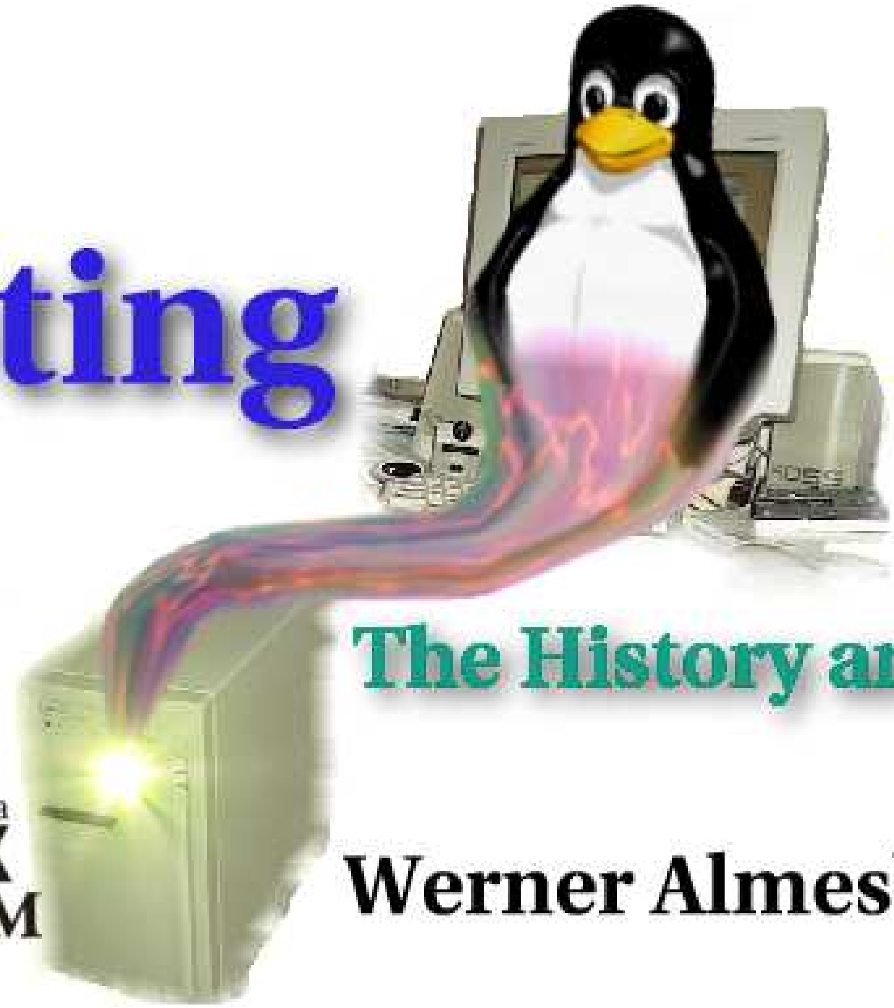
Booting Linux



The History and the Future

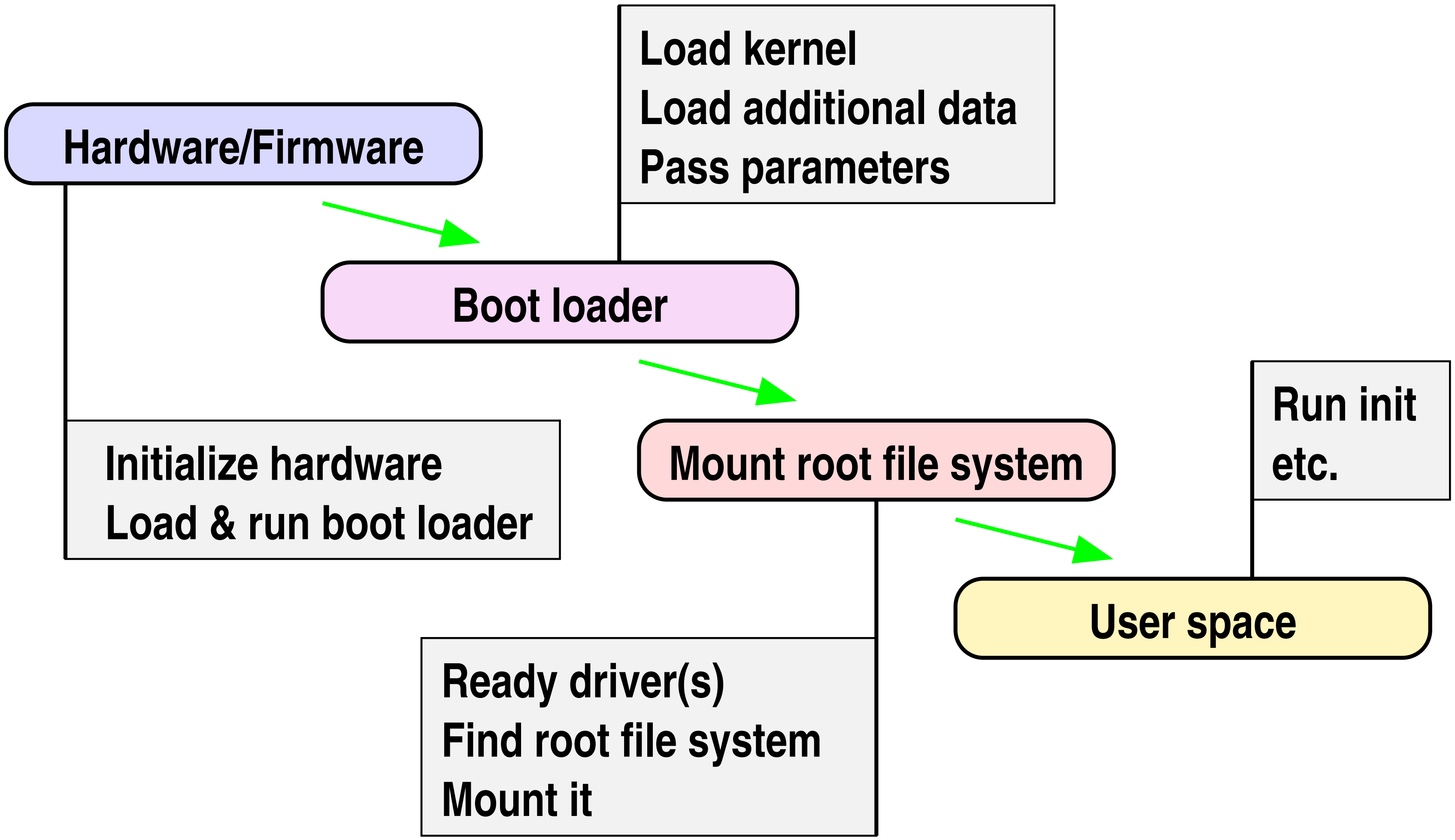
2000 Ottawa Linux Symposium

Werner Almesberger
EPFL ICA

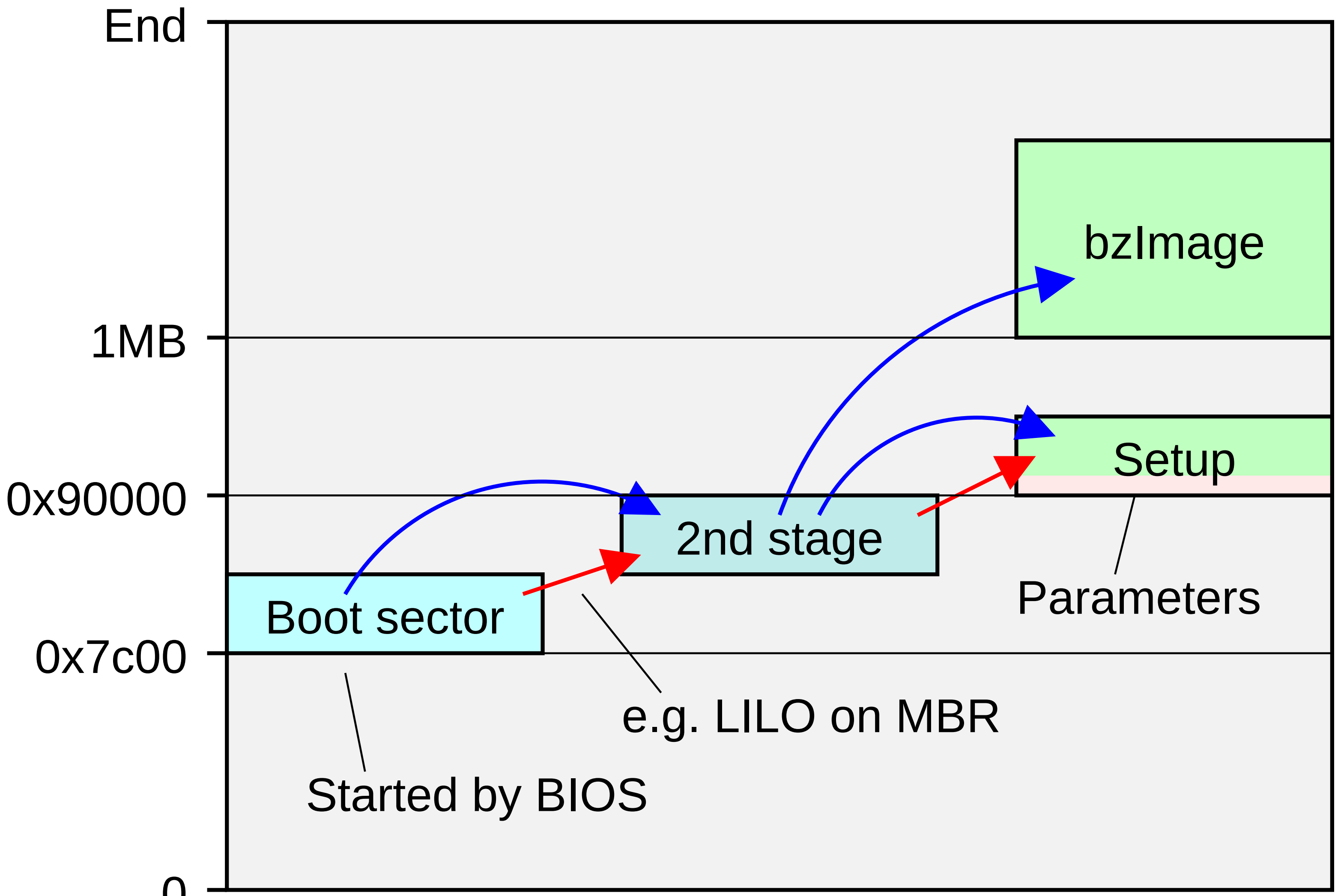
Overview

- The i386 boot process
  - Overview
  - bzImage
- Evolution
  - Floppy boot sector, Shoelace
  - LILO, GRUB, etc.
  - Initial RAM disk (initrd)
  - Changing the root file system
  - Linux boots Linux

