Container Images Considered Harmful

(... and some things we can do about it.)

Aleksa Sarai

Senior Software Engineer

@lordcyphar

<cyphar@cyphar.com>

An Ideal Image Format

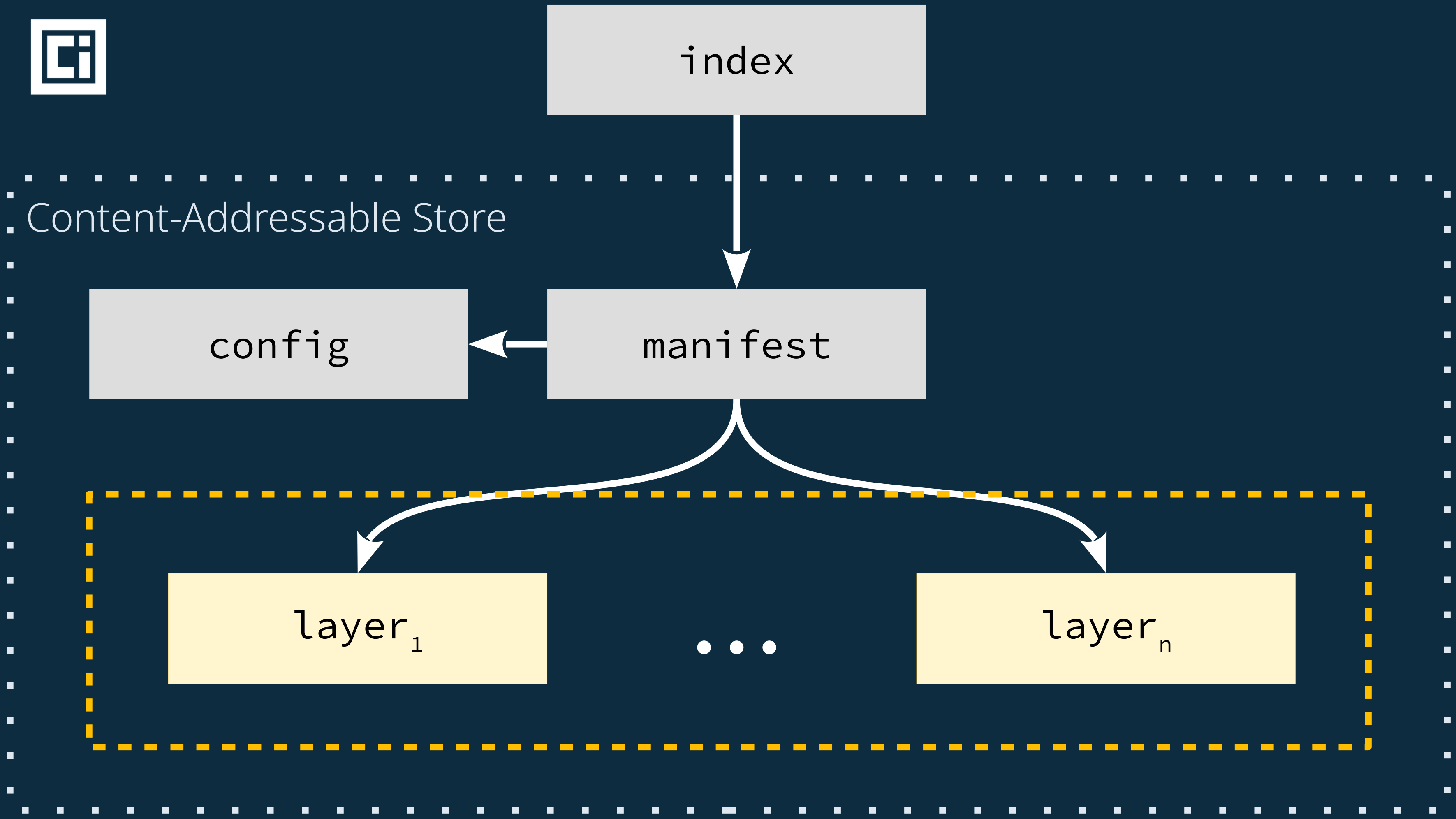
Deduplicated as much as possible (*transfer* and *storage*)

Parallelisable (*transfer* and *storage*)

Reproducible (and have a canonical representation)

Non-avalanching

Transparent


index
Content-Addressable Store
config
manifest
layer₁
. . .
layerₙ

What’s Wrong With Tar?

- A fair bit.

An Ideal Image Format

Deduplicated as much as possible (*transfer* and *storage*)

Parallelisable (*transfer* and *storage*)

Reproducible (have a canonical representation)

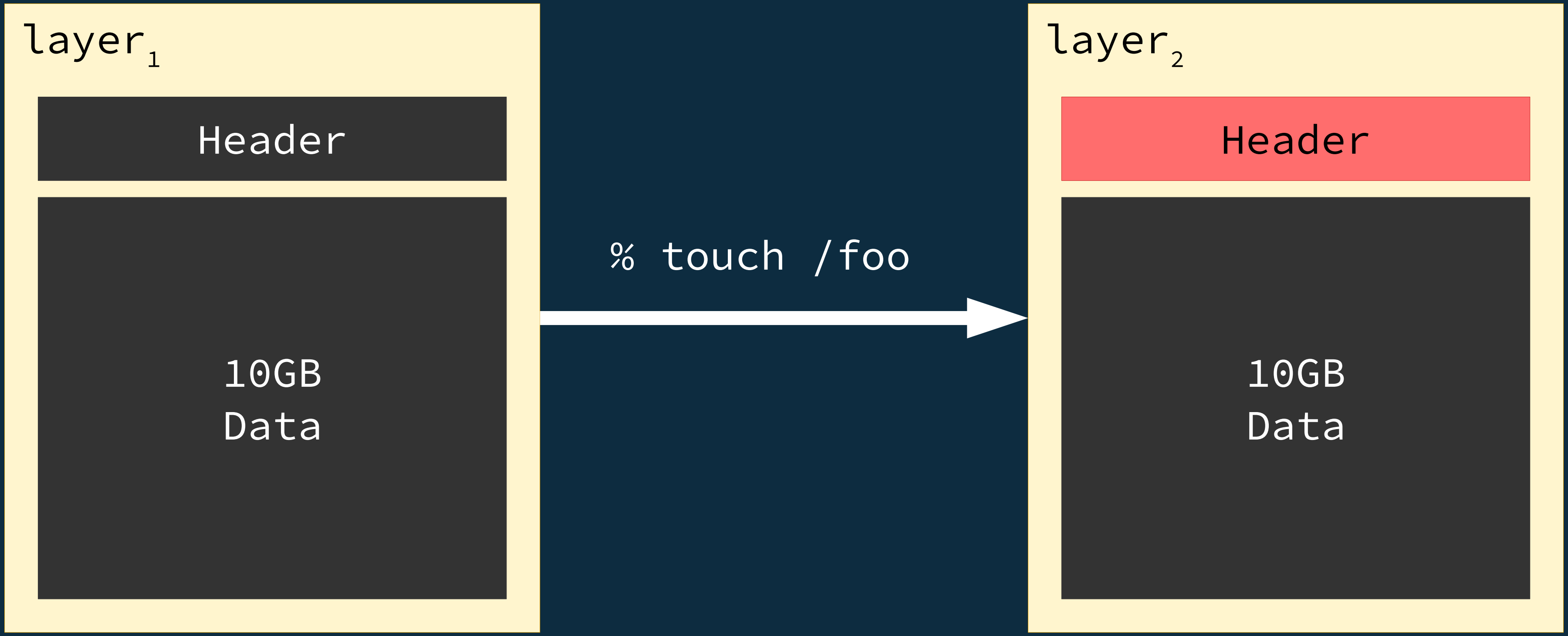
“Non-avalanching”

Transparent

What Tar Gives Us

What Tar Gives Us

(This page intentionally left blank.)



