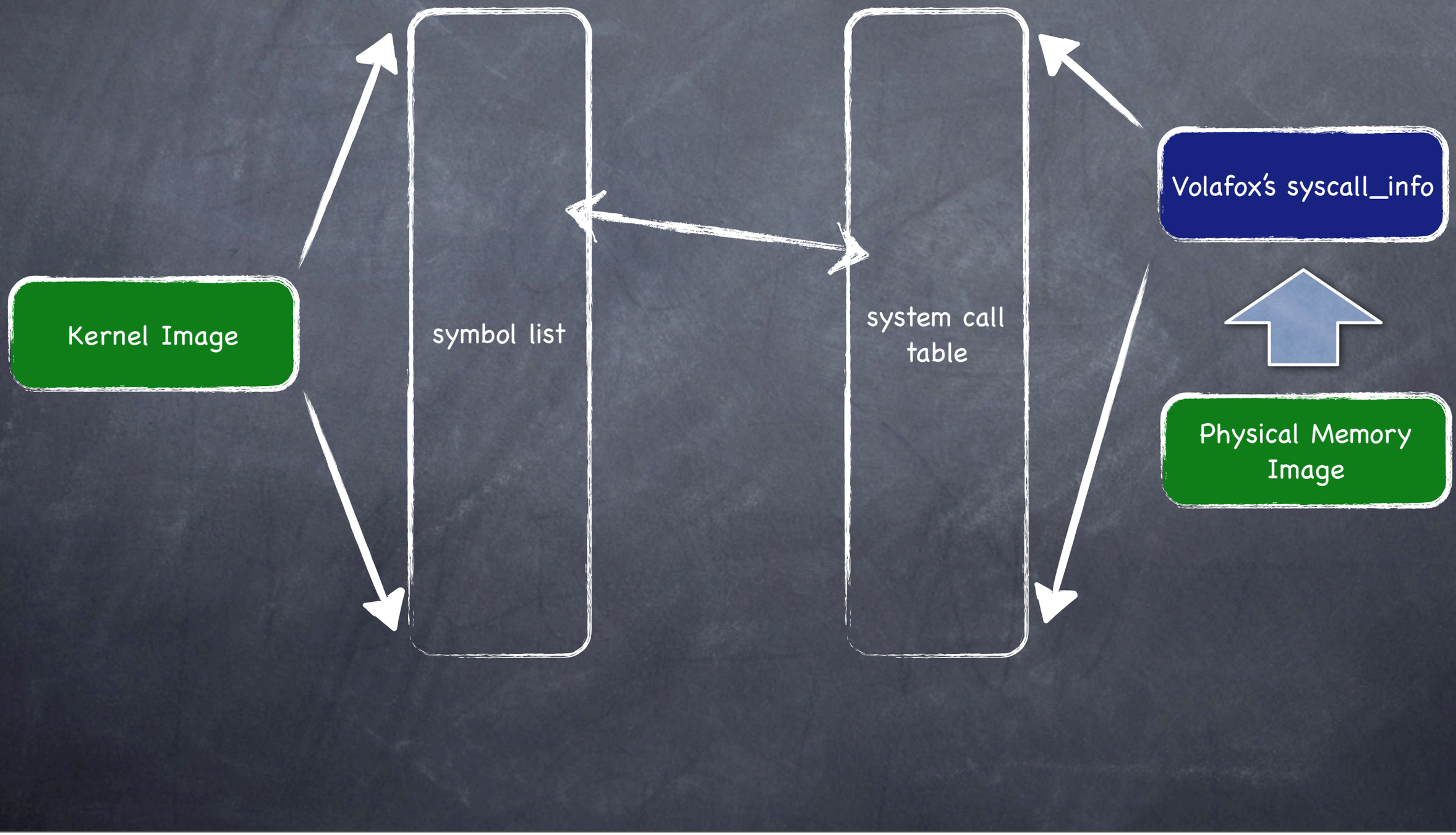
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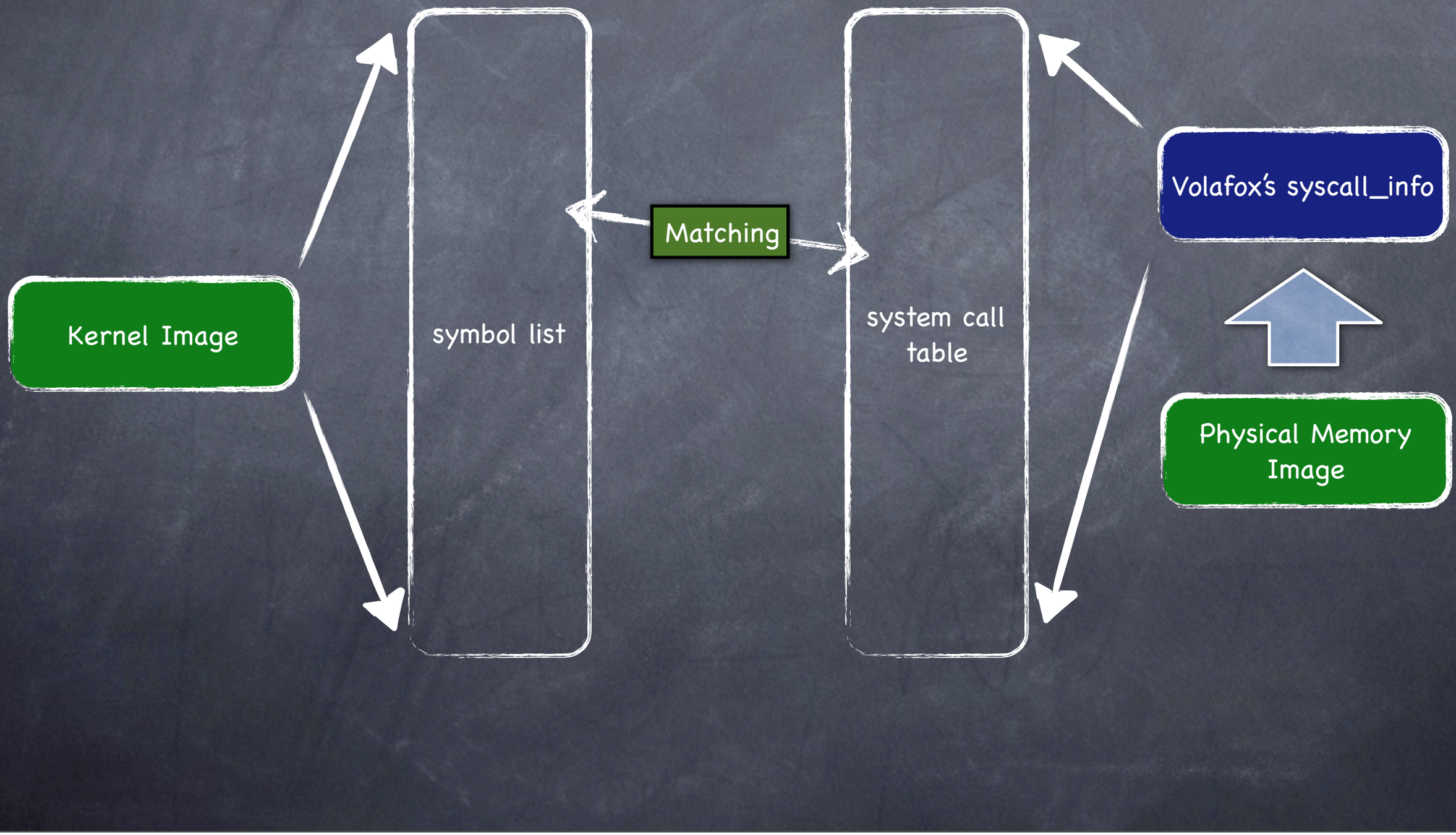
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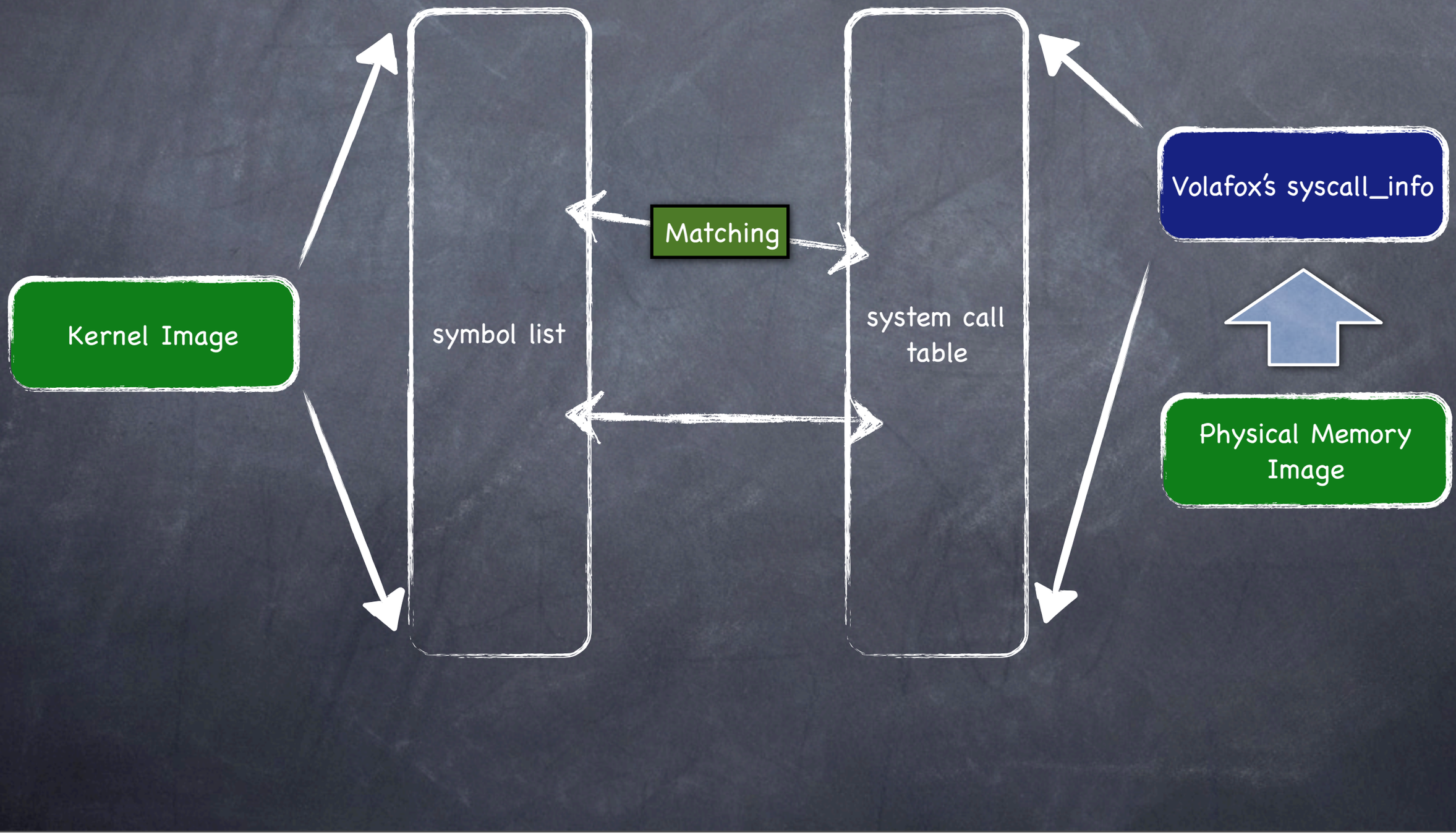