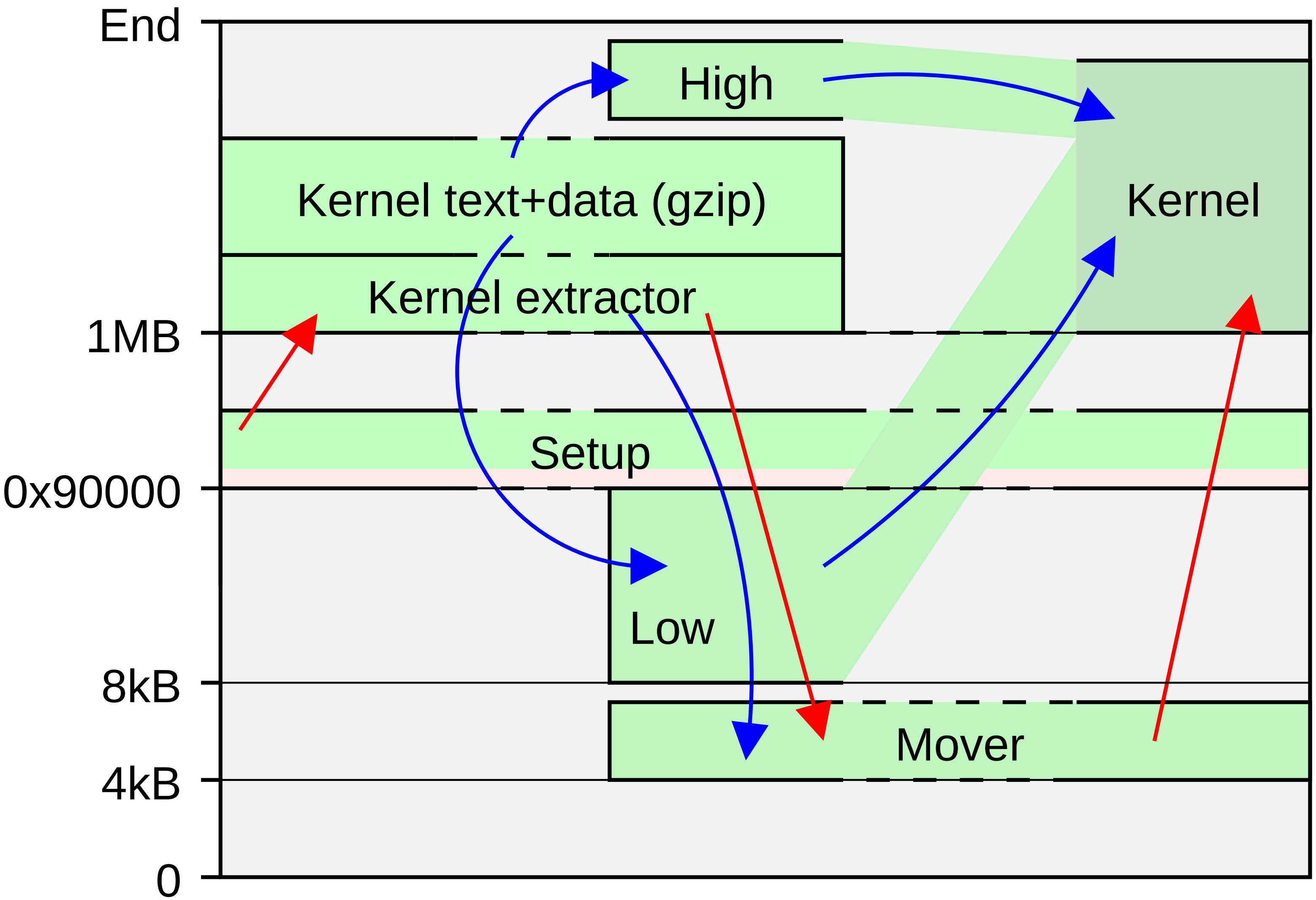
Boot process



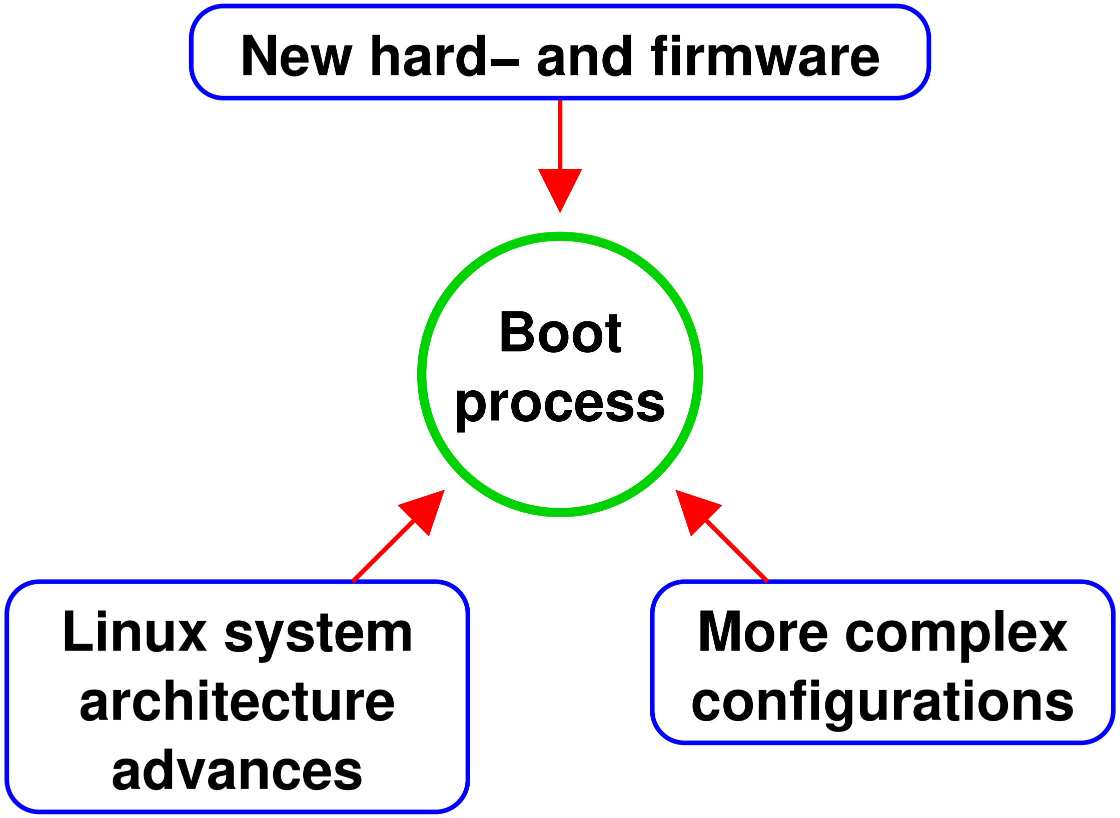
Loading bzImage



Starting bzImage



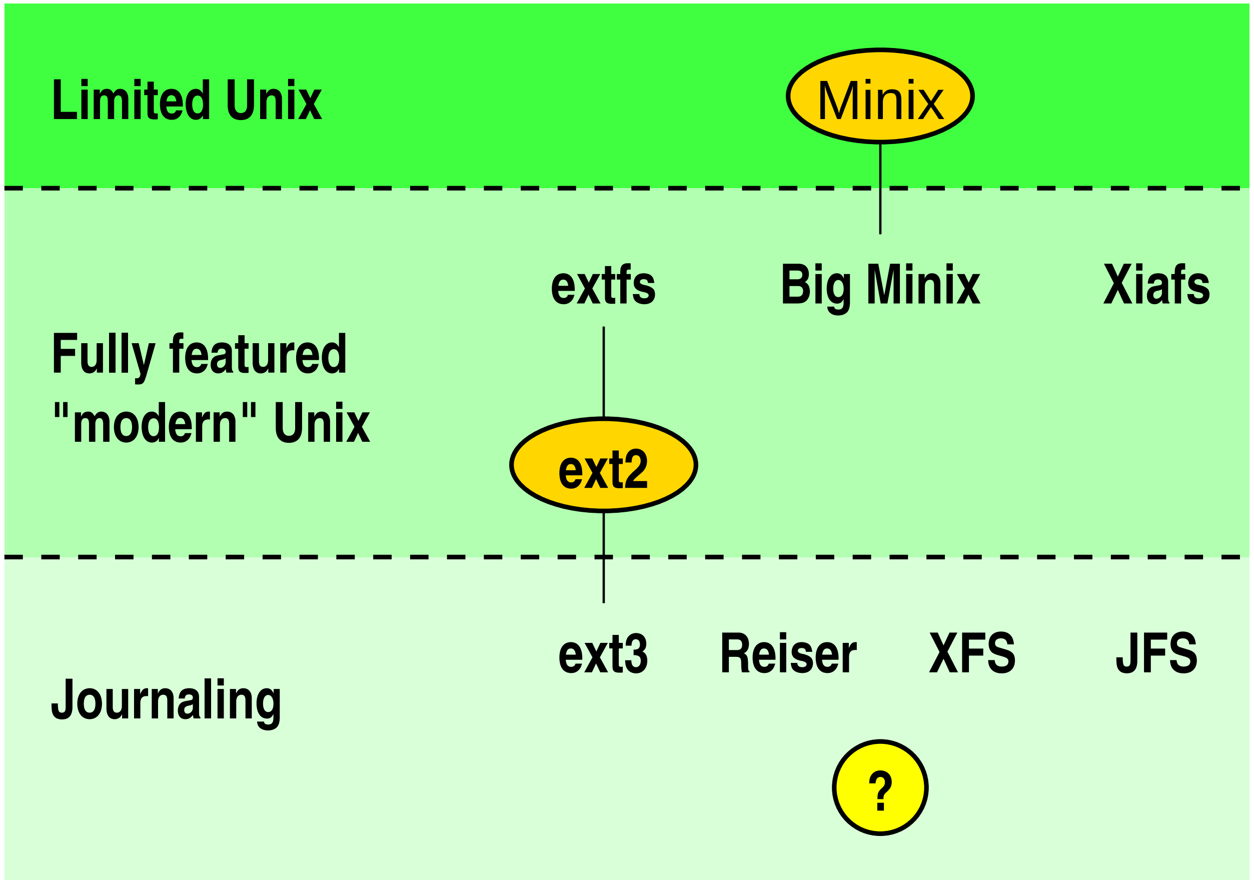
Challenges


New hard– and firmware
Boot process
Linux system architecture advances
More complex configurations