layer$_1$

Header

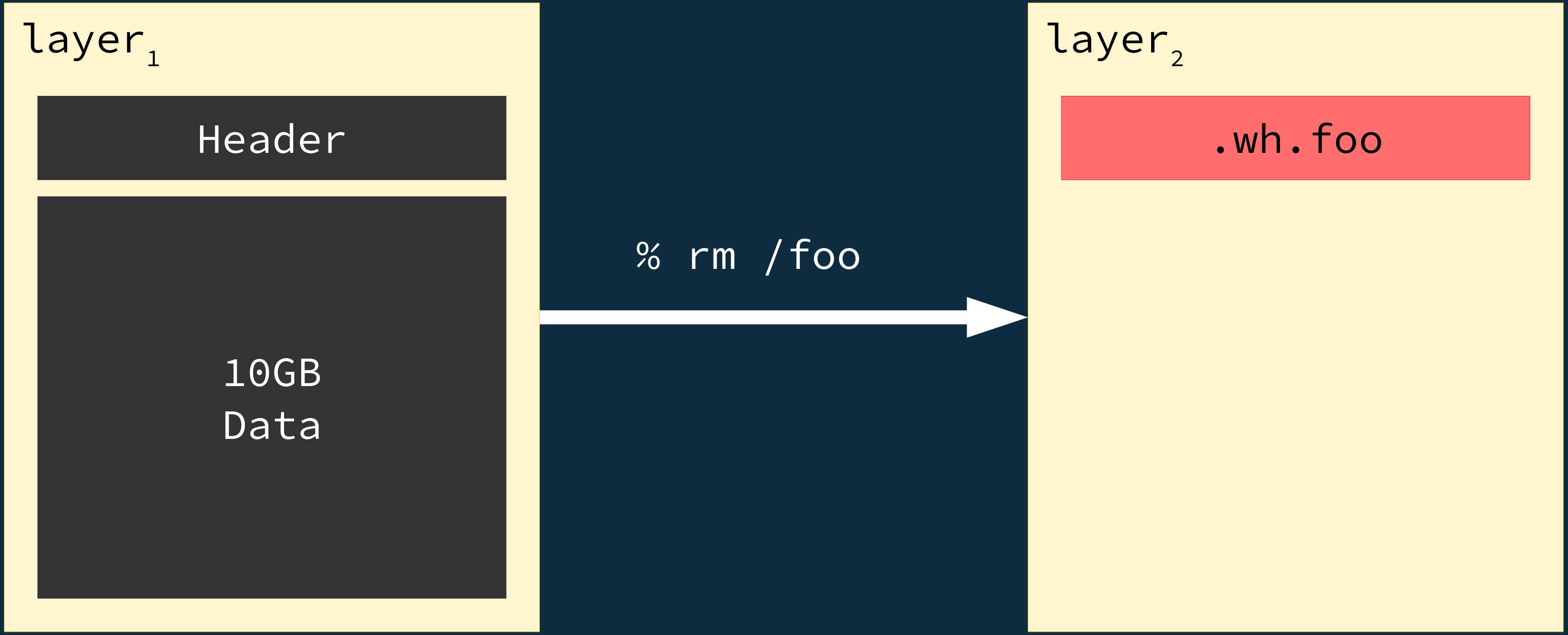
10GB
Data

```
% touch /foo
```

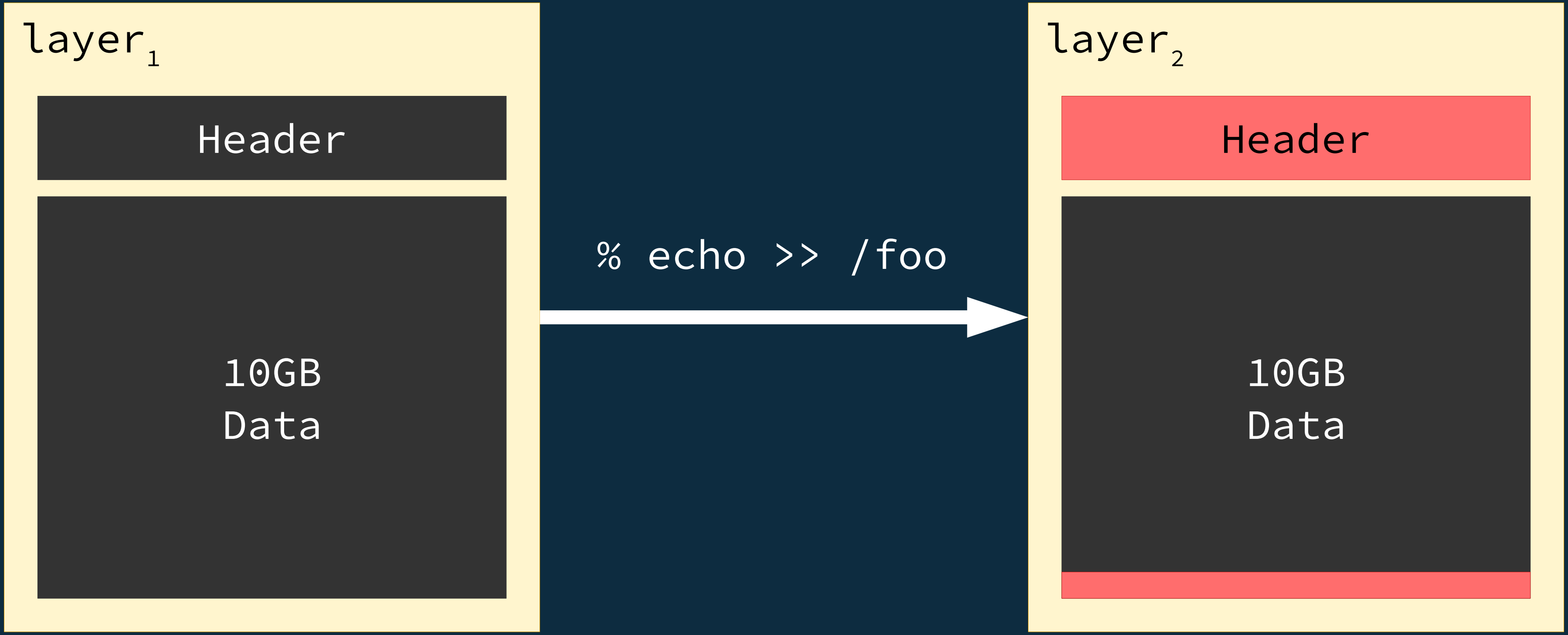
layer$_2$

Header

10GB
Data



I'm not pranking you – your image gets **bigger**.



layer$_1$

Header

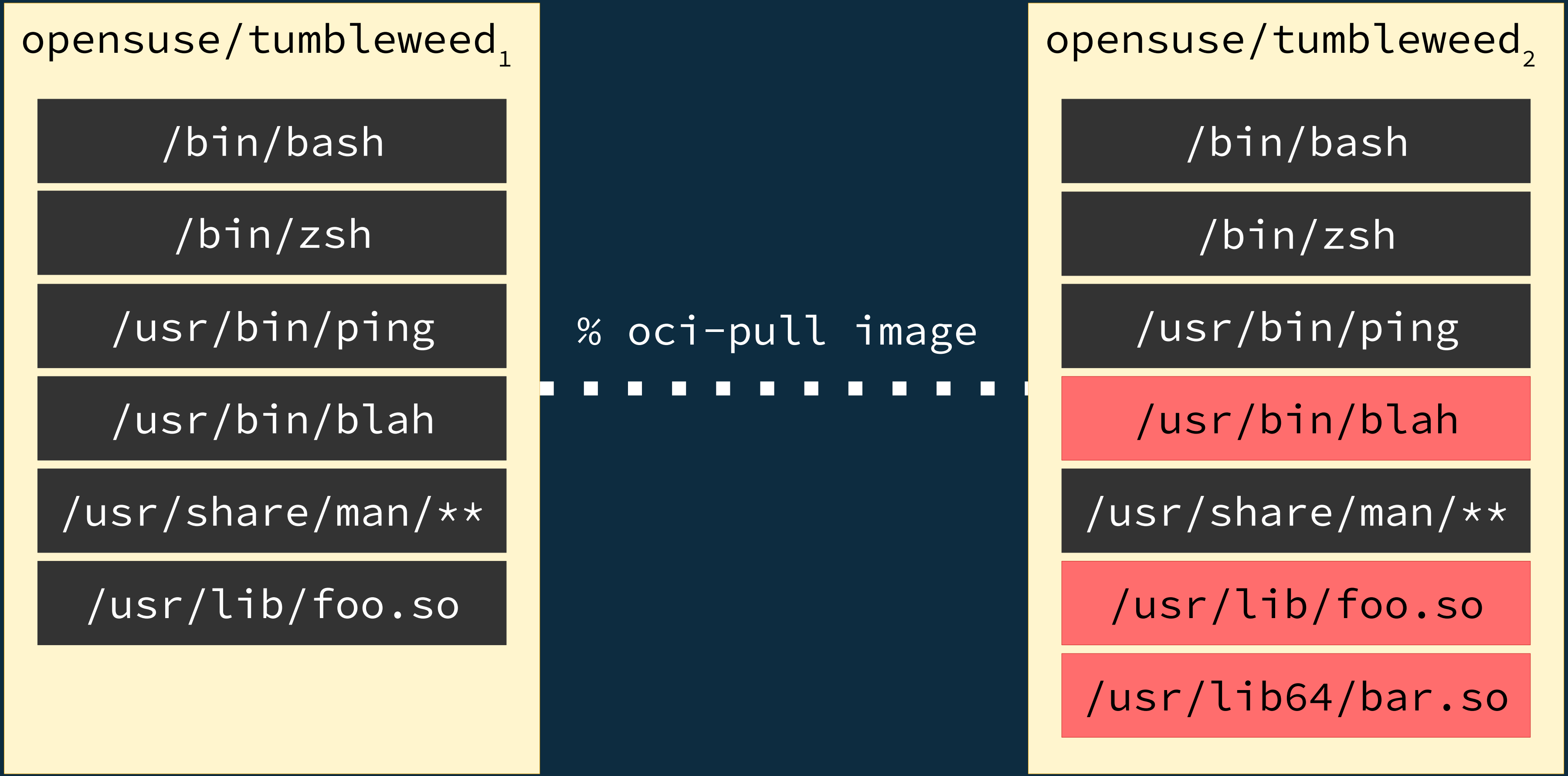
10GB
Data

```
% echo >> /foo
```

layer$_2$

Header

10GB
Data



opensuse/tumbleweed$_1$

/bin/bash

/bin/zsh

/usr/bin/ping

/usr/bin/blah

/usr/share/man/**

/usr/lib/foo.so

```
% oci-pull image
```

opensuse/tumbleweed$_2$

/bin/bash

/bin/zsh

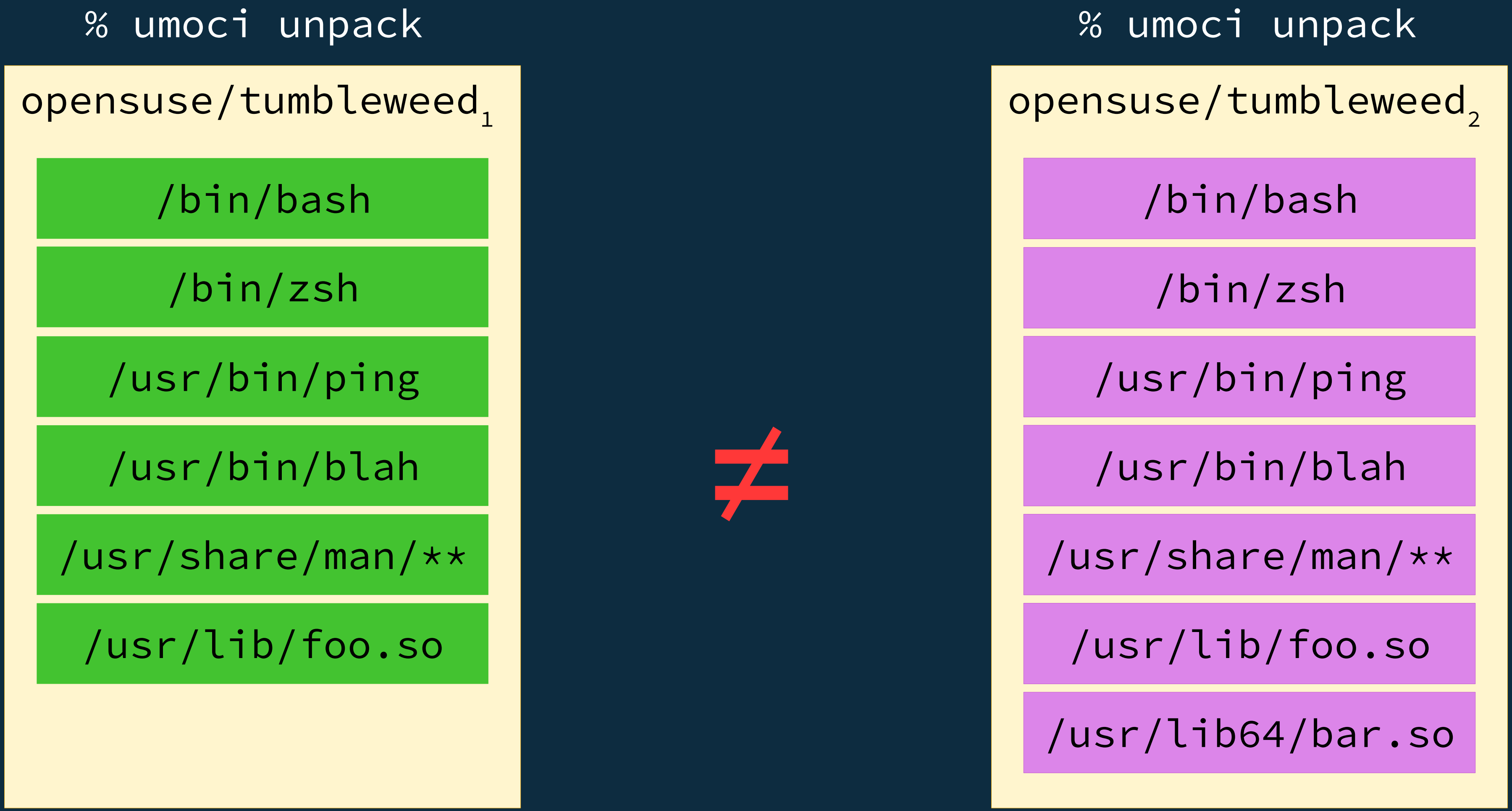
/usr/bin/ping

/usr/bin/blah

/usr/share/man/**

/usr/lib/foo.so

/usr/lib64/bar.so



```
% umoci unpack
```

opensuse/tumbleweed$_1$

- /bin/bash
- /bin/zsh
- /usr/bin/ping
- /usr/bin/blah
- /usr/share/man/**
- /usr/lib/foo.so

