fs123

A scalable, read-only, network filesystem with pervasive caching

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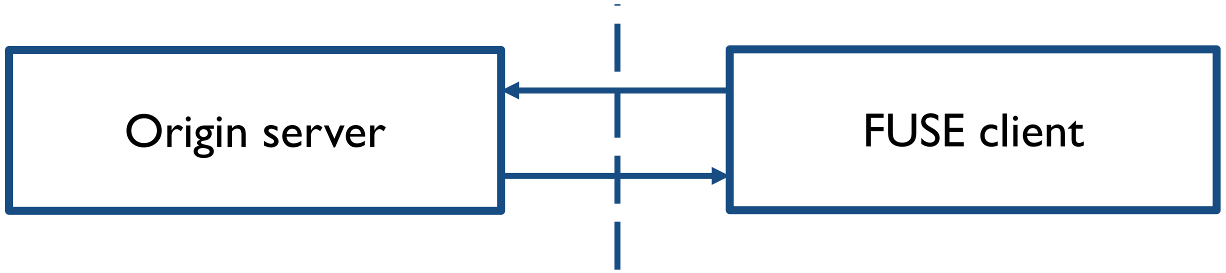
The Problem

- We have >15 petabytes of simulation data and >1 terabyte of code/binaries
  - Growing at ~10 terabytes/day and ~10 new software packages/versions/day.
- POSIX is non-negotiable for executables
- Read-only access is sufficient
- Three geographically distributed data centers, remote workers, laptops, …
  - NFS is a non-starter

The solution: fs123

- Read-only distributed POSIX filesystem
- How does it work?
  - Loosely-coupled client-server protocol built on HTTP
  - Client implements a Filesystem in USErspace (FUSE) filesystem
  - HTTP origin server exports a backend POSIX filesystem



- That’s it!

The fs123 protocol: map low-level FUSE callbacks to HTTP

FUSE client gets callback from kernel:

```
fuse_lowlevel_ops::getattr(req, ino, fi)
```

FUSE client translates that into HTTP (or HTTPS):

```
GET http://server/ID/fs123/7/2/a/some/file
```

Origin server replies with:

```
HTTP/1.1 200
        ...
        cache-control: max-age=86400, errno=0,
        uid=503, gid=503, mtime=1573923416, …
```

FUSE client translates the reply into:

```
fuse_reply_attr(ino, &stat, timeout=86400)
```

The software

- A single client binary (no special permission required)
  $ fs123p7 mount http://thesalmons.org:8888/ mtpt

- A single server binary (no special permission required)
  $ fs123p7exportd –port 8888 –export-root=/public/stuff

- About 10k lines of C++, available on github (2-clause license):

