

TinyRange: Next-generation Virtualization for Cyber and Beyond

Joshua D. Scarsbrook - The University of Queensland

July 11th, 2024

Slides

<https://vbitz.github.io/presentations/2024/tinyrange2>



\$ whoami

Joshua Scarsbrook (j.scarsbrook@uq.edu.au)

Research Officer at **The University of Queensland**

Interested in...

- **Operating Systems**
- **Virtualization**
- **Embedded Hardware**

Working in the **Computational Imaging Group** of **EECS**

Virtual Machines vs. Containers

- **Virtual Machines:** Isolated at the CPU Level. Emulates real hardware or specialized virtual hardware.
- **Containers:** Isolated at the Operating System Level. Fast, easy to build, and efficient with resources.

The biggest limiting factor for virtual machines is how you build them.

How do we get files into **Virtual Machines**?

- **Block Devices:** Direct emulation of hardware. Fast and well supported but slow to build.
- **Network Filesystems:** Moderate support and moderate speed (e.g. **SMB**, **NFS**, **sshfs**).
- **VM Filesystems:** Highly specialized and very fast (e.g. **virtio-fs**, **virtio-9p**).

What is TinyRange?

Next-generation Virtualization for Cyber and Beyond

Long Term Goal: Make running and building *any* software effortless on all modern hardware.

Where are we today?: Super fast and easy **Linux** virtual machines.

TinyRange is Open Source!

License: Apache License 2.0

Source Code: <https://github.com/tinyrange/tinyrange>

Virtual `ext4` Filesystems.

- A write-only `ext4` driver in `Go`.
- Mapped to virtual machines using `NBD` as a regular block device.
- Performance comparable to a regular disk image or RAM disk.

How?

- A custom language that defines structures with safe byte-level indexing.

```
type DirEntry2 struct {  
    inode          u32_le // Number of the inode that this directory points to.  
    rec_len        u16_le // Length of this directory entry.  
    name_len       u8      // Length of the file name.  
    file_type      u8      // File type code, see ftype table below.  
}
```

- Virtual memory mapping emulated in Userspace with byte-level granularity.
- ~2000 lines of **Go** to implement **ext4** support.

Benchmarks

Command	Mean [ms]	Min [ms]	Max [ms]	Relative
tinyrange	376.6 ± 1.8	372.6	379.2	2.26 ± 0.20
docker	220.8 ± 16.0	199.1	259.6	1.33 ± 0.15
podman	166.3 ± 14.6	145.4	200.9	1.00

TinyRange Research Gaps

1. **Software Installation:** Now we can get files into a virtual machine how do we get software installed?
2. **Virtualization:** Currently using QEMU. A better replacement could enable running all this in a web browser.
3. **Alternate Guest Operating Systems:** Needs a driver for the filesystem and a bootloader.

Scripting Preview

```
make_vm([
    define.plan(
        builder = "alpine@3.20",
        packages = [
            query("ifupdown-ng"), query("busybox"), query("busybox-binsh"),
            query("alpine-baselayout"), query("openrc"), query("docker"),
            query("docker-openrc"), query("hyperfine"),
        ],
        tags = ["level3"],
    ),
    vm_modfs,
    directive.add_file("/run/openrc/softlevel", file("")),
    directive.add_file("/etc/network/interfaces", file("")),
    directive.run_command("openrc"),
    directive.run_command("service docker start"),
    directive.run_command("""while (! docker version > /dev/null 2>&1); do
        sleep 0.1
    done"""),
])
```

What am I using this for?

NeuroDesk

- Headed by Dr. Steffen Bollmann with many other contributors.
- Currently built with generated **Dockerfiles** and two containers using TinyRange.
- Hoping to use TinyRange in the future.
- ~100 Neuroimaging tools distributed publicly with **Docker**, **Singularity**, **CVMFS**.
- Users all over the world.

Thanks for Listening

Source Code: <https://github.com/tinyrange/tinyrange>

Email: j.scarsbrook@uq.edu.au

Mastodon: [@jscarsbrook@infosec.exchange](https://infosec.exchange/@jscarsbrook)