≠

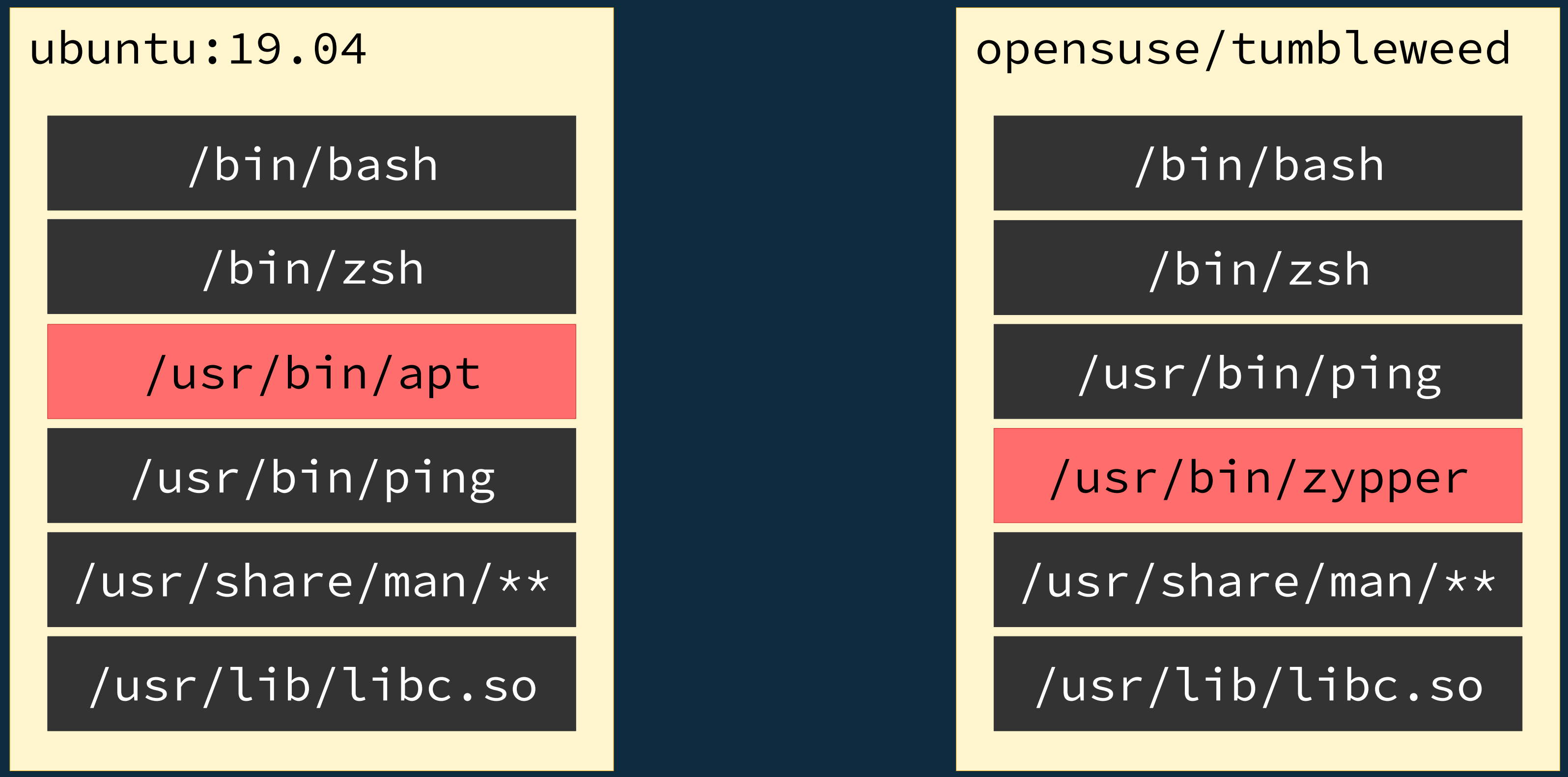
```
% umoci unpack
```

opensuse/tumbleweed$_2$

- /bin/bash
- /bin/zsh
- /usr/bin/ping
- /usr/bin/blah
- /usr/share/man/**
- /usr/lib/foo.so
- /usr/lib64/bar.so

```
% oci-pull ubuntu
```

```
% oci-pull opensuse
```

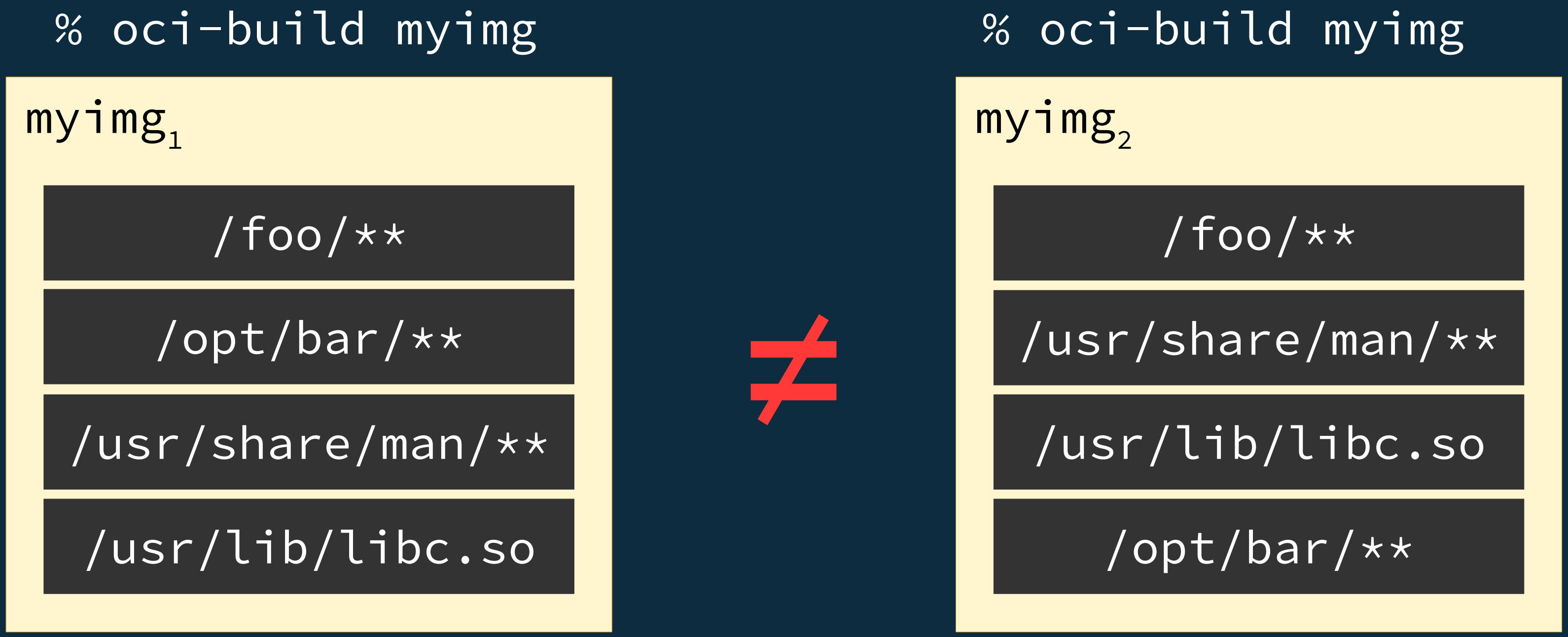


ubuntu:19.04

- /bin/bash
- /bin/zsh
- /usr/bin/apt
- /usr/bin/ping
- /usr/share/man/**
- /usr/lib/libc.so

opensuse/tumbleweed

- /bin/bash
- /bin/zsh
- /usr/bin/ping
- /usr/bin/zypper
- /usr/share/man/**
- /usr/lib/libc.so



```
% oci-build myimg
```

$\texttt{myimg}_1$

```
/foo/**
/opt/bar/**
/usr/share/man/**
/usr/lib/libc.so
```

