

The Nanvix Operating System

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Agenda

Introduction

The Nanvix Operating System

Baby Steps

The Nanvix Kernel

Perspectives

Introduction

Context

- ▶ Early days of the Computer Era
 - ▶ Computers filled up entire rooms to perform simple calculations
 - ▶ Programs were written in machine code
 - ▶ Computer scientists had to deal with the bare hardware

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 - ▶ Computers filled up entire rooms to perform simple calculations
 - ▶ Programs were written in machine code
 - ▶ Computer scientists had to deal with the bare hardware
- ▶ Information Era
 - ▶ Parallel architectures
 - ▶ Large-scale distributed systems
 - ▶ Modern programming languages

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 - ▶ Computers filled up entire rooms to perform simple calculations
 - ▶ Programs were written in machine code
 - ▶ Computer scientists had to deal with the bare hardware
- ▶ Information Era
 - ▶ Parallel architectures
 - ▶ Large-scale distributed systems
 - ▶ Modern programming languages
- ▶ What has enabled such evolution?
 - ▶ Computer abstractions
 - ▶ Software stack hardware

Introduction

Motivation

- ▶ Roles of an operating system
 - ▶ Multiplex access to resources
 - ▶ Extend the functionalities of the underlying

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 - ▶ Design complex systems
 - ▶ Master powerful mechanisms and strategies
 - ▶ Deliver extra expertise in emerging topics

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 - ▶ Multiplex access to resources
 - ▶ Extend the functionalities of the underlying
- ▶ Expertise in operating systems
 - ▶ Design complex systems
 - ▶ Master powerful mechanisms and strategies
 - ▶ Deliver extra expertise in emerging topics
- ▶ Problems when learning about operating systems design
 - ▶ Simplistic, unrealistic or complex operating systems
 - ▶ Lack in documentation and teaching material

Agenda

Introduction

The Nanvix Operating System

Baby Steps

The Nanvix Kernel

Perspectives

Agenda

Introduction

The Nanvix Operating System

Baby Steps

The Nanvix Kernel

Perspectives

The Nanvix Operating System

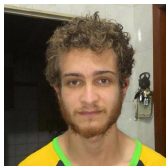
Project Overview

- ▶ Created from scratch for educational purposes
- ▶ Designed to be small, simple, modern and fully featured
- ▶ Publicly available under the GPL v3 license at:

www.github.com/ppenna/nanvix



Pedro H. Penna
UFSC



Davidson Francis
PUC Minas



Subhra Sarkar
EchoStar Corp.

Figure: People involved in the Nanvix Project.

The Nanvix Operating System

Kernel Features

- ▶ POSIX compliant system call interface
- ▶ Unix System V architecture
- ▶ Non-preemptive
- ▶ Time-sharing
- ▶ Multiprogramming
- ▶ Interprocess communication
- ▶ Virtual memory with swapping
- ▶ Minix file system
- ▶ Uniform device interface

The Nanvix Operating System

User-Land Features

- ▶ Standard C Library
- ▶ Unix-Like utilities

```
Nanvix - A Free Educational Operating System

The programs included with Nanvix system are free software
under the GNU General Public License Version 3.

Nanvix comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.

Copyright(C) 2011-2016 Pedro H. Penna <pedrohenriquepenna@gmail.com>
                2015-2015 Davidson Francis <davidsondfg@gmail.com>
                2016-2016 Subhra S. Sarkar <rurtle.coder@gmail.com>

# echo "Hello World"
"Hello World"
# ps
----- Process Status -----
NAME          PID   UID   PRIORITY   NICE   UTIME   KTIME   STATUS
idle          0     0     40         20     0       4334   READY
init          1     0     40         20     1       0       WAITING
tsh           2     0     40         20     0       1       WAITING
ps            4     0     40         20     0       0       RUNNING

Last process: idle, pid: 0
#
```

Figure: Nanvix running.

Agenda

Introduction

The Nanvix Operating System

Baby Steps

The Nanvix Kernel

Perspectives

Baby Steps

Source Tree

► bin: binaries

Baby Steps

Source Tree

- ▶ `bin:` binaries
- ▶ `doc:` documentation

Baby Steps

Source Tree

- ▶ `bin`: binaries
- ▶ `doc`: documentation
- ▶ `include`
 - ▶ `include/dev`: device drivers headers
 - ▶ `include/fs`: file systems headers
 - ▶ `include/i386`: platform-specific headers
 - ▶ `include/nanvix`: kernel headers

Baby Steps

Source Tree

- ▶ `bin`: binaries
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 - ▶ `include/nanvix`: kernel headers
- ▶ `lib`: libraries

