# RISC-V Software Ecosystem

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February 8, 2015

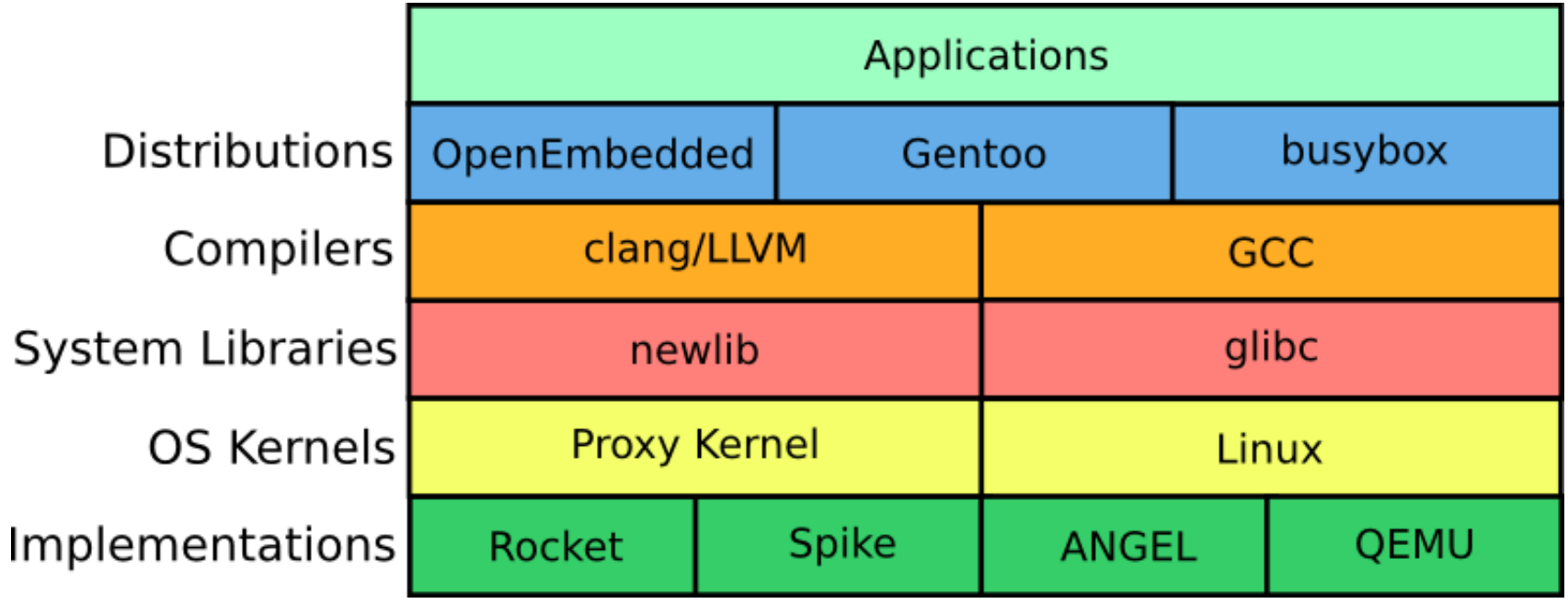

# Software on RISC-V

So it turns out there is a lot of software...