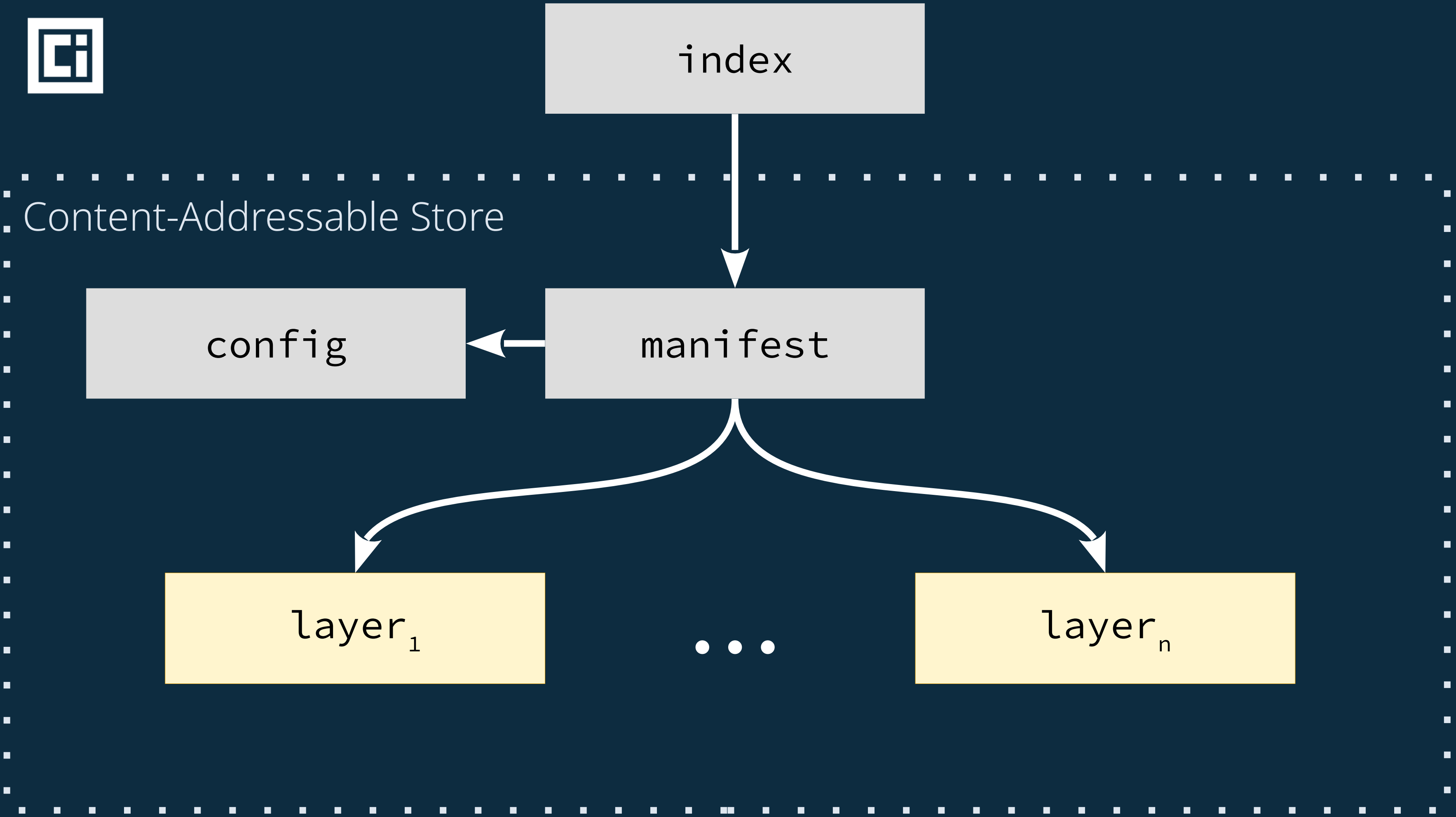
≠

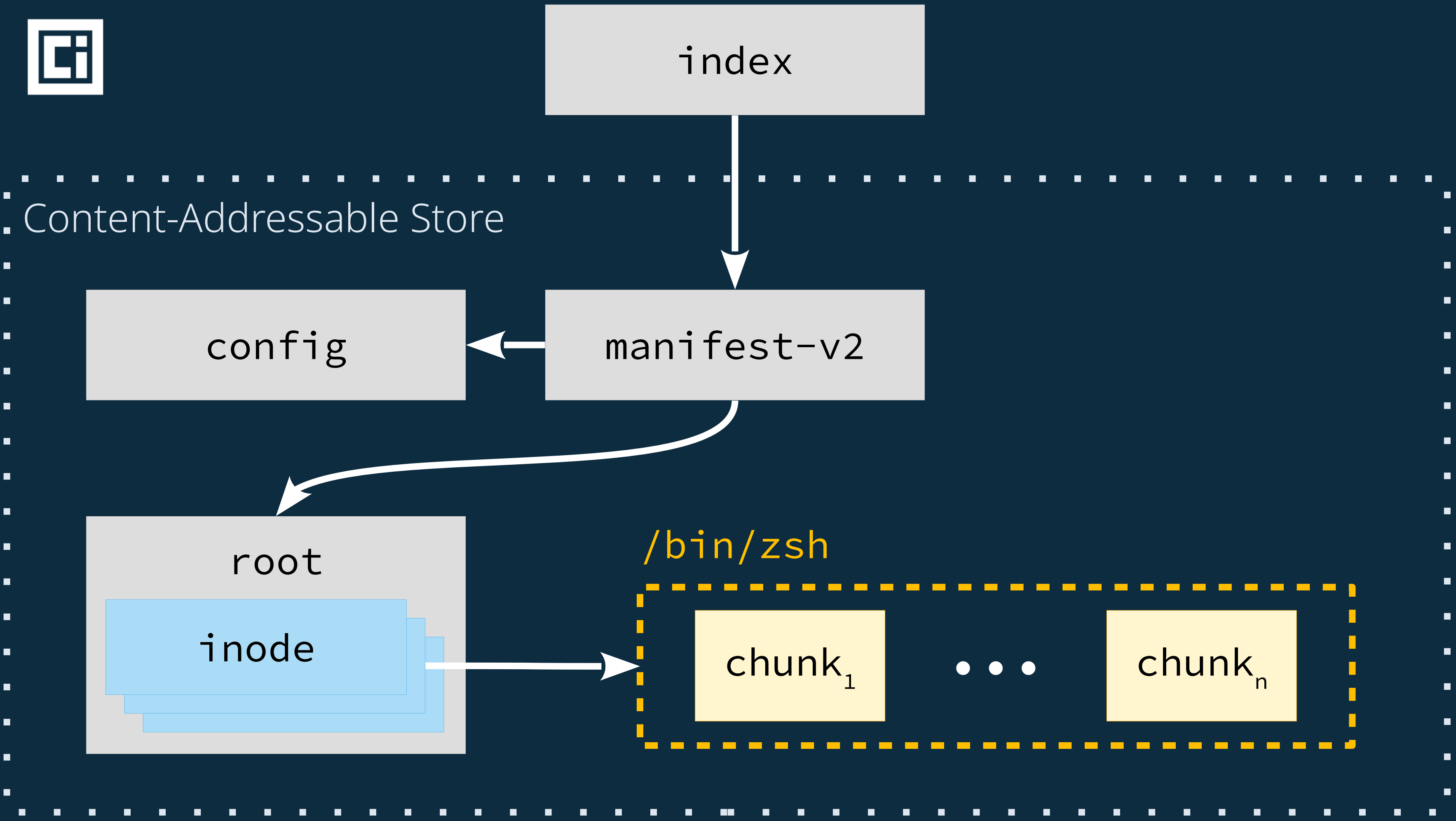
```
% oci-build myimg
```

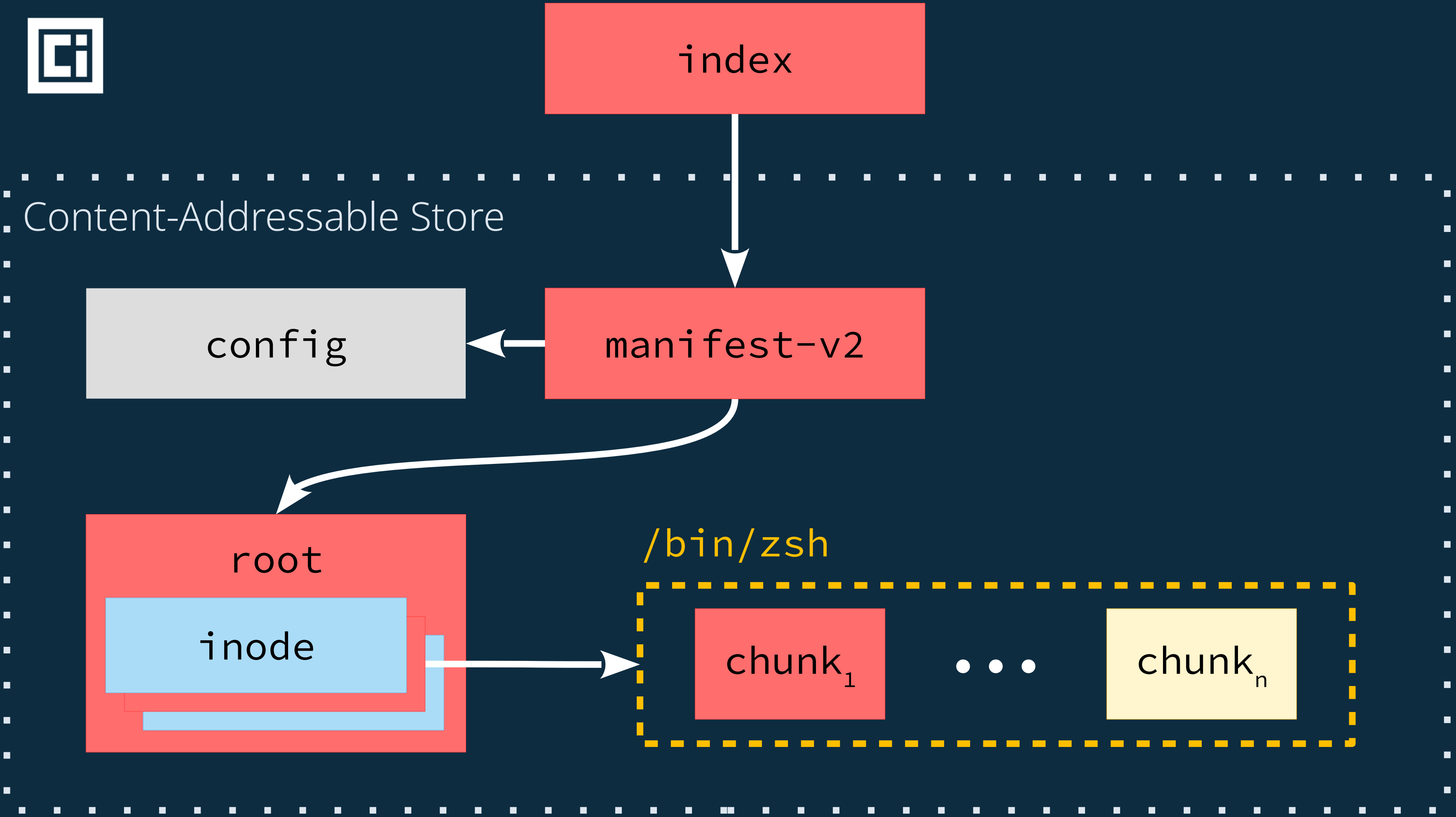
$\texttt{myimg}_2$

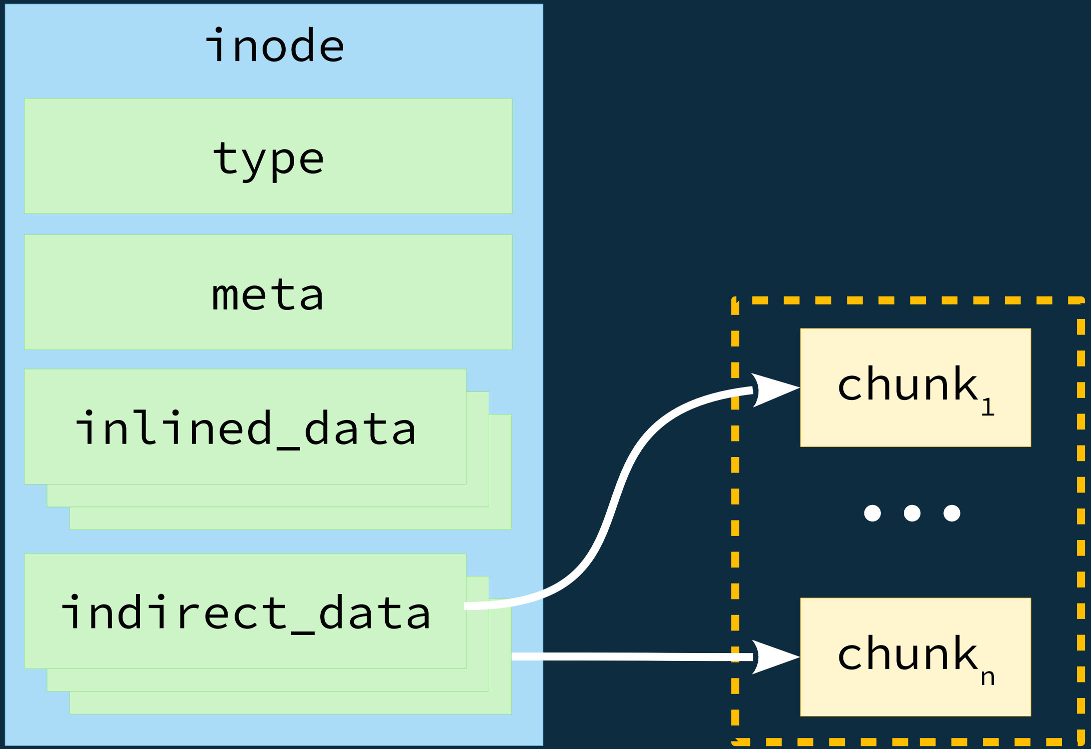
```
/foo/**
/usr/share/man/**
/usr/lib/libc.so
/opt/bar/**
```

What is the alternative?


index
Content-Addressable Store
config
manifest
layer$_1$
...
layer$_n$

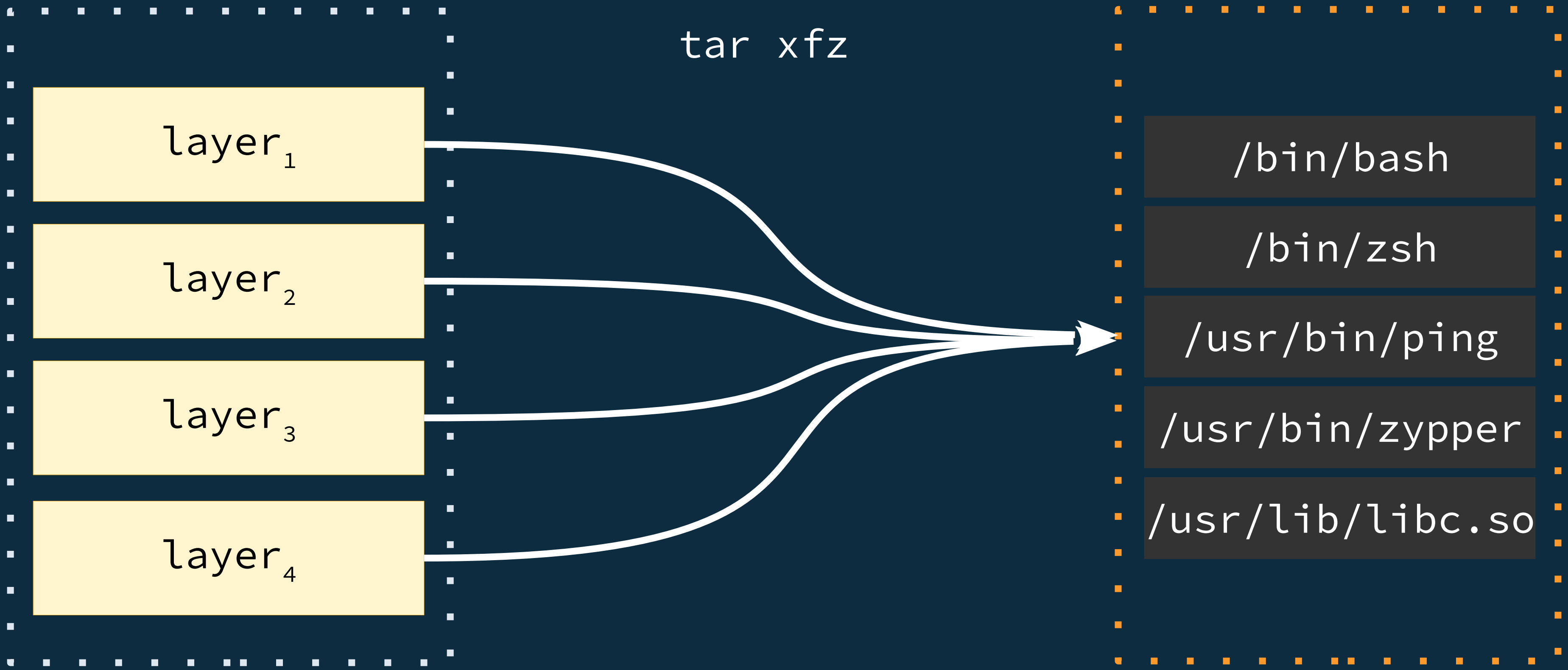

index
Content-Addressable Store
config
manifest-v2
root
inode
/bin/zsh
chunk$_1$
• • •
chunk$_n$


index
Content-Addressable Store
config
manifest-v2
root
inode
/bin/zsh
chunk$_1$
• • •
chunk$_n$


inode
type
meta
inlined_data
indirect_data
chunk$_1$
• • •
chunk$_n$

(v1)

