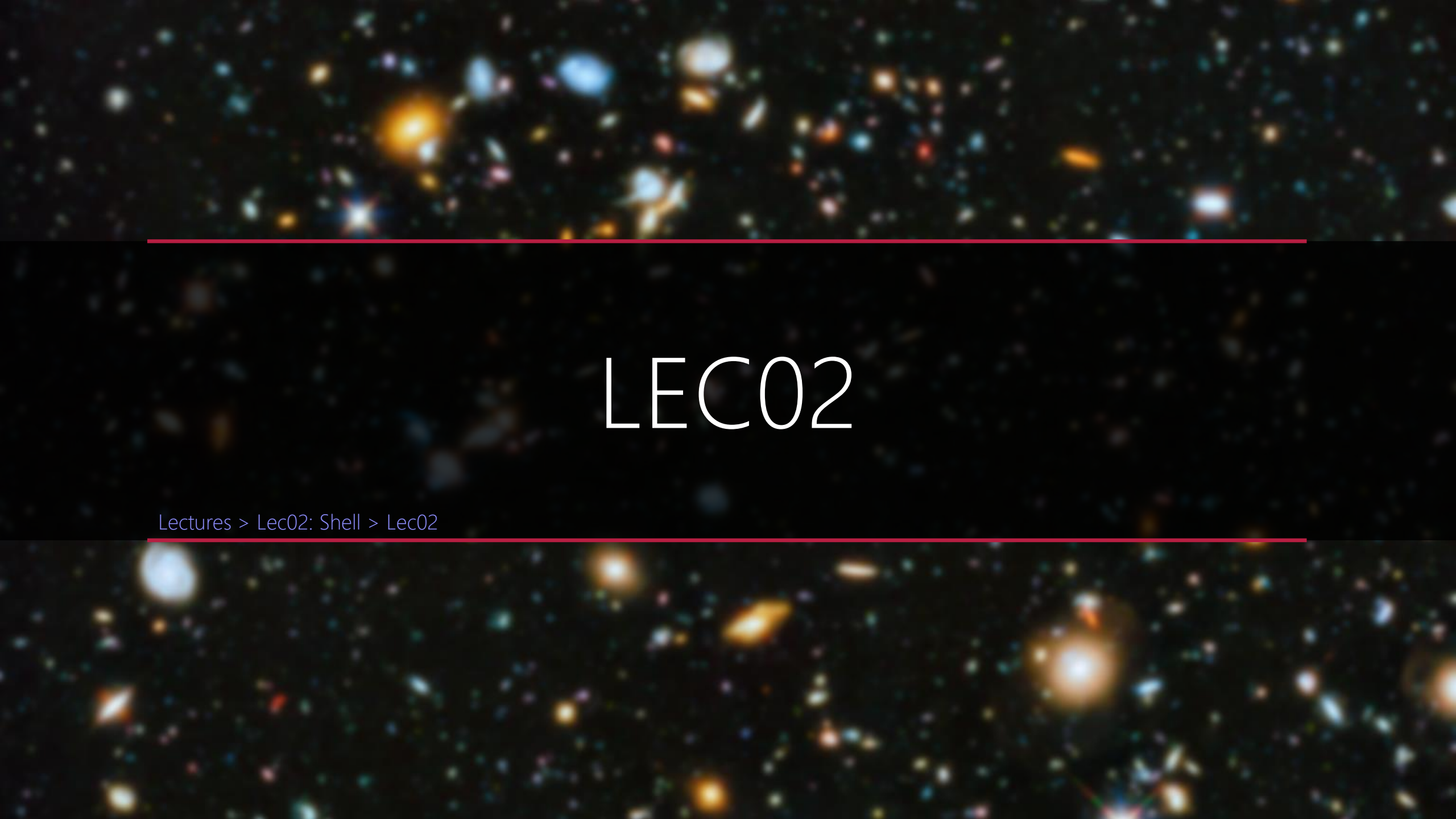

Ezekiel 25:17, Pulp Fiction (1994), Quentin Tarantino
You read the Bible, Brett?



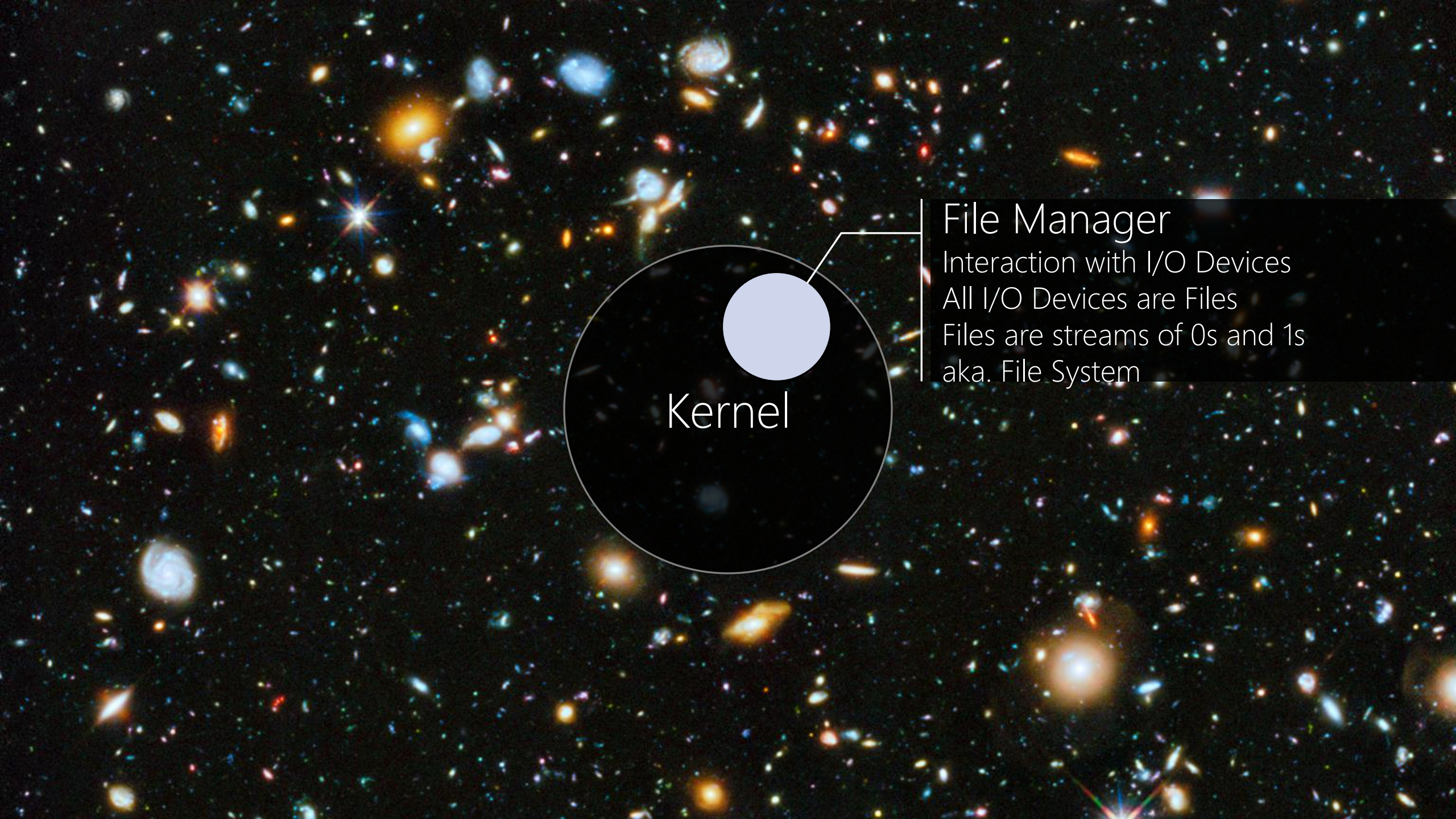
LEC02

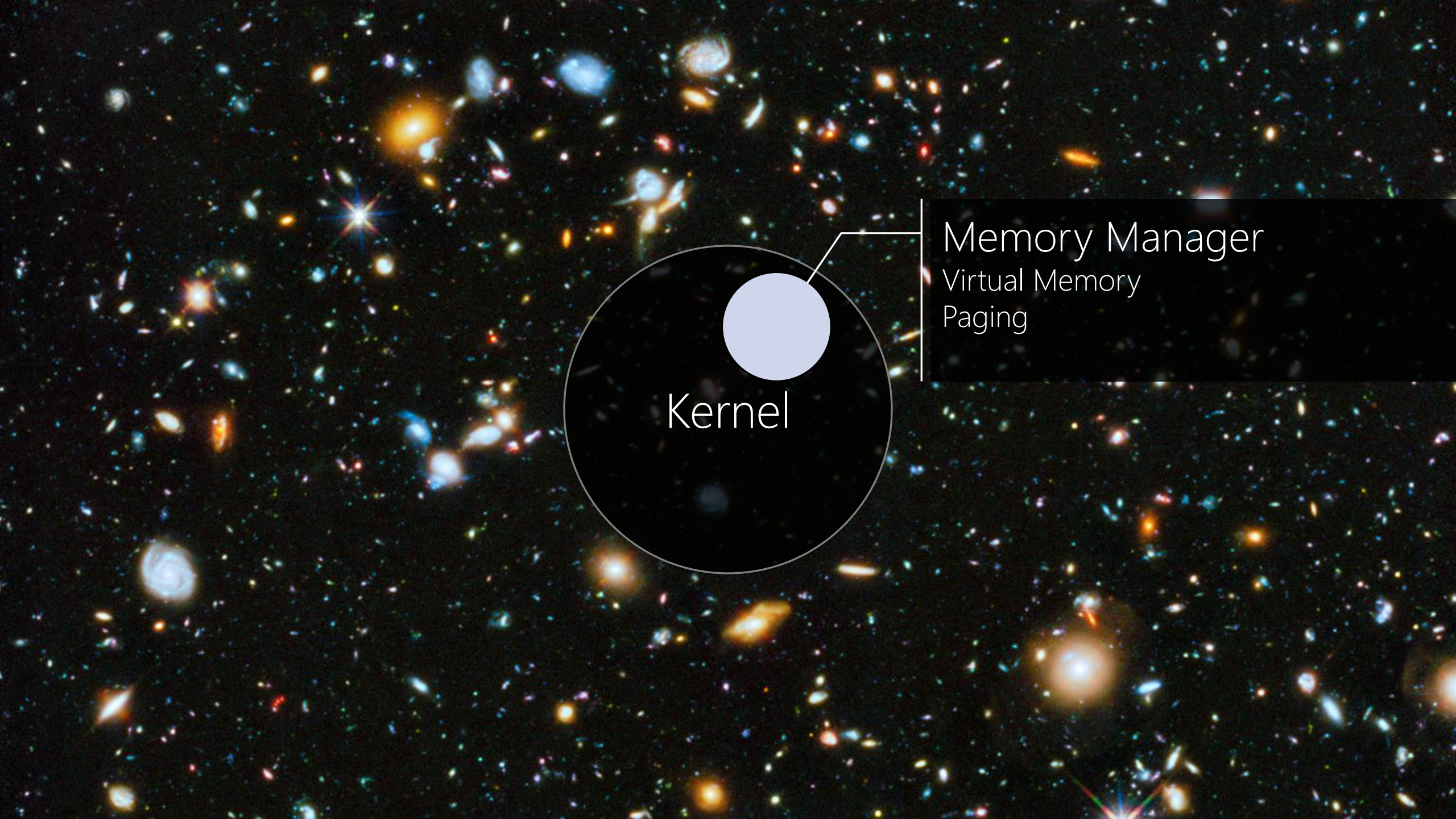
Lectures > Lec02: Shell > Lec02

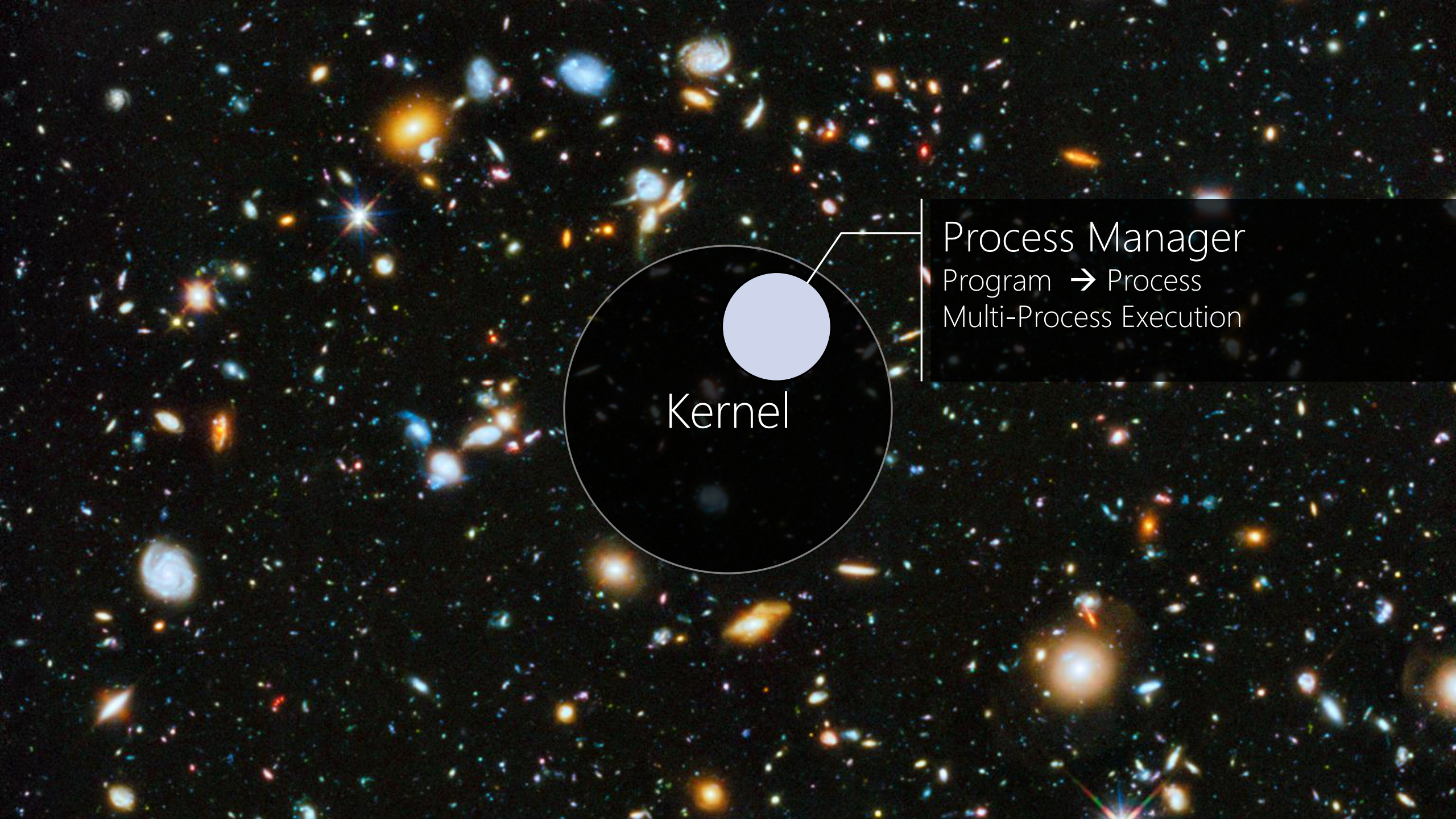
LAB02

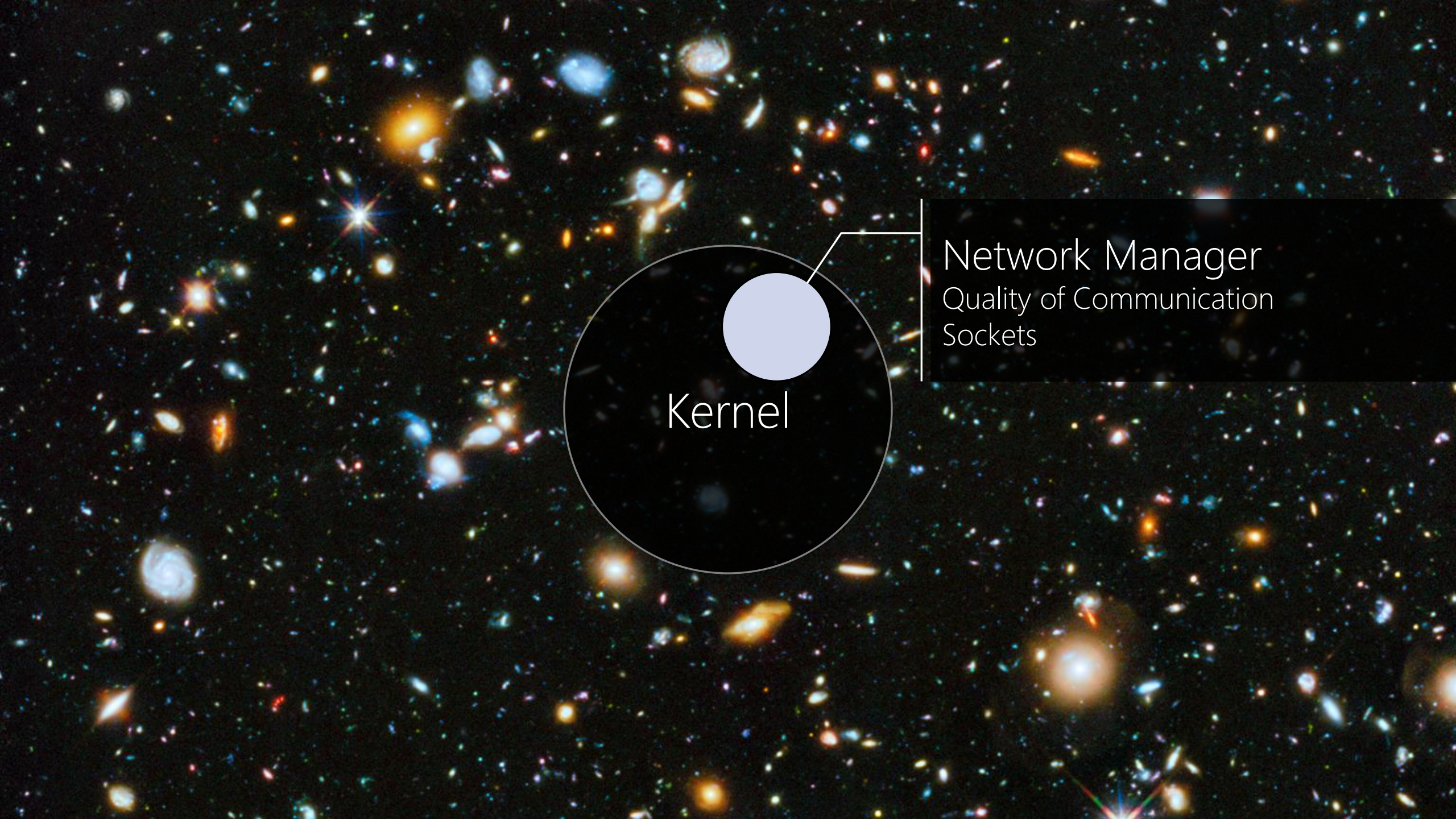
Labs > Lab02: Working Environment Setup > Lab02