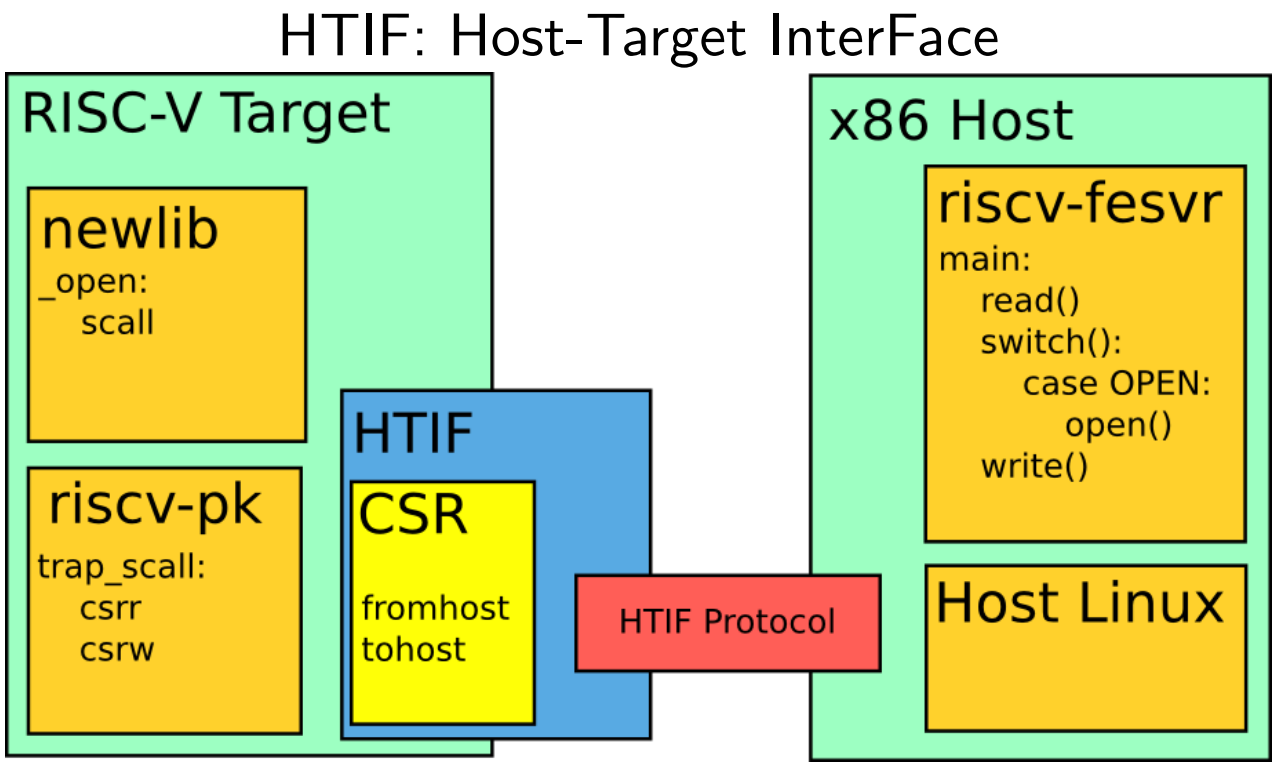
# Software on RISC-V

sys-libs/zlib-1.2.8-r1
virtual/libintl-0-r1
sys-libs/ncurses-5.9-r3
sys-apps/gentoo-functions-0.8
dev-libs/gmp-6.0.0a
sys-libs/db-6.0.30-r1
virtual/libiconv-0-r1
app-arch/bzip2-1.0.6-r7
sys-apps/busybox-1.23.0-r1
sys-devel/gcc-config-1.8
sys-libs/timezone-data-2014j
app-misc/editor-wrapper-4
net-firewall/iptables-1.4.21-r1
sys-libs/e2fsprogs-libs-1.42.12
dev-libs/libpipeline-1.4.0
sys-libs/gdbm-1.11
app-portage/portage-utils-0.53
sys-apps/sandbox-2.6-r1
app-misc/pax-utils-0.9.2
dev-lang/python-exec-2.0.1-r1
app-misc/mime-types-9
dev-libs/expat-2.1.0-r4
dev-libs/libffi-3.2.1
sys-apps/sysvinit-2.88-r7
sys-kernel/linux-headers-3.18
sys-apps/kbd-2.0.2
sys-apps/net-tools-1.60
app-arch/xz-utils-5.2.0
app-arch/tar-1.28
app-arch/gzip-1.6
sys-apps/which-2.20-r1
sys-apps/diffutils-3.3
sys-apps/baselayout-2.2
sys-devel/patch-2.7.3
sys-devel/gnuconfig-20140728
x11-proto/xproto-7.0.26
x11-proto/xextproto-7.3.0
x11-proto/inputproto-2.3.1
x11-libs/xtrans-1.3.5
media-libs/libjpeg-turbo-1.3.1-r1
sys-apps/coreutils-8.23
sys-libs/readline-6.3_p8-r2
sys-libs/glibc-2.20-r1
sys-apps/util-linux-2.25.2-r2
sys-apps/sed-4.2.2
sys-apps/file-5.22
dev-libs/mpfr-3.1.2_p10
sys-process/psmisc-22.21-r2
net-misc/netifrc-0.3.1
dev-libs/popt-1.16-r2
sys-devel/binutils-config-4-r1
virtual/libffi-3.0.13-r1
sys-libs/cracklib-2.9.2
sys-apps/kmod-19
sys-devel/make-4.1-r1
sys-process/procps-3.3.10-r1
sys-apps/iproute2-3.18.0
virtual/dev-manager-0
sys-apps/findutils-4.5.14-r1
virtual/os-headers-0
x11-libs/libICE-1.0.9
virtual/jpeg-0-r2
media-libs/libpng-1.6.16
x11-proto/fixesproto-5.0-r1
x11-libs/libXdmcp-1.1.1-r1
x11-libs/libXau-1.0.8
dev-libs/libpcre-8.36
app-shells/bash-4.3_p33-r1
app-admin/eselect-1.4.4
net-misc/rsync-3.1.1
sys-apps/openrc-0.13.8
dev-libs/mpc-1.0.2-r1
sys-apps/debianutils-4.4
sys-apps/shadow-4.2.1
app-editors/nano-2.3.6
sys-devel/binutils-2.25-r1
virtual/modutils-0
sys-apps/gawk-4.1.1-r1
virtual/shadow-0
sys-apps/less-471
app-admin/eselect-python-20140125
sys-apps/grep-2.21-r1
virtual/service-manager-0
virtual/editor-0
sys-devel/gcc-4.9.2-r1
x11-libs/libX11-1.6.2
virtual/pager-0
x11-libs/libXext-1.3.3
x11-libs/libXfixes-5.0.1
x11-libs/libXt-1.1.4
x11-libs/fltk-1.3.3-r2
x11-libs/libXi-1.7.4
x11-libs/libXtst-1.2.2
net-misc/tigervnc-1.3.1-r2
dev-lang/perl-5.20.1-r4
app-admin/perl-cleaner-2.19
perl-core/Data-Dumper-2.154.0
virtual/perl-Data-Dumper-2.154.0
perl-core/File-Temp-0.230.400-r1
virtual/perl-File-Temp-0.230.400-r2
dev-perl/Text-Unidecode-0.40.0-r1
dev-perl/libintl-perl-1.230.0
virtual/perl-File-Spec-3.480.0
dev-perl/Unicode-EastAsianWidth-1.330.0-r1
sys-apps/texinfo-5.2
sys-apps/groff-1.22.3
sys-apps/man-db-2.7.1
virtual/man-0-r1
sys-apps/man-pages-posix-2013a
sys-apps/man-pages-3.78
dev-libs/openssl-1.0.2-r1
app-misc/ca-certificates-20140927.3.17.2
net-misc/openssh-6.7_p1-r3
net-misc/wget-1.16.1
net-misc/iputils-20121221-r1
www-client/dillo-3.0.4.1
virtual/ssh-0