Root Filesystem



layer$_1$

layer$_2$

layer$_3$

layer$_4$

`tar xfz`

/bin/bash

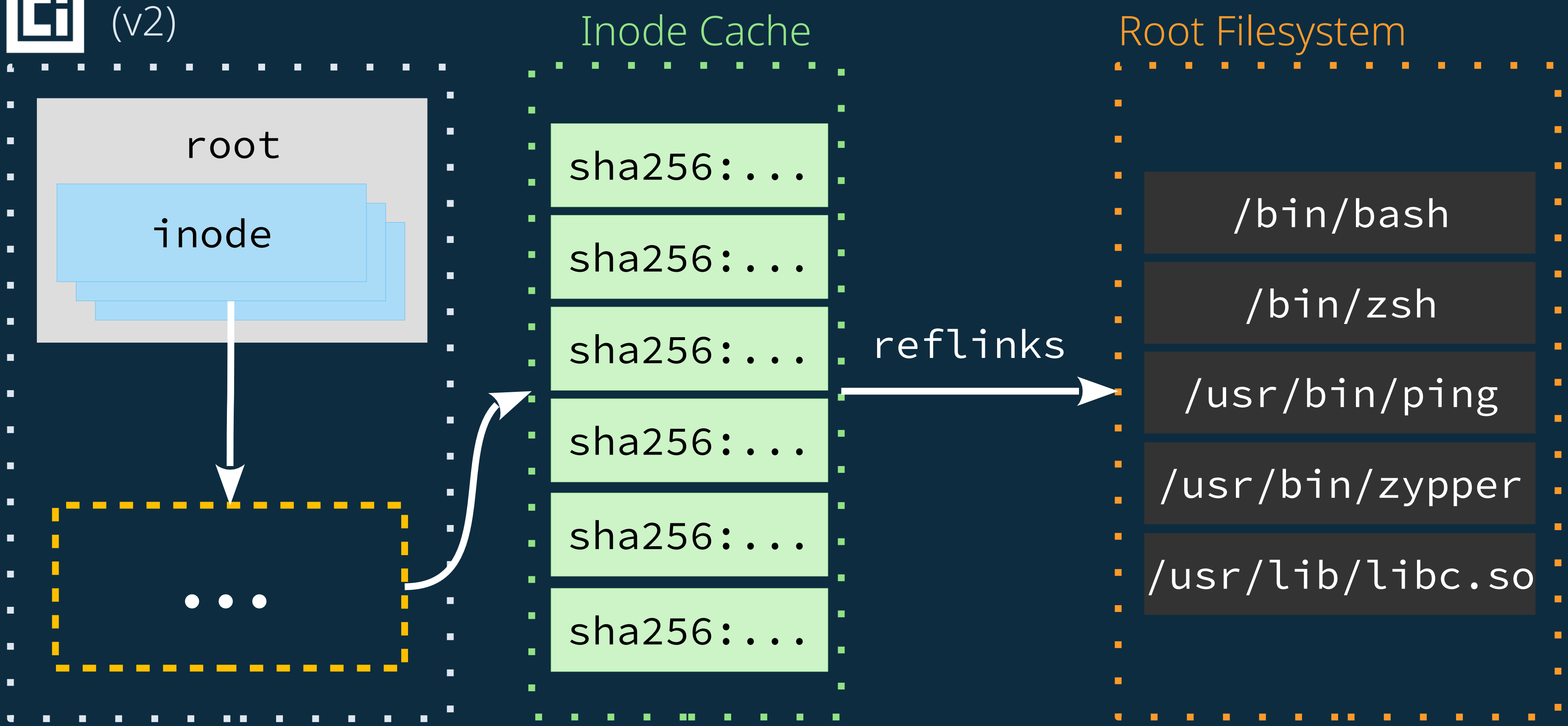
/bin/zsh

/usr/bin/ping

/usr/bin/zypper

/usr/lib/libc.so

(v2)



Inode Cache

Root Filesystem

root

inode

...

sha256:...

sha256:...

sha256:...

sha256:...

sha256:...

sha256:...

