Advanced Operating Systems and Virtualization

Alessandro Pellegrini

A.Y. 2017/2018

Basic Information

- Lecture Schedule:
  - Course begins today! ☺
  - Course ends on June 1st
  - Lecture slots:
    - Tuesday, 08.00 am –10.00 am (Room A3)
    - Friday, 08.00 am –11.00 am (Room A3).
- Office Hours:
  - 1st and 3rd Wednesday of each month, at 3.00 pm
- Contact: pellegrini@dis.uniroma1.it

Exam Rules

- A written test (2/5 of the final mark)
- A code project (3/5 of the final mark)
  - Implementation of facilities within the Linux Kernel
  - Specifications will be given during the course

- We will see internals from Linux 2.4/2.6/3.0/4.0
  - Pick your preferred version!
  - Best if you are compatible with more than one!

Course Outline

- Booting on an x86 System
  - Memory Management
  - Virtual File System
  - Process/Thread Management
  - Kernel API (e.g., System Calls)
  - Interrupt Management
  - Kernel Data Structures

- How to make a portable Kernel

Course Outline

- Additional Kernel Facilities
  - Kernel Loadable Modules
  - Kernel Debugging
  - Hot Patching
- Security
  - Rootkits
  - Operating systems security aspects
  - Authentication and abilitation
  - Protection domains and secure operating systems
  - System internal attacks and countermeasures
  - IDS and Reference Monitor architectures