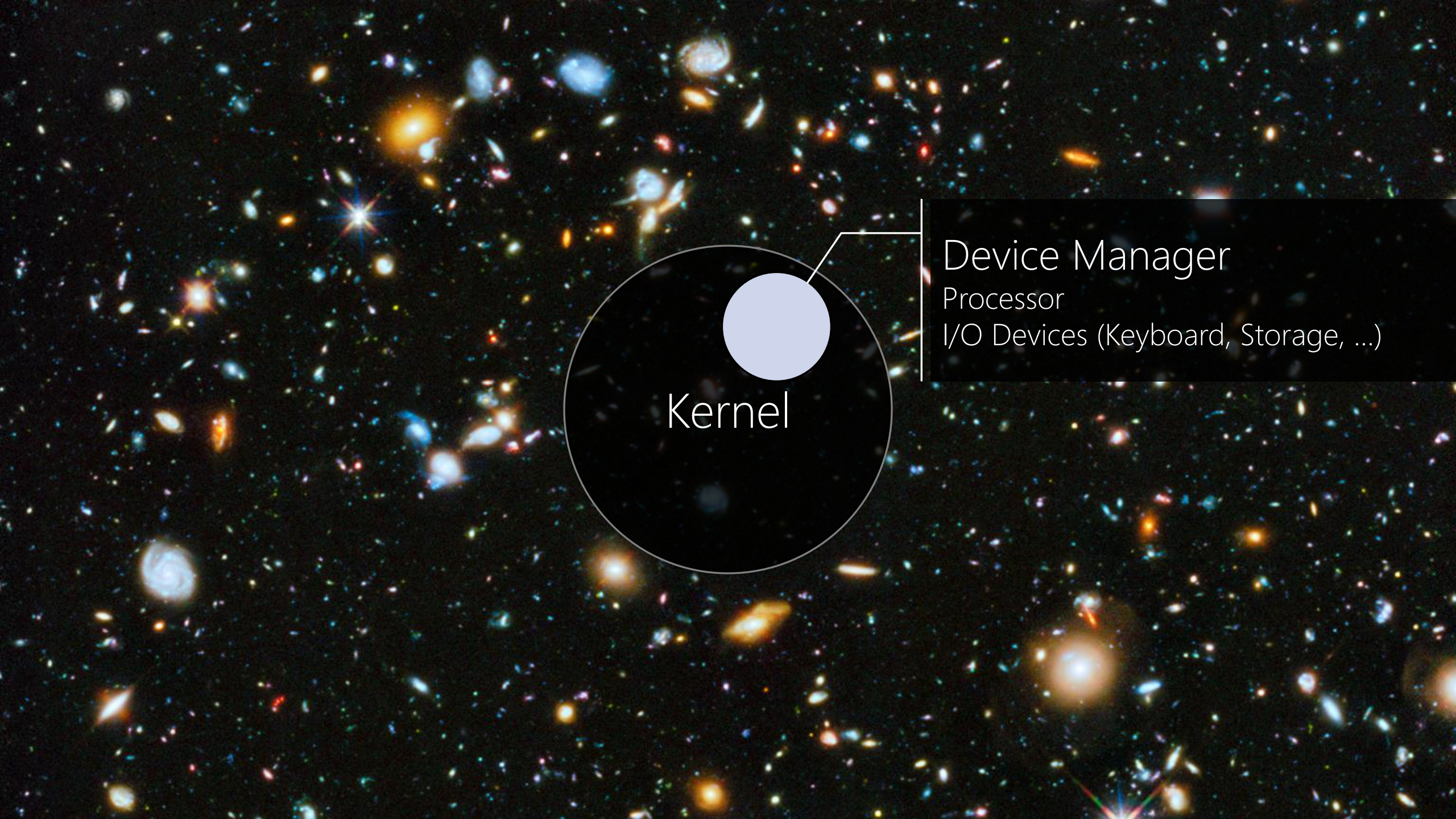

UNIX
Kernel

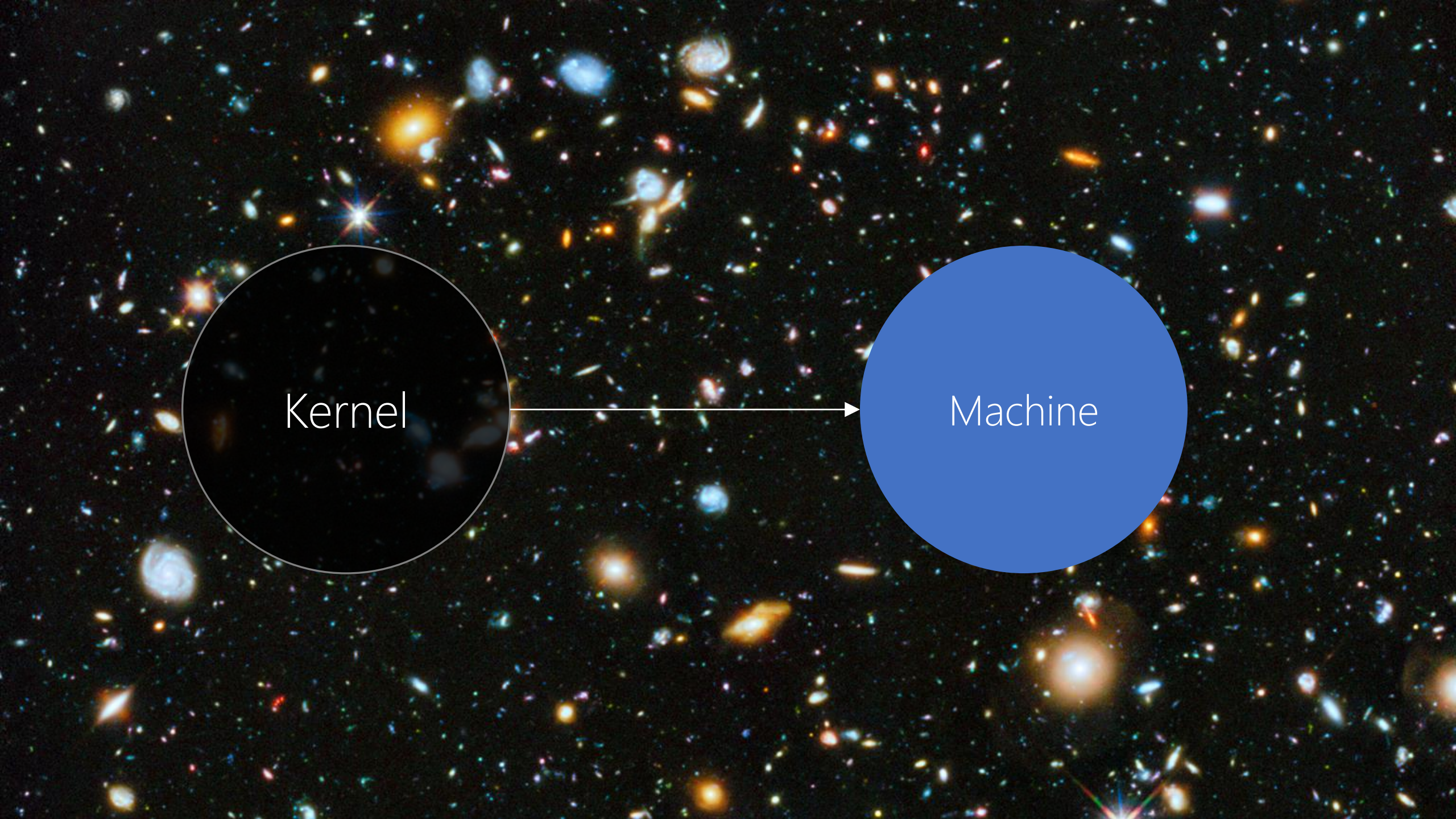

Kernel
File Manager
Interaction with I/O Devices
All I/O Devices are Files
Files are streams of 0s and 1s
aka. File System


Memory Manager
Virtual Memory
Paging
Kernel


Kernel
Process Manager
Program → Process
Multi-Process Execution


Kernel
Network Manager
Quality of Communication
Sockets


Kernel
Device Manager
Processor
I/O Devices (Keyboard, Storage, ...)

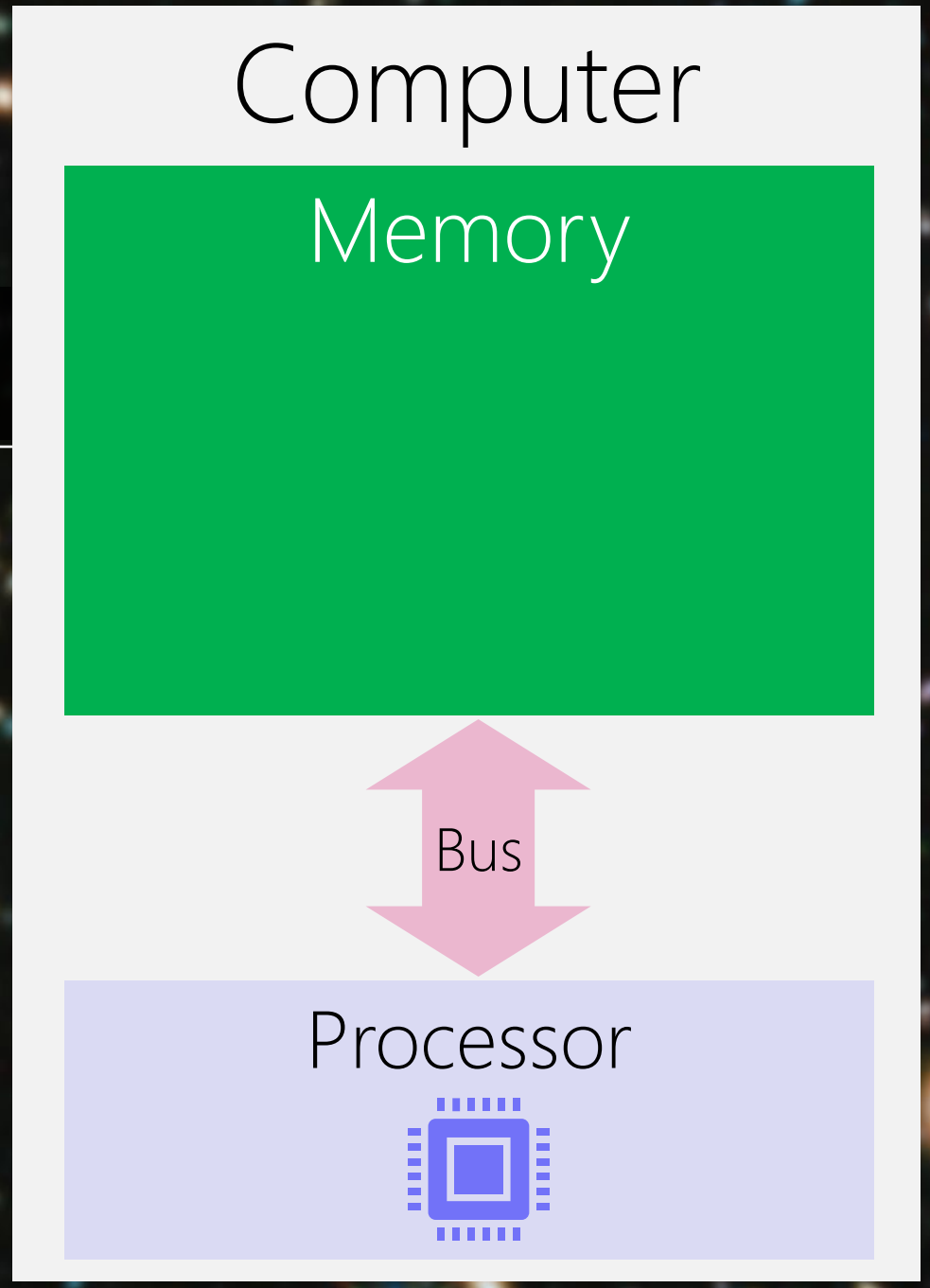

Kernel
Machine

Kernel

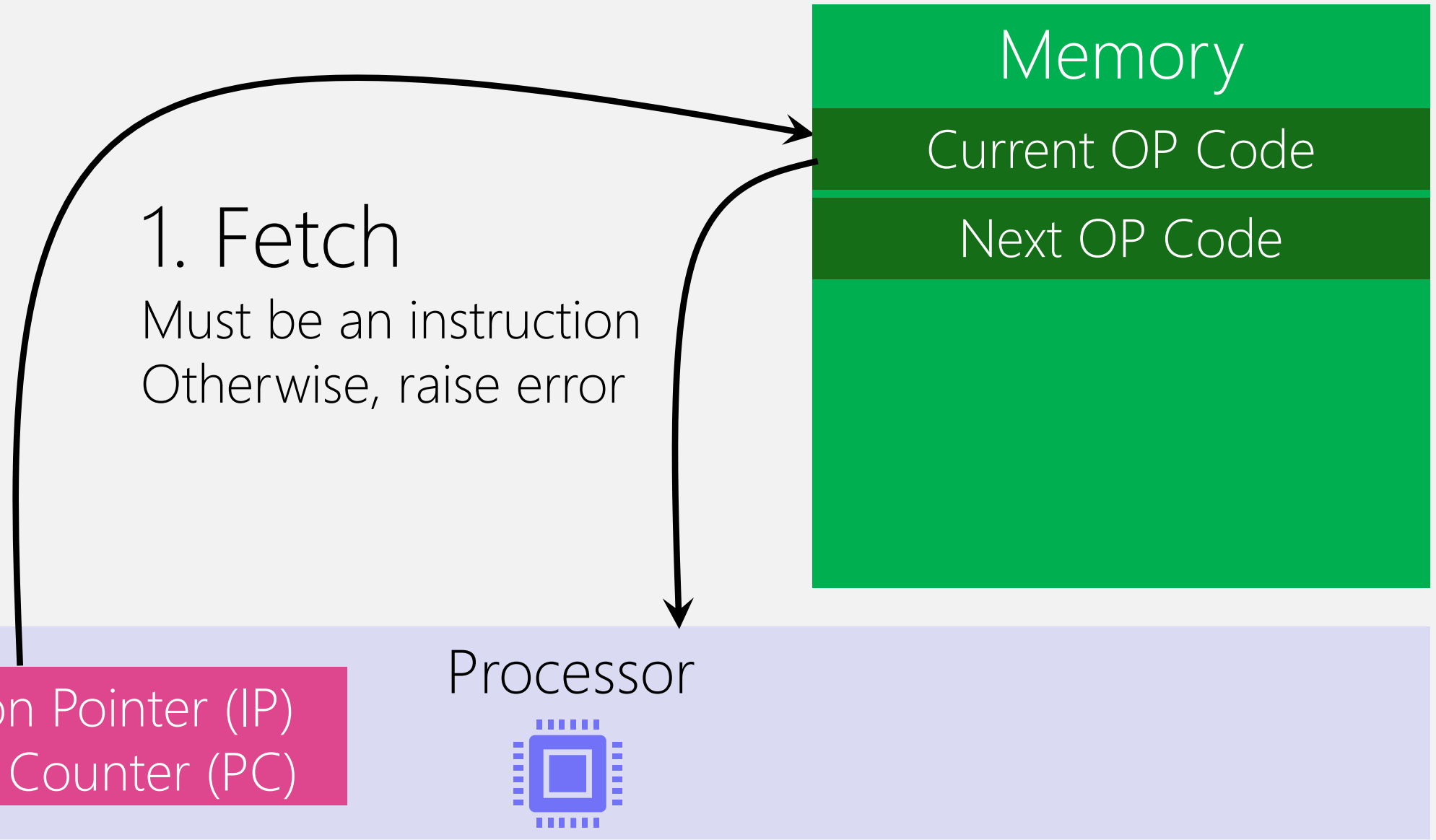
Bootup

Boot is short for bootstrap

pull oneself up by one's bootstraps



Computer


Memory
Current OP Code
Next OP Code
1. Fetch
Must be an instruction
Otherwise, raise error
Processor
Instruction Pointer (IP)
Program Counter (PC)