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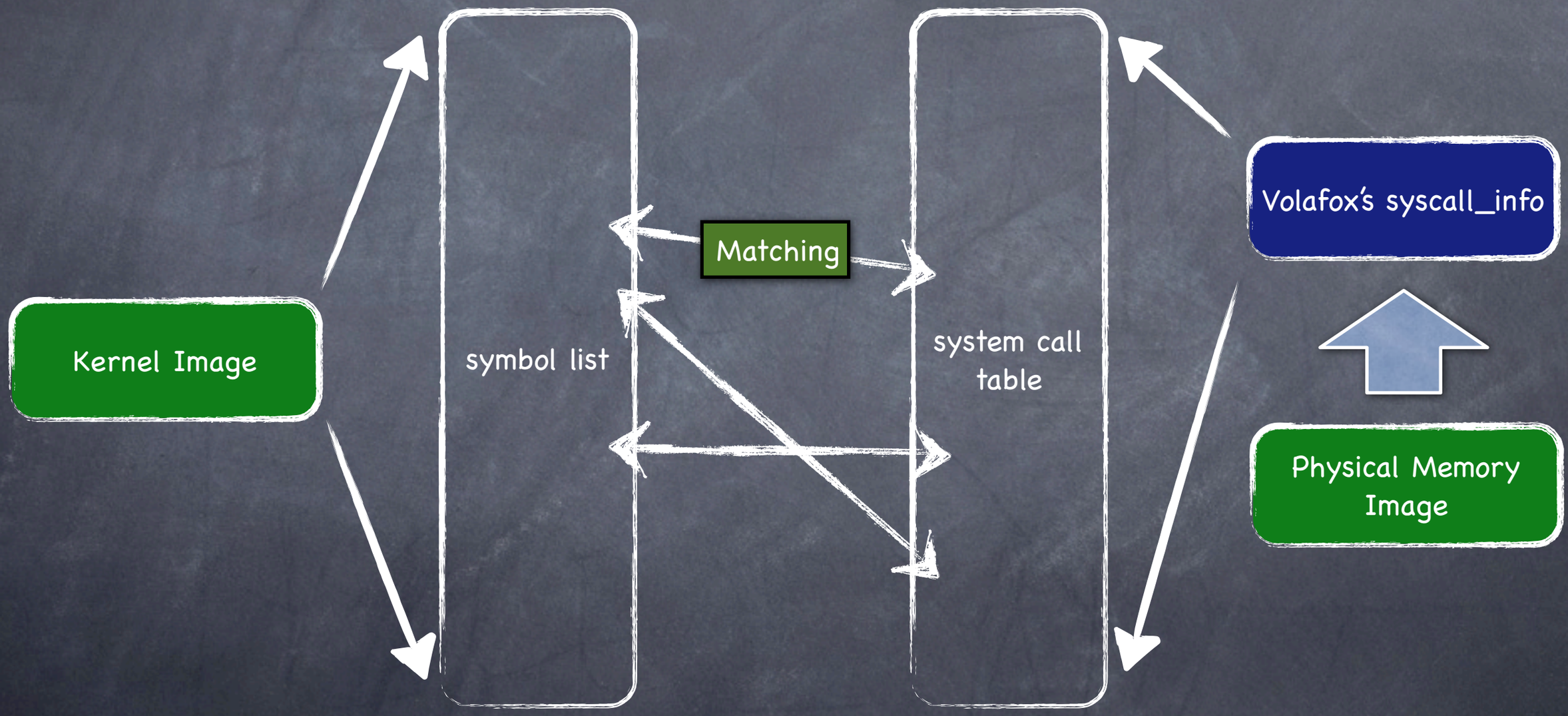
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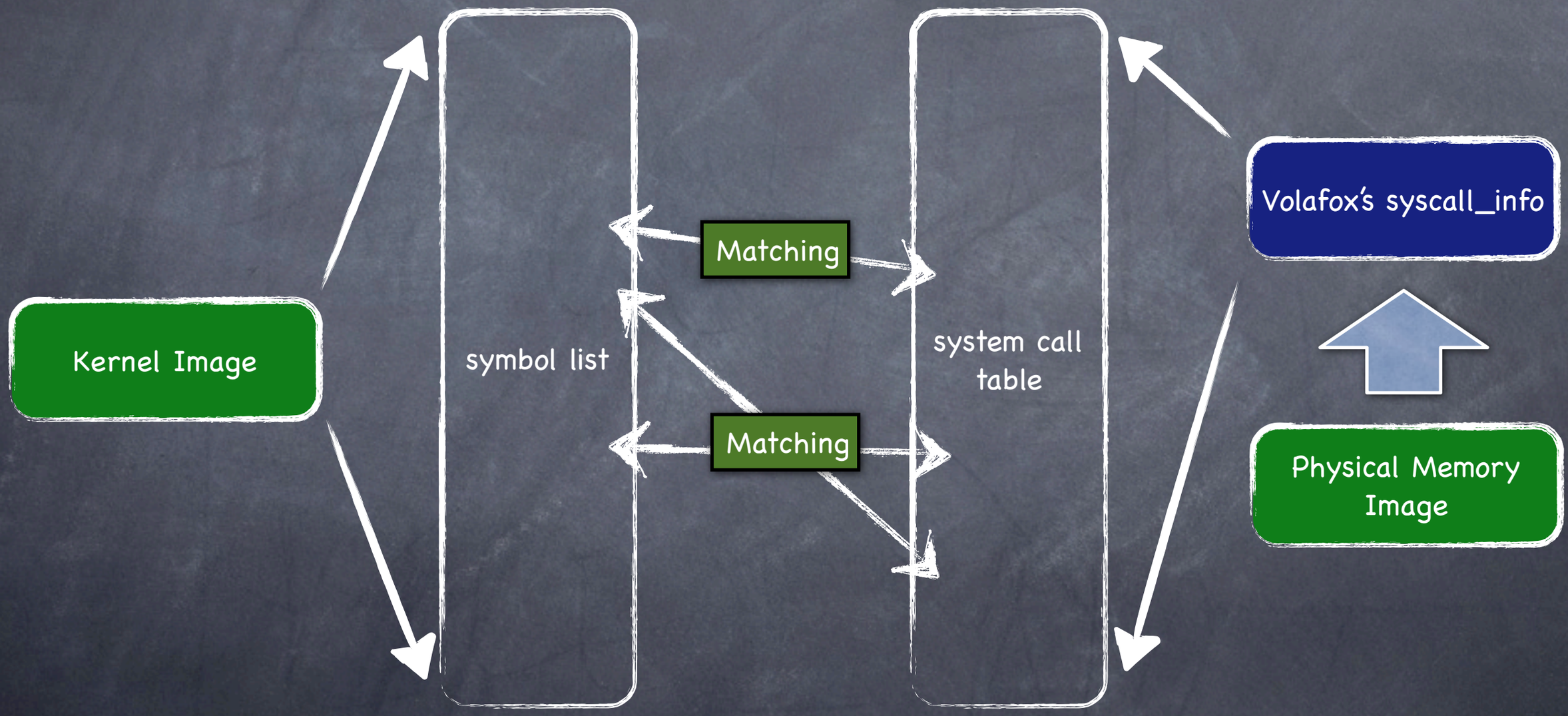
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