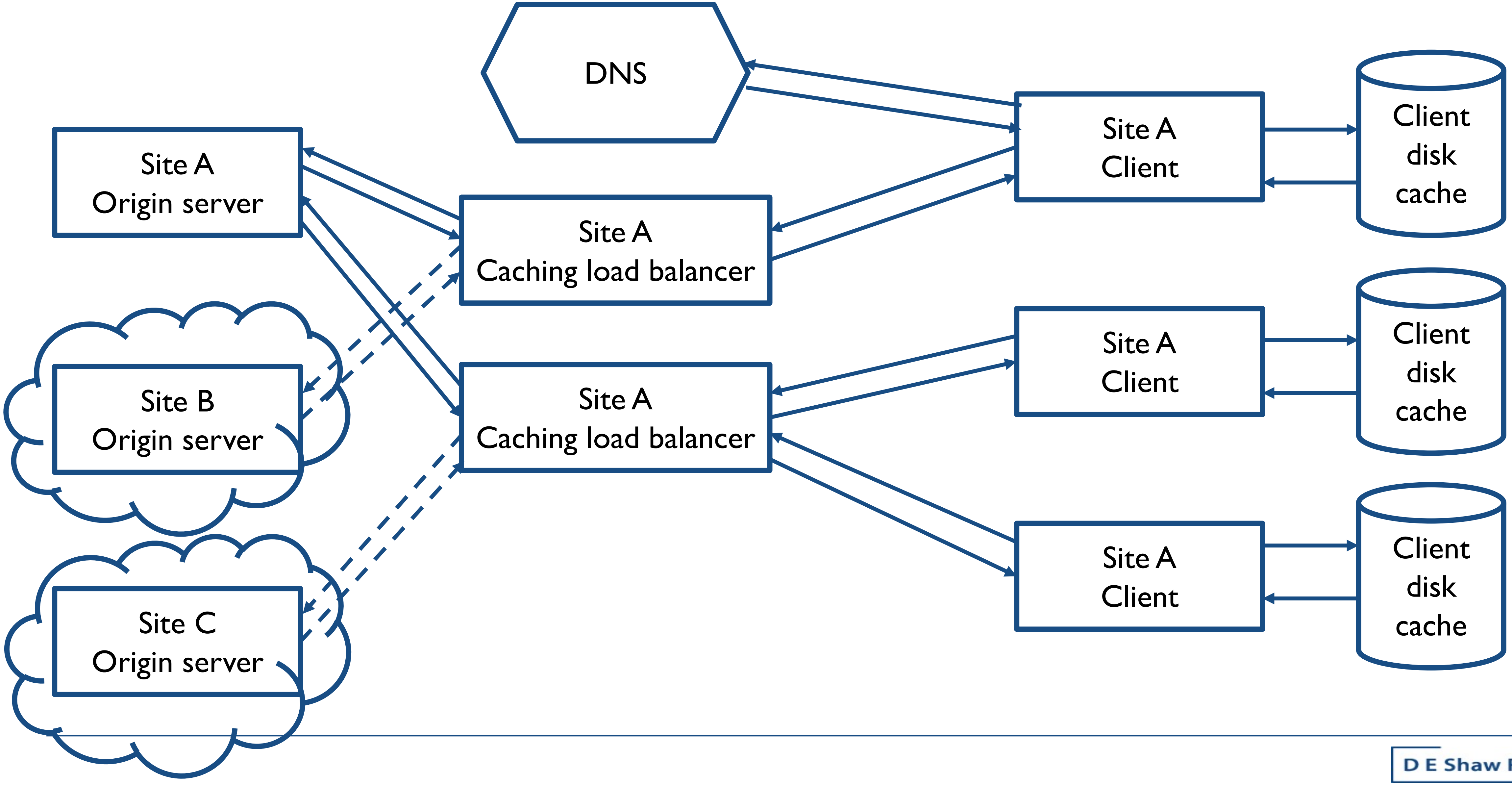
  https://github.com/DEShawResearch/fs123

- In production. Critical to our day-to-day scientific operations.

Why HTTP?

- Inherently wide-area
- Resilient on intermittent networks
- Standardized cache-management strategies
- Well understood by sysadmins

Well understood by sysadmins



Caching is essential for scalability

- Kernel caches
  - indispensable, require careful management
- Client-side disk caches
  - great for hiding network latency and coming back quickly after reboots
- Proxy caches (e.g., Varnish, Squid)
  - essential for wide-area operation

Caching would be easy if the data were immutable

- HTTP Cache-control (RFC7234) allows proxies to work read-only, mutable data
- fs123 adheres to RFC7234 for its kernel and disk cache
- RFC7234 is not quite enough:
  - Monotonic validator: "The file you're asking about has changed since the last time you asked about it, so you (the client filesystem) should flush everything you have cached about its contents".
  - Estale cookie: "The file you're asking about (by name) has disappeared (inode) since the last time you asked about it, so any attempt to see more of it must fail with errno=ESTALE."

Try it now

https://github.com/DEShawResearch/fs123

IF you're comfortable running a static Linux binary from my personal URL:

```
$ wget https://thesalmons.org/fs123/fs123p7 && chmod +x fs123p7
$ mkdir mtpt c
$ ./fs123p7 mount –oFs123CacheDir=c http://thesalmons.org:8888 mtpt
# look around in mtpt:  ls, find, cat, emacs (read-only)
# if you feel lucky, and have devel versions of libevent, libcurl libsodium
$ mkdir build; pushd build
$ make –f ../mtpt/GNUmakefile
 # it's a fuse daemon.  To shut it down, do:
$ fusermount –u ../mtpt # or, in a pinch, pkill -9 fs123p7
```