Computer

2. IP = IP + 1

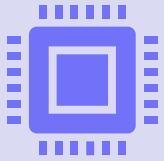
Memory

Current OP Code

Next OP Code

Instruction Pointer (IP)
Program Counter (PC)

Processor



Current OP Code

Computer

3. Execute

Could be in parallel to fetch

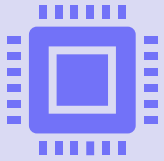
Memory

Current OP Code

Next OP Code

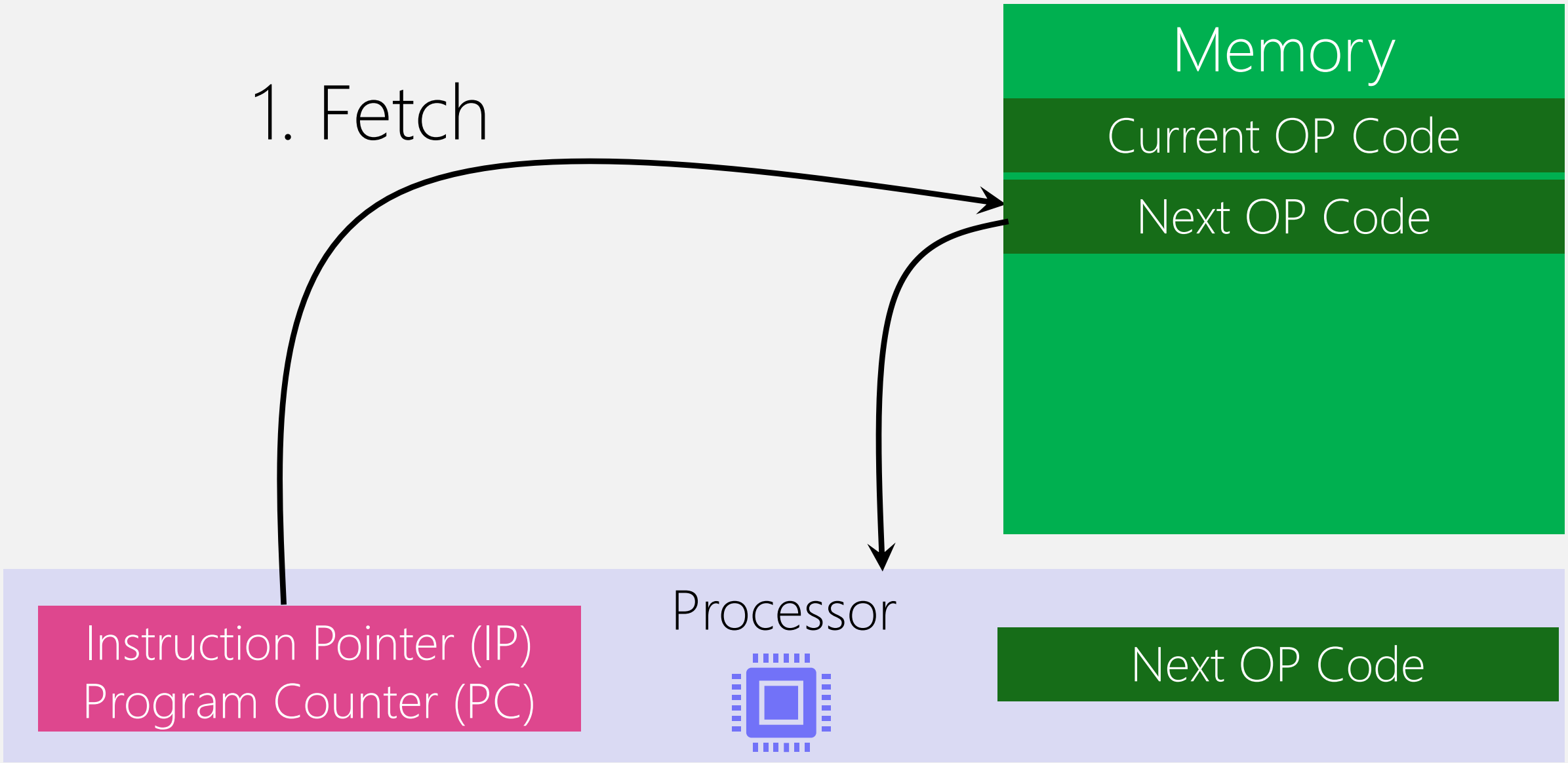
Instruction Pointer (IP)
Program Counter (PC)