Baby Steps

Source Tree

- ▶ `bin`: binaries
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 - ▶ `include/nanvix`: kernel headers
- ▶ `lib`: libraries
- ▶ `src`
 - ▶ `src/kernel`: kernel sources
 - ▶ `src/lib`: libraries sources
 - ▶ `src/sbin`: superuser utilities sources
 - ▶ `src/ubin`: user utilities sources

Baby Steps

Building & Running Nanvix

```
$ cd ~
$ git clone https://github.com/pppenna/nanvix.com
$ cd nanvix
$ sudo bash tools/dev/setup-toolchain.sh
$ sudo bash tools/dev/setup-bochs.sh
$ sudo reboot now
$ cd ~/nanvix
$ make nanvix
$ sudo make image
$ sudo bash tools/run/run.sh
```

Agenda

Introduction

The Nanvix Operating System

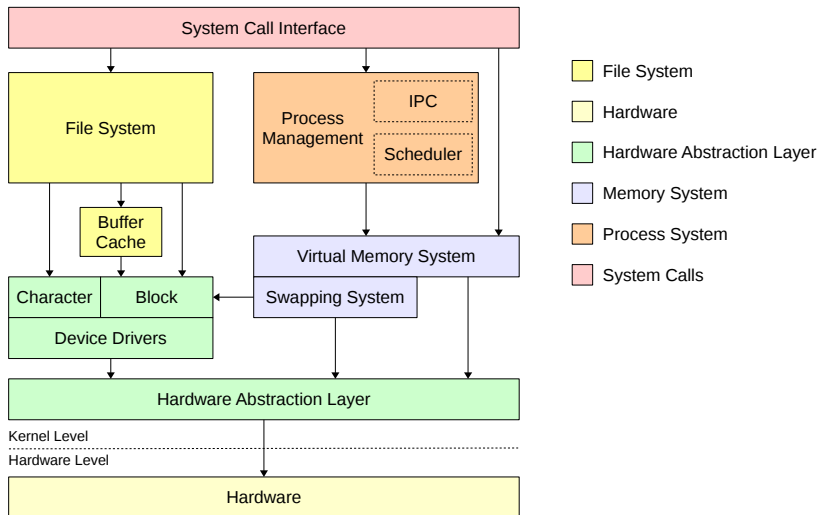
Baby Steps

The Nanvix Kernel

Perspectives

The Nanvix Kernel

Overview



The Nanvix Kernel

Overview

Table: Key system calls in Nanvix.

Category	System Call(s)	Description
File System	<code>open()</code> , <code>close()</code>	Opens/Closes a File Descriptor
	<code>read()</code> , <code>write()</code>	Reads/Writes to a File
	<code>link()</code> , <code>unlink()</code>	Creates/Removes a Link to a File
	<code>stat()</code>	Retrieves the Status of a File
	<code>chown()</code>	Changes the File Ownership
Process Management	<code>fork()</code>	Creates a Process
	<code>execve()</code>	Executes a Program
	<code>kill()</code>	Sends a Signal to a Process
	<code>pause()</code> , <code>exit()</code>	Suspends/Terminates the Process

The Nanvix Kernel

The Process Management Subsystem

Table: Key fields in a Process Control Block in Nanvix.

Category	Field	Description
Context Switch	kstack	Kernel Stack
File System	pwd	Current Working Directory
	ofiles	Opened Files
Memory Management	pregs	Memory Regions
	pgdir	Page Directory
Process Management	state	Current State
	counter	Remaining Quantum
	pid	Process ID
	nice	User-Level Priority

The Nanvix Kernel

The Process Management Subsystem

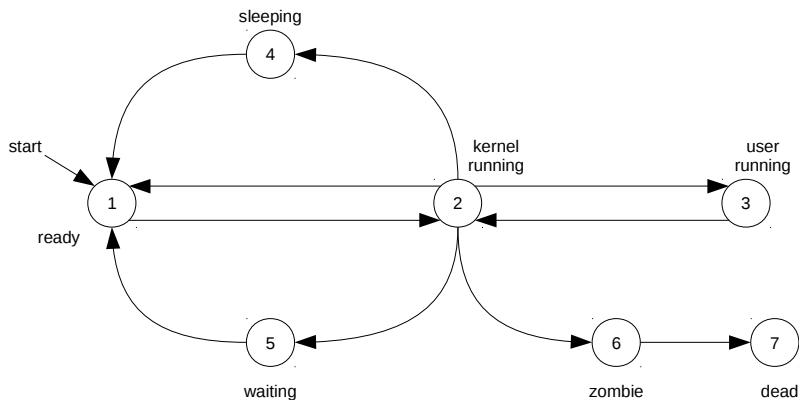


Figure: Figure: Life cycle of a process in Nanvix.