# Software on RISC-V



# A Note on Tethered Boot



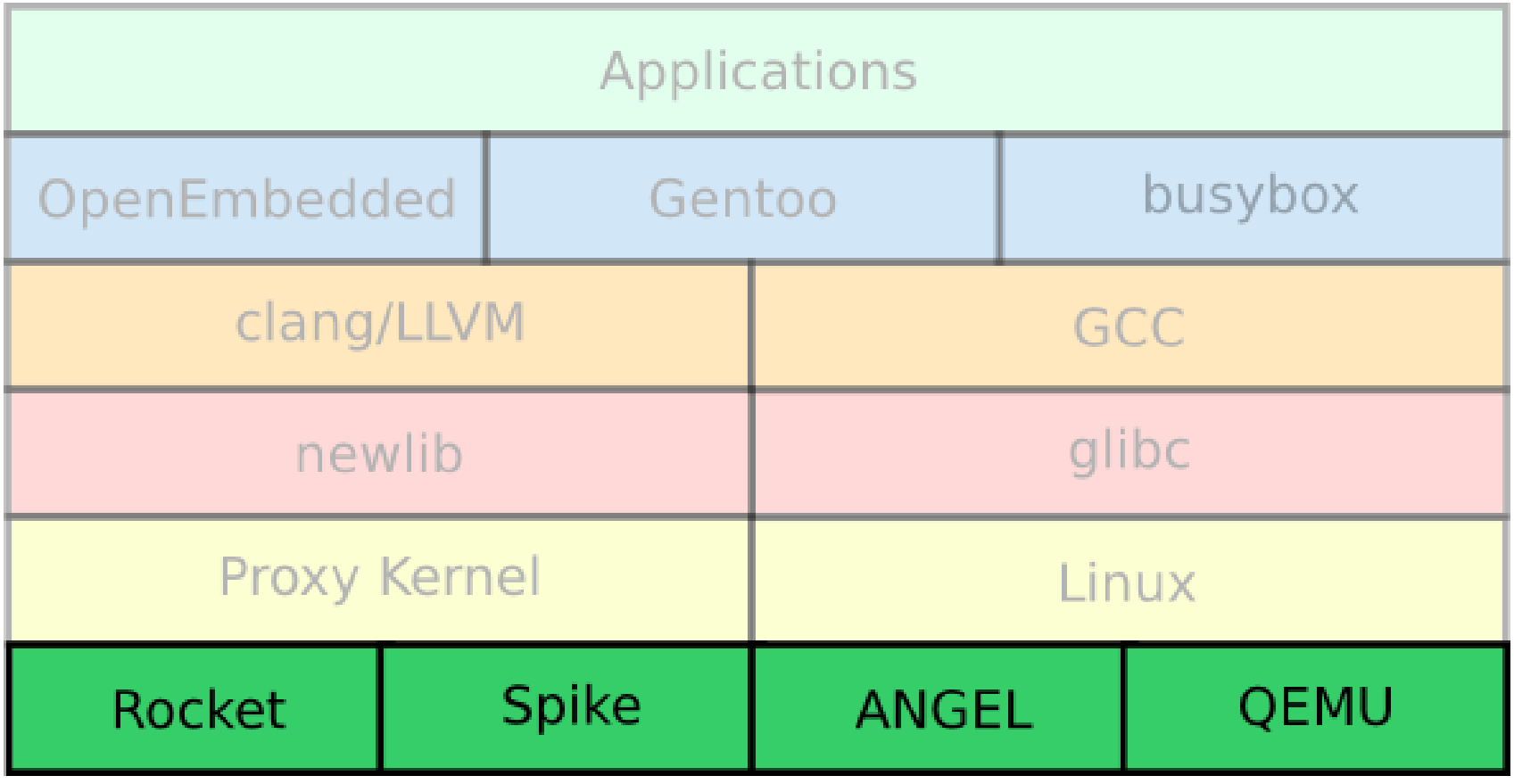

- We build test chips
  - No DRAM, disk, etc
  - Proxy IO to host
- Spike simulates HTIF
  - Boots tethered system
- No disk bootloader