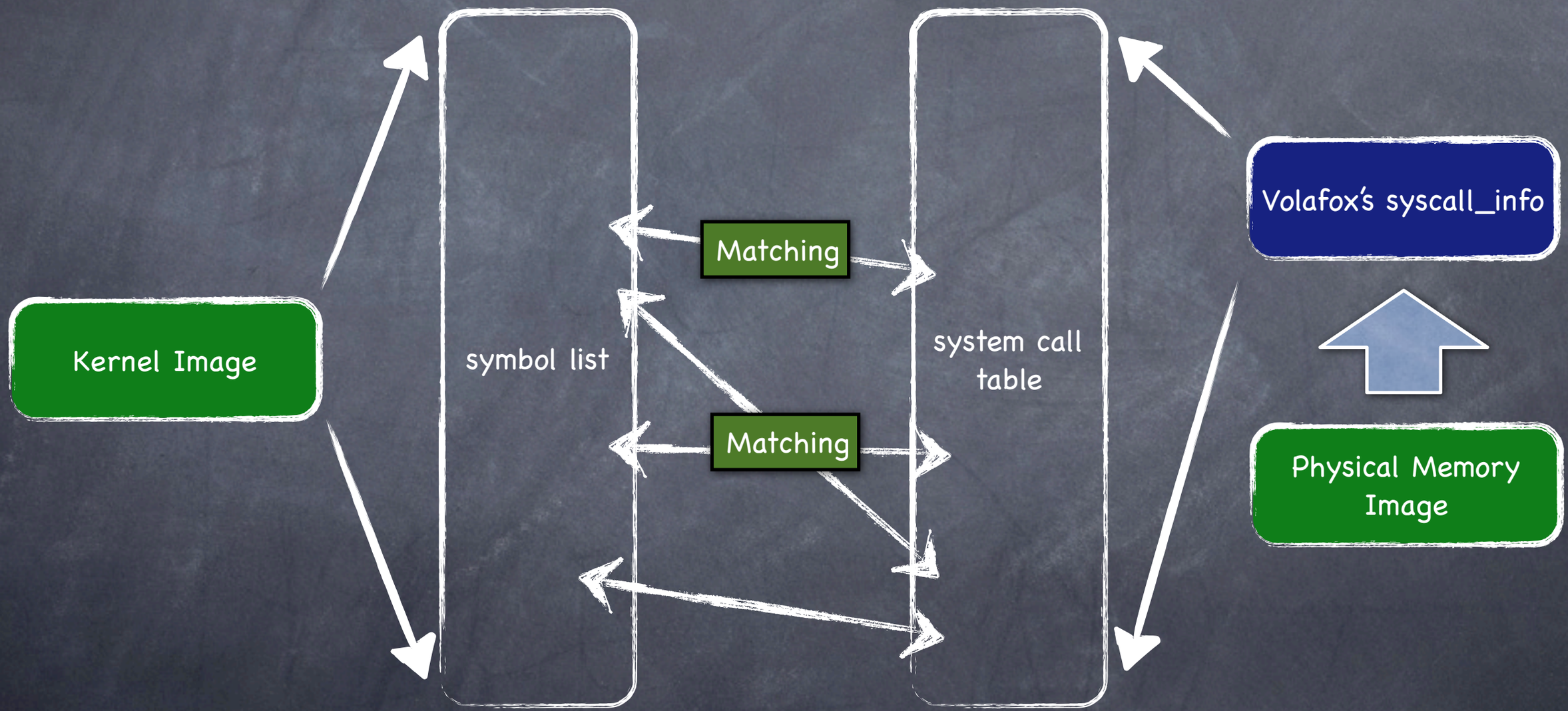
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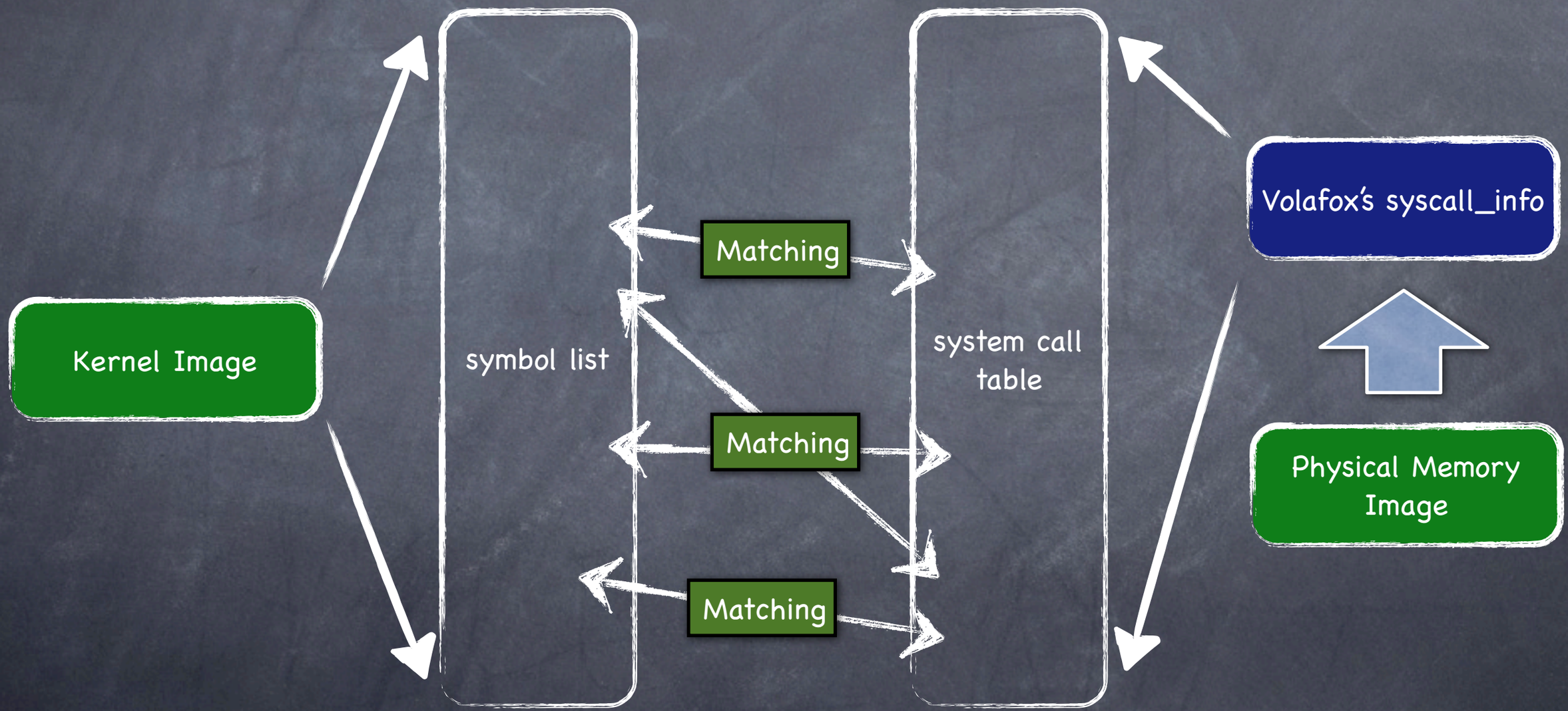
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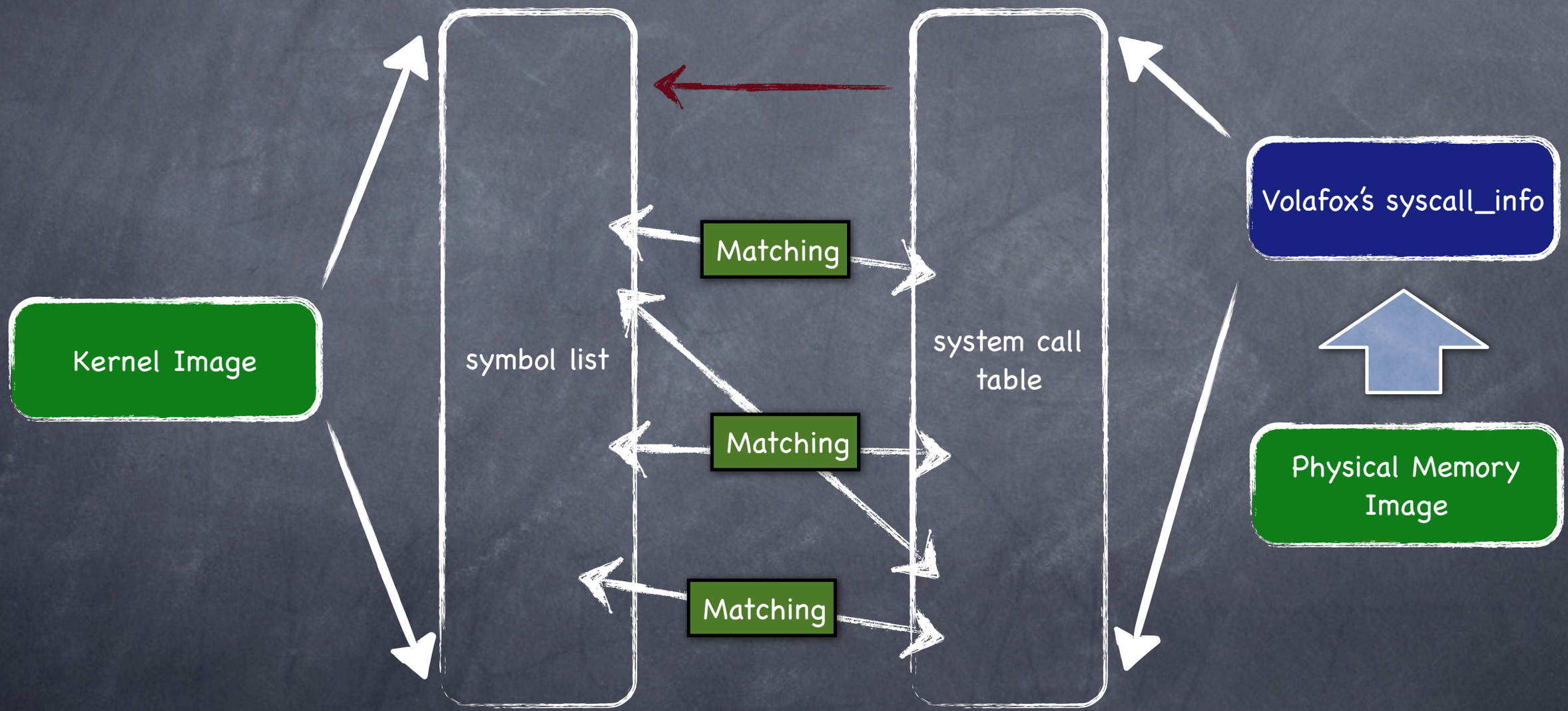