reflinks

/bin/bash

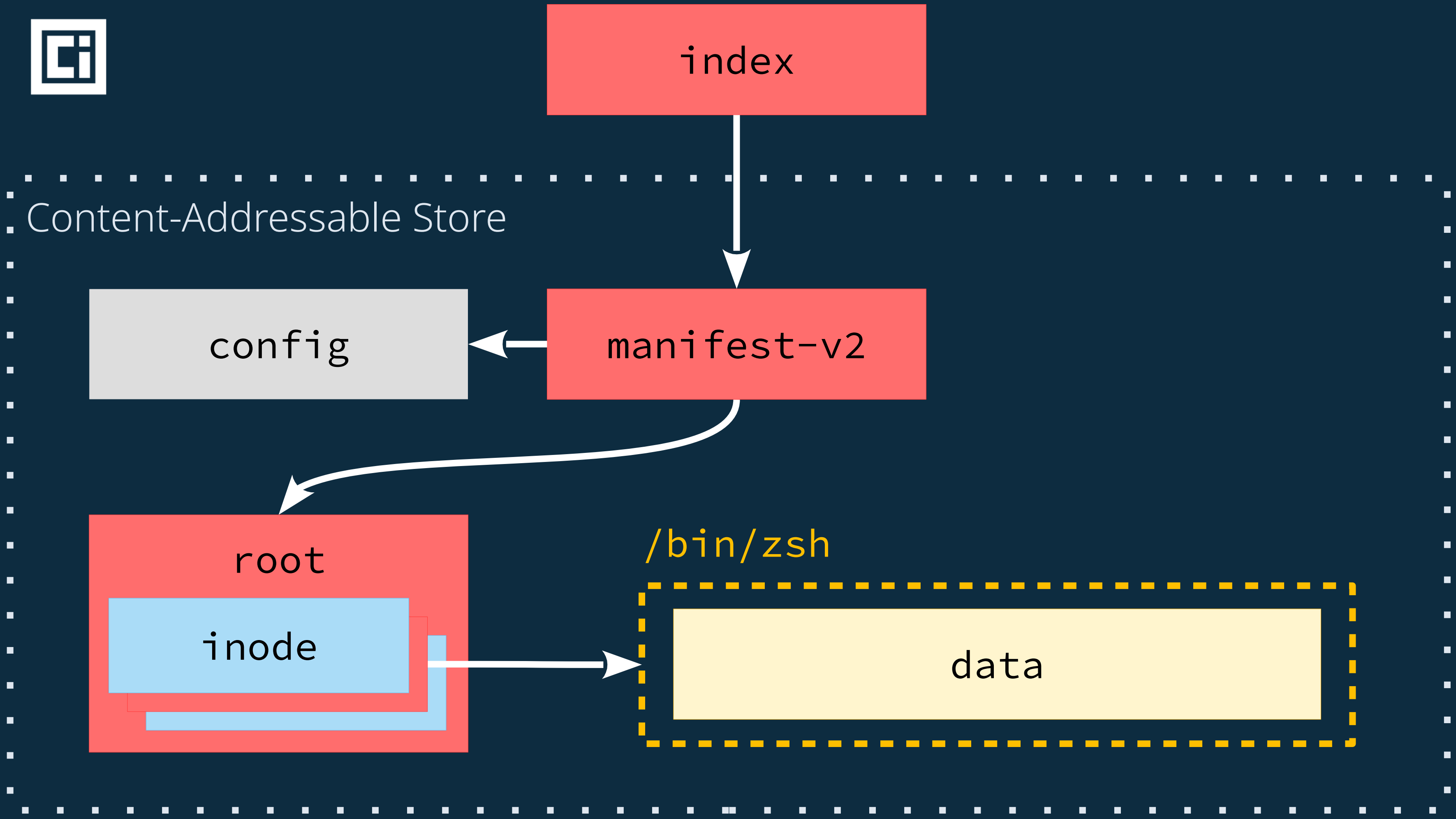
/bin/zsh

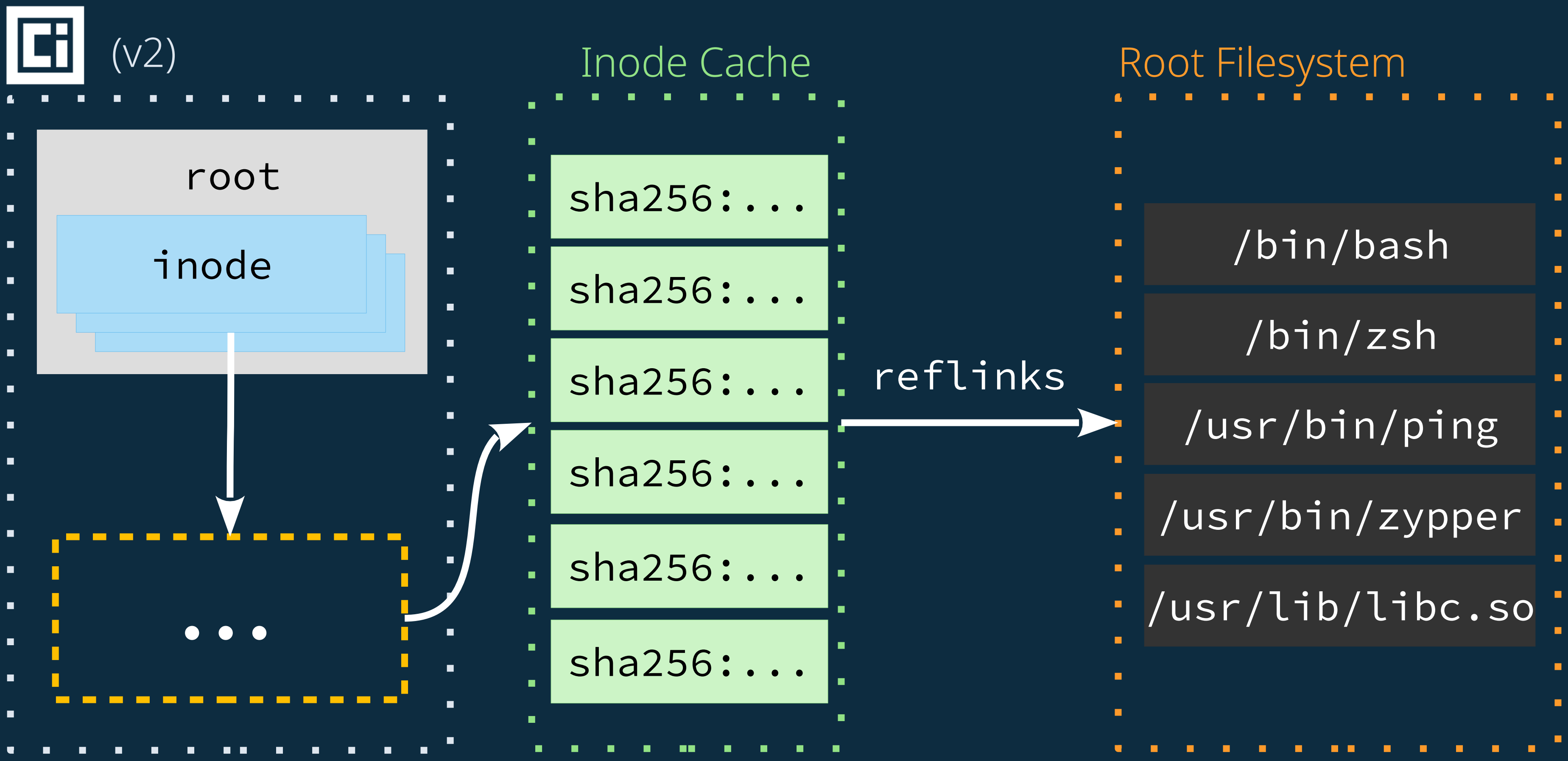
/usr/bin/ping

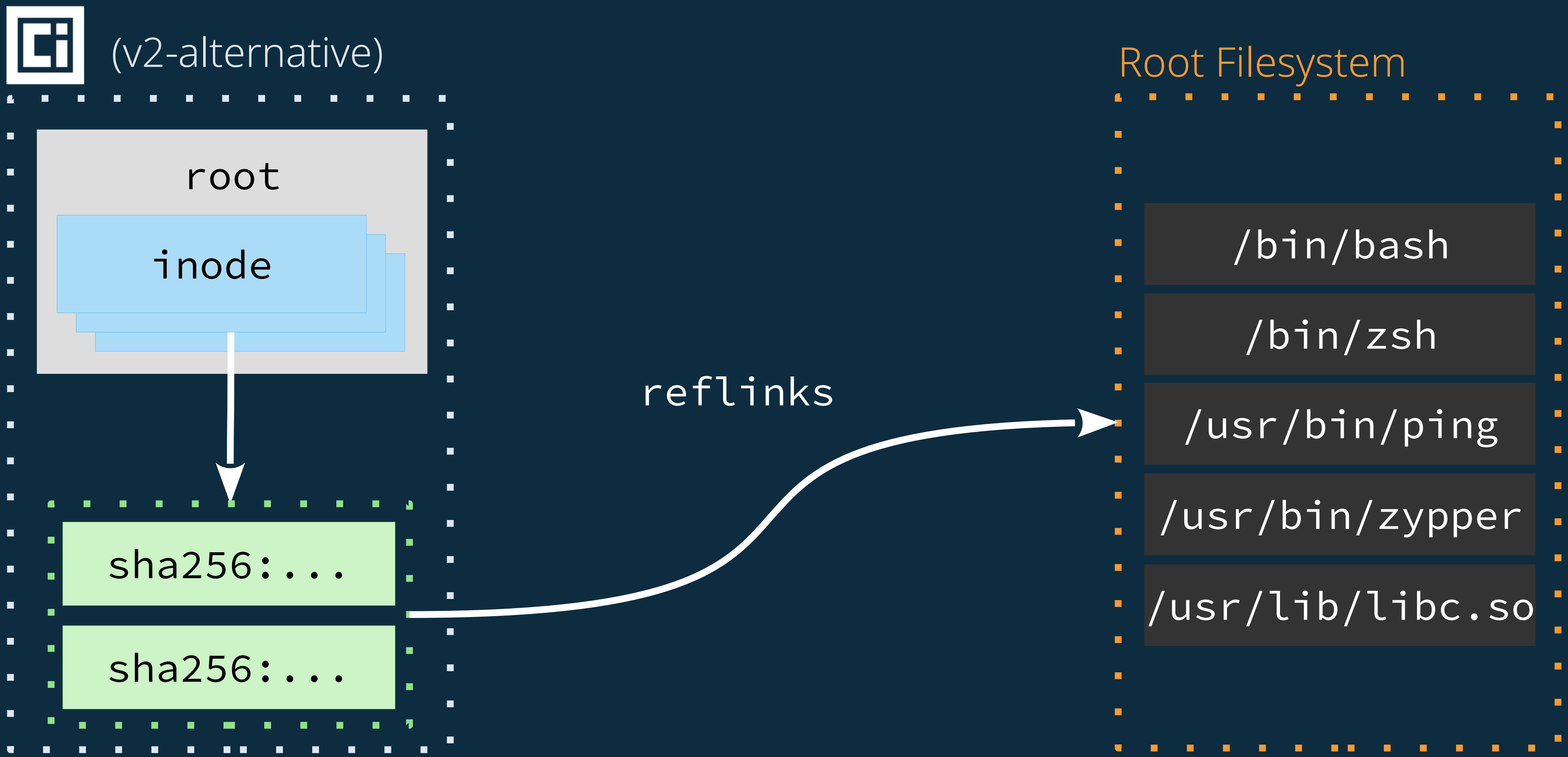
/usr/bin/zypper

/usr/lib/libc.so

Another alternative...


index
Content-Addressable Store
config
manifest-v2
root
inode
/bin/zsh
data

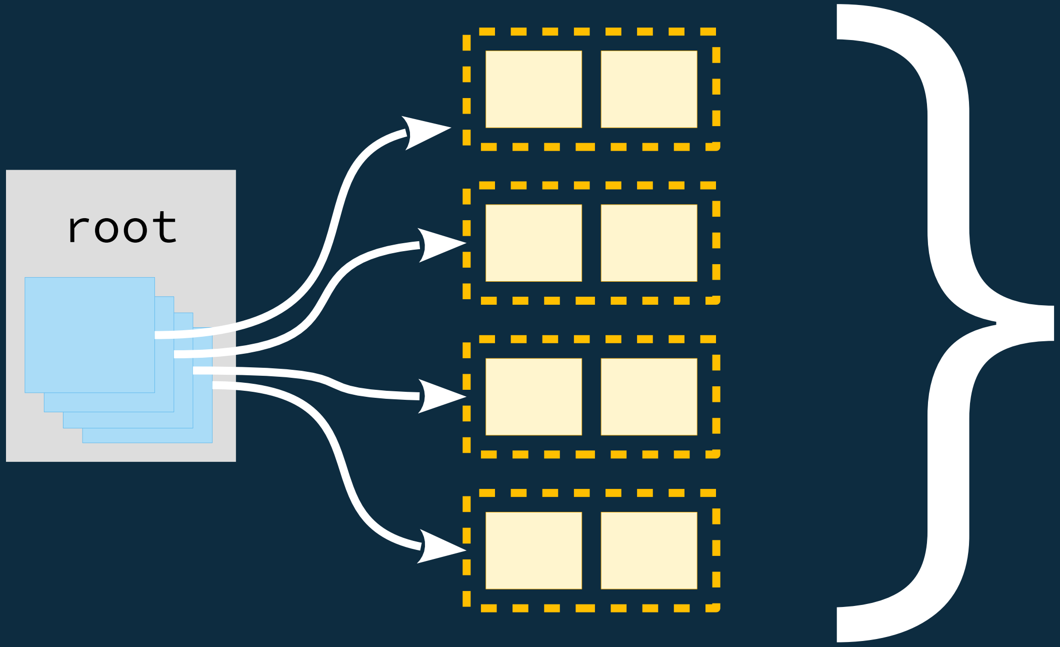

(v2)
Inode Cache
Root Filesystem
root
inode
...
sha256:...
sha256:...
sha256:...
sha256:...
sha256:...
sha256:...
reflinks
/bin/bash
/bin/zsh
/usr/bin/ping
/usr/bin/zypper
/usr/lib/libc.so


(v2-alternative)
root
inode
sha256:...
sha256:...
reflinks
Root Filesystem
/bin/bash
/bin/zsh
/usr/bin/ping
/usr/bin/zypper
/usr/lib/libc.so

Stop!

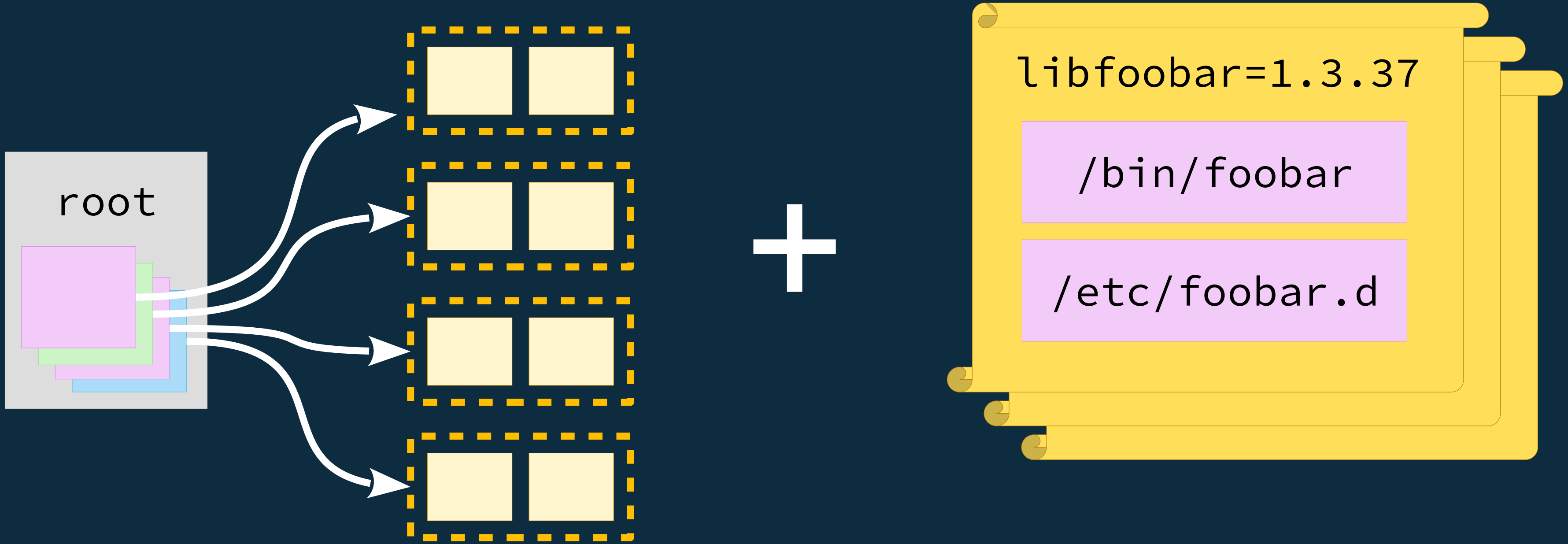
Demo time.

Bill of Materials



What is actually in this thing?

Bill of Materials



root

+

libfoobar=1.3.37

/bin/foobar

/etc/foobar.d

Yet More Alternatives...

- `catar` (from systemd) does attempt to solve similar problems.
  - Might be useful for transfer, but doesn’t match our reflink storage needs.
  - Maybe using a “single blob” model for transfer (like `catar`) would help.
    - OCI distribution could use HTTP Range requests.
    - Have a catar-like jump-table at the tail of the blob.

Where?

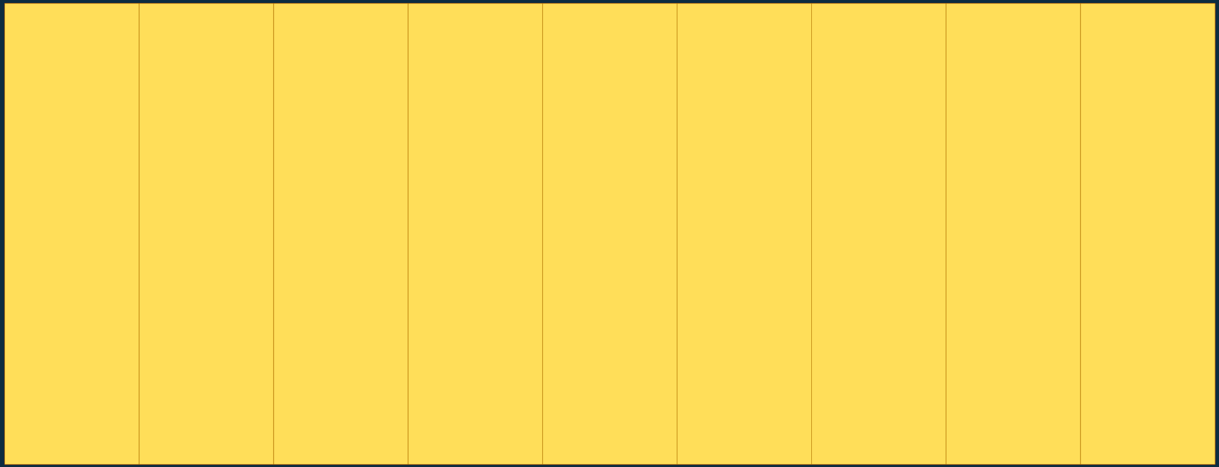
- `https://github.com/openSUSE/umoci`
  - There is a *very* experimental branch with the demo code.
- `https://www.cyphar.com/blog/post/20190121-ociv2-images-i-tar/`
  - The much more long-form rant about `tar`.
- `https://github.com/cyphar/talks`
  - Where you can get the slides later.

