Immutable Infrastructure with Flatcar Container Linux

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Hi, I'm Kai

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Flatcar Container Linux

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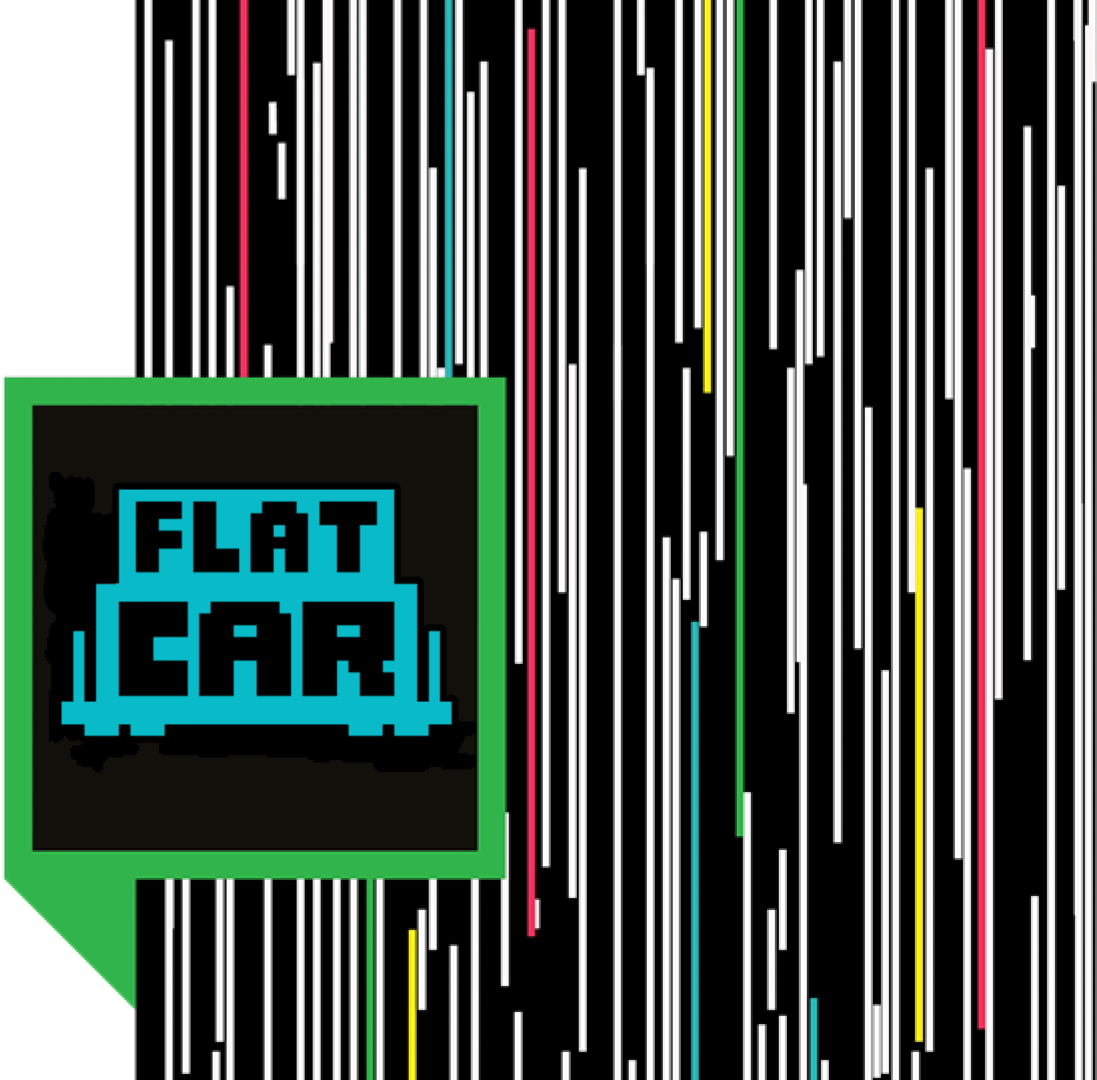


Immutable Infrastructure

»Immutable Infrastructure«

- ❑ Paradigm to reprovision servers instead of managing their configuration after provisioning
- ❑ Pros:
  - ❑ Reproducible and consistent configuration, e.g., matching a git repository
- ❑ Cons:
  - ❑ Reprovisioning takes longer
  - ❑ Data gets lost (local application data, logs, SSH host keys, …)
  - ❑ New IP address depending on cloud environment

Flatcar Container Linux

(Fork/Continuation of CoreOS Container Linux)

Why Flatcar Container Linux?