# Obtaining RISC-V Software Ports

- Nothing is upstream
- Traditionally development done at UC Berkeley
  - Used to live at `http://github.com/ucb-bar/`
  - `ucb`: UC Berkeley
  - `bar`: Berkeley Architecture Research
- Coordinated at `http://github.com/riscv/`
  - New!
  - RISC-V is more than Berkeley, so we have a new organization

# RISC-V Implementations

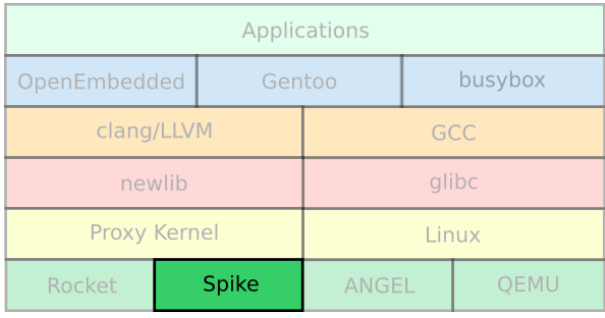
- It'd be great if there was just RISC-V silicon lying around



# Spike ISA Simulator

`http://github.com/riscv/riscv-isa-sim`

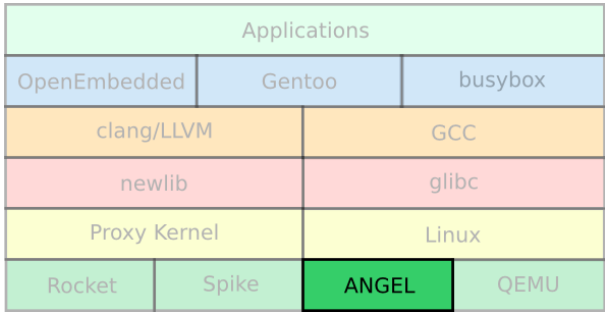
- RISC-V golden model
  - Designed to be easy to modify
  - Full ROCC support



# ANGEL JavaScript ISA Simulator

`http://github.com/riscv/riscv-angel`

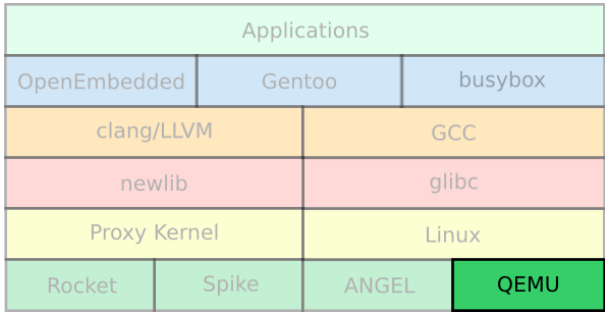
- Pure client-side Java Script
  - Boot Linux in your browser
  - At 13 MIPS
- Designed for education and outreach
  - Nothing to install
  - `http://riscv.org/angel`