The Nanvix Kernel

The Process Management Subsystem

```
PUBLIC void yield(void) {
    struct process *p, *next = IDLE;

    if (curr_proc->state == PROC_RUNNING)
        sched(curr_proc);

    for (p = FIRST_PROC; p <= LAST_PROC; p++) {
        if (p->state != PROC_READY)
            continue;
        if (p->counter > next->counter) {
            next->counter++; next = p;
            continue;
        }

        p->counter++;
    }

    switch_to(next);
}
```

The Nanvix Kernel

The Memory Management Subsystem

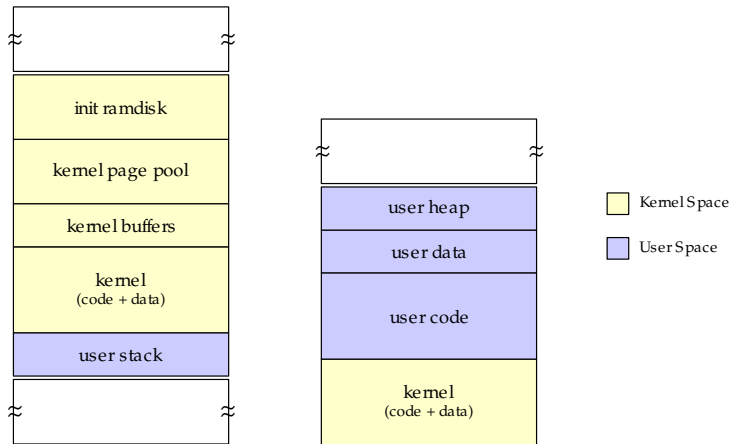


Figure: Memory layout in Nanvix.

The Nanvix Kernel

The Memory Management Subsystem

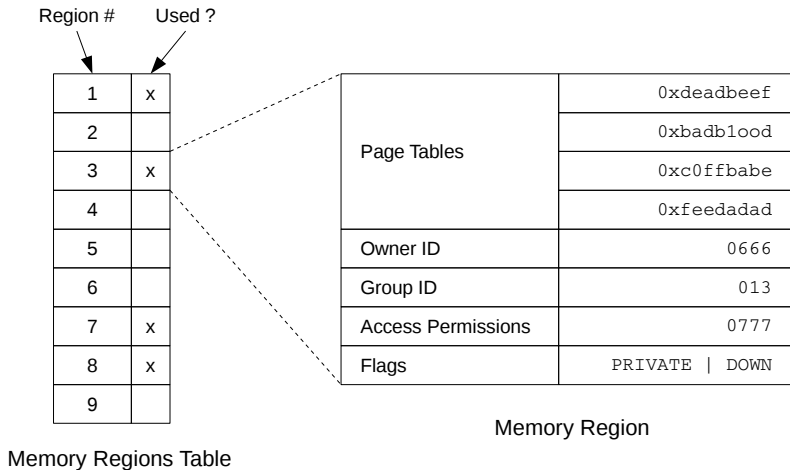


Figure: Memory regions in Nanvix.

The Nanvix Kernel

The Memory Management Subsystem

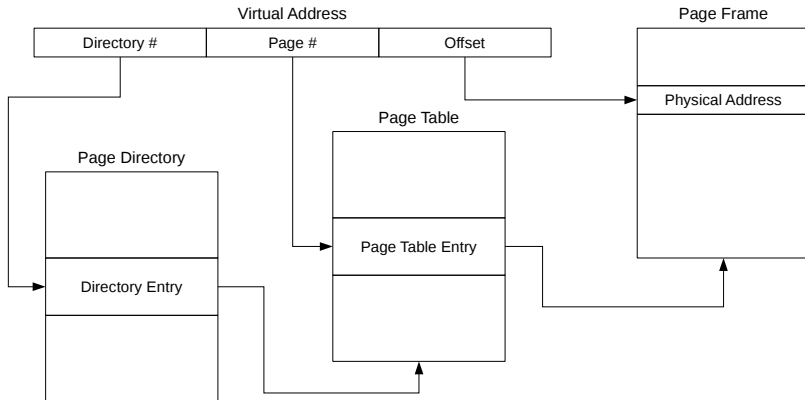


Figure: Paging scheme used in Nanvix.

The Nanvix Kernel

The Memory Management Subsystem

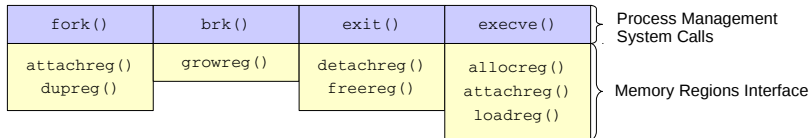


Figure: Memory regions interface in Nanvix.