Processor



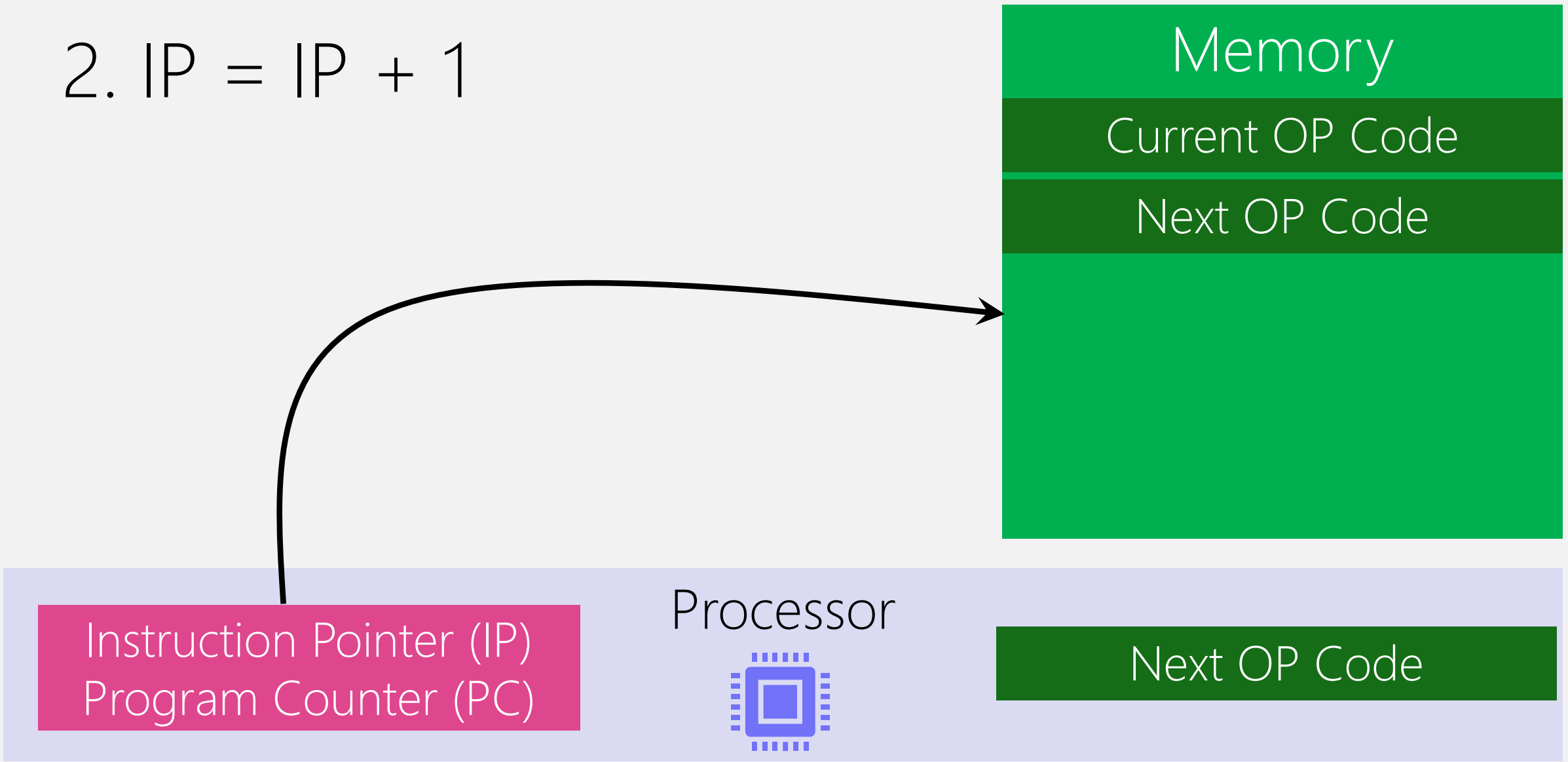
Current OP Code

Computer


1. Fetch
Memory
Current OP Code
Next OP Code
Processor
Instruction Pointer (IP)
Program Counter (PC)
Next OP Code

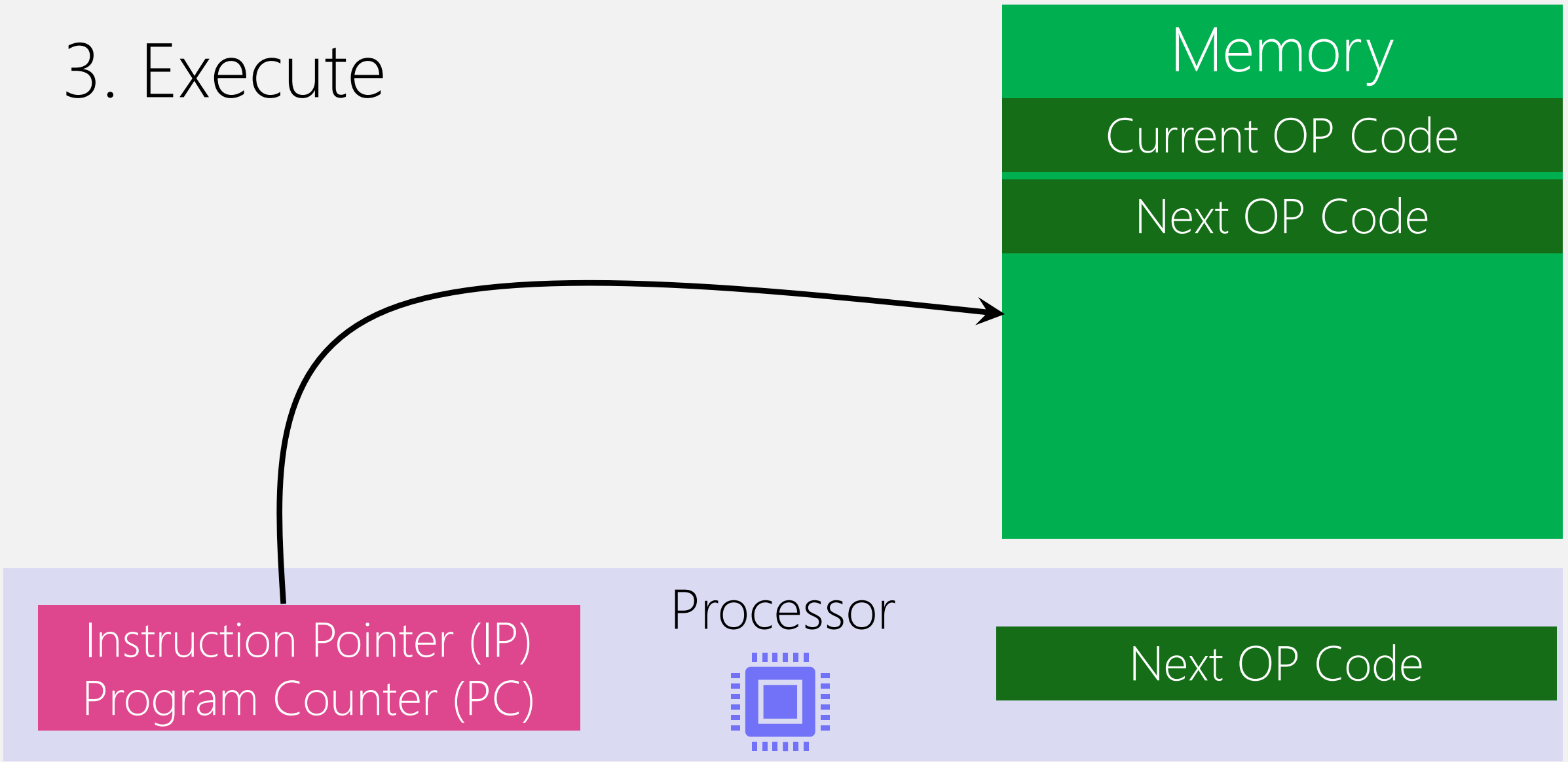
Computer

2. IP = IP + 1

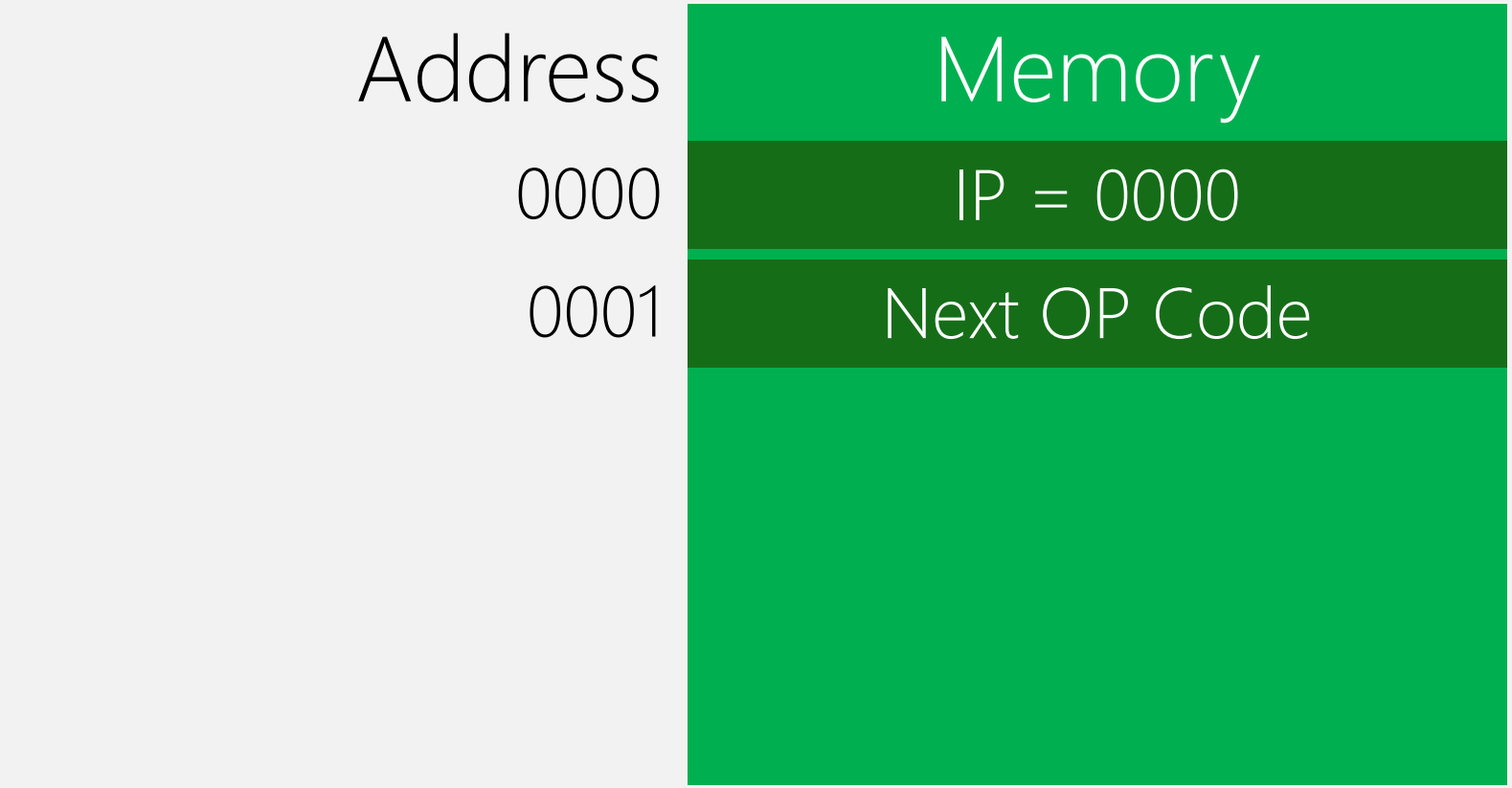


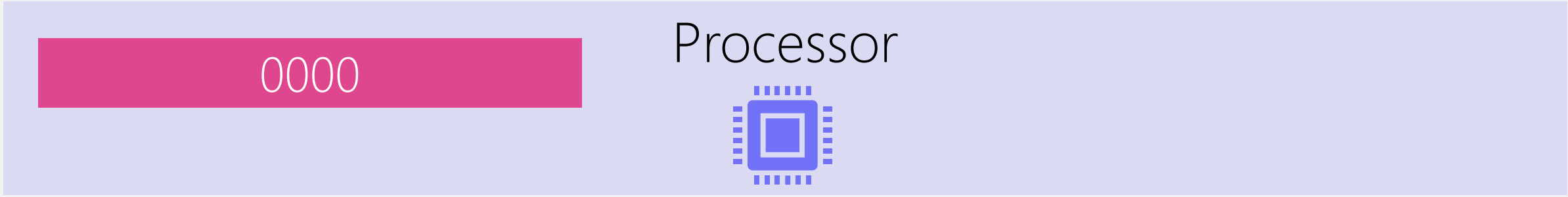
Computer

3. Execute



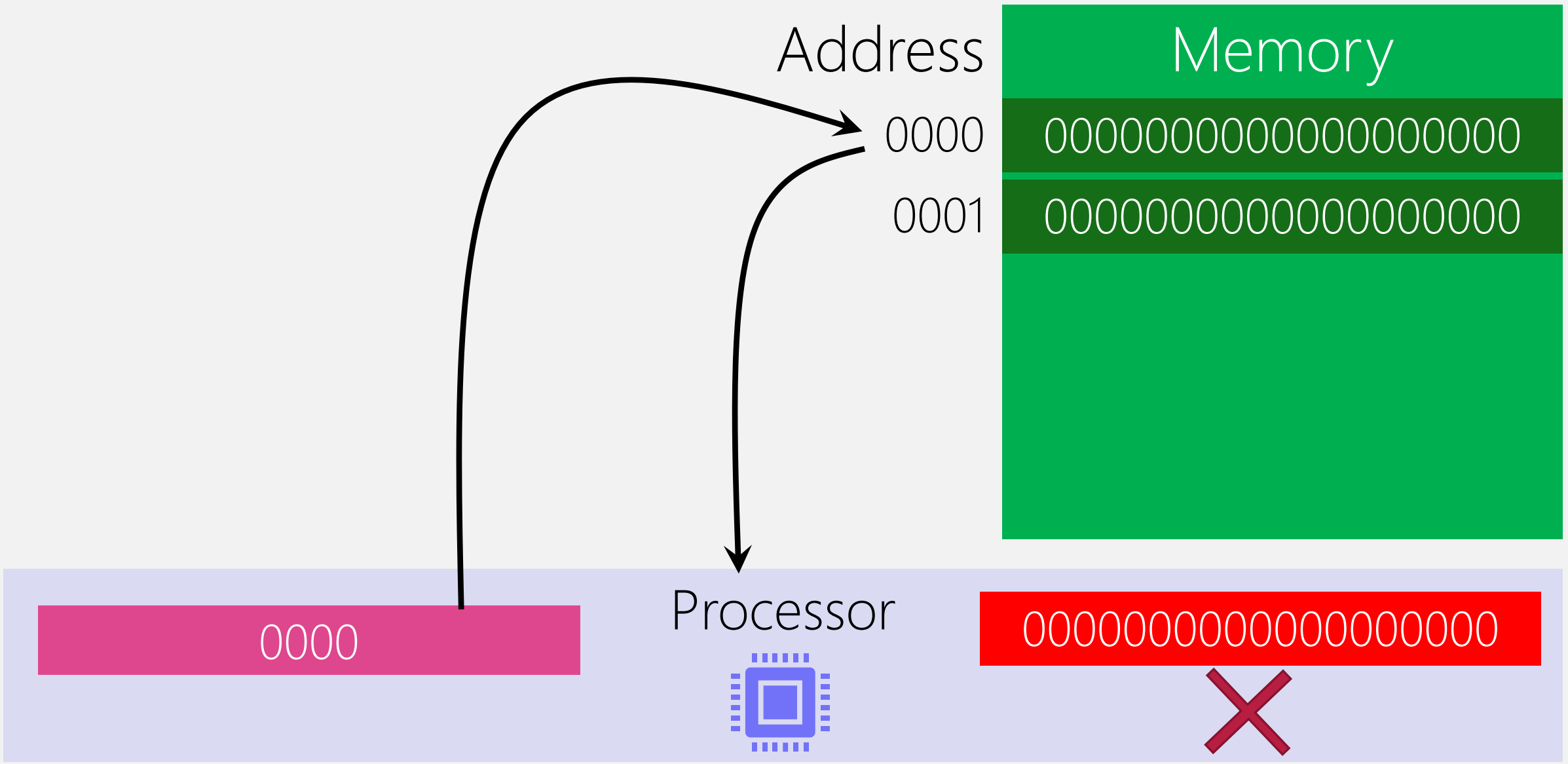
What happens?

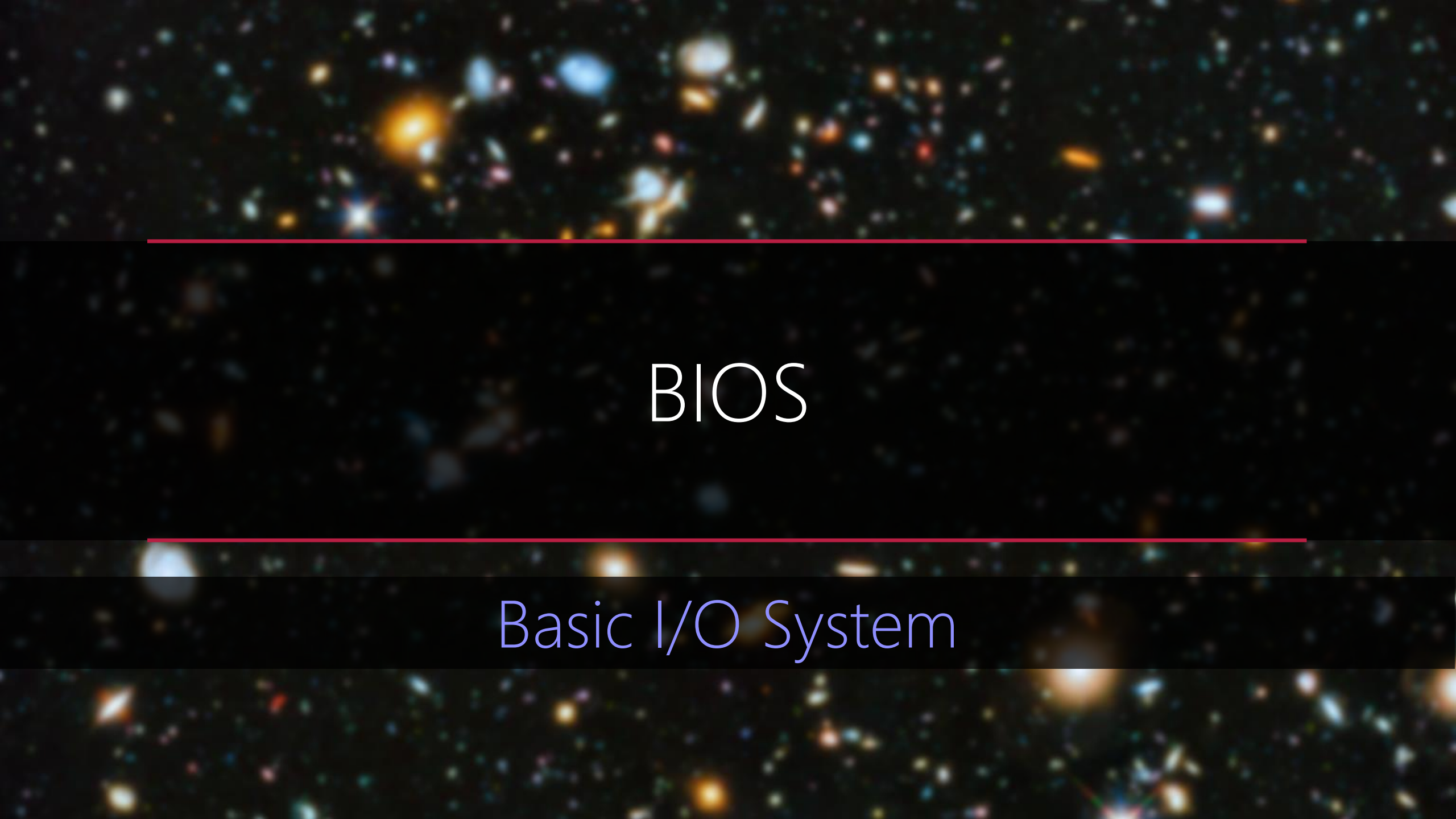





Busy-Waiting
Busy-Looping
Spinning
Loveless (2017), Andrey Zvyagintsev

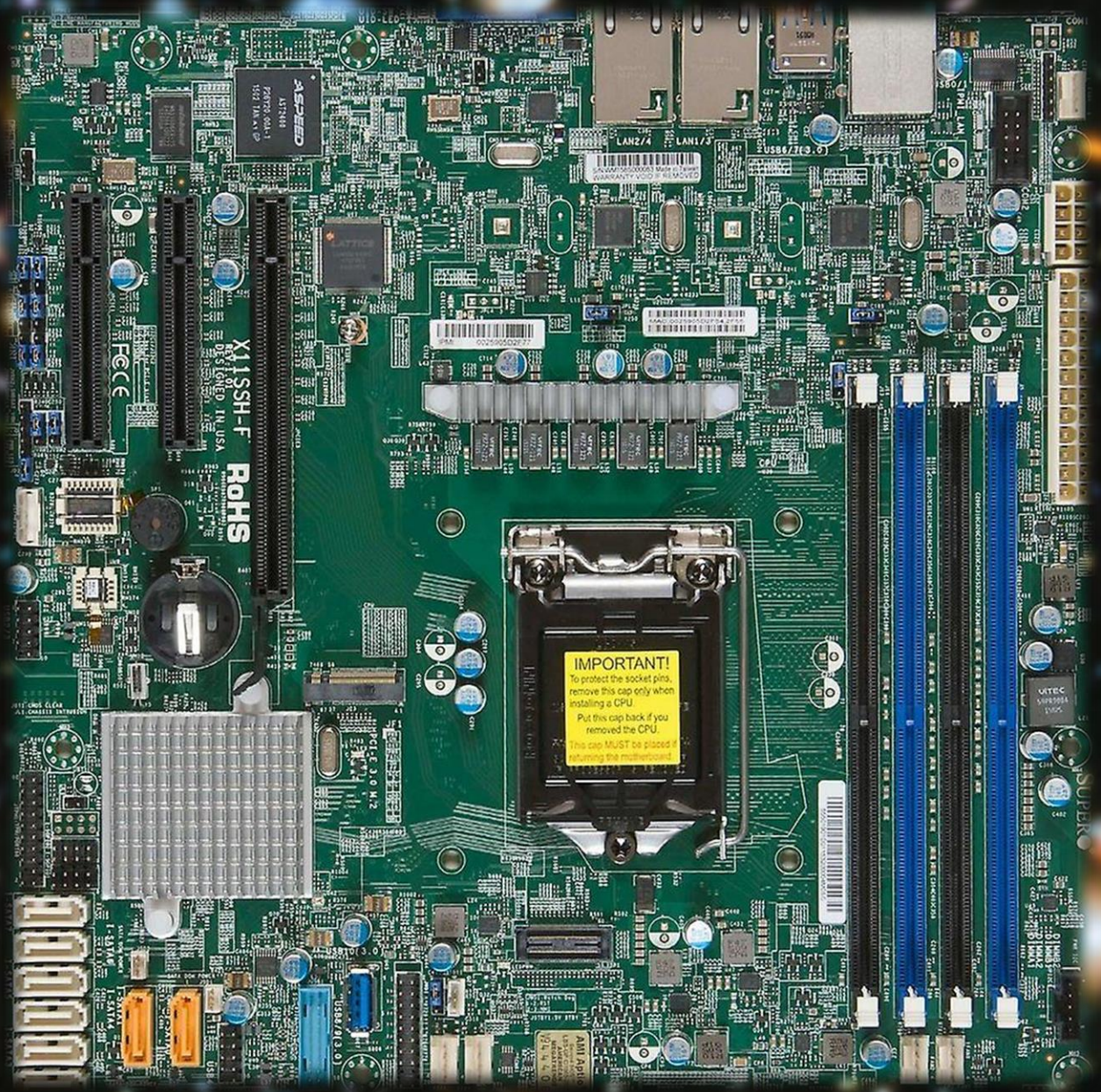
Turn ON


Address
Memory
0000
0001
0000000000000000
0000000000000000
0000
Processor
0000000000000000



BIOS

Basic I/O System

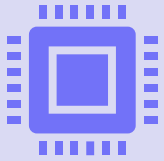

X11SSH-F
REV:1.01
DESIGNED IN USA
RoHS
IMPORTANT!
To protect the socket pins, remove this cap only when installing a CPU.
Put this cap back if you removed the CPU.
This cap MUST be placed if returning the motherboard.
LAN2/4
LAN1/3
USB6/7(3.0)
USB0/1(3.0)
USB4/5(3.0)
SUPER

Basic I/O System (BIOS)

Address	Memory
0000	BIOS: Check
0001	BIOS: Load MBR
0010	BIOS: IP = &MBR

Processor

0000



Basic I/O System (BIOS)

Address	Memory
0000	BIOS: Check
0001	BIOS: Load MBR
0010	BIOS: IP = &MBR

0000

Processor

BIOS: Check

Basic I/O System (BIOS)

Address	Memory
0000	BIOS: Check
0001	BIOS: Load MBR
0010	BIOS: IP = &MBR

0001

Processor

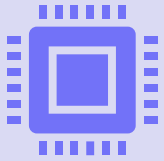
BIOS: Load MBR

Basic I/O System (BIOS)

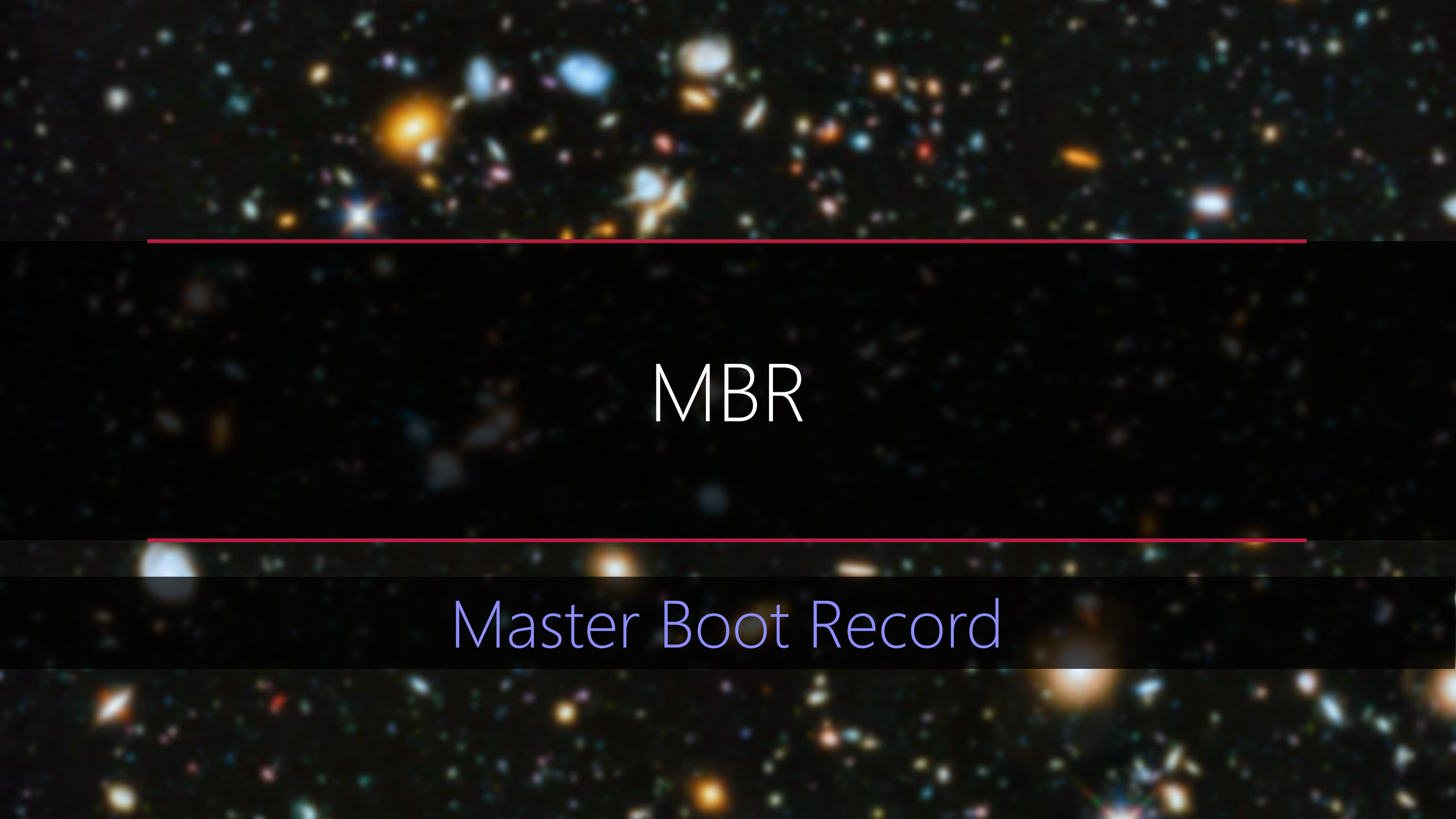
Address	Memory
0000	BIOS: Check
0001	BIOS: Load MBR
0010	BIOS: IP = &MBR
xxx0	MBR: Load Kernel
xxx1	MBR: IP = &Kernel

