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hhuOS

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18. Juli 2018

Introduction

Facts about hhuOS

- A small operating system for teaching and learning purposes
- written for x86 32-bit architecture (64-bit maybe later)
- written in C++ and x86-Assembler using g++ and nasm
- Open-Source, published under the GPL v3 license

hhuOS - Features

- Round-robin based preemptive scheduling for threads
- Support for AHCI, USB (partially), PCI and VESA-Graphics
- Different memory managers
- Paging with higher half kernel
- FAT- Filesystem and VFS

Memory & Paging

Overview : Memory & Paging

- Paging is used to abstract physical memory from virtual address spaces
- new pages can be mapped in/out dynamically
- it is possible to create different address spaces
- Kernel is mapped at 3GB → Higher-Half-Kernel
- the addresses above 3GB are mapped into all address spaces as Kernelspace
- everything below 3GB can be used for usermode later

Difficulties implementing paging

The bootstrapping process:

- How to allocate memory when no memory manager is available?
- How to map the Kernel-code at 3GB without losing the EIP?
- Solution: activate paging in three steps
  1. First: Create a rough basic mapping for important areas using 4MB paging
  2. Then initialize all important memory managers and the page frame allocator
  3. Set up the first 4KB-Pagedirectory and reload CR3 register

Difficulties implementing paging

Invoking BIOS-calls:

- BIOS-calls are necessary to set up VESA-Graphics
- BUT: BIOS-calls run in 16-bit mode without paging
- every BIOS-call would crash immediately if used with Higher-Half Kernel
- Solution:
  1. Switch to a simple 4MB-Pagedirectory that maps the Kernel to low addresses
  2. jump down to low addresses with EIP and switch to 16-bit mode without paging
  3. After returning from BIOS-call restore the old state

Filesystem

Storage

- *StorageDevice* as interface for block devices
- Only 5 methods: *getSectorCount() getSectorSize()*, *read()*, *write()*, *getHardwareName()*
- Implemented for AHCI, EHCI, Floppy, Virtual Drives, and Partitions
- File in */dev* for every device (similar to Linux)

Virtual File System

- Overlay over physical file systems
- Storage devices can be mounted to any folder
- Interface *FsDriver* for physical file systems
- Currently, only FAT is supported as physical file system

Kernel Features

Utility Classes

hhuOS includes some utility classes to ease implementing new features

Array **ArrayList** **LinkedList** **HashMap**

HashSet **BlockingQueue** **RingBuffer**

Each utility class can be used in conjuction with any type by using template parameters

Utility Classes : Arrays

Array copies can be created using a simple assignment

code/Arrays.cpp C++

```cpp
Util::Array<uint32_t> a = {1, 2};

Util::Array<uint32_t> b = a;

a[1] = 3;

printf("a[0]=%d , a[1]=%d\n", a[0], a[1]);

printf("b[0]=%d , b[1]=%d\n", b[0], b[1]);
```

```
a[0]=1 , a[1]=3
b[0]=1 , b[1]=2
```

Utility Classes : HashMaps

HashMaps can be used to store key-value pairs with any type

code/HashMaps.cpp C++

```cpp
Util::HashMap<String, uint32_t> hashMap =
    {{ "startup", 0xC0100020}, {"main", 0xC014F7C8}};

printf("Function 'main' is at 0x%08x\n", hashMap.get("main"));
```

```
Function 'main' is at 0xC014F7C8
```

Kernel Modules

hhuOS’ functionality can be extended using kernel modules

code/Hello.h C++

```cpp
#include <kernel/Module.h>

class Hello : public Module {
public:
    Hello() = default;
    int32_t initialize() override;
    int32_t finalize() override;
    String getName() override;
    Util::Array<String> getDependencies() override;
};
```