The Nanvix Kernel

The File System

- ▶ Hierarchical file system
- ▶ Inodes hold metainformation about files

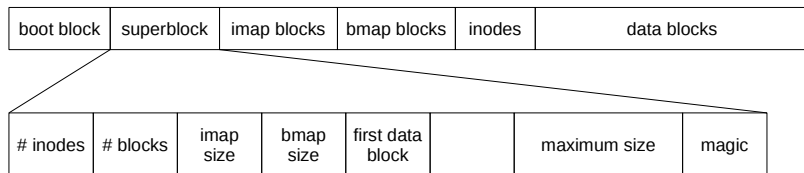


Figure: Nanvix file system layout.

The Nanvix Kernel

The File System

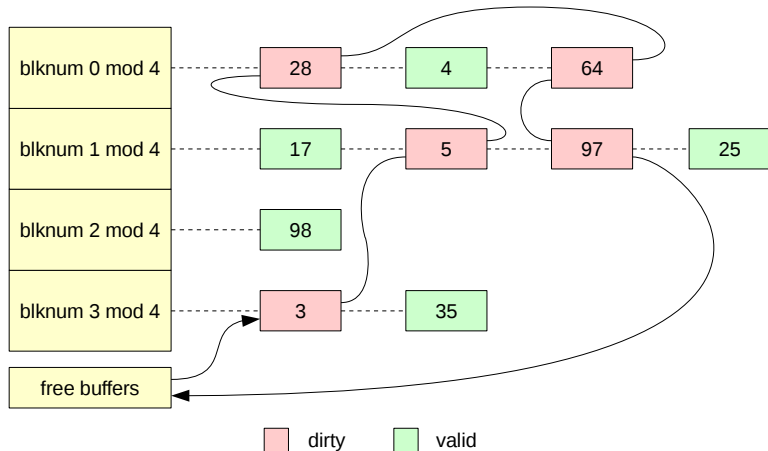


Figure: The buffer cache subsystem.

Agenda

Introduction

The Nanvix Operating System

Baby Steps

The Nanvix Kernel

Perspectives

Perspectives

High Performance Computing

- Manycore architectures
- Heterogeneous architectures
- Reconfigurable platforms

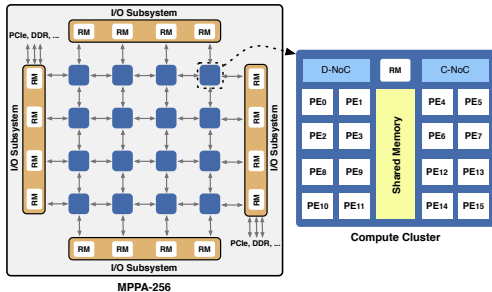


Figure: Kalray's MPPA-256 manycore processor

Perspectives

High Performance Computing

- ▶ Manycore architectures
- ▶ **Heterogeneous architectures**
- ▶ Reconfigurable platforms

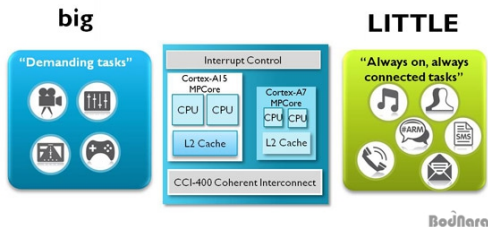


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Perspectives

High Performance Computing

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- ▶ Heterogeneous architectures
- ▶ Reconfigurable platforms

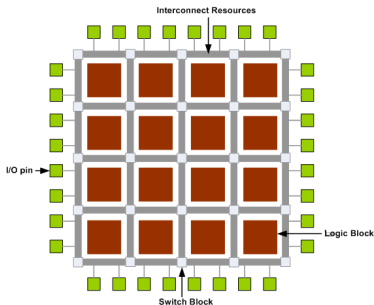


Figure: Kalray's MPPA-256 manycore processor

Perspectives

Manycore Architectures

- ▶ Enhance the memory management subsystem
 - ▶ Mini-regions

Perspectives

Manycore Architectures

- ▶ ~~Enhance the memory management subsystem~~
 - ▶ ~~Mini-regions~~
- ▶ Port user-level software
 - ▶ Newlib C Library
 - ▶ Assembler, Compiler & Linker

Perspectives

Manycore Architectures

- ▶ ~~Enhance the memory management subsystem~~
 - ▶ ~~Mini-regions~~
- ▶ Port user-level software (ongoing)
 - ▶ Newlib C Library
 - ▶ Assembler, Compiler & Linker
- ▶ Add multithreading support
 - ▶ Kernel threads

Perspectives

Manycore Architectures

- ▶ ~~Enhance the memory management subsystem~~
 - ▶ ~~Mini-regions~~
- ▶ Port user-level software (ongoing)
 - ▶ Newlib C Library
 - ▶ Assembler, Compiler & Linker
- ▶ Add multithreading support
 - ▶ Kernel threads
- ▶ Add message passing support
 - ▶ Light-weight MPI implementation