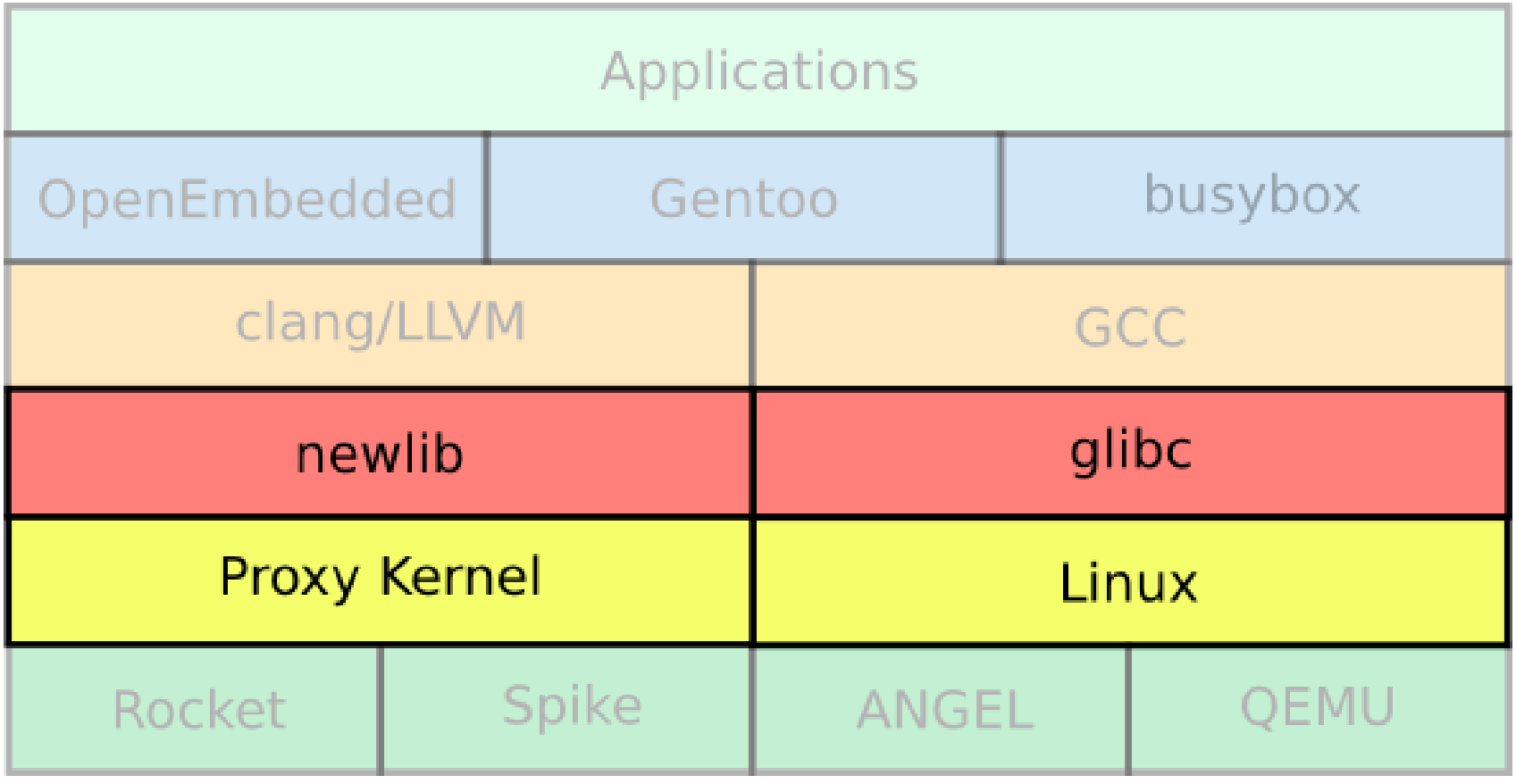
# QEMU Full-System Simulator

`http://github.com/riscv/riscv-qemu`

- Fastest RISC-V implementation ($\approx 1$ BIPS)
- Emulates a full RISC-V system
  - 8250 UART for serial console
  - Virtio for network and disks



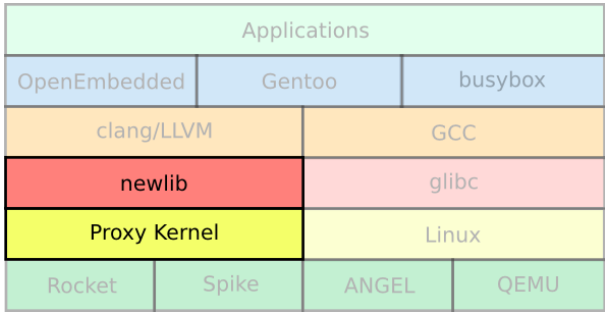
# Operating Systems and System Libraries



# Proxy Kernel

`http://github.com/riscv/riscv-pk`

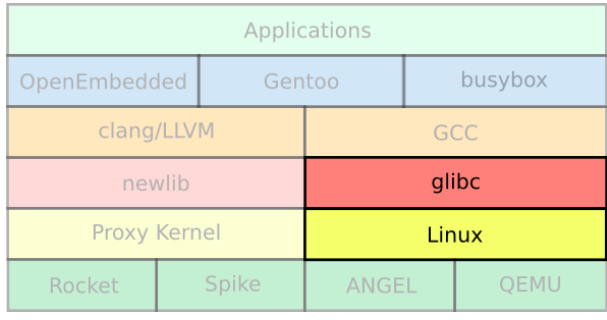
- Designed for tethered operation
  - Requires host running `riscv-fesvr`
  - Forwards system calls over HTIF
- Emulates a minimal POSIX environment
  - Runs without virtual memory
  - Single process, one thread per core
- Mostly used with newlib, an embedded C library