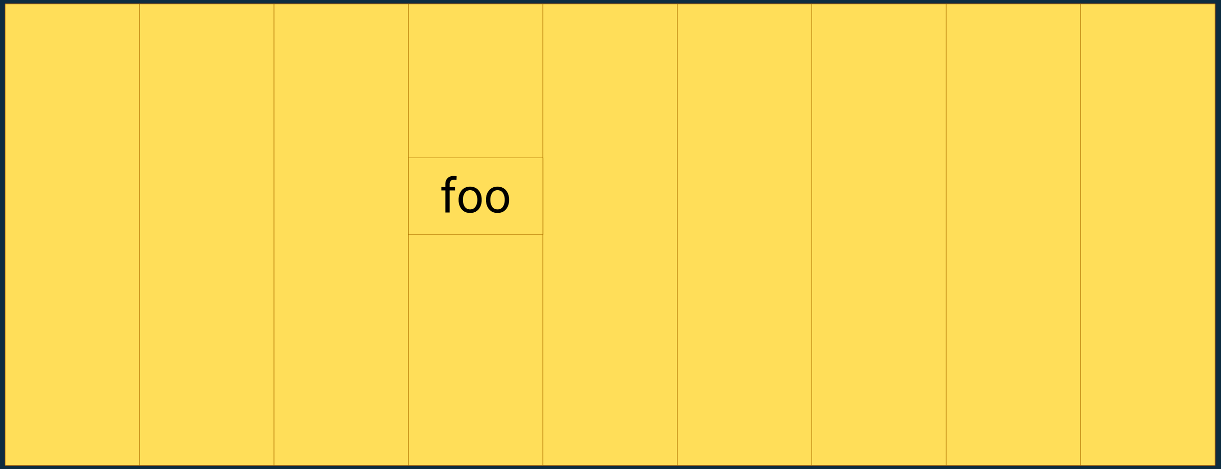
Next Steps?

- Reduce size of transfers (compression still beats us in many cases).
- Design the “bill of materials” format.
- Write a specification and submit it for review.
  - Make sure all possible users are happy with switching.
- Get everyone to switch.
  - This last one might take a while.

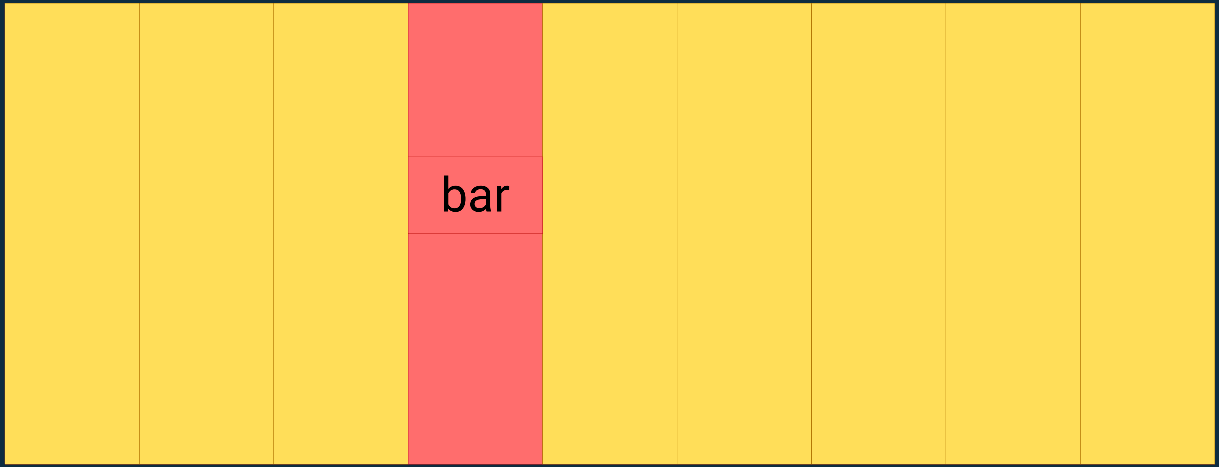
Questions?

Pictured: A Humble File.