Evolution: The humble beginnings

- Floppy boot sector
  - Boots from floppy disks
  - One kernel per floppy
  - Kernel parameter changes via `rdev`
- Shoelace
  - Boots from IDE disks
  - Requires Minix file system
  - Kernel parameter changes via `rdev`
  - Needs 3rd party boot selector

File system history



Problem: Non-Minix root

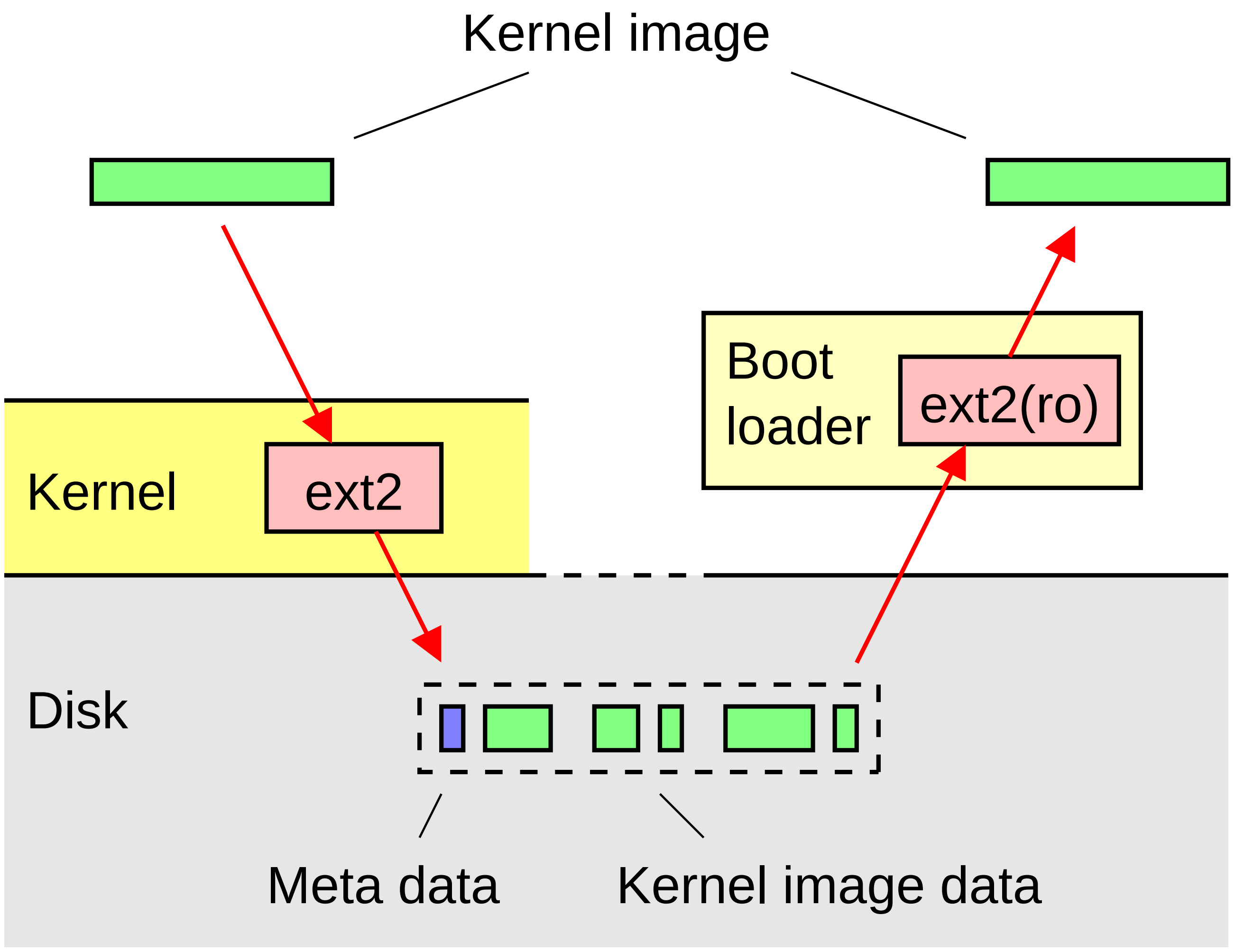
- Shoelace required Minix FS
  $\longrightarrow$ needed extra partition with Minix FS
- Solution: teach boot loader to load from other FS
- Problem: there are so many of them ...
- Solution: let the kernel do the mapping