Each module needs to inherit from the `Module` class

Kernel Modules

hhuOS's functionality can be extended using kernel modules

code/Hello.cpp C++

```cpp
#include "Hello.h"
#include "lib/libc/printf.h"

MODULE_PROVIDER { return new Hello(); };
int32_t Hello::initialize() { printf("Hello hhuOS!\n"); return 0; }
int32_t Hello::finalize() { printf("Bye hhuOS!\n"); return 0; }
String Hello::getName() { return "hello"; }
Util::Array<String> Hello::getDependencies() { return Util::Array<String>(0); }
```

In this example, the `Hello` module prints `Hello hhuOS!` on initialization

Kernel Modules

hhuOS supports loading kernel modules at runtime

code/Modules.cpp C++

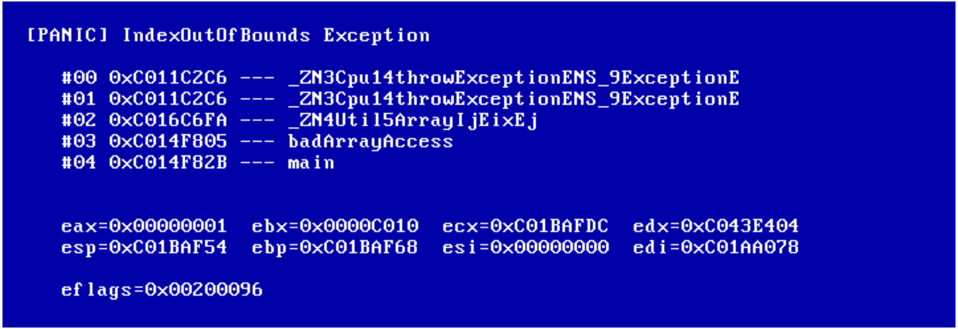
```cpp
auto moduleLoader = Kernel::getService<ModuleLoader>();

auto file = File::open("/mod/hello.ko", "r");

moduleLoader->load(file);
```

```
Hello hhuOS!
```

Compiled modules can be placed on an external storage device

Bluescreen / Stacktrace

If something goes wrong, hhuOS prints out a bluescreen containing useful information such as a stacktrace



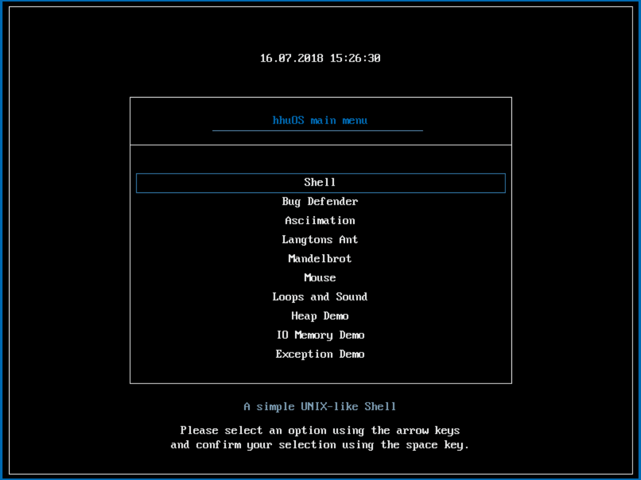
```
[PANIC] IndexOutOfBounds Exception

   #00 0xC011C2C6 --- _ZN3Cpu14throwExceptionENS_9ExceptionE
   #01 0xC011C2C6 --- _ZN3Cpu14throwExceptionENS_9ExceptionE
   #02 0xC016C6FA --- _ZN4Util5ArrayIjEixEj
   #03 0xC014F805 --- badArrayAccess
   #04 0xC014F82B --- main


   eax=0x00000001  ebx=0x0000C010  ecx=0xC01BAFDC  edx=0xC043E404
   esp=0xC01BAF54  ebp=0xC01BAF68  esi=0x00000000  edi=0xC01AA078

   eflags=0x00200096
```

Future Work

Future Work

- Implement more device drivers (sound, graphics card, etc.)
- Ring protection / user mode
- Process system
- Enhanced scheduling (priorities, I/O management)
- New (custom) filesystems
- Multicore support

Demo



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A simple UNIX-like Shell

Please select an option using the arrow keys
and confirm your selection using the space key.