# Linux Kernel Tinification

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Linux Plumbers Conference 2014

100%

ONE HUNDRED PERCENT

COMPREHENSIVE
AUTHORITATIVE
WHAT YOU NEED

ONE HUNDRED PERCENT

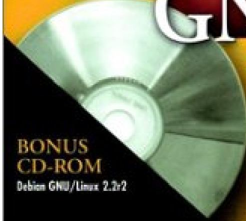
"Steve Hunger's book is the most comprehensive and up-to-date guide to Debian GNU/Linux in print."
—Branden Robinson, Debian Developer

**Master** Linux system administration

**Discover** the power of Debian's package management system

**Build** a network and set up Linux servers

# Debian® GNU/Linux® Bible



BONUS CD-ROM

Debian GNU/Linux 2.2r2

Steve Hunger

Foreword by Ian Murdock, Founder of Debian and now Cofounder of Progeny Linux Systems

## boot-floppies

## two floppies and an Internet connection

2.2.19 - 977k compressed

## debian-installer

one floppy and
an Internet connection

2.4.27 - 797k compressed

2.4.27 - 797k compressed
2.6.8 - 1073k compressed

“Linux runs on everything from cell phones to supercomputers”

## This is not an embedded system anymore

2GB RAM

16GB storage

## Original motivation

- Size-constrained bootloaders (why use GRUB?)
- x86 boot track: 32256 bytes

## Embedded systems

- Tiny flash part (1-8MB or smaller) for kernel and userspace
- CPU with onboard SRAM ($< 1024$kB)

## Compression

- vmlinuz is compressed
- Decompression stub for self-extraction

## Execute in place

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- 3.17-rc1: `tinyconfig`: enable `CC_OPTIMIZE_FOR_SIZE`, `OPTIMIZE_INLINING`, `KERNEL_XZ`, `SLOB`, `NOHIGHMEM`,
- Manually simulated "tinyconfig" on older kernels for size comparisons

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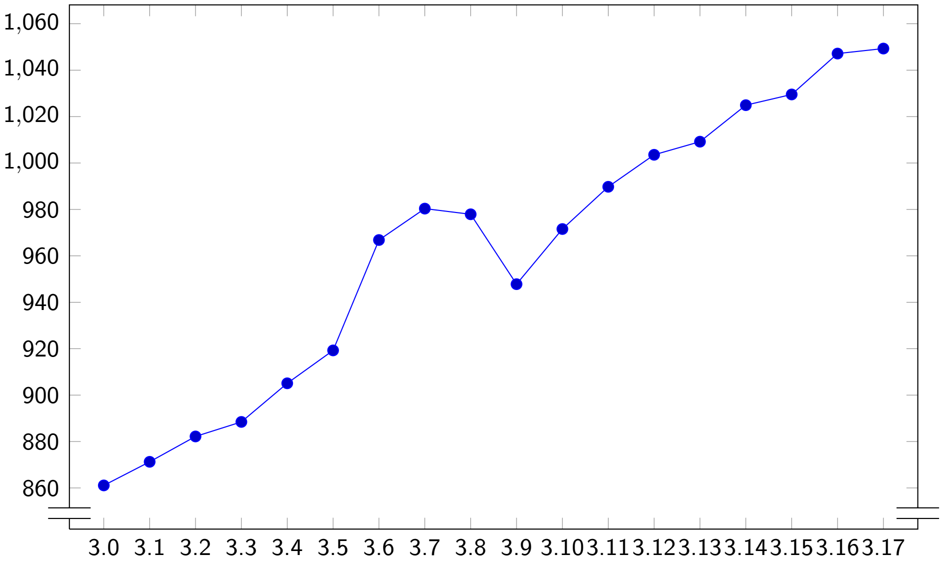
| + flash storage | | |
| + filesystem | | |
| + networking | | |
| ... | | |

## minimum kernel size (kB) by kernel version



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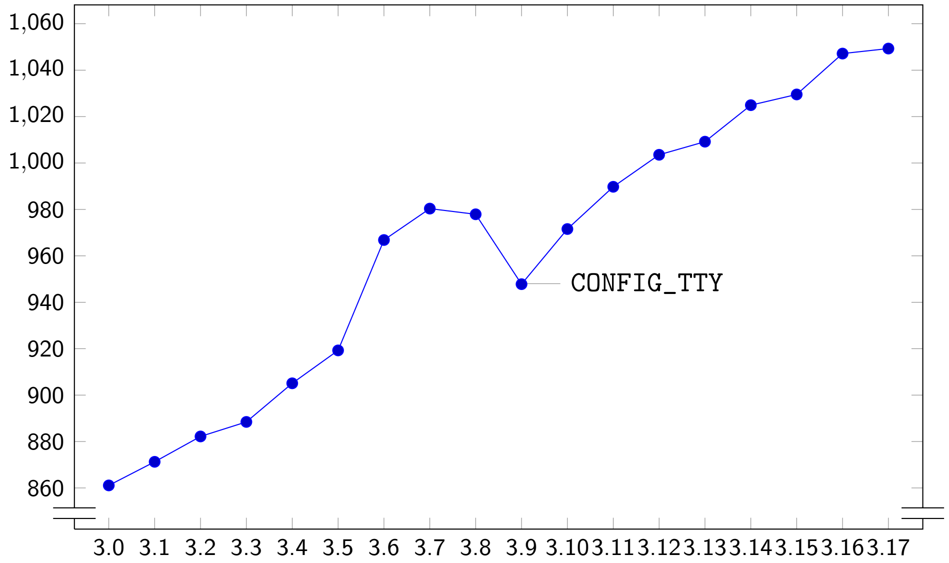