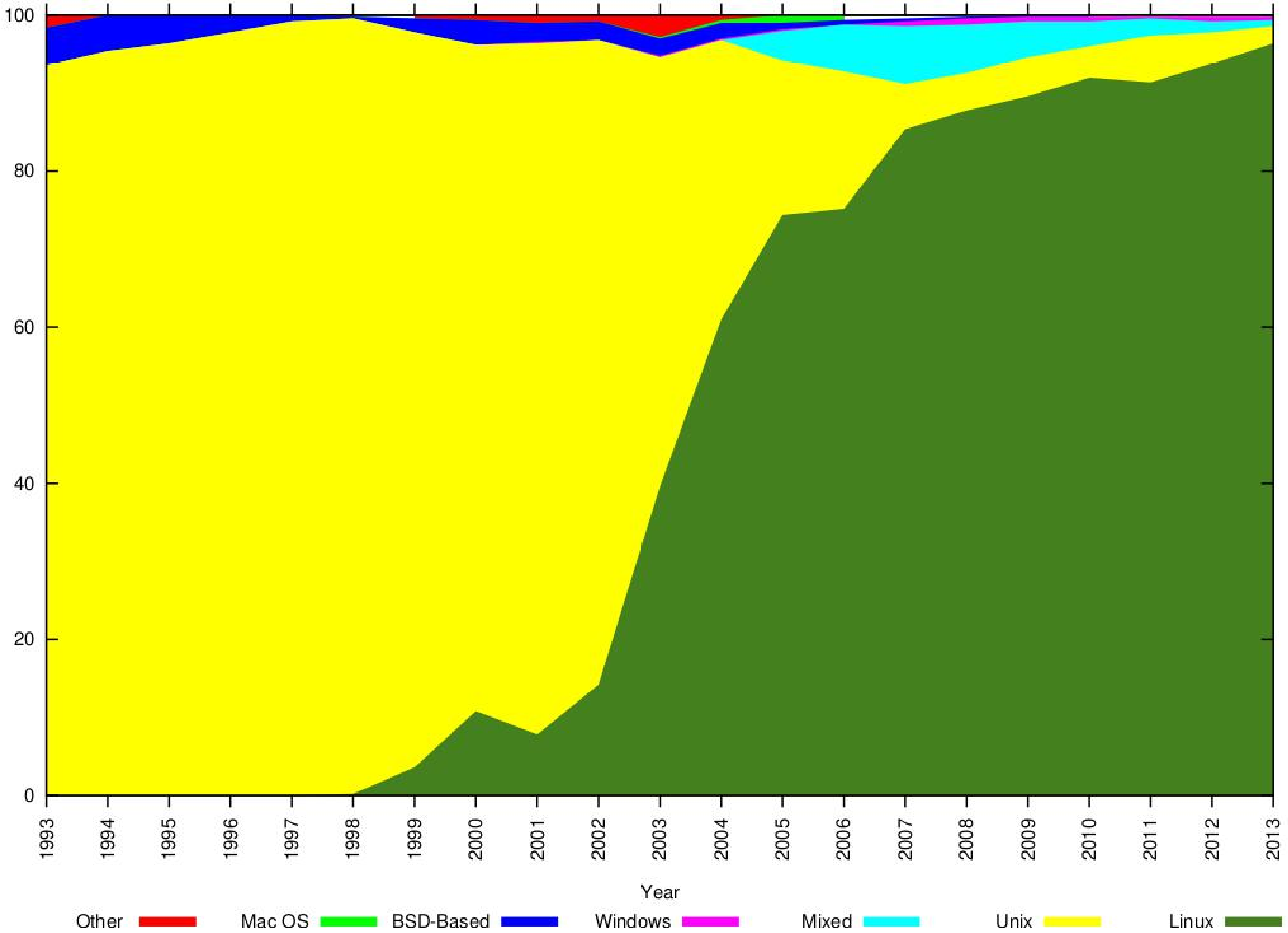
Course Outline

- System Virtualization
  - Basic techniques for system virtualization
  - Support for the guest system execution flow

What you should know already

- Computing Architectures
  - Registers, I/O, Interrupts principles, flat memory model, ...
  - Numerical Representations
- Basic x86 assembly notation
- Operating Systems Principles
  - Threads and Processes
  - System Calls
- Algorithms and Data Structures
- Some notions on Concurrency
  - Synchronization, race conditions, critical sections, locks, ...

Why Linux?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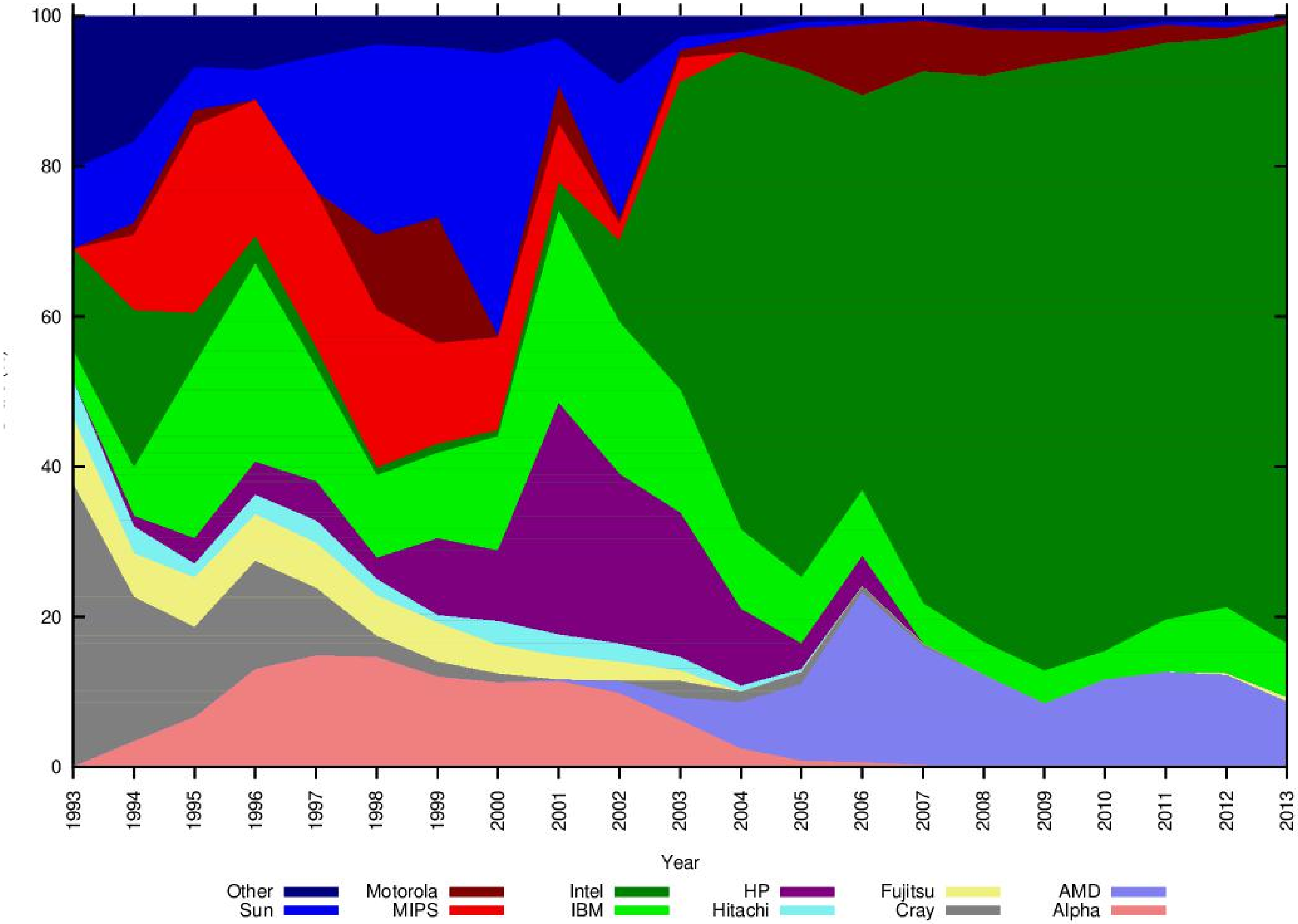
Linux