0010

Processor



BIOS: IP = &MBR



MBR

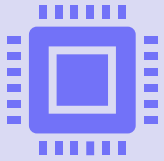
Master Boot Record

Master Boot Record (MBR)

Address	Memory
0000	BIOS: Check
0001	BIOS: Load MBR
0010	BIOS: IP = &MBR
xxx0	MBR: Load Kernel
xxx1	MBR: IP = &Kernel

xxx0

Processor



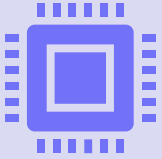
MBR: Load Kernel

Kernel

Address	Memory
0000	BIOS: Check
0001	BIOS: Load MBR
0010	BIOS: IP = &MBR
xxx0	MBR: Load Kernel
xxx1	MBR: IP = &Kernel
yyy0	Kernel: Device Manager
yy11	Kernel: Memory Manager
y111	Kernel: Process Manager

yyy0

Processor



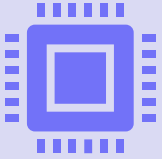
MBR: IP = &Kernel

Kernel

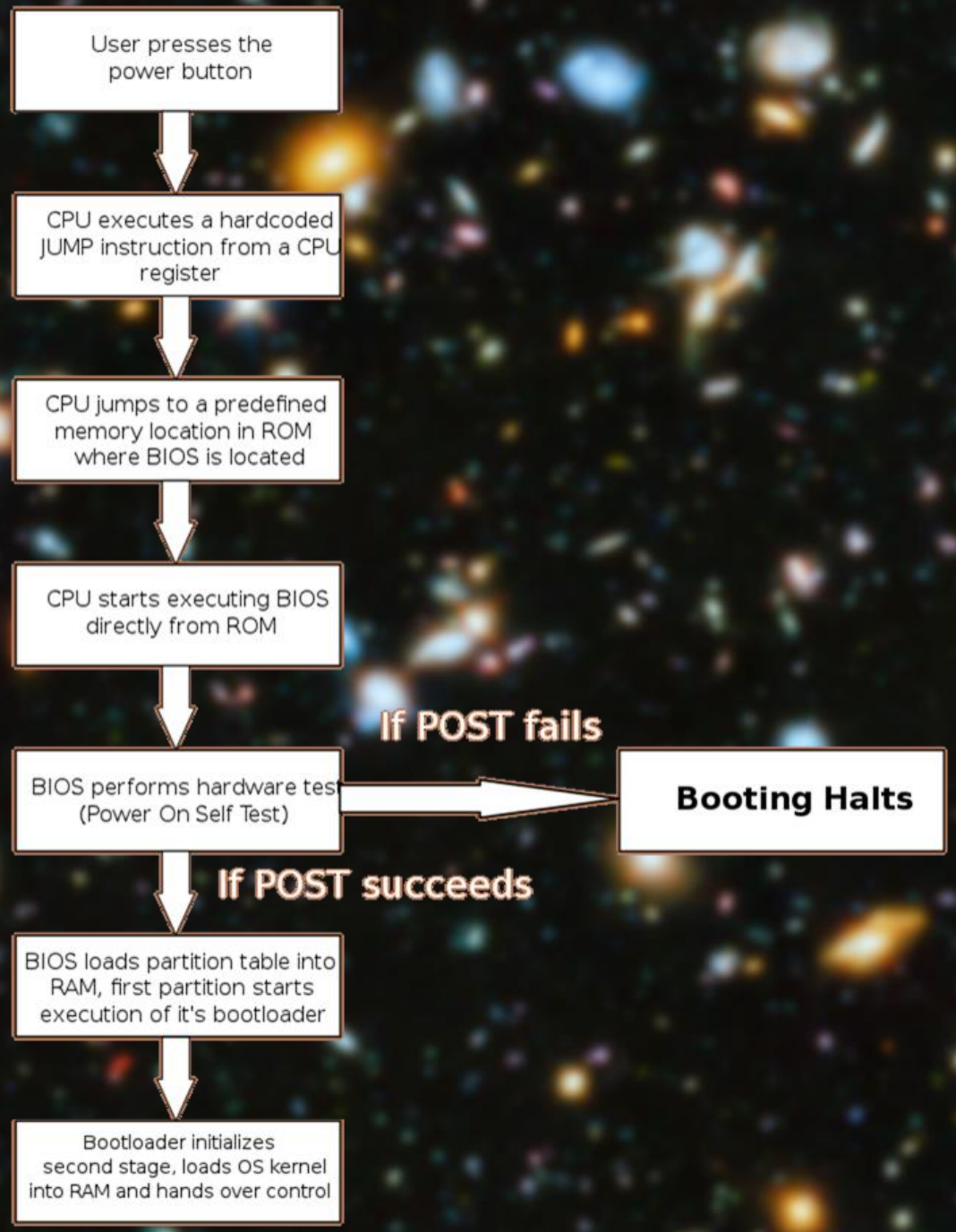
Address	Memory
0000	BIOS: Check
0001	BIOS: Load MBR
0010	BIOS: IP = &MBR
xxx0	MBR: Load Kernel
xxx1	MBR: IP = &Kernel
yyy0	Kernel: Device Manager
yy11	Kernel: Memory Manager
y111	Kernel: Process Manager

yyy0

Processor



Kernel



Computer

Memory

Kernel: Device Manager

Kernel: Memory Manager

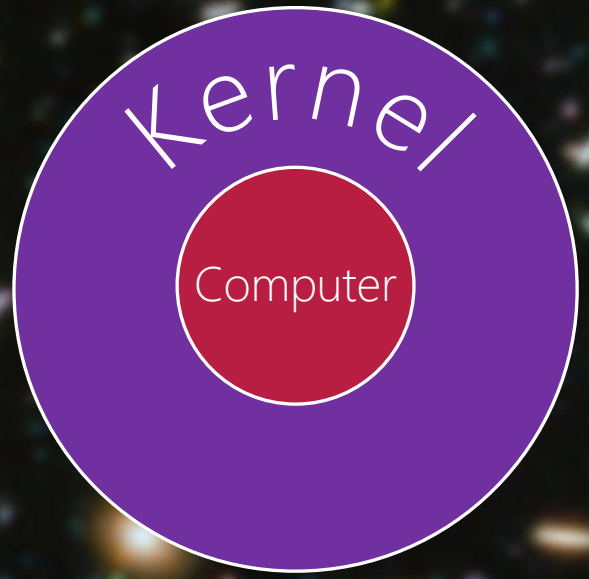
Kernel: File Manager

Kernel: Network Manager

Kernel: Process Manager

Bus

Processor



Computer

Memory

Kernel: Device Manager

Kernel: Memory Manager

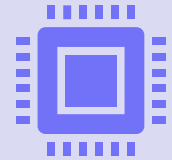
Kernel: File Manager

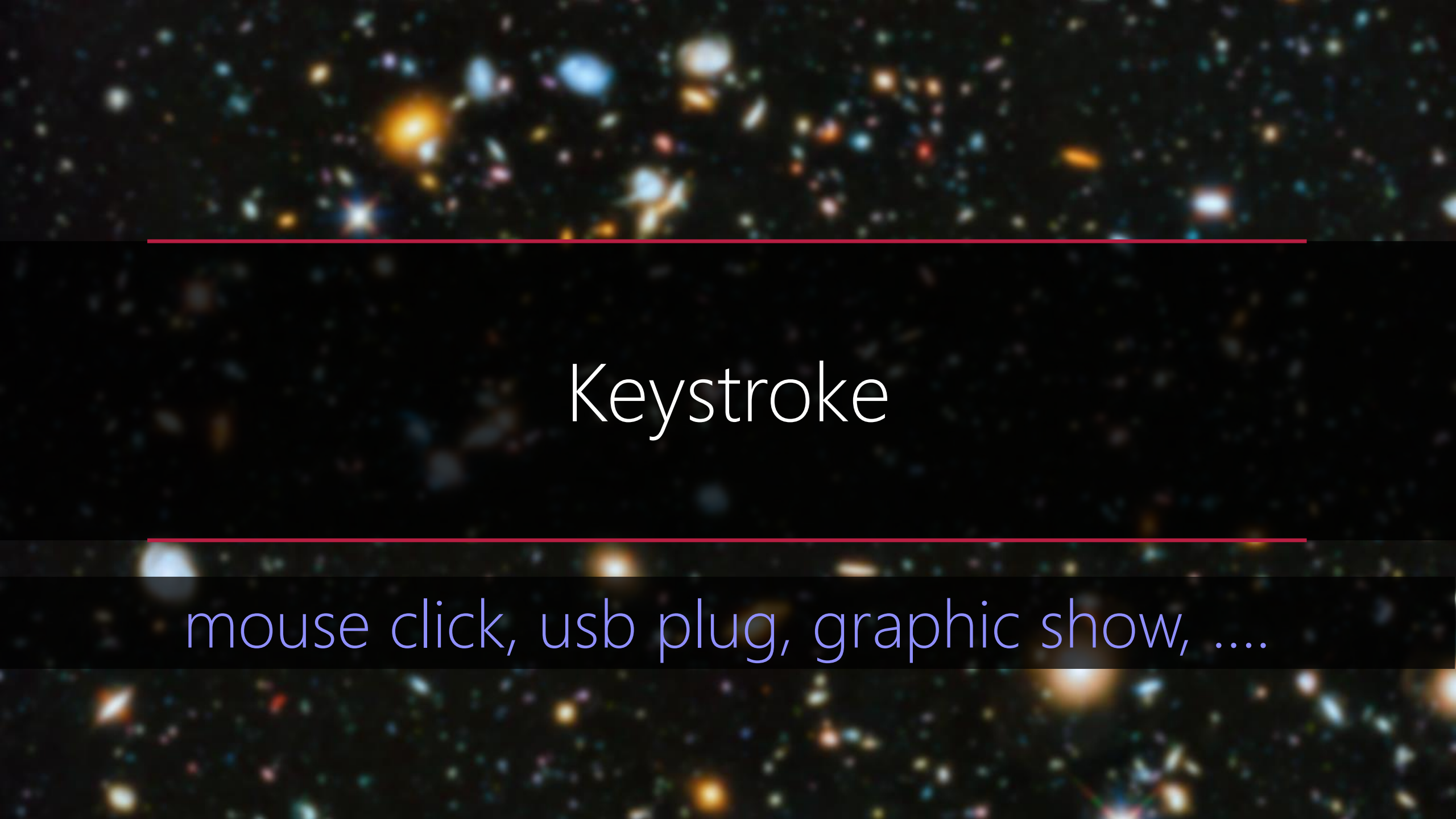
Kernel: Network Manager

Kernel: Process Manager

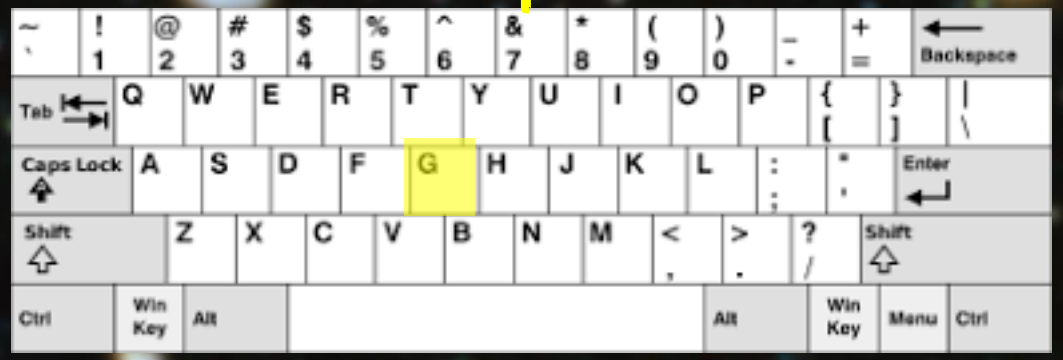
Bus

Processor




Keystroke
mouse click, usb plug, graphic show, ...