Minimal distribution for containers

Reduced dependencies

Less base software to manage

Reduced attack surface area

Secure, immutable file system

Read-only /usr partition

No package installation or modification of base OS files

Removes entire category of security threats (e.g., runc vulnerability CVE-2019-5736)

Automated, streamlined updates

Easily apply all latest security patches

Atomic updates and rollbacks

Co-ordinated with Kubernetes control plane (update operator)

Declarative provisioning

First boot setup from declarative configuration

Immutable infrastructure (no custom per-node changes during production)

Repeatable deployment

Ignition Config

- ❑ JSON format
- ❑ Declaration of files, systemd units, networks, users, filesystems, and partitions
- ❑ Referencing data from external resources
- ❑ Applied from initramfs (first-boot flag file for GRUB sets kernel parameter)
- ❑ Contrast to cloud-init which runs after the initramfs, and on every boot

Container Linux Config (CLC)

- ❑ Friendlier YAML format with extras (octal permissions, variables for metadata)
- ❑ Transpiled to Ignition JSON through transpiler “ct”

```
cat cl.yaml | docker run --rm -i quay.io/coreos/ct:latest-dev > ignition.json
./flatcar_production_qemu.sh -i ignition.json
```

- ❑ Spec: flatcar.org/docs/latest/provisioning/config-transpiler/configuration/

Container Linux Config Example

```
storage:
  files:
    - path: /etc/some.conf
      filesystem: root
      mode: 0644
      contents:
        inline: |
          A=a
          B=b
```

Or with remote instead of '`inline`' content:

```
  remote:
    url: …
```

Terraform

Terraform and Ignition

- ❑ Ignition config is set through instance user-data attribute (no need for the SSH provisioner)
- ❑ terraform-ct-provider to transpile CLC to Ignition, often combined with the template-provider
- ❑ Or: terraform-ignition-provider (1.x) to assemble Ignition JSON from HCL

Terraform Example

```
resource "digitalocean_droplet" "machine" {
  for_each  = toset(var.machines)
  image     = digitalocean_custom_image.flatcar.id
  user_data = data.ct_config.machine-ignition[each.key].rendered
}
data "ct_config" "machine-ignition" {
  for_each = toset(var.machines)
  content  = data.template_file.machine-cl-config[each.key].rendered
}
data "template_file" "machine-cl-config" {
  for_each = toset(var.machines)
  template = file("${path.module}/cl/machine-${each.key}.yaml.tmpl")
  vars     = { something = var.something }
}
```

Configuration Changes
and
Instance Lifecycle

Instance Lifecycle with Replacement

- ❑ Instance replacement for user-data changes can be disruptive: downtime, data transfer needed, slow, maybe IP address changes, too, etc.
- ❑ Workarounds: `create_before_destroy`, backups or only using external storage, last resort: delaying replacement with `ignore_changes` (→ config drift)

Instance Lifecycle without Replacement?

- ❏ Ansible: Flatcar bootstrap with pypy in home folder
- ❏ Not really immutable infra without reprovisioning as old files may be lingering around → config drift
- ❏ Also, half Ignition, half Ansible gets messy
- ❏ Can't we just somehow rerun Ignition?

Instance reprovisioning with Ignition

- `touch /boot/flatcar/first_boot` is not enough:
  - Must remove old versions of config files
  - Must remove `/etc/machine-id` to trigger systemd first-boot semantics for preset evaluation
- Big hammer: Reformat rootfs through Ignition (use other disks for persistent data)

Reformat with Ignition

CLC snippet:

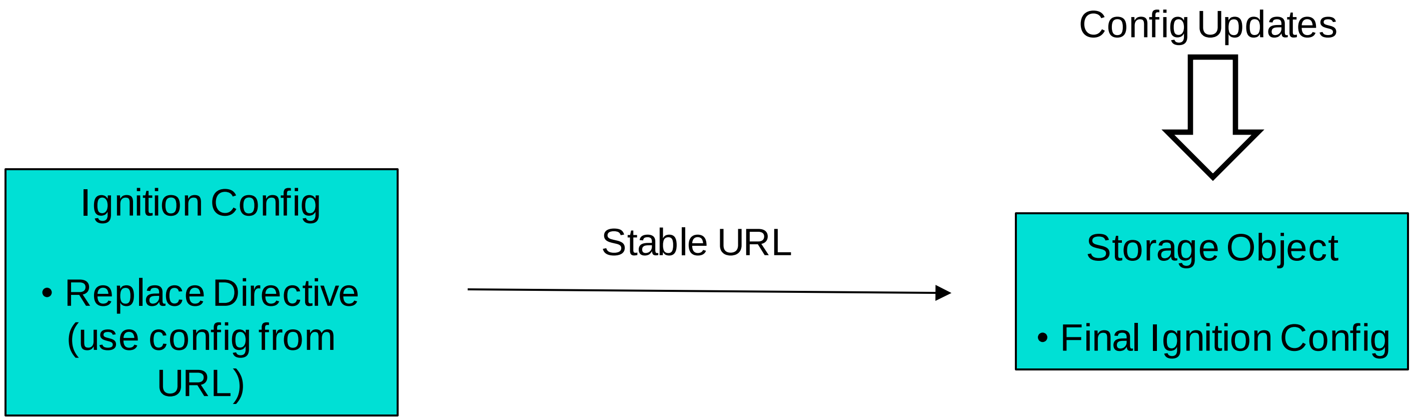
```
filesystems:
  - name: root
    mount:
    device: /dev/disk/by-label/ROOT
    format: ext4
    wipe_filesystem: true
    label: ROOT
```

Quite fast, preserves the IP address but still loses most local data…

More problems: User-data Updates

- ❏ Terraform cloud providers and cloud APIs in general make it hard to update user data in-place
- ❏ Workaround: Indirection through cloud bucket/blob storage like S3/GCS, let instance user data point to the storage object (stable reference), and update the config in the storage object

Ignition Config Indirection



Ignition Config in Storage Object

Point to storage URL:

```
ignition: → config: → replace: → source: → URL
```

Terraform Example:

```
resource … {
  user_data = "{ \"ignition\": { \"version\": \"2.3.0\",
\"config\": { \"replace\": { \"source\":
\"s3://${aws_s3_bucket_object.object.bucket}/${aws_s3_bucket_object.ob
    ject.id}\" } } } }"
}
resource "aws_s3_bucket_object" "object" {
  content = data.ct_config.machine-ignition.rendered
}
```

Trigger Reboot and Ignition Rerun

Terraform null resource:

```
resource "null_resource" "reboot-when-ignition-changes" {
  triggers = { config = data.ct_config.machine-ignition.rendered }
  depends_on = [ aws_s3_bucket_object.object ]
  provisioner "local-exec" {
    command = "[… SSH cmd to create first_boot file and reboot …]"
  }
}
```

Not the nicest workaround, some git-ops like daemon on the instance to check the storage object can work, too

Idea: Teach Ignition to Preserve State

- ❑ Instead of discarding the whole rootfs, let's improve Ignition to be able to selectively keep wanted files
- ❑ A Draft PR implements this, e.g.:

```
"cleanExcept":
   ["/etc/ssh/ssh_host_.*", "/var/log", …]
```

- ❑ Specify app data or container image folders
- ❑ The machine ID can be preserved with `systemd.machine_id=…` in `grub.cfg`

Proof-of-Concept Demo

- ❑ Using the qemu helper script instead of Terraform: asciinema.org/a/462614

Results with the Proof-of-Concept

- ❏ Fast reprovisioning, preserves IP address and all local data (SSH host keys, system logs, application data, as needed)
- ❏ Declarative config management without drift
- ❏ Since only SSH is needed it's even viable for bare metal lacking IPMI automation (place/update `config.ign` file on OEM partition)
- ❏ Some workarounds were needed, though

Summary

- ❑ Immutable Infra possible even for stateful systems
- ❑ Flatcar Container Linux already simplifies OS maintenance through immutable A/B updates
- ❑ Choose your strategy for user-data config changes
- ❑ Terraform examples on GitHub: flatcar-linux/flatcar-terraform

Thank you!

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Flatcar Container Linux

Website: flatcar.org

GitHub Repos: flatcar-linux

Terraform Examples:
flatcar-linux/flatcar-terraform