Why x86?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Other
Sun
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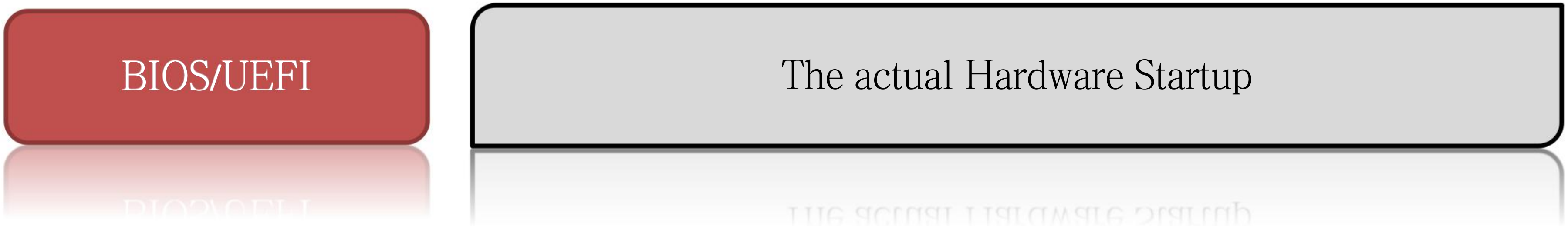
Hitachi
Fujitsu
Cray
AMD
Alpha

Boot Sequence

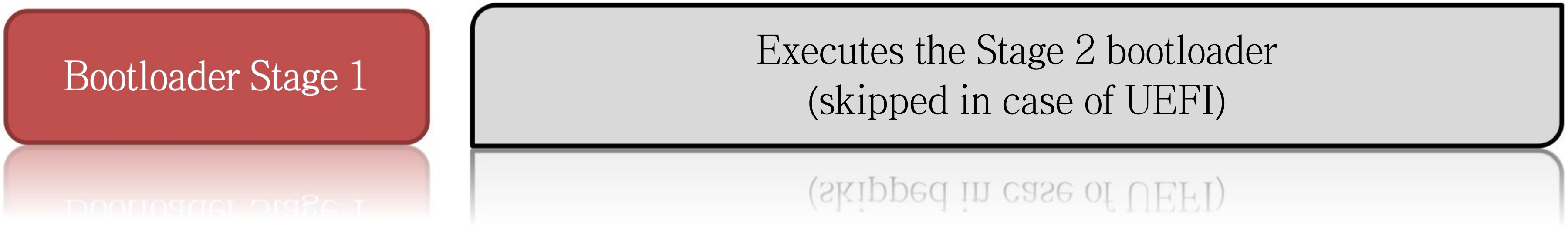
BIOS/UEFI	The actual Hardware Startup
Bootloader Stage 1	Executes the Stage 2 bootloader (skipped in case of UEFI)
Bootloader Stage 2	Loads and starts the Kernel
Kernel Startup	The Kernel takes control of and initializes the machine (machine–dependent operations)
Init	First process: basic environment initialization (e.g., SystemV Init, systemd)
Runlevels/Targets	Initializes the user environment (e.g., single–user mode, multiuser, graphical, …)