E.g., Keystroke



Computer

Memory

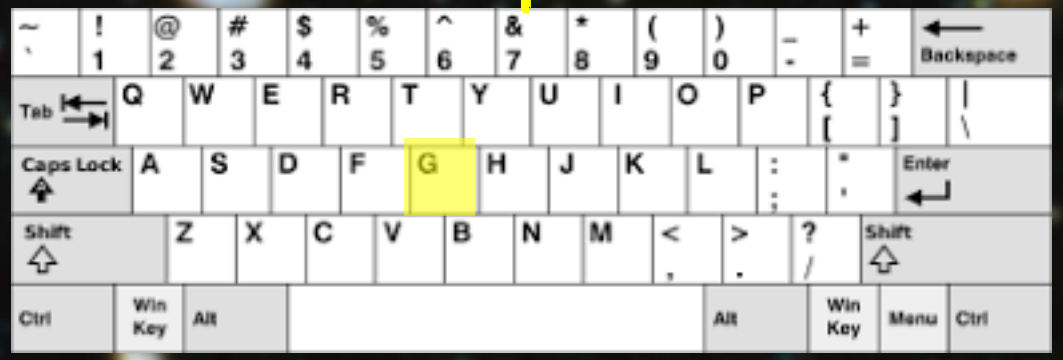
Kernel

Bus

Processor

E.g., Keystroke

1. Electric Signal



Computer

Memory

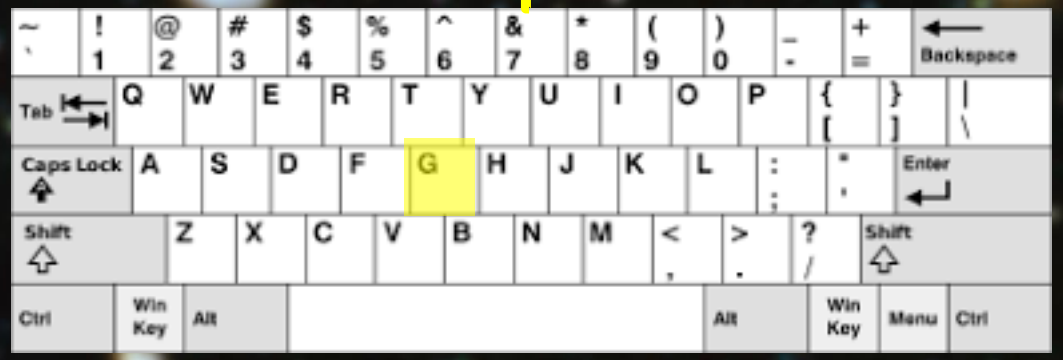
Kernel

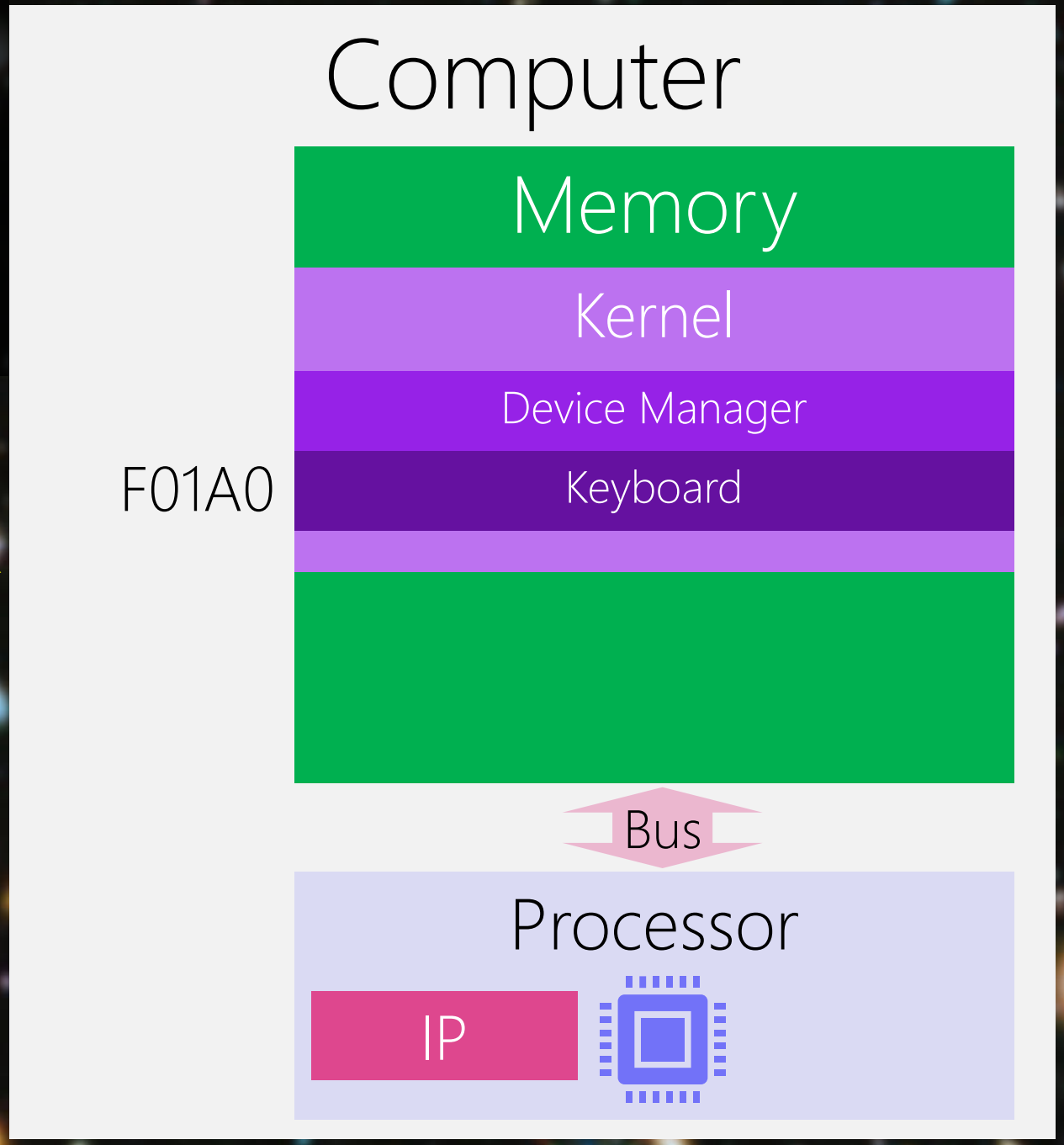
Bus

Processor

E.g., Keystroke

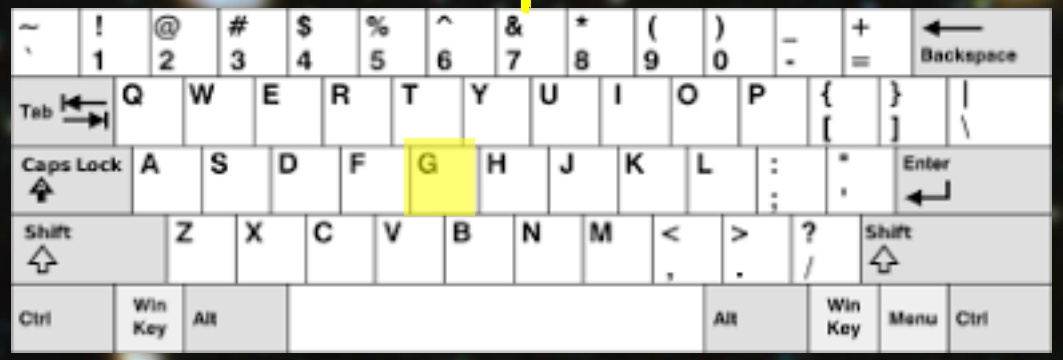
2. Kernel's Device Manager for Keyboard





E.g., Keystroke

3. IP = F01A0



Computer

F01A0

Memory

Kernel

Device Manager

Keyboard

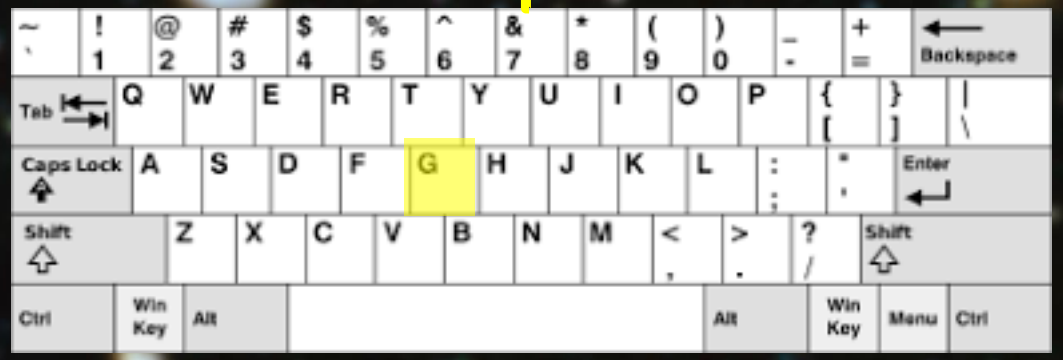
Bus

Processor

?

E.g., Keystroke

Who does IP = F01A0?



Computer

F01A0

Memory

Kernel

Device Manager

Keyboard

Bus

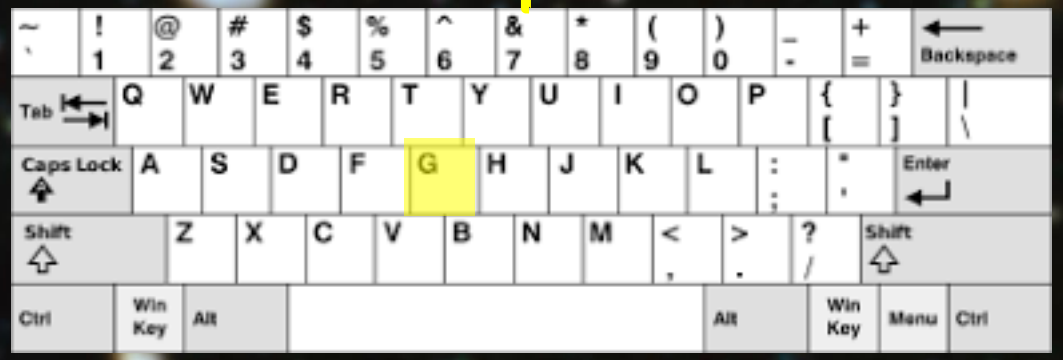
Processor

?

E.g., Keystroke

Who does IP = F01A0?

Electrical Signal → Kernel's Program



Computer

F01A0

Memory

Kernel

Device Manager

Keyboard

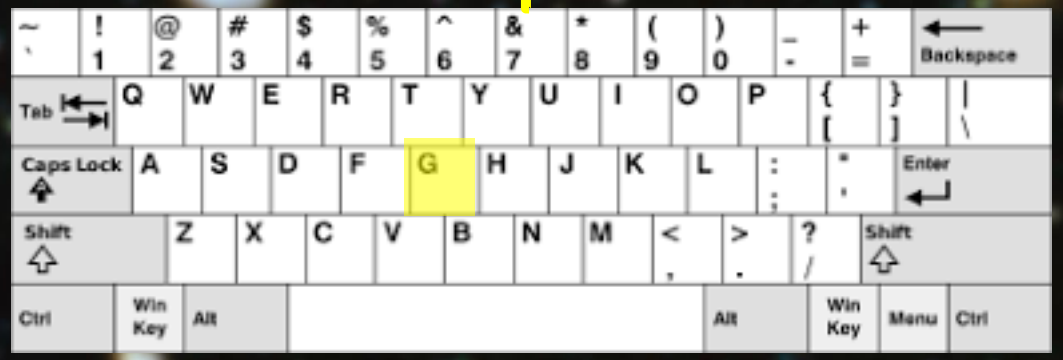
Bus

Processor

?

E.g., Keystroke

Interrupt Request (IRQ)
Interrupt Request Handler



Computer

Memory

Kernel

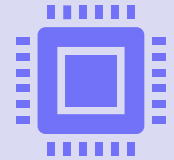
Device Manager

F01A0 Keyboard

Bus

Processor

?



```
bob@suse1:~> sudo cat /proc/interrupts
           CPU0
  0:         78   IO-APIC-edge      timer
  1:       9012   IO-APIC-edge      i8042
  3:          1   IO-APIC-edge
  4:       6609   IO-APIC-edge
  6:          7   IO-APIC-edge      floppy
  7:          0   IO-APIC-edge      parport0
  8:          1   IO-APIC-edge      rtc0
  9:          0   IO-APIC-fasteoi   acpi
 12:     101705   IO-APIC-edge      i8042
 14:       1374   IO-APIC-edge      ata_piix
 15:      28050   IO-APIC-edge      ata_piix
 16:        893   IO-APIC-fasteoi   Ensoniq AudioPCI
 17:      77088   IO-APIC-fasteoi   ioc0, ehci_hcd:usb1
 18:        112   IO-APIC-fasteoi   uhci_hcd:usb2
 19:       5167   IO-APIC-fasteoi   eth0
 40:          0   PCI-MSI-edge      PCIe PME, pciehp
 41:          0   PCI-MSI-edge      PCIe PME, pciehp
 42:          0   PCI-MSI-edge      PCIe PME, pciehp
 43:          0   PCI-MSI-edge      PCIe PME, pciehp
 44:          0   PCI-MSI-edge      PCIe PME, pciehp
 45:          0   PCI-MSI-edge      PCIe PME, pciehp
 46:          0   PCI-MSI-edge      PCIe PME, pciehp
```

IRQ	Usage
0	system timer (cannot be changed)
1	keyboard controller (cannot be changed)
2	cascaded signals from IRQs 8–15
3	second RS-232 serial port (COM2: in Windows)
4	first RS-232 serial port (COM1: in Windows)
5	parallel port 2 and 3 or sound card
6	floppy disk controller
7	first parallel port
8	real-time clock
9	open interrupt
10	open interrupt
11	open interrupt
12	PS/2 mouse
13	math coprocessor
14	primary ATA channel
15	secondary ATA channel

```
hfani@charlie:~$ procinfo
Memory:          Total        Used        Free     Buffer
RAM:        264118524    22664004   241454520      105852
Swap:        67378172           0    67378172

Bootup: Thu Aug 19 15:26:13 2021   Load average: 0.17 0

user   :      1w 1d 12:02:18.71   5.3%  page in :
nice   :            00:33:45.08   0.0%  page out:
system:      3w 2d 02:48:23.42  14.5%  page act:
IOwait:            01:10:09.71   0.0%  page dea:
hw irq:            00:00:00.00   0.0%  page flt:          3
sw irq:            09:31:11.65   0.2%  swap in :
idle   :     18w 1d 12:22:16.05  79.9%  swap out:
uptime:      1w 2d 23:19:40.99         context :

irq   0:          49  2-edge timer          irq  33:    3636919  1572868-edge eth0
irq   1:           4  1-edge i8042          irq  34:   12534197  1572869-edge eth0
irq   8:           1  8-edge rtc0           irq  35:    3728604  1572870-edge eth0
irq   9:           0  9-fasteoi acpi        irq  36:    6064430  1572871-edge eth0
irq  12:           6  12-edge i8042         irq  37:    5535547  1572872-edge eth0
irq  14:           0  14-edge pata_atii     irq  39:    6264652  1048576-edge mega
irq  15:           0  15-edge pata_atii     irq  41:          0  1574912-edge eth1
irq  16:           6  16-fasteoi ohci_h     irq  42:     430781  1574913-edge eth1
irq  17:           0  17-fasteoi ehci_h     irq  43:     430781  1574914-edge eth1
irq  18:          37  18-fasteoi ohci_h     irq  44:     430781  1574915-edge eth1
irq  19:           2  19-fasteoi ehci_h     irq  45:     430781  1574916-edge eth1
```

IRQ	Usage
0	system timer (cannot be changed)
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5	parallel port 2 and 3 or sound card
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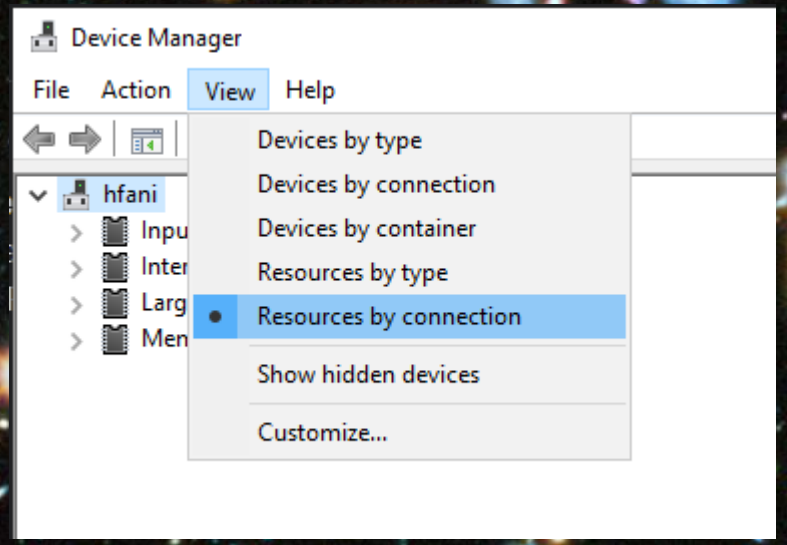
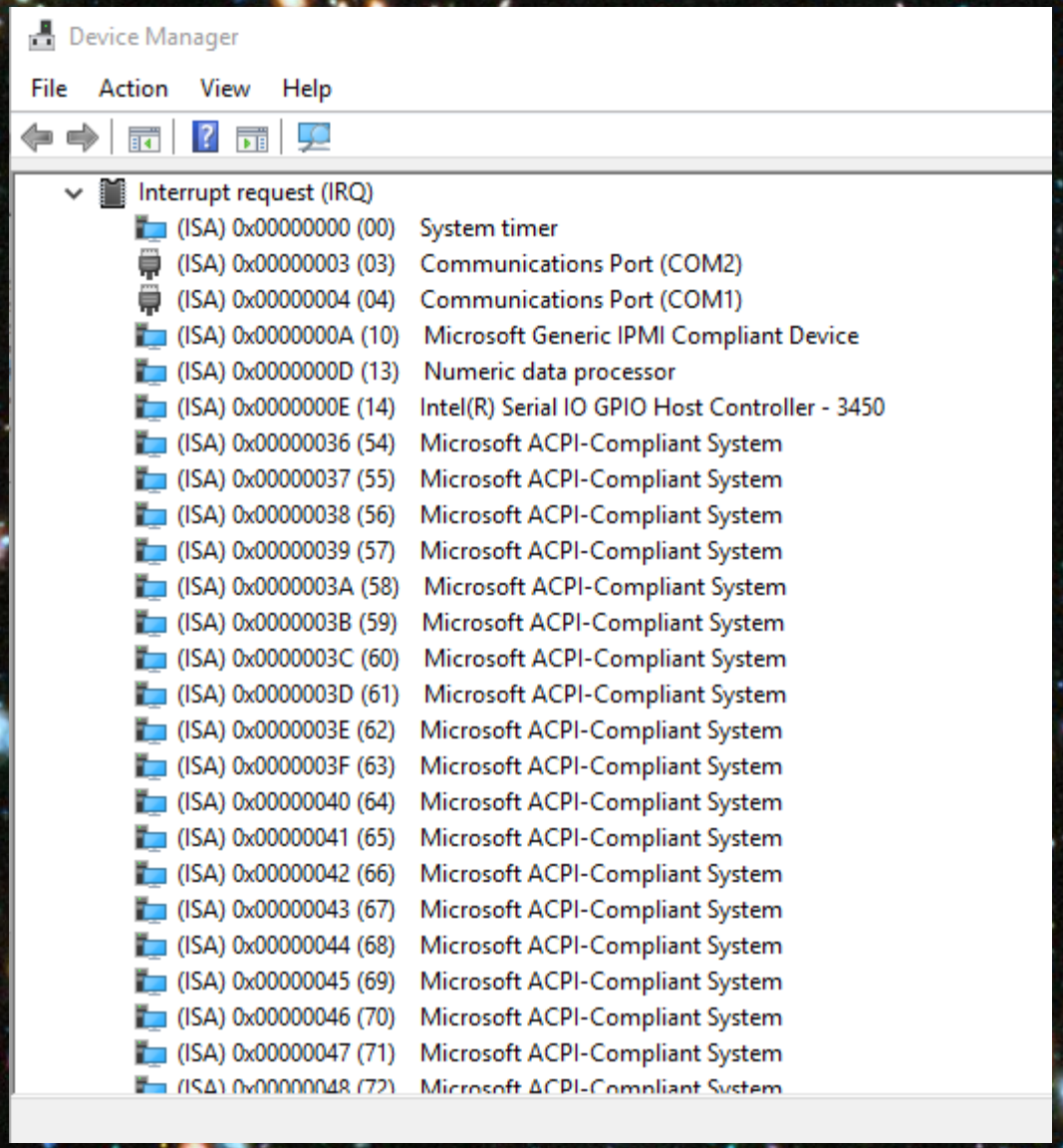
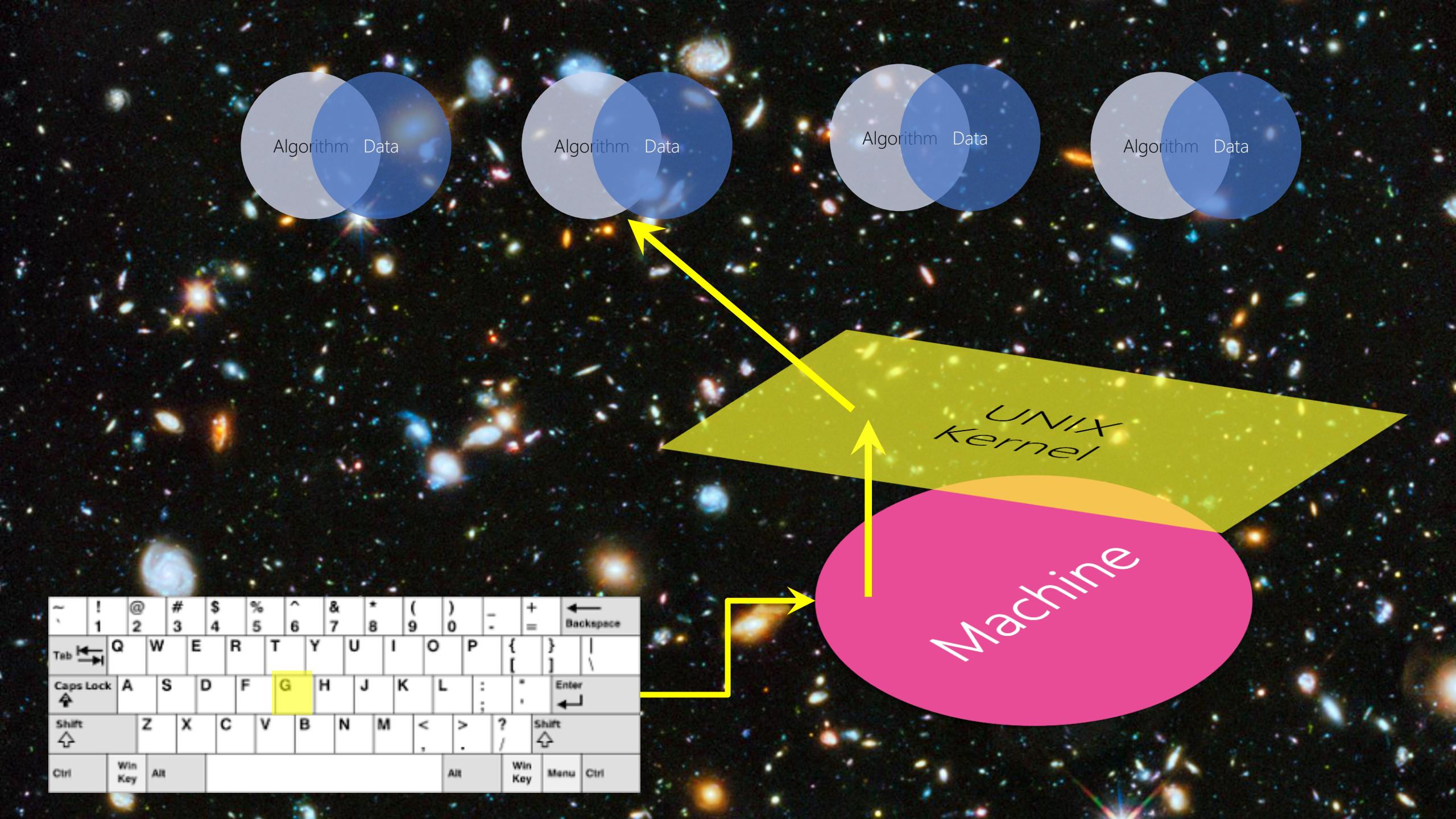
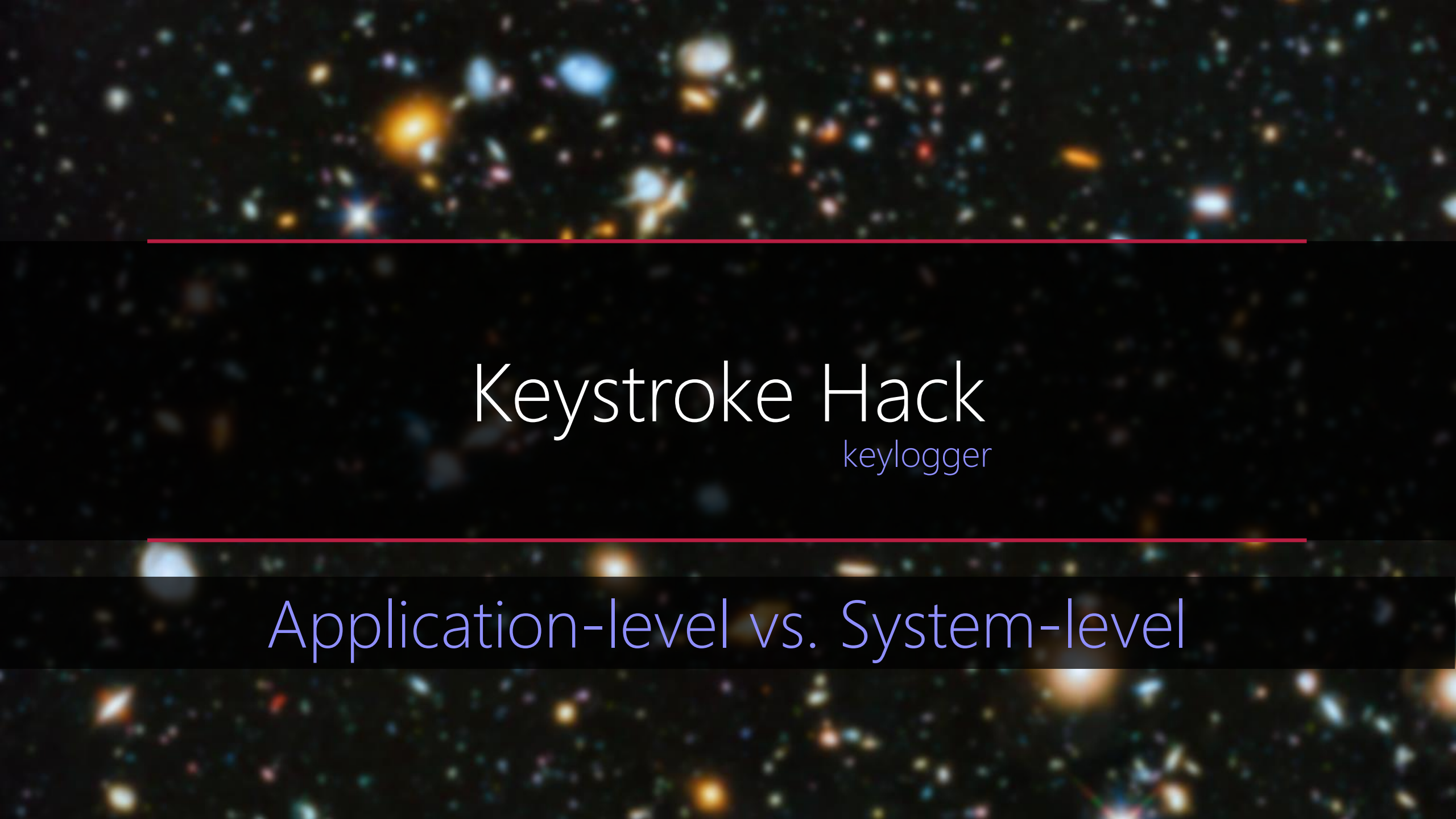
9	open interrupt
10	open interrupt
11	open interrupt
12	PS/2 mouse
13	math coprocessor
14	primary ATA channel
15	secondary ATA channel