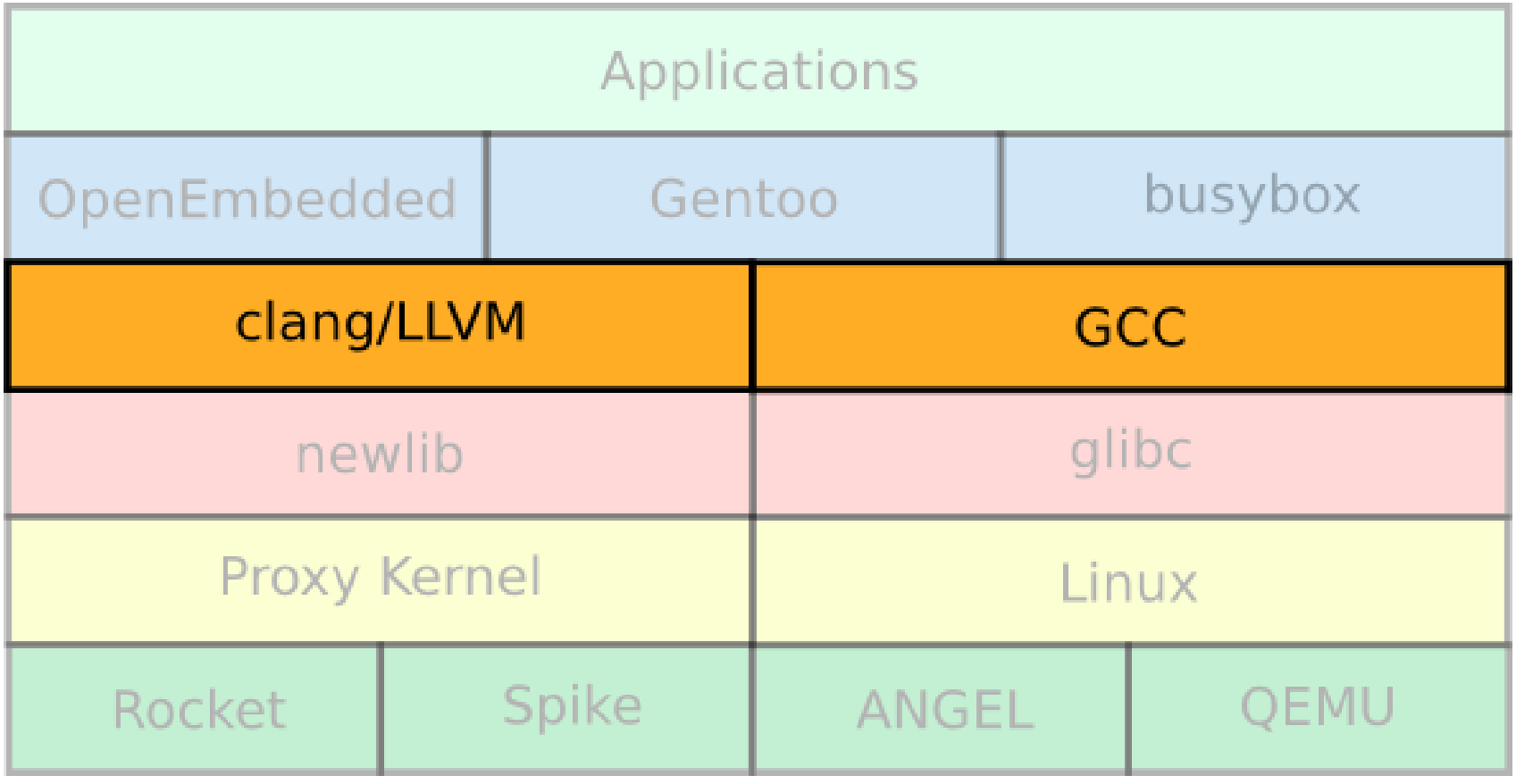
# Linux

`http://github.com/riscv/riscv-linux`

- 3.14
- Missing a lot
  - `CONFIG_SMP`
  - `CONFIG_PREEMPT`
  - `CONFIG_HAVE_BPF_JIT`
  - Anything instrumentation related (`ftrace`, `ptrace`, `kprobes`, `perf_events`)
- No public supervisor spec
  - Quite a bit of Berkeley-specific code



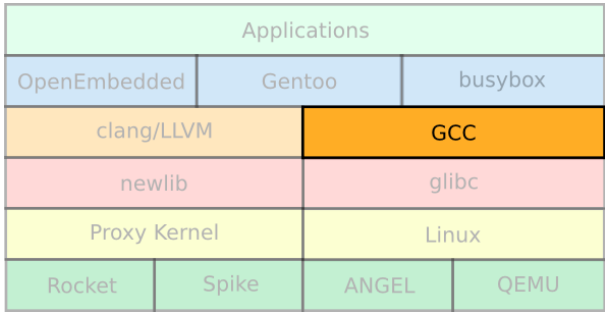
# Toolchains


Applications
OpenEmbedded
Gentoo
busybox
clang/LLVM
GCC
newlib
glibc
Proxy Kernel
Linux
Rocket
Spike
ANGEL
QEMU

# GNU (binutils, GCC, and glibc)

`http://github.com/riscv/riscv-gnu-toolchain`

- Wrapper to build RISC-V cross compiler
- Current with upstream releases
  - `binutils-2.25`, `GCC-4.9.2`, `glibc-2.20`
- Reasonable quality
  - C, C++, Fortran, OpenMP
  - 99.6% of GCC tests pass
  - Support for all RV32/RV64 ISA variants
- Fancier things not implemented
  - `libSegFault.so`
- Also contains the newlib C library port