LILO '92

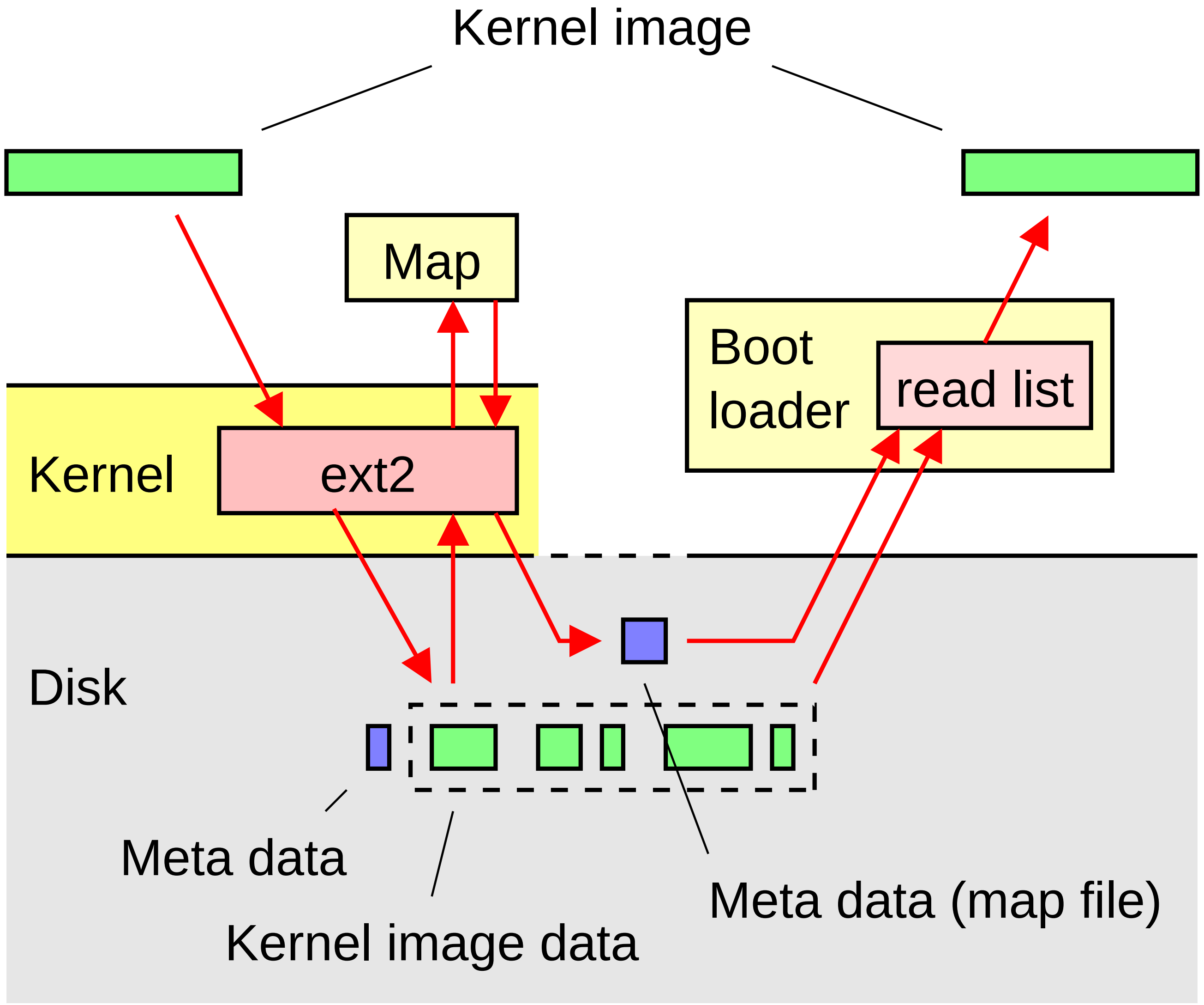
- Files are "mapped"
- Boots from (almost) arbitrary file system
- Boots from floppy or any hard disk known to BIOS
- Boot command line
- Includes boot selector

Now maintained by John Coffman.

File system aware, e.g. GRUB



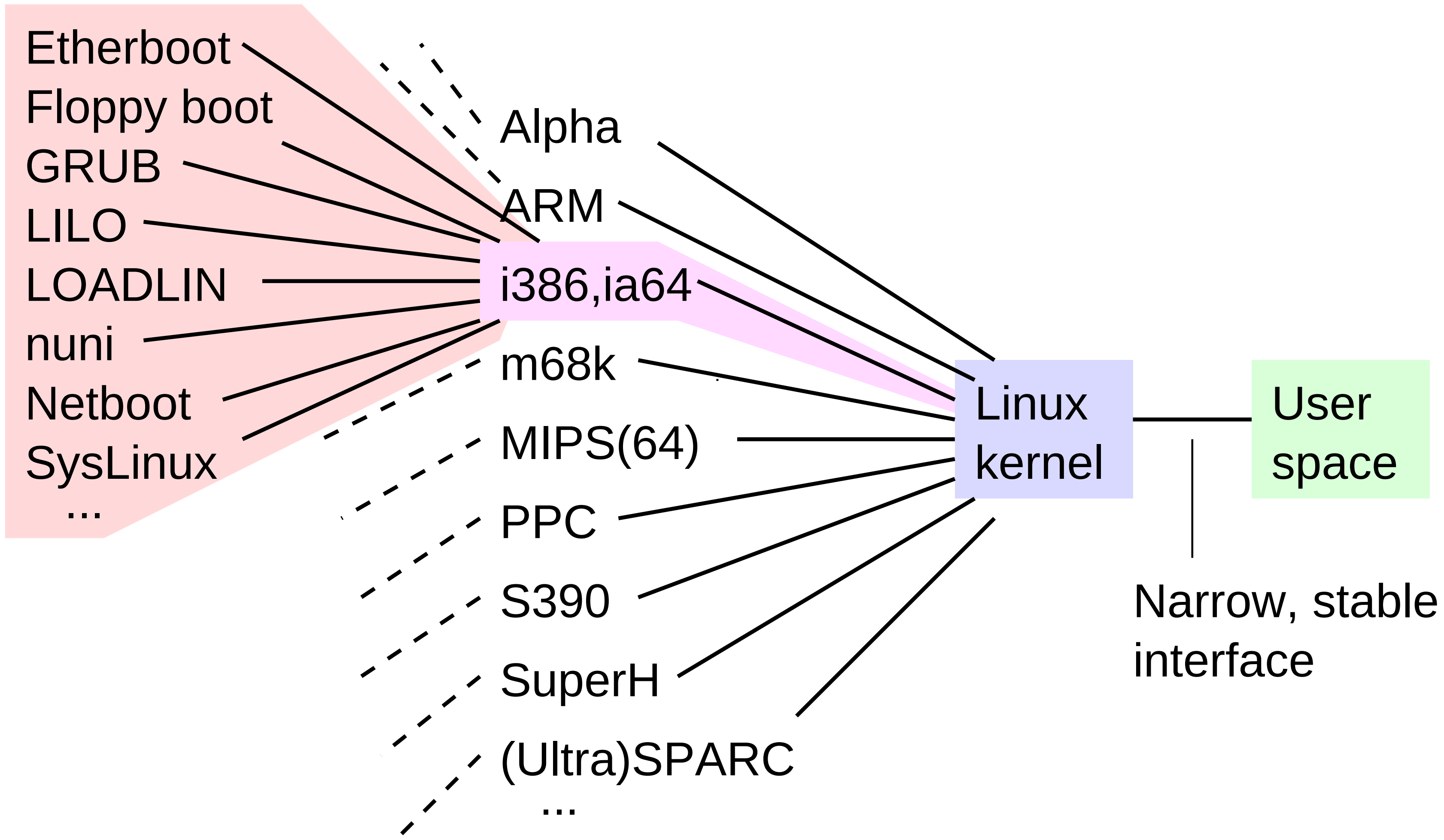
File system unaware



What's better ?

- Most people don't notice
- Consistency check
  - Hardware limitations (e.g. RAM disk, NFS)
  - Configuration file (e.g. for command line)
- Autonomy
  - Pick any kernel
  - File system navigation
  - Editor, Web browser, ... ?