Device Manager
File
Action
View
Help
Devices by type
Devices by connection
Devices by container
Resources by type
Resources by connection
Show hidden devices
Customize...
hfani


Device Manager
File
Action
View
Help
Interrupt request (IRQ)
(ISA) 0x00000000 (00) System timer
(ISA) 0x00000003 (03) Communications Port (COM2)
(ISA) 0x00000004 (04) Communications Port (COM1)
(ISA) 0x0000000A (10) Microsoft Generic IPMI Compliant Device
(ISA) 0x0000000D (13) Numeric data processor
(ISA) 0x0000000E (14) Intel(R) Serial IO GPIO Host Controller - 3450
(ISA) 0x00000036 (54) Microsoft ACPI-Compliant System
(ISA) 0x00000037 (55) Microsoft ACPI-Compliant System
(ISA) 0x00000038 (56) Microsoft ACPI-Compliant System
(ISA) 0x00000039 (57) Microsoft ACPI-Compliant System
(ISA) 0x0000003A (58) Microsoft ACPI-Compliant System
(ISA) 0x0000003B (59) Microsoft ACPI-Compliant System
(ISA) 0x0000003C (60) Microsoft ACPI-Compliant System
(ISA) 0x0000003D (61) Microsoft ACPI-Compliant System
(ISA) 0x0000003E (62) Microsoft ACPI-Compliant System
(ISA) 0x0000003F (63) Microsoft ACPI-Compliant System
(ISA) 0x00000040 (64) Microsoft ACPI-Compliant System
(ISA) 0x00000041 (65) Microsoft ACPI-Compliant System
(ISA) 0x00000042 (66) Microsoft ACPI-Compliant System
(ISA) 0x00000043 (67) Microsoft ACPI-Compliant System
(ISA) 0x00000044 (68) Microsoft ACPI-Compliant System
(ISA) 0x00000045 (69) Microsoft ACPI-Compliant System
(ISA) 0x00000046 (70) Microsoft ACPI-Compliant System
(ISA) 0x00000047 (71) Microsoft ACPI-Compliant System