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symbol list
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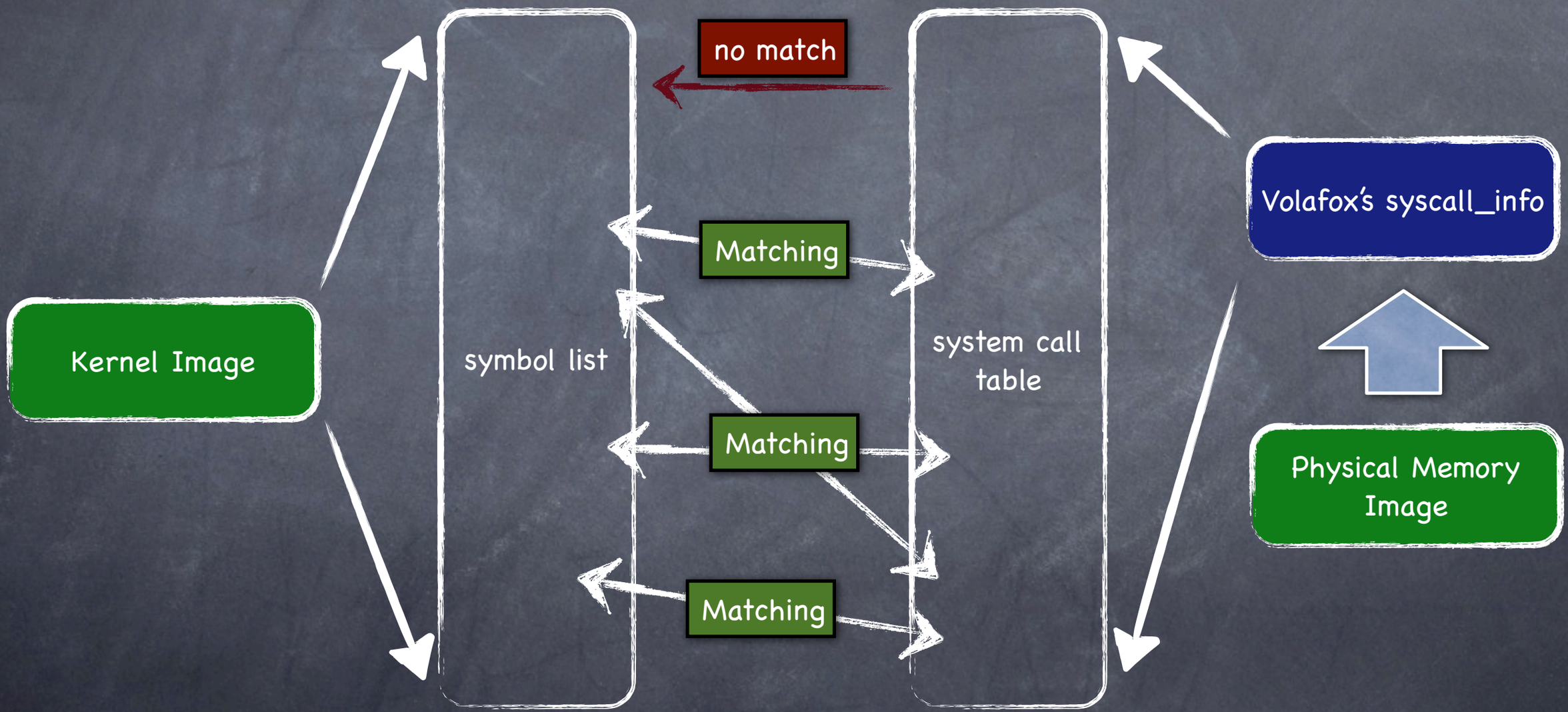
Matching
Matching
Matching
Volafox's syscall_info
Physical Memory Image

Detection


no match
Matching
Matching
Matching
Kernel Image
symbol list
system call table
Volafox's syscall_info
Physical Memory Image

Demo

Terminal — bash — 80×24

```
n0fate:volafox n0fate$ python volafox.py
Memory analyzer for OS X 0.5 - n0fate
Contact: rapfer@gmail.com
usage: python volafox.py -i MEMORY_IMAGE -s KERNEL_IMAGE -o INFORMATION

-= CAUTION =-
this program need to physical memory image, kernel image(mach_kernel)
and it support to Intel x86 Architecture only :(

INFORMATION:
os_version          Dawin kernel detail version
machine_info        Kernel version, cpu, memory information
mount_info          Mount information
kern_kext_info      Kernel KEXT(Kernel Extensions) information
kext_info           KEXT(Kernel Extensions) information
proc_info           Process list
syscall_info        Kernel systemcall information
n0fate:volafox n0fate$
```

Question?

mail: rapfer@gmail.com
blog: http://feedbeef.blogspot.com