Adding features



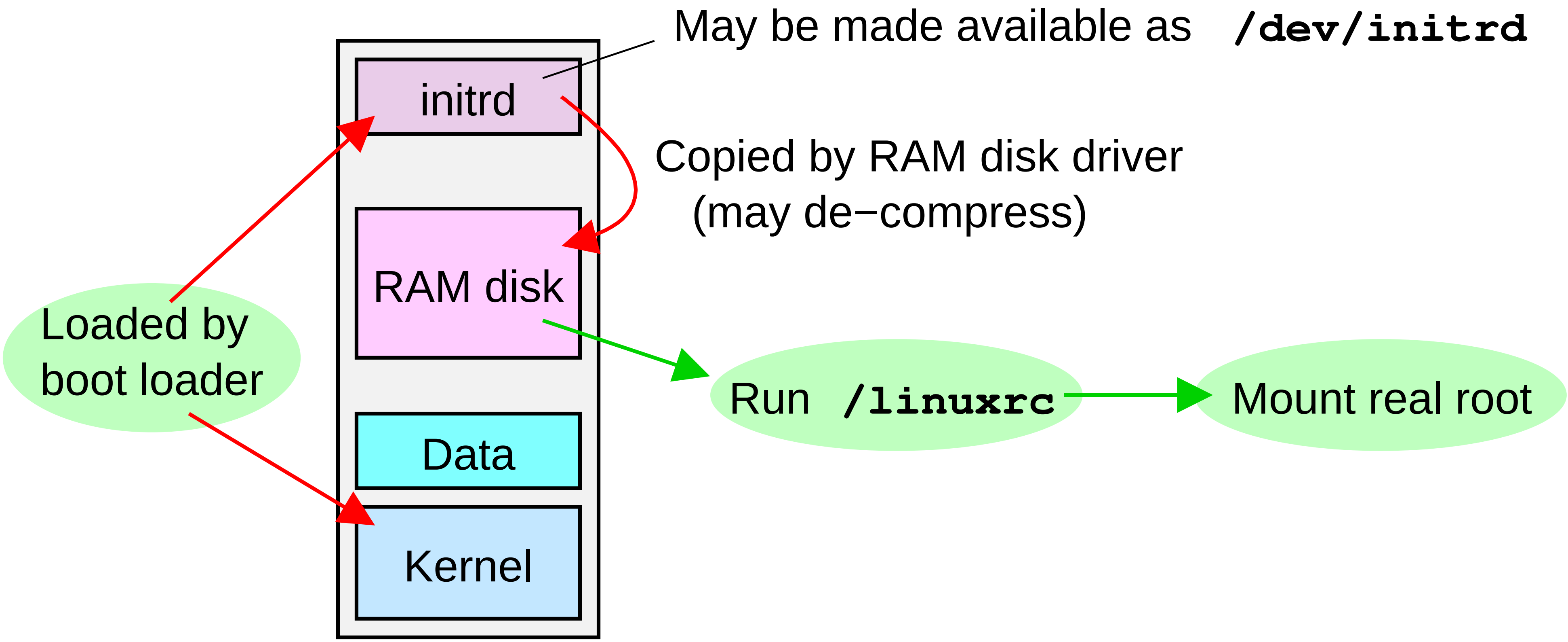
Problem: Driver conflicts

- Hardware auto-detection is unreliable:
  - Hardware X may lock up when probing for hardware Y
  - Driver may mis-detect hardware X as Y, and crash

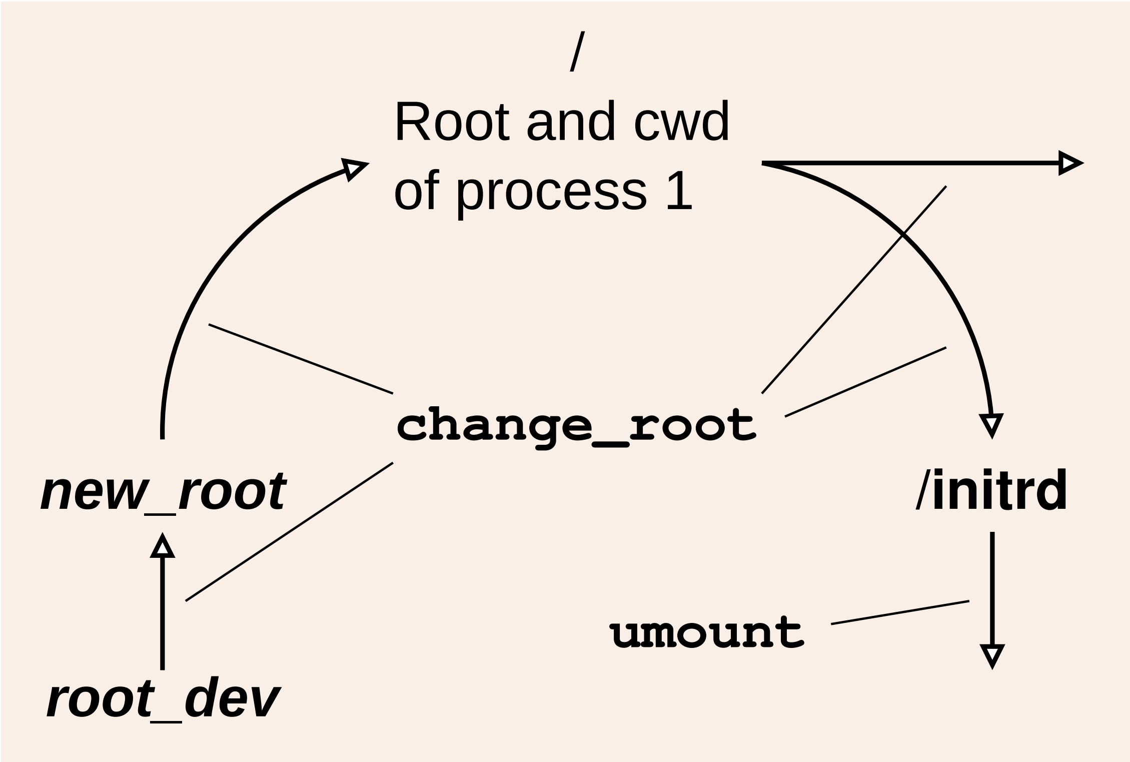
  $\longrightarrow$ "generic kernel" is not possible
- Solution: load driver modules when needed
- Problem: what if driver for root file system needs to be loaded ?
- Solution: boot loader loads RAM disk as temporary root

Initial RAM disk (1.3.73 3/96)