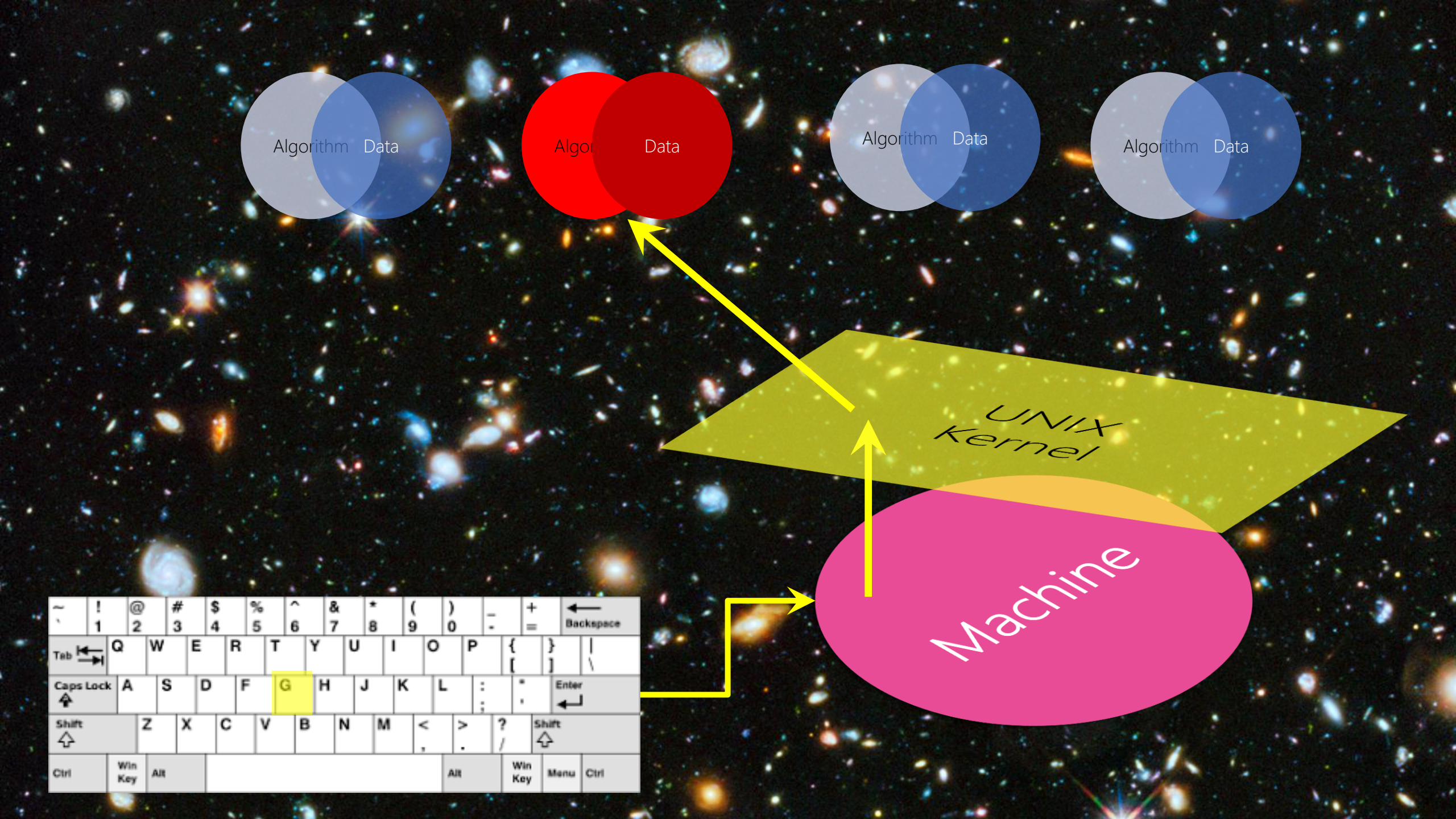

Algorithm Data
Algorithm Data
Algorithm Data
Algorithm Data
UNIX kernel
Machine

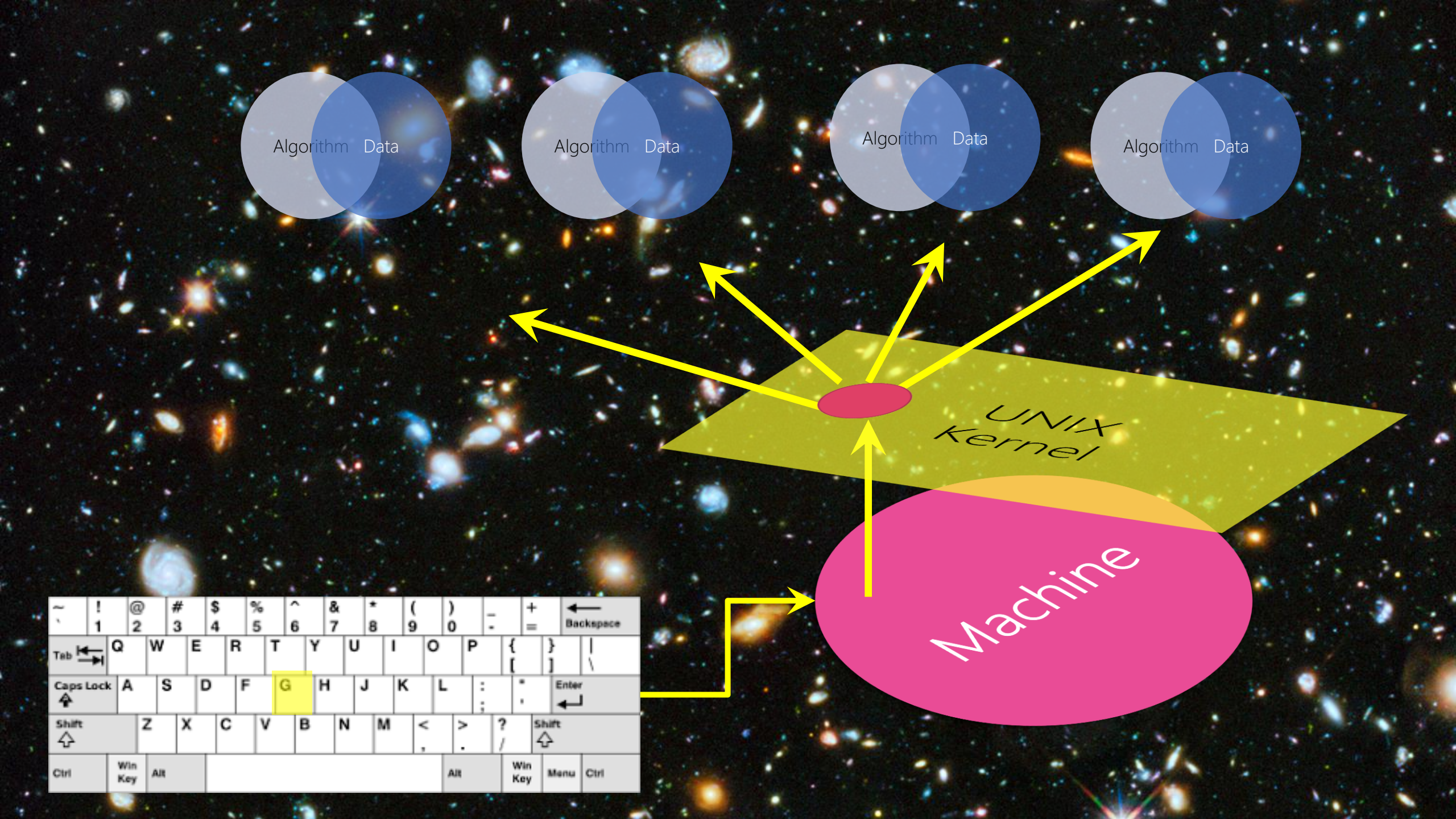


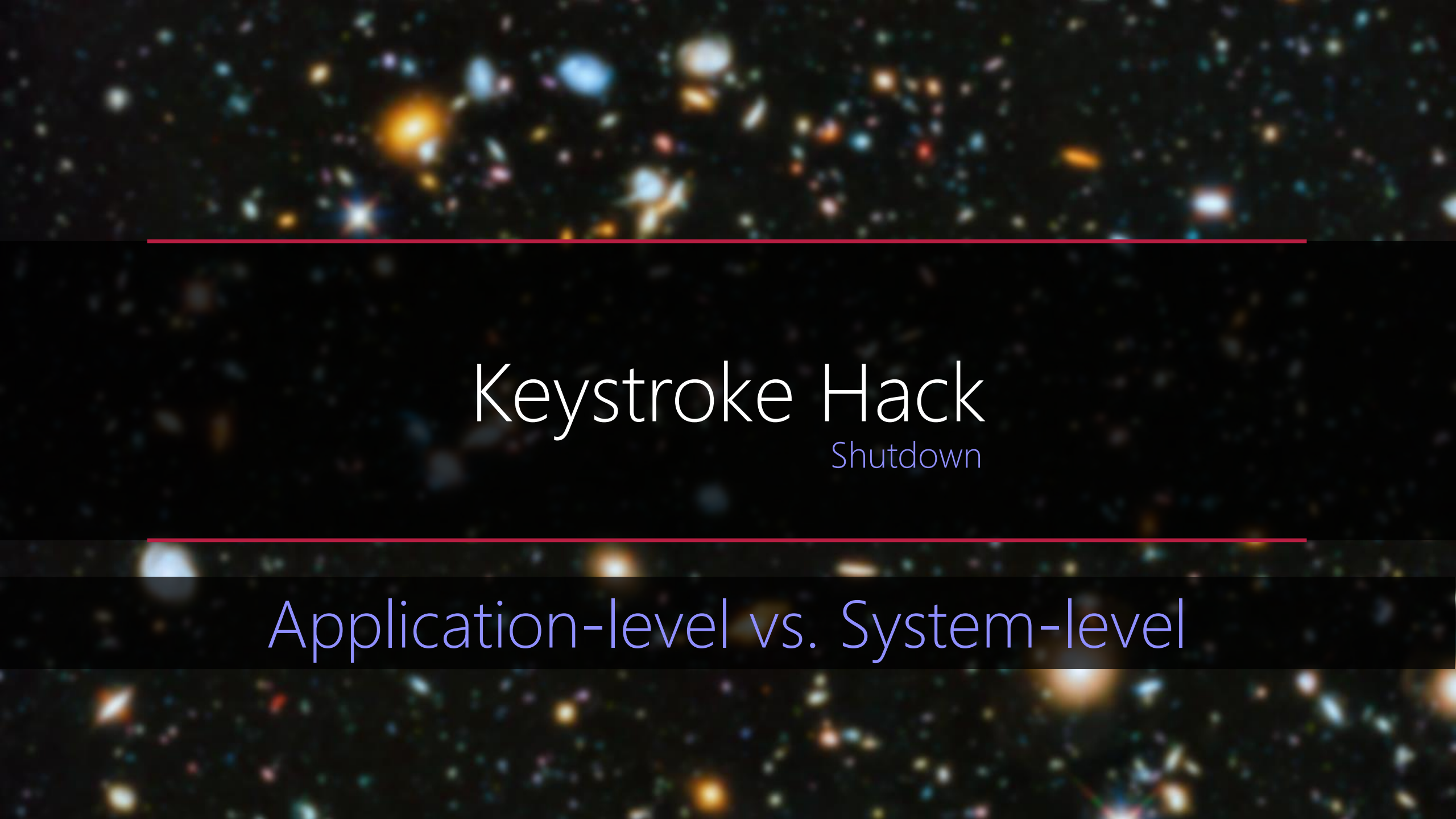
Keystroke Hack

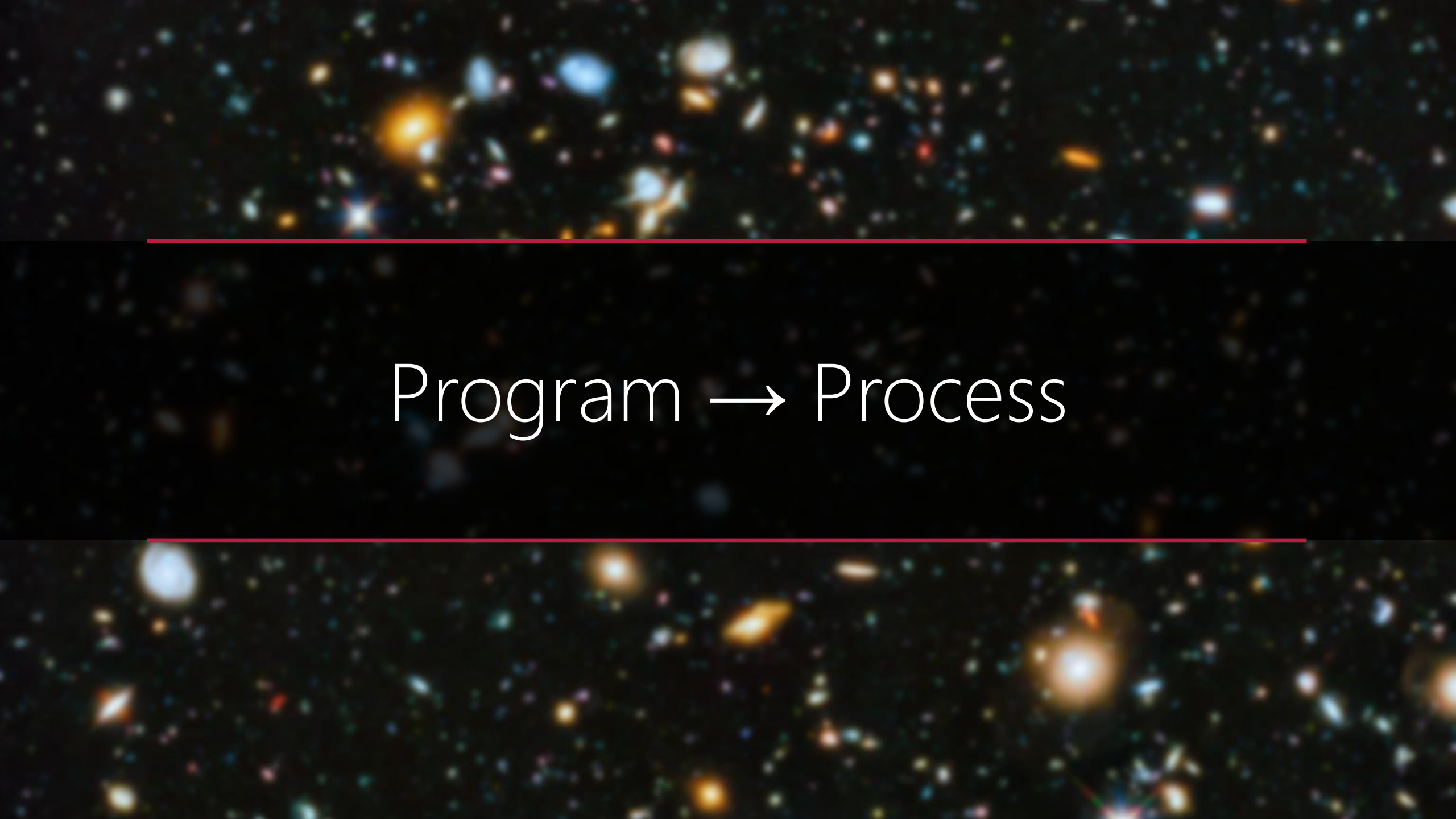
keylogger

Application-level vs. System-level


Algorithm Data
Algo Data
Algorithm Data
Algorithm Data
UNIX kernel
Machine


Algorithm Data
Algorithm Data
Algorithm Data
Algorithm Data
UNIX
Kernel
Machine

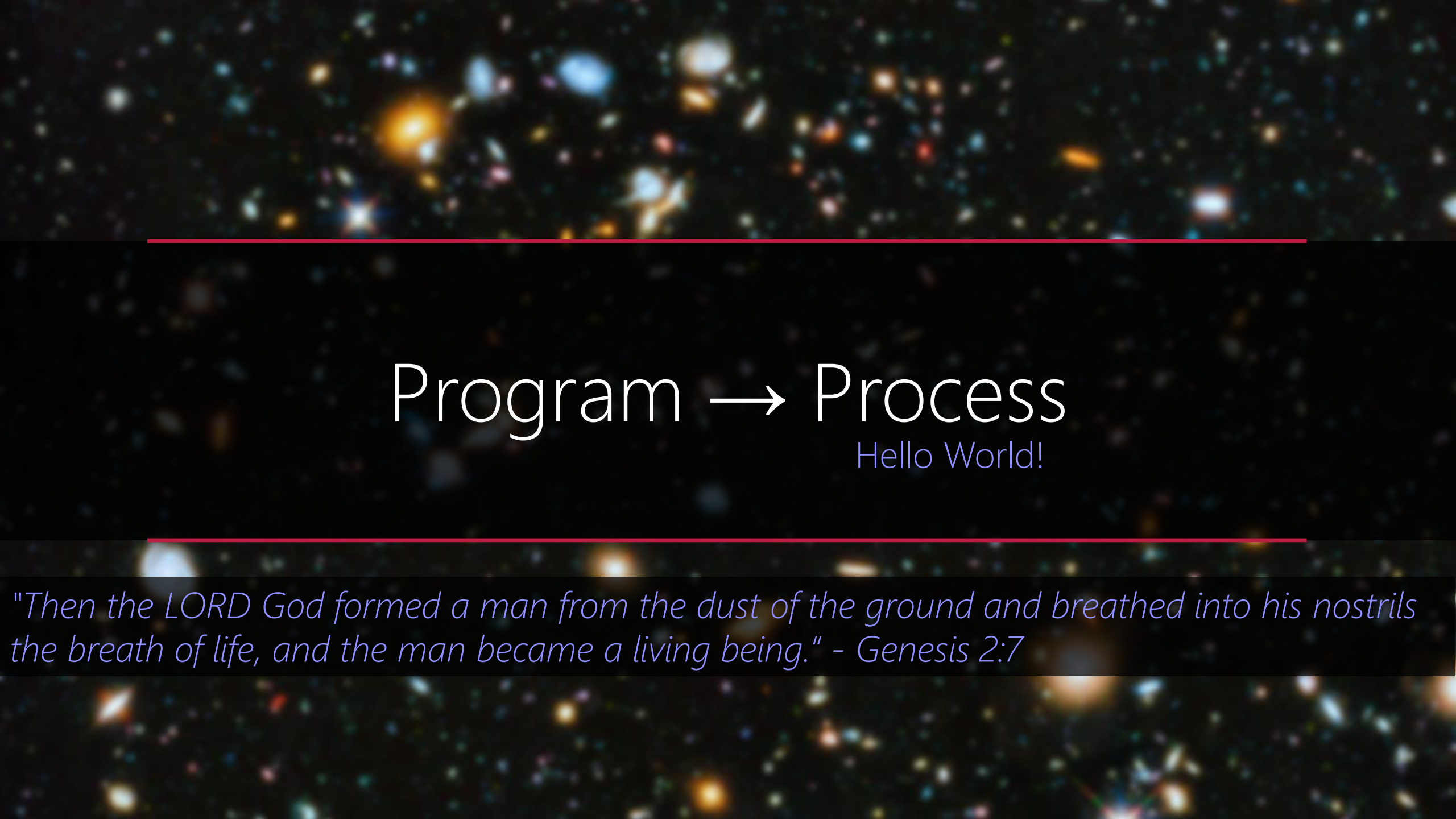

Keystroke Hack
Shutdown
Application-level vs. System-level



Program → Process


Ezekiel 25:17, Pulp Fiction (1994), Quentin Tarantino
You read the Bible, Brett?


Ezekiel 25:17, Pulp Fiction (1994), Quentin Tarantino
Well, there's this passage I've got
memorized; sorta fits this occasion.



Program → Process

Hello World!

"Then the LORD God formed a man from the dust of the ground and breathed into his nostrils the breath of life, and the man became a living being." - Genesis 2:7

C

```
hfani@alpha:~$ vi hello.c
```

```
#include <stdio.h>
void main(){
      printf("hello world!");
}
```

Compiler

Assembly

```
<printf@plt>:
jmpq        *0x3002(%rip)
pushq       $0x0
jmpq        401000 <.plt>
<main>:
push        %rbp
mov         %rsp,%rbp
lea         0xfd5(%rip),%rdi
mov         $0x0,%eax
callq       401010 <printf@plt>
nop
pop         %rbp
retq
```

Assembler

OP Code

```
hfani@alpha:~$ cc hello.c -o hello
```

```
0001 0000 0000 0000 0000 0000 0000 0000
0011 0000 0003 0000 0000 0000 0000 0000
0000 0000 0000 0000 3309 0000 0000 0000
0096 0000 0000 0000 0000 0000 0000 0000
0001 0000 0000 0000 0000 0000 0000 0000
```

Program

```
0001 0000 0000 0000 0000 0000 0000 0000
0011 0000 0003 0000 0000 0000 0000 0000
0000 0000 0000 0000 3309 0000 0000 0000
0096 0000 0000 0000 0000 0000 0000 0000
0001 0000 0000 0000 0000 0000 0000 0000
```

Computer

FF1C0

Memory to Store

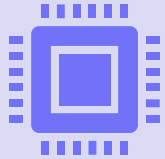
Kernel

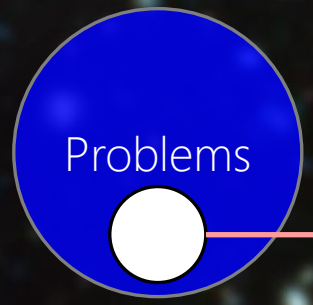
Process Manager
Program → Process

Bus

Processor

?





Program

```
0001 0000 0000 0000 0000 0000 0000 0000
0011 0000 0003 0000 0000 0000 0000 0000
0000 0000 0000 0000 3309 0000 0000 0000
0096 0000 0000 0000 0000 0000 0000 0000
0001 0000 0000 0000 0000 0000 0000 0000
```

1. Locate the program: /home/hfani/...
2. Call Process Manager for loading the program
   IP = FF1C0
3. Point IP to the first line of the program
   IP = &first opcode

Computer

FF1C0

Memory to Store

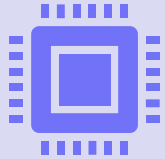
Kernel

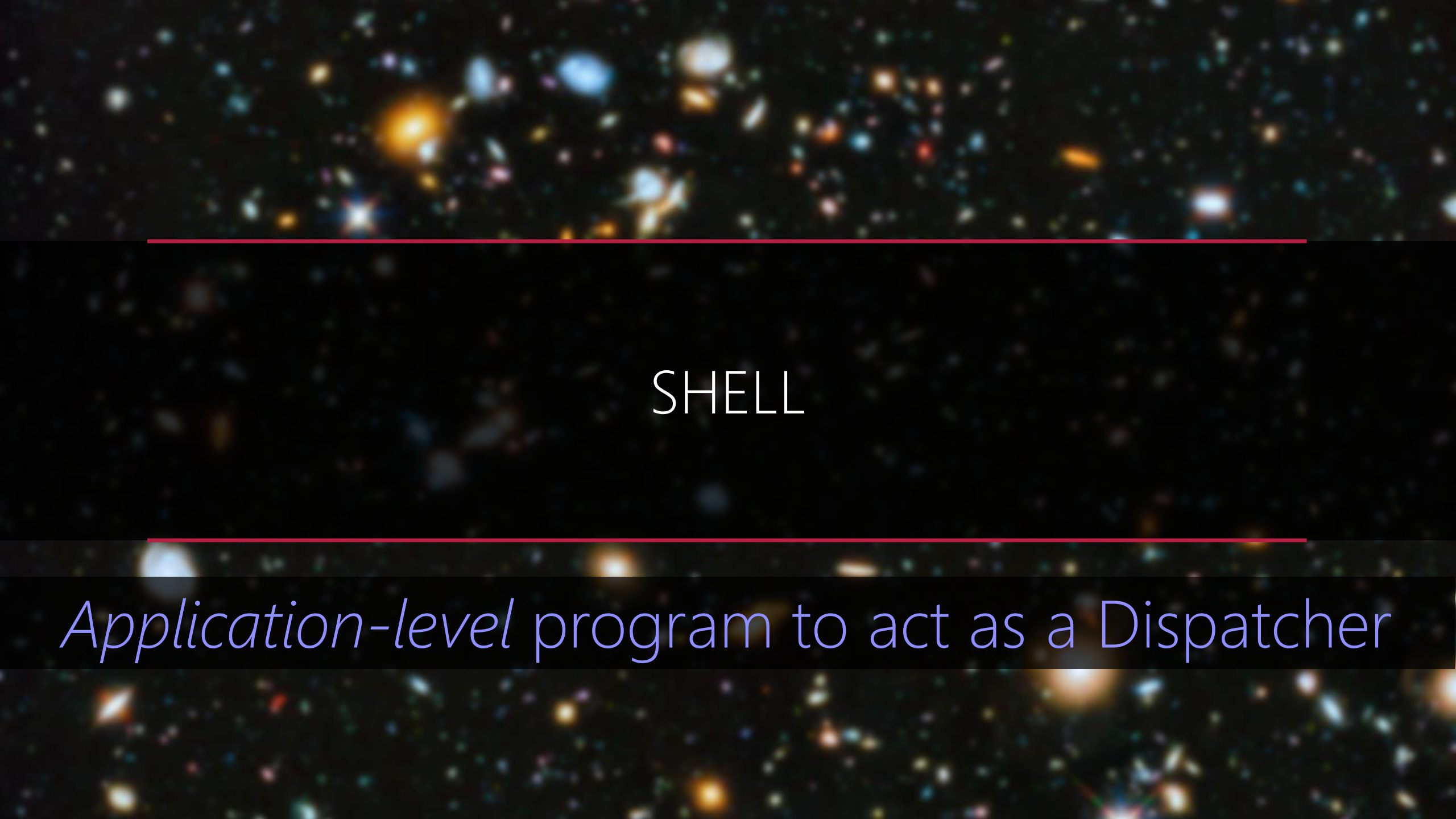
Process Manager
Program → Process

Bus

Processor

?





SHELL

Application-level program to act as a Dispatcher