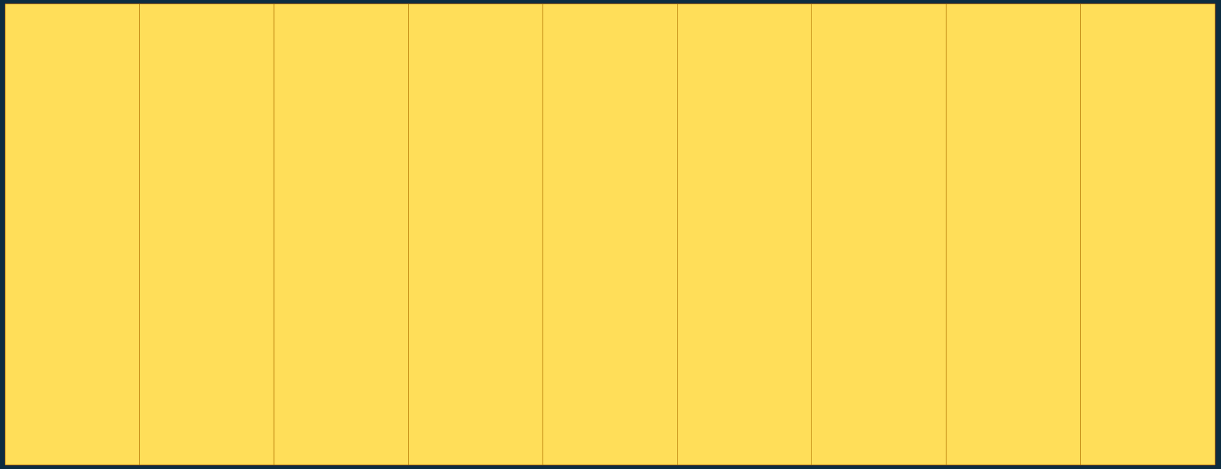


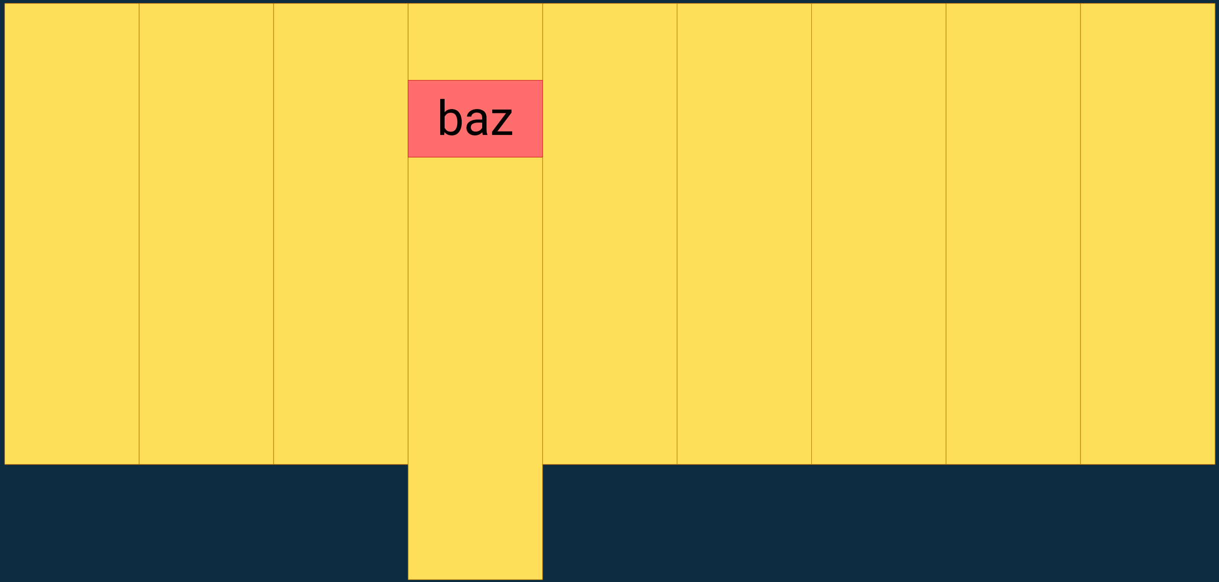


foo

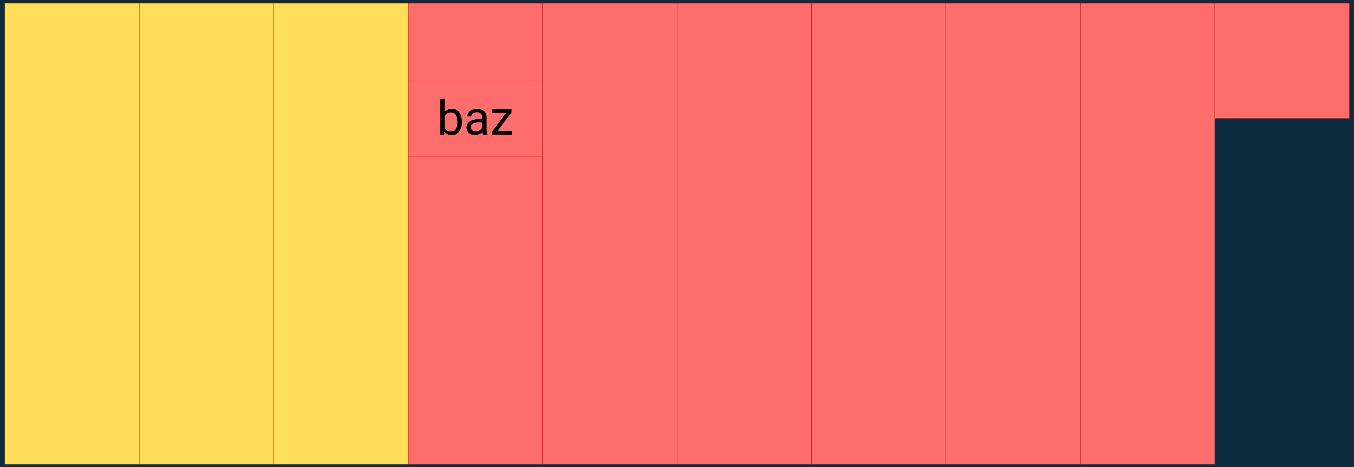


bar

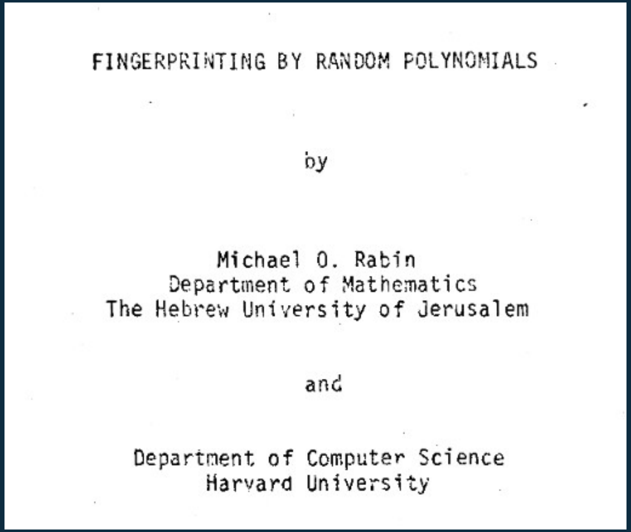




baz



baz



FINGERPRINTING BY RANDOM POLYNOMIALS

by

Michael O. Rabin
Department of Mathematics
The Hebrew University of Jerusalem

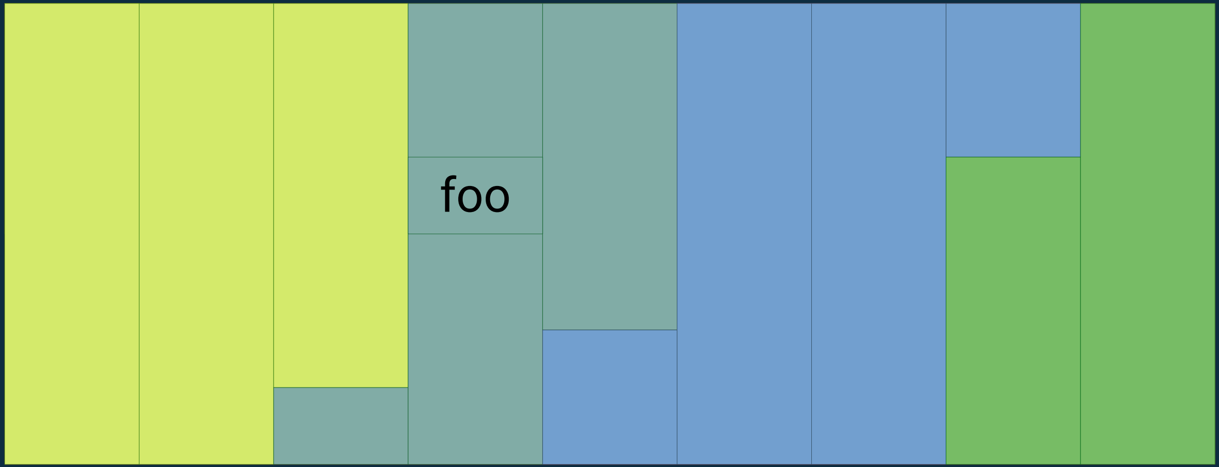
and

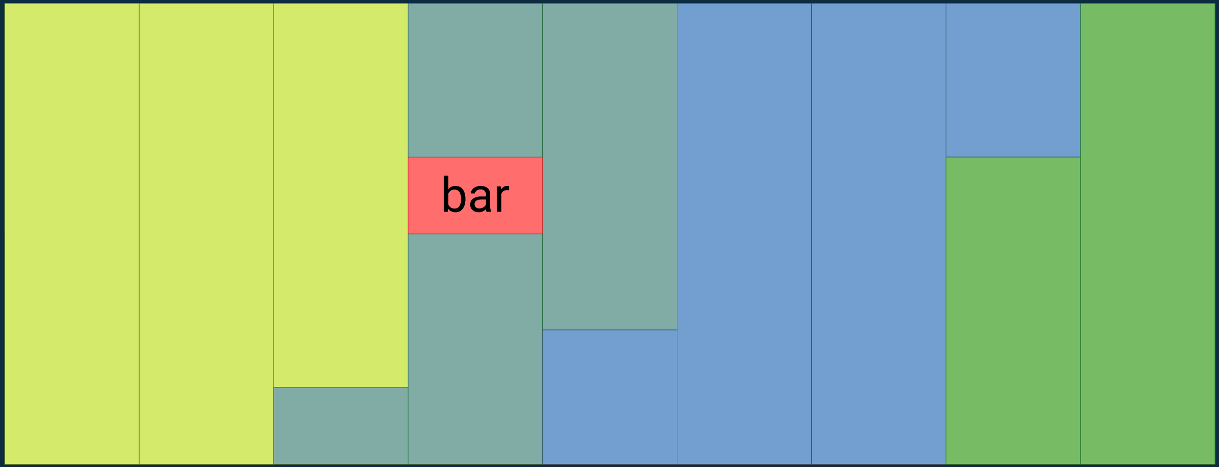
Department of Computer Science
Harvard University

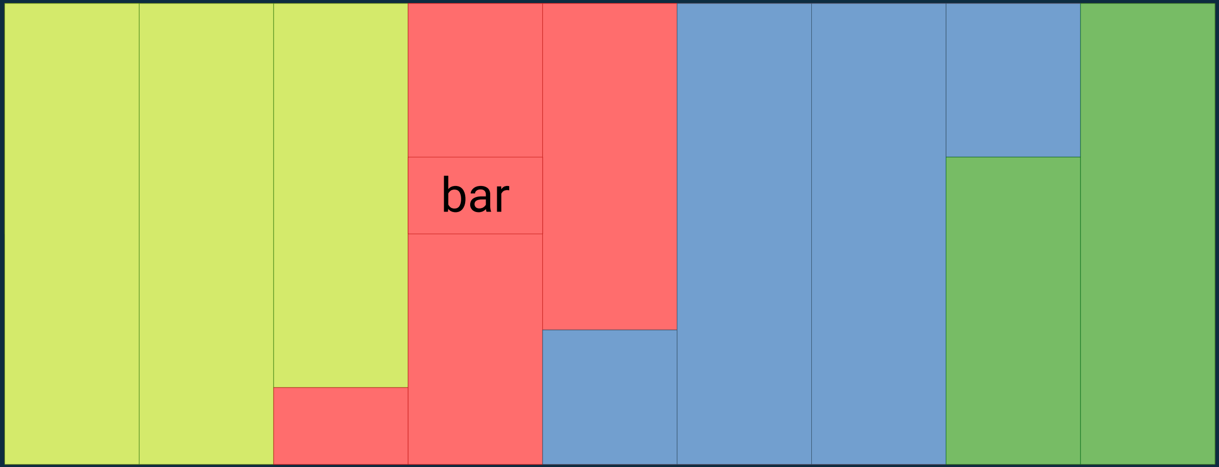
We have to go back (to 1981)!

Content-Defined Chunking

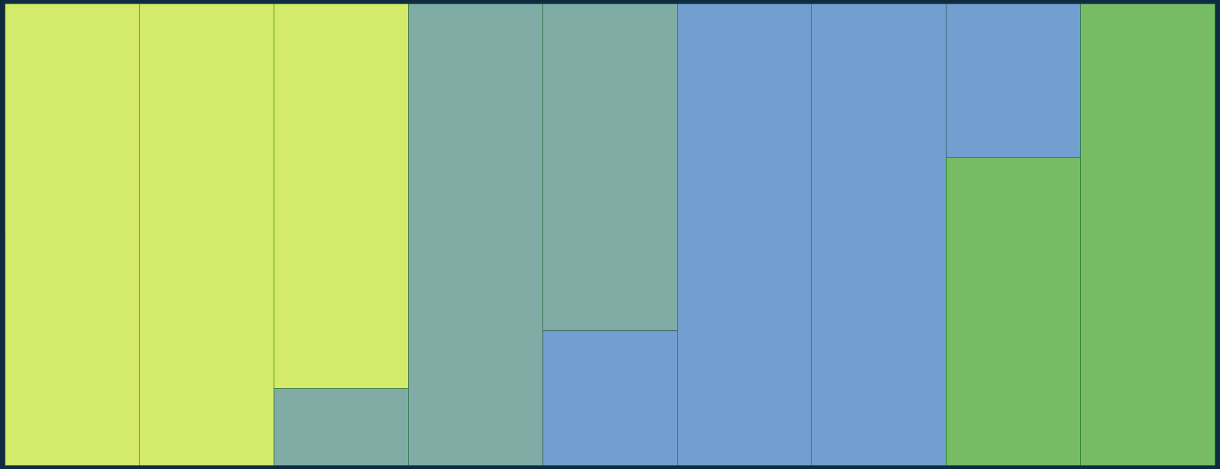
Pictured: A(nother) Humble File.

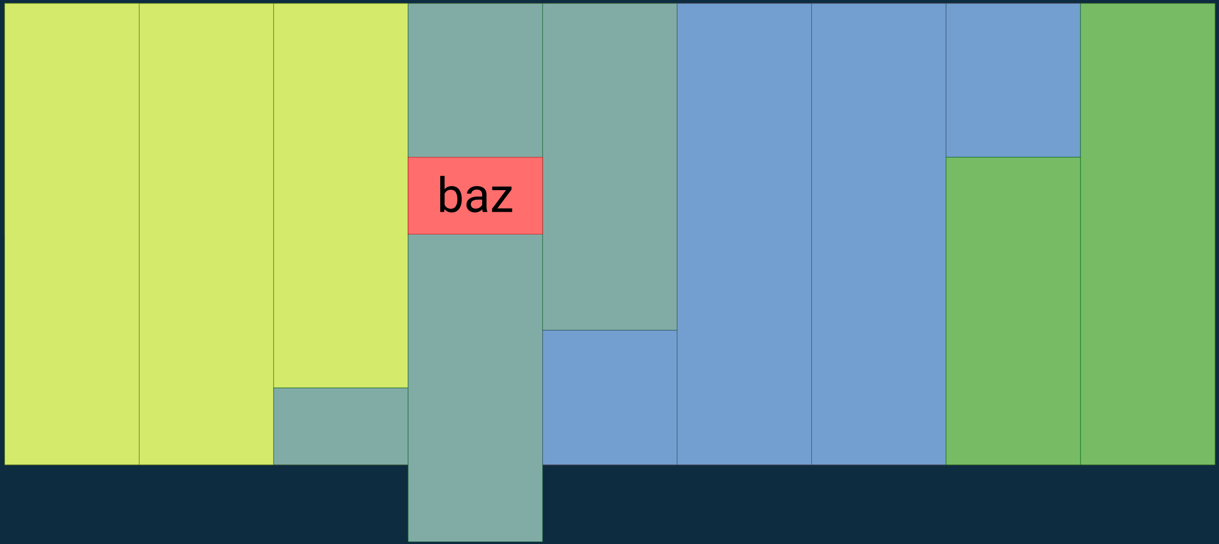

foo

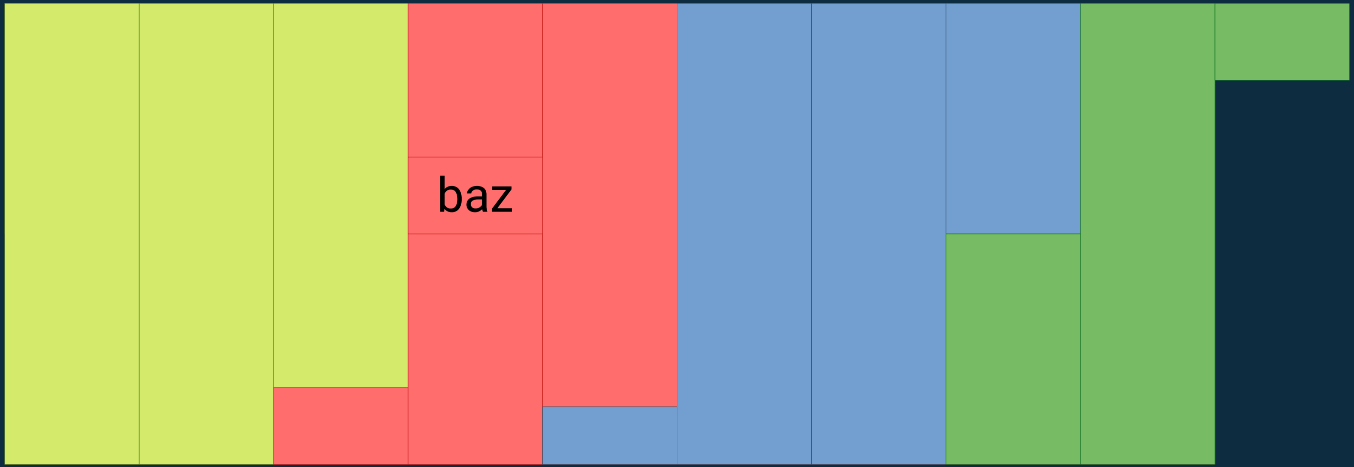

bar



bar




baz



baz