Designed in cooperation with Hans Lermen

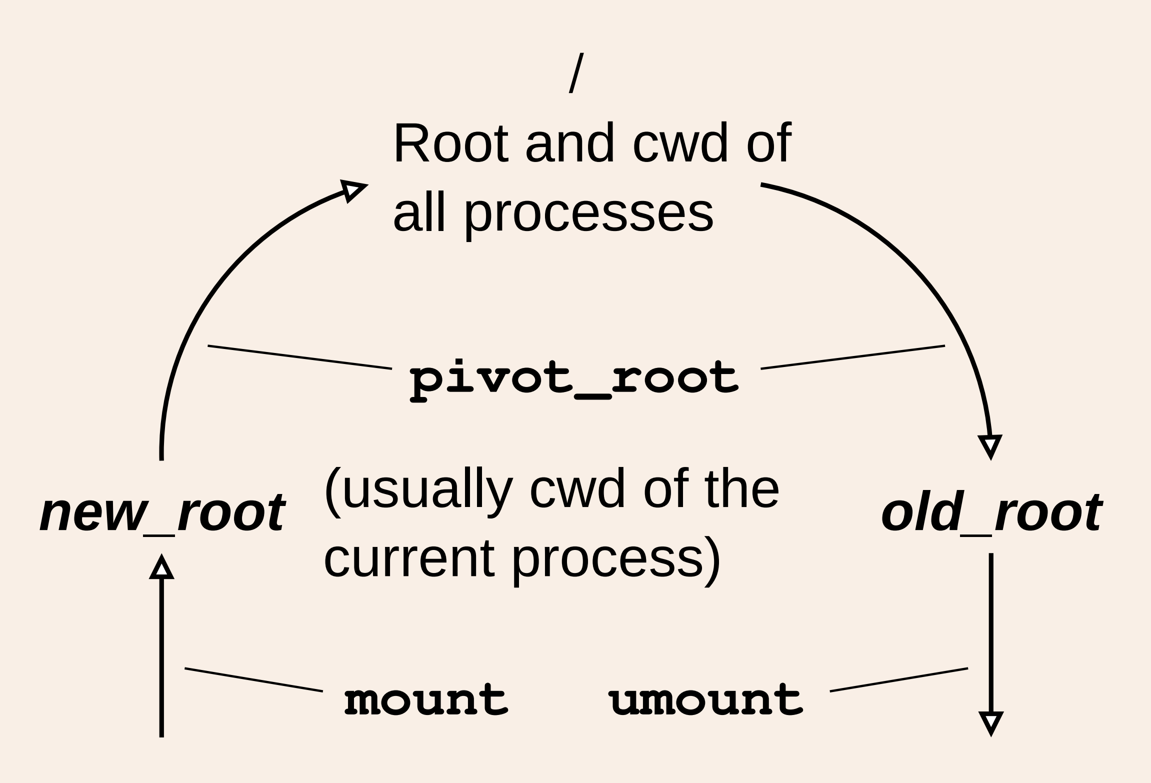


change_root (1.3.73, Mar '96)



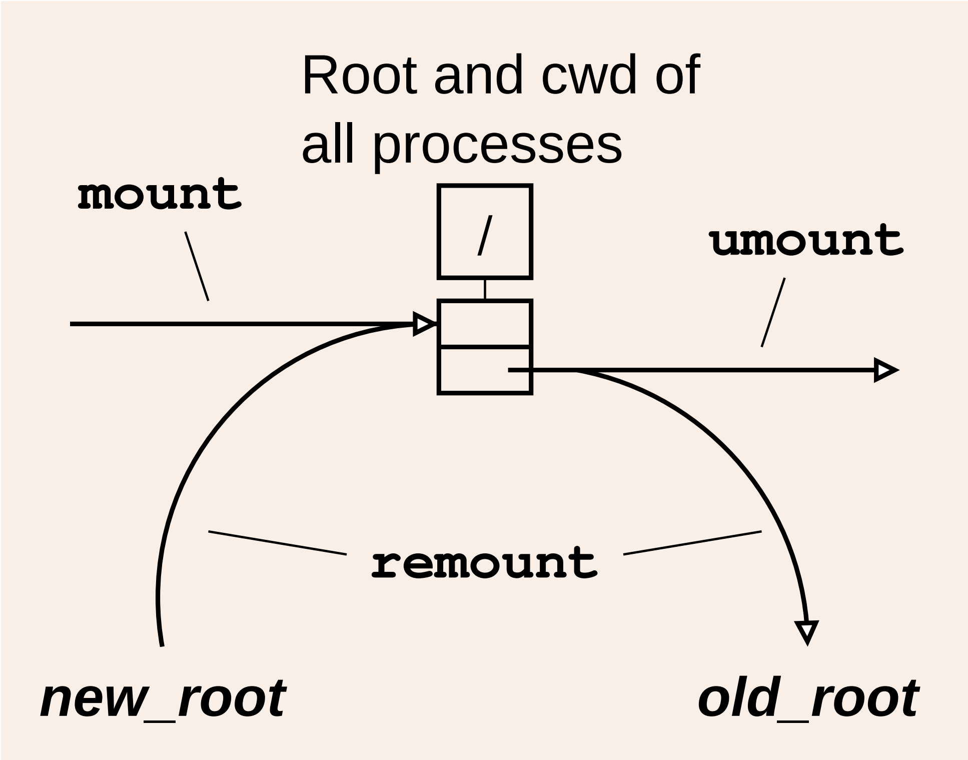
- Tightly integrated (uses lots of "magic")
- Only works for regular block devices (special case: NFS)
- Background processes may keep old root busy
- Can only be used once

pivot_root (2.3.41, Jan '00)



- Works with any file system
- Can be repeated
- Very ugly solution for demons

Union mounts (future)



- Designed by VFS guru Alexander Viro
- As generic as `pivot_root`
- Clean solution for demons
- Will probably work with existing system calls and tools

Problem: Exotic kernel source

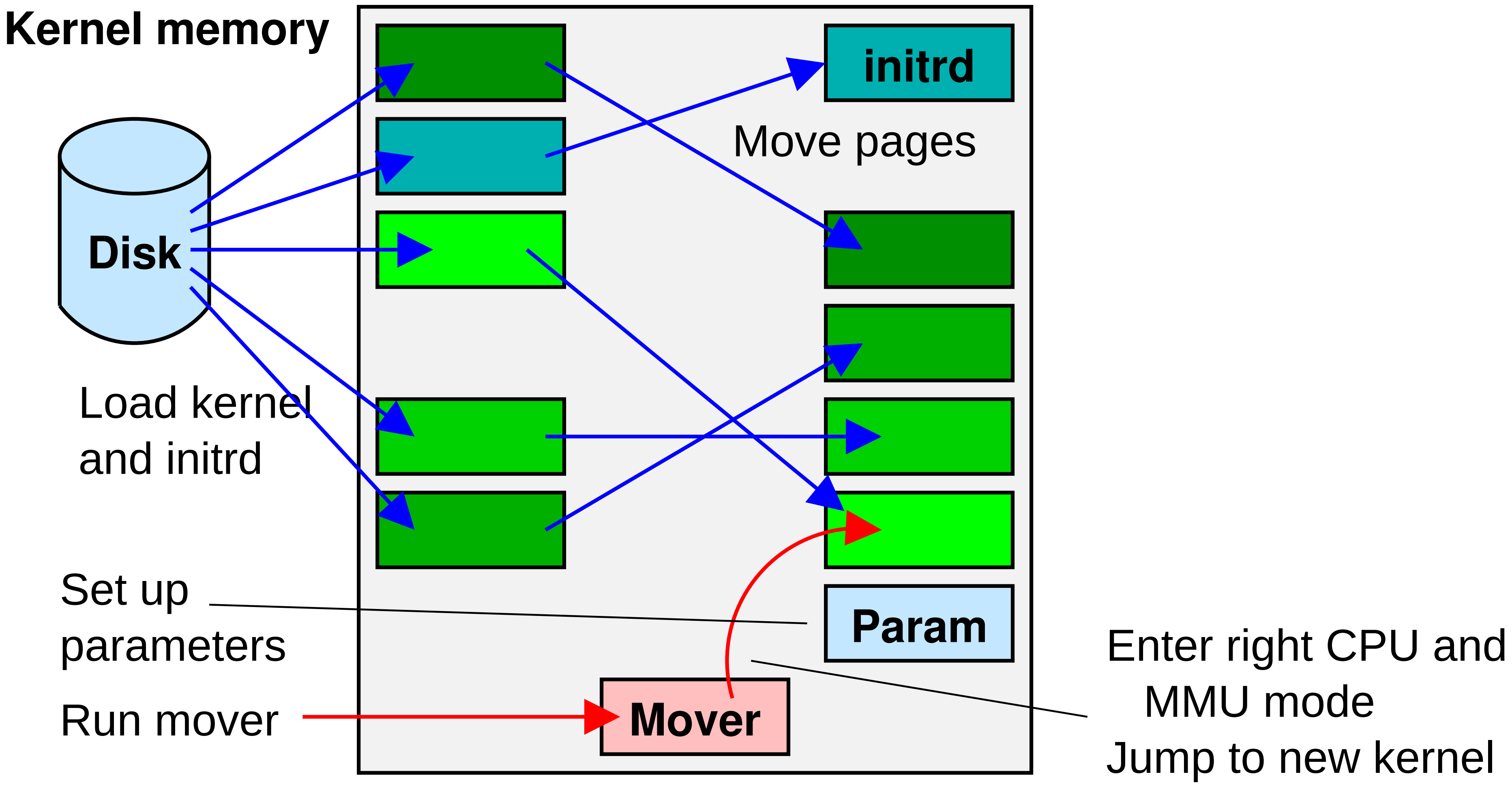
- New complex file systems:
  - No blocks: Tails (e.g. in ReiserFS), Database-oriented
  - Blocks move: Journaling
  - No direct mapping: RAID
- Kernels stored at unusual places:
  - TFTP, NFS, HTTP, HTTPS, ...
  - Character device