Boot Sequence



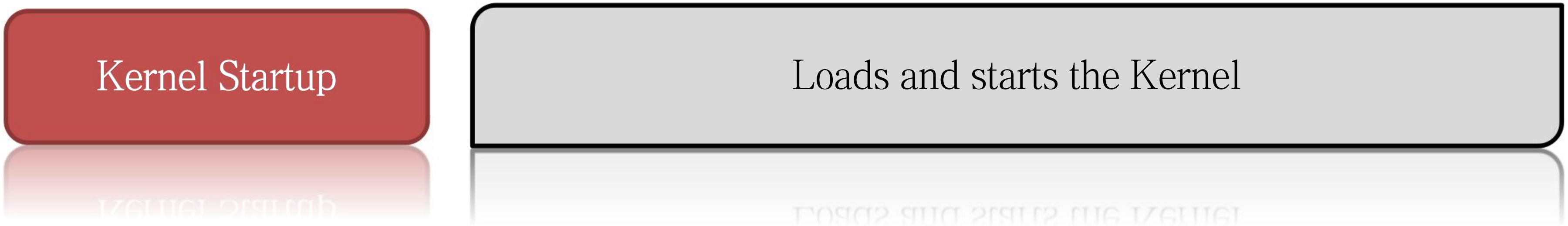
- BIOS: Basic Input/Output System
  - Performs some system integrity checks
  - Searches, loads, and executes the Stage 1 boot loader program.
- UEFI: Unified Extensible Firmware Interface
  - More standardized than BIOS
  - Gives much more versatility

Boot Sequence



- Stored in the Master Boot Record (MBR)
- Less than 512 bytes in size
  - primary boot loader info in 1st 446 bytes
  - partition table info in next 64 bytes
  - mbr validation check in last 2 bytes.
- Not enough space to load the kernel: activates Bootloader Stage 2

Boot Sequence

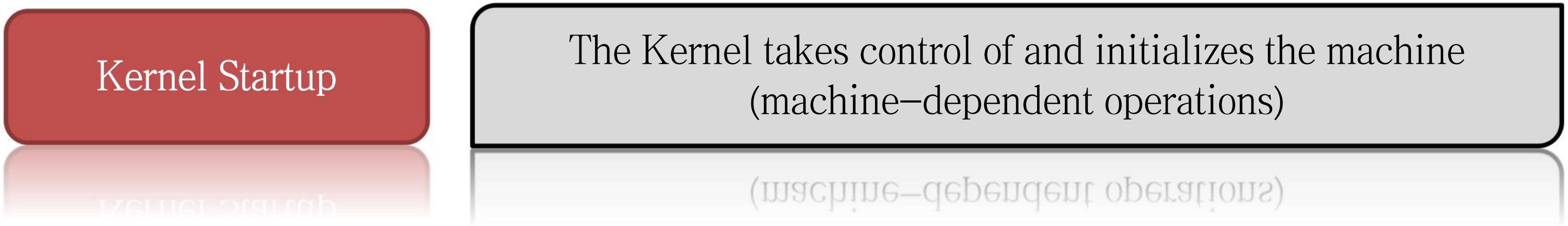


Kernel Startup

Loads and starts the Kernel

- Typical software: LILO or GRUB
- Allows kernel selection
- Loads from disk the actual kernel startup image and gives control to it

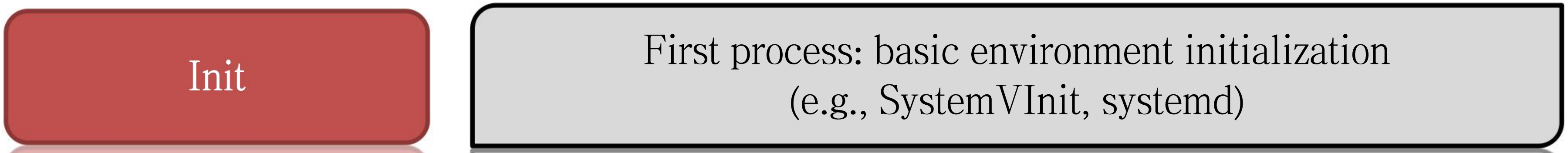
Boot Sequence


Kernel Startup

The Kernel takes control of and initializes the machine (machine–dependent operations)

- Configures the hardware environment
  - On x86 this requires multiple memory image initializations
- Mounts the root file system
- Configures internal data structures
- Spawns the first process (init)

Boot Sequence



Init

First process: basic environment initialization
(e.g., SystemVInit, systemd)

- Configures the software environment
- Loads the default runlevel
- Spawns other (interactive) processes

Boot Sequence

Runlevels/Targets

Initializes the user environment
(e.g., single–user mode, multiuser, graphical, ...)

- They represent the state of a machine
  - running processes and services offered
- On UNIX, they are traditionally six
  - 0: halts the machine
  - 1: single-user mode
  - 2-5: multi-user with different services/facilities
  - 6: reboots the machine