

NOTE FOR READER: At this point, I had already taken a stab at the kernel and linker

Red = me

Blue = Codex

I've got the kernel and linker created, here's what this code needs

Step one: Spend about 2 hours generating something, adding as many features as you can:

loading separate programs

running multiple programs simultaneously

synchronization

protection

file system?

How to create/load new programs, etc.

anything else you can think of).

Step two: Get it running in QEMU (5 minutes to 5 hours). For your README, specifically, give the commands to get this up and running on a lab machine.

Step three: Understand what you have (I suggest working together or at least separating the work). One thing I do like about AI is using it to explain code.

Step four: Complete documentation and submit.

Let's get to it

Added multitasking playground features and documentation. Key updates (see kernel.c, apps.c, fs.c, prog.c, sync.c, README.md):

Shell grew FS and user-program commands: fs ls/read/write/rm/format and prog ls/load/run/drop (capability bitmask 1=UART, 2=FS read, 4=FS write, 8=spawn).

In-memory filesystem + simple string/memory utils; RAM-only with small files (fs.c, string.c).

User-program loader/interpreter with basic protection checks; scripts support

print/yield/sleep/read/write/spawn/exit and run as their own threads (prog.c).

Sync primitives (mutex + semaphore) and demo apps for concurrency, FS, and script loading (sync.c, apps.c).

Makefile builds new modules; README documents quickstart, commands, and examples.

How to run (lab machine): make then qemu-system-riscv64 -machine virt -nographic -bios none -kernel kernel.bin. At \$ prompt try ls, run sync, fs write note hello, prog load demo 15 "print hi;read note;exit", prog run demo.

What's there now:

Cooperative threads with producer/consumer demo showing synchronization.  
RAM-backed FS for sharing data between threads/programs.  
Scriptable user programs with capability-checked syscalls for basic protection.  
Built-in apps for concurrent behavior (pinger, counter, sync, fs-demo, prog-demo).  
Tested: make -j2 (builds kernel.bin). Next steps: boot in QEMU and exercise new shell commands; extend interpreter or FS if you want persistence.

### Summarize what you just did

Features added: multi-app spawning, basic synchronization (mutex/semaphore), a RAM file store, a toy user-program loader with capability checks, new demo apps, shell commands to manage all of the above. README now has lab machine build/run commands.  
Not yet done: I haven't actually booted it in QEMU to verify runtime behavior. Also the "explain code"/final documentation step is minimal; README is short and there's no deeper walkthrough of how loading/protection works.  
Limitations to be aware of: everything is cooperative (no preemption), FS/programs are RAM-only, capability enforcement is coarse, and there's no real protection/isolation beyond the interpreter checks.  
If you want it "complete," we should: 1) boot/test in QEMU and note any fixes, 2) add a short code walkthrough section to README (or separate doc) describing threads/FS/prog loader/protection, and 3) optionally extend protection or persistence if required.

```
$ run prog-demo
spawned prog-demo tid:4
$ [trampoline] enter
[thread_start_run] enter
[thread_start_run] thread fn returned
[thread_start_run] about to clean up / exit
[thread_start_run] call thread_exit()
[thread_exit] thread marked finished
[thread_exit] switching to next ready thread
[trampoline] enter
[thread_start_run] enter
[prog:script1] start
[prog:script1] script boot
[prog:script1] wrote note
[prog:script1] hi!
spawned pinger tid:6
[trampoline] enter
[thread_start_run] enter
[app:pinger] ping
[prog:script1] bye
[prog:script1] exit
[thread_start_run] thread fn returned
```

[thread\_start\_run] about to clean up / exit  
[thread\_start\_run] call thread\_exit()  
[thread\_exit] thread marked finished  
[thread\_exit] switching to next ready thread  
[app:pinger] ping  
[app:pinger] ping

\$ [app:pinger] ping

\$ [app:pinger] ping

\$ [app:pinger] ping

\$ [app:pinger] ping

\$ [app:pinger] ping

\$ [app:pinger] ping

\$ [app:pinger] ping

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\$ [app:pinger] ping

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\$ [app:pinger] ping

\$ [app:pinger] ping

\$ [app:pinger] ping

\$ [app:pinger] ping

\$ [app:pinger] ping

\$ [app:pinger] ping

\$ [app:pinger] ping

\$ [app:pinger] done

[thread\_start\_run] thread fn returned  
[thread\_start\_run] about to clean up / exit