  $\longrightarrow$ just loading the kernel gets harder
- Solution: let the Linux system do the loading

Linux boots Linux (1)

- Simple boot loader loads boot kernel
- Driver setup using initrd
- Maybe user interaction (e.g. boot shell)
- Loads real kernel

Linux boots Linux (2)



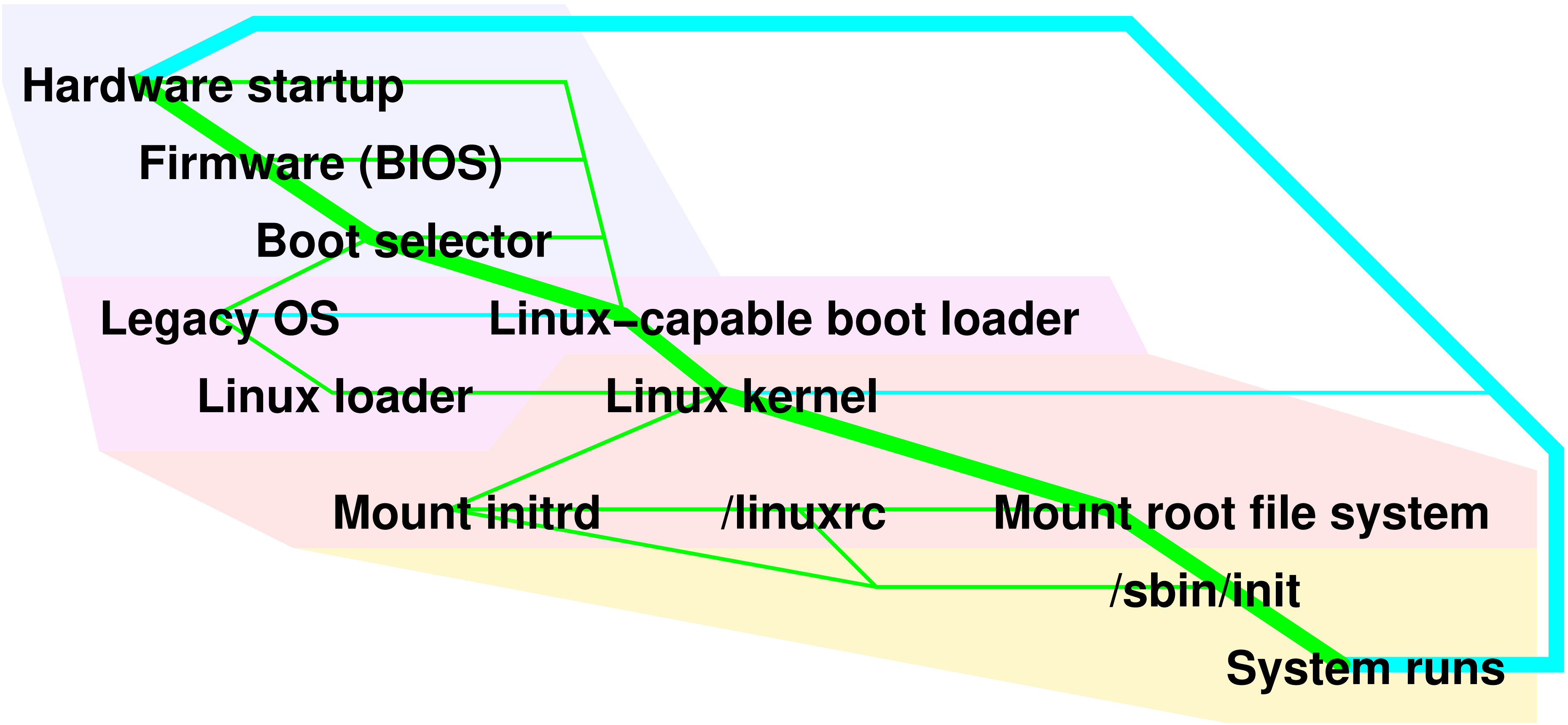
Linux boots Linux (3)

- The time is ripe:
  - LOBOS (Ron Minnich)
  - bootimg (Werner Almesberger)
  - Two Kernel Monte (Erik Hendriks)
- More fun with booting:
  - High-speed reboot (ca. 15 sec)
  - LinuxBIOS
  - Crash Dump

    Problem:
    - BIOS clears memory on reboot
    - Cannot use current drivers (or BIOS)

    Solution:
    - Keep small system inside current system
    - Reset drivers and write dump on crash

The whole truth



Future

- Union root mount
- Early freeing of initrd pages
  - Reduce peak memory usage
- Linux boots Linux
  - Small C library or boot shell
  - Parameter passing
- Better support for RAID, etc.
  - Specialized loaders
  - Partial convergence for simple loaders
  - Extended data location information from kernel

Links

- Directory:
  `ftp://icaftp.epfl.ch/pub/people/almesber/booting/`
- This presentation:
  `ols-booting-slides.ps.gz`
  `ols-booting-slides.tar.gz`
- Paper "Booting Linux: The History and the Future":
  `bootinglinux-current.ps.gz`
  `bootinglinux-current.tar.gz`