# Linker Relaxation in RISC-V Binutils

- Expressing 32/64-bit addresses takes multiple instructions
- Most addresses are small offsets
  - Full address offsets not known until link time
  - Code generation has to happen at compile time
- Solution: compiler emits long sequences, linker shortens them
  - Function Calls

| gcc emits | ld optimizes to |
|---|---|
| `auipc t0, target[31:12]` | |
| `jalr ra, t0, target[11:0]` | `jal ra, target[21:0]` |

  - Global Variables

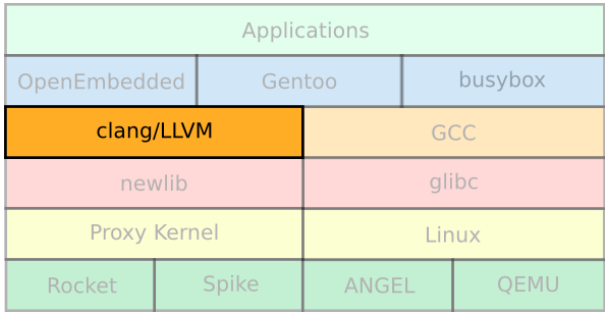
| gcc emits | ld optimizes to |
|---|---|
| `auipc t0, global[31:12]` | |
| `ld t0, global[11:0](t0)` | `ld t0, offset(global ptr)` |

- 7% code size reduction in Linux!

# LLVM

`http://github.com/riscv/riscv-llvm`

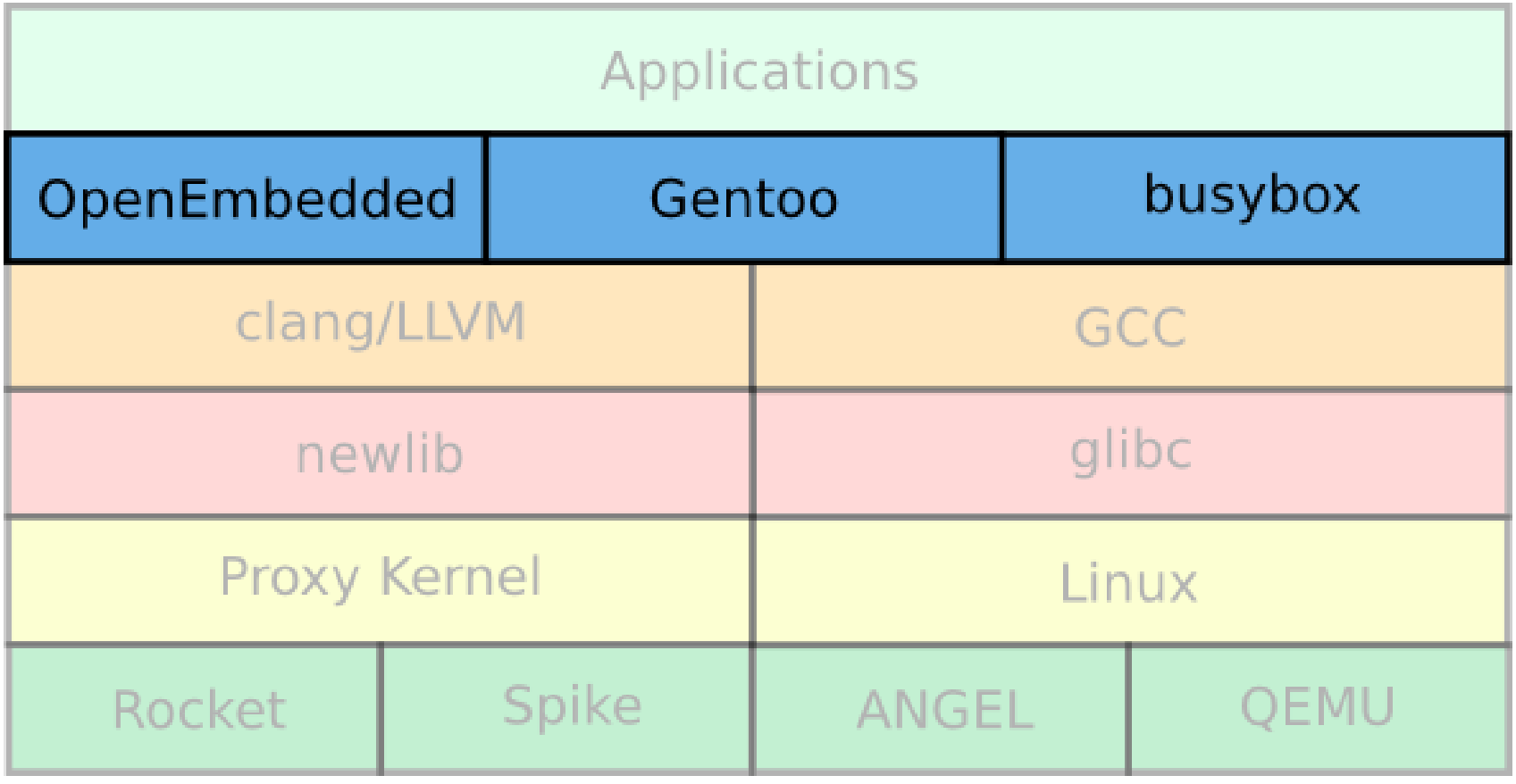
- Probably what you want to use for compiler projects
- Stable and development versions
  - Stable port of LLVM-3.3
  - Weekly upstream trunk merges (do development here)
- Currently a work in progess
  - Only targets newlib
  - Integrated assembler not ported
- Plans for LLVM
  - Work towards upstreaming
  - Increase test coverage
  - Improve robustness, clean up code
  - Improve code generation
  - Assembler, disassembler