[thread\_start\_run] call thread\_exit()  
[thread\_exit] thread marked finished  
[thread\_exit] restoring main context

heres a test output in QEMU, this doesn't look right

Looks good and matches the expected flow:

First thread is the prog-demo app thread: it enters trampoline, runs app\_prog\_demo, returns immediately after loading/running the script, and exits. That explains the first [trampoline] enter / thread fn returned sequence.

Scheduler switches to the user program thread (script1): it starts, prints, writes/reads the FS, spawns pinger, then exits. Those logs look right.

The spawned pinger thread runs next, printing 20 “ping” lines then “done” and exits. The \$ prompts interleaving are just the shell resuming in between thread yields/finishes.

So the run shows multi-threading, program loader, FS ops, and sync via thread\_yield working as intended. If you want less noisy logs, we can drop some of the [thread\_\*] debug prints.

go ahead and update the readme, include what each .c file does briefly, and explain how to set up qemu. Im going to delete my qemu and test again after downloading it your way

README is beefed up: added QEMU/toolchain setup, build/run steps, shell usage, user-program examples, file system notes, and a brief description of each source file/module. You can now reinstall QEMU, rebuild with make, and run via qemu-system-riscv64 -machine virt -nographic -bios none -kernel kernel.bin following the updated instructions.

Lets include a runqemu.sh that will check if qemu is downloaded. If not, it will move up one directory, create a tools directory, put qemu there, then move back to the right directory and run qemu

Added runqemu.sh to auto-run QEMU:

Checks for qemu-system-riscv64 in PATH or ../tools; if missing, goes up one level, creates tools, and attempts to download/extract QEMU there via apt-get download qemu-system-misc.

Builds kernel.bin if it isn't present, then launches with the correct flags.

README updated with the script workflow.

Run it with ./runqemu.sh from the repo root. Note: the download step relies on apt-get and network access; if that's unavailable, install QEMU manually or place the binary in ../tools.

## BOOT & SHELL

Show it boots, show the shell works, run "help"

I want to do a short 1.5 minute video explaining these concepts. What code should I show to quickly explain this?

Boot flow you can show on screen:

entry.S sets the stack and jumps into C: `_start` → `la sp, _stack_top` → `call kernel_main`.  
kernel.c early init: `kernel_main` calls `fs_init()`; `prog_init()`; `uart_puts("tiny-shell: type 'help' or 'stop'\n")`; then drops to the REPL.

The shell loop (same file) reads chars from UART, handles backspace/echo, and on newline dispatches commands. The help branch prints the command list; `ls/apps` show built-ins; run `<app>` spawns threads; `ps/kill` manage them; `fs ...` and `prog ...` route to helpers.

If you want to justify apps, flash `apps.c` showing the `apps[]` table and simple demos like `pinger/counter`.

Terminal demo plan (fits ~1.5 min):

Build once: `make`.

Launch: `qemu-system-riscv64 -machine virt -nographic -bios none -kernel kernel.bin`.

On boot, the UART prints `tiny-shell: type 'help' or 'stop' and $`.

Type `help` to show the commands. Optional quick follow-ups: `ls` to show apps, run `pinger` to prove threads interleave, `ps` to show tids, `stop` to halt.

Script beats for the narration:

“Boot code is only a few lines” – point at `entry.S` setting SP and jumping to C.

“Kernel init and shell prompt” – highlight the top of `kernel_main` where FS/program loader init happens and the prompt is emitted.

“Help is just a branch” – show the `if (!strcmp(buf, "help")) { ... }` block printing the available commands.

“Apps table drives run `<app>`” – briefly show `apps.c`’s `apps[]` array and `app_spawn`.

You can keep the terminal visible while you scroll those snippets: show the code, flip back to QEMU, type `help`, maybe run one small app, then exit with `Ctrl-A x`. That covers “boot + shell works + help” in under 90 seconds.