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- Let's make the core as small as possible
- Leave maximum room for useful functionality

## nm --size-sort vmlinux

- Find large symbols for potential removal

```
00001000 d raw_data
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00001210 r intel_tlb_table
00002000 D init_thread_union
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```
00001000 d raw_data                VDSO
00001000 d raw_data                Another VDSO
00001210 r intel_tlb_table         Hmmmm...
00002000 D init_thread_union       initial thread and stack
00002000 r nhm_lbr_sel_map         tiny/disable-perf (-147k)
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static const struct _tlb_table intel_tlb_table[] = {
{ 0x01, TLB_INST_4K, 32, " TLB_INST 4 KByte pages ..." },
{ 0x02, TLB_INST_4M, 2,  " TLB_INST 4 MByte pages ..." },
/* ... 34 entries total ... */
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struct _tlb_table {
        unsigned char descriptor;
        char tlb_type;
        unsigned int entries;
        /* unsigned int ways; */
        char info[128];
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- $34 * 128 = 4352$ bytes (0x1100)

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## Shrinking `intel_tlb_table`

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- Absolutely nothing references those descriptions!
- Just delete the info field
- Make the descriptions comments
- How much did we save?

## `scripts/bloat-o-meter`

- Compare symbol sizes between two kernels
- Similar to diffstat
- `scripts/bloat-o-meter vmlinux-old vmlinux-new`

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```
add/remove: 0/0 grow/shrink: 0/2 up/down: 0/-4361 (-4361)
function                old     new   delta
intel_detect_tlb        876     867      -9
intel_tlb_table        4624     272   -4352
```

## TLB round 2

```
struct _tlb_table {
        unsigned char descriptor;
        char tlb_type;
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```

- All values for `entries` fit in a u16
- Result is copied into a u16 after lookup
- Wastes 4 bytes per entry (including padding)

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add/remove: 0/0 grow/shrink: 0/2 up/down: 0/-146 (-146)
function                old     new   delta
intel_detect_tlb        867     857     -10
intel_tlb_table         272     136    -136
```

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- Why do we decode the TLB, anyway?
- A single printk at boot time
- `#ifndef CONFIG_PRINTK`

```
add/remove: 0/3 grow/shrink: 0/0 up/down: 0/-1215 (-1215)
function                old     new   delta
intel_tlb_table         136       -    -136
cpu_detect_tlb_amd      222       -    -222
intel_detect_tlb        857       -    -857
```

## TLB summary

```
add/remove: 0/3 grow/shrink: 0/0 up/down: 0/-5722 (-5722)
function                old     new   delta
cpu_detect_tlb_amd  222       -    -222
intel_detect_tlb    876       -    -876
intel_tlb_table    4624       -   -4624
```

- 4.5k saved on every kernel
- 1.2k more saved on embedded kernels
- Patches in tinification tree, tiny/tlb branch

## syscalls

- Current Linux (on 32-bit x86) has ∼353 syscalls
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- /bin/true uses ~11 (less if static)
- Embedded systems fall somewhere in the middle
- `make tinyconfig` kernel has ~247
- Far too many unconditionally available syscalls

## A few unconditionally available syscalls

- adjtime/adjtimex and NTP support
- Older compatibility syscalls
- fallocate
- tee/splice
- kill and signal handling
- Scheduler configuration and priorities
- xattrs
- ptrace

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- Compile out the infrastructure

## Example: omitting madvise and fadvise

init/Kconfig:

```
+config ADVISE_SYSCALLS
+       bool "Enable madvise/fadvise syscalls" if EXPERT
+       default y
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kernel/sys_ni.c:

```
+cond_syscall(sys_fadvise64);
+cond_syscall(sys_fadvise64_64);
+cond_syscall(sys_madvise);
```

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mm/Makefile:

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-mmu-$(CONFIG_MMU) := ... highmem.o madvise.o memory.o ...
+mmu-$(CONFIG_MMU) := ... highmem.o memory.o ...
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- Saves 2.2k
- Merged during 3.18 merge window

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  - In-kernel ELF library loader
- `iopl` and `ioperm` (9k)
  - Piles of task-switching code
  - Most of `init_tss` (seen in `nm --size-sort`)
- perf (147k)
  - Performance counter infrastructure
  - Complete x86 instruction decoder
  - Large per-CPU data tables
  - Hardware breakpoints

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- Could reduce `#ifdef` logic to just top-level interfaces

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  - Major code churn to switch from field to accessor functions
- Constant folding through function pointer fields
  - Automatically notice no calls to a function pointer
  - Automatically omit it as above
  - Omit functions stored in that function pointer
  - Recurse

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Project list and tinification tree:

tiny.wiki.kernel.org