# OpenCL on RISC-V (via LLVM)

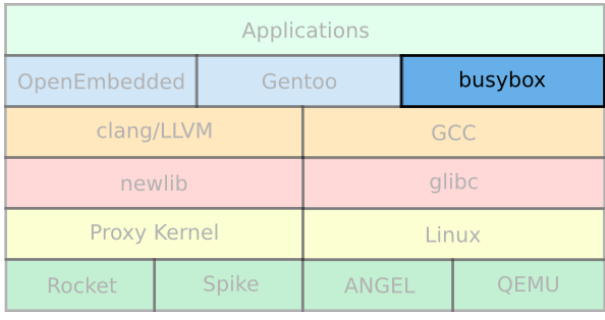
- clang OpenCL frontend, pocl OpenCL library
  - Full support for scalar RISC-V codegen
- We're building parallel machines
  - Working on OpenCL codegen for UCB vector unit

# Linux Distributions



# Busybox

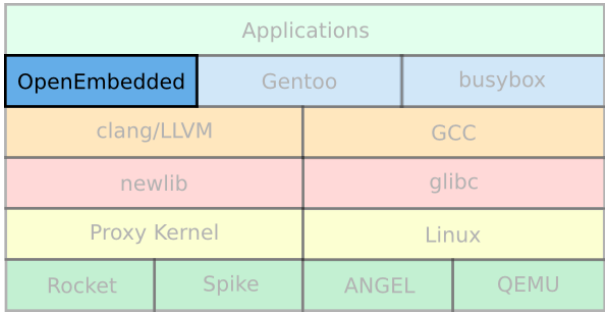
- Absolute simplest userland distribution
  - Commonly used in emdedded systems
  - Cross compiled, low storage and memory footprint
- Good way to get started with RISC-V
  - Cross-compile your application, put in an initramfs, and boot
  - Try it out at `http://riscv.org/angel`
- Don't try and compile complicated dependency chains yourself



# OpenEmbedded

`http://github.com/riscv/riscv-poky`

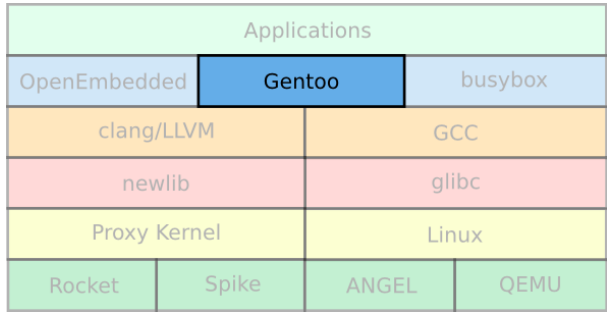
- Popular embedded Linux distribution
  - Cross compiles a huge amount of software
  - One-click full system image builds
- What you want to use to build embedded images
  - Building dependencies for research code
  - Building firmwares for embedded products



# Gentoo

`http://github.com/riscv/riscv-gentoo-infra`

- Less popular desktop Linux distribution
  - Cross compiles system software
  - Native compilation for the rest
- What you want to use when your laptop runs RISC-V



# The Rest of Userland

- Lots of stuff "just works"
  - `bash`, `perl`, `make`, `coreutils`
- Some work is in progress
  - `libffi`
  - `gdb`/`strace`
  - LLVM
- Many things haven't been started
  - Any sort of Java
  - Mozilla

# Contributing to Userland

- Try `riscv-poky`, it probably just builds
- If it doesn't build, most software is trivial
  - Submit a pull request to `riscv-poky`
  - Not in a position to upstream userland yet
- If it's complicated, ask for a `github.com/riscv` repo!

# RISC-V Verification Suite

`http://github.com/riscv/riscv-tests`

- Hand-written tests for each instruction in the ISA
- Simple test kernels
  - Various sorts, matmul, etc
  - Serve a simple performance test cases
- Directed-random program generators (`torture` and `schadenfreude`)
  - Compilers don't generate very interesting code
  - Generate pathological instruction sequences
  - Not yet released, need a big cleanup
- We'd love help with our verification story!


# Questions


# Questions
# Virtual Machine Setup
# Coffee Break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`http://riscv.org/tutorial-hpca2015.html`