A journey to performance

Using Rust in Mercurial

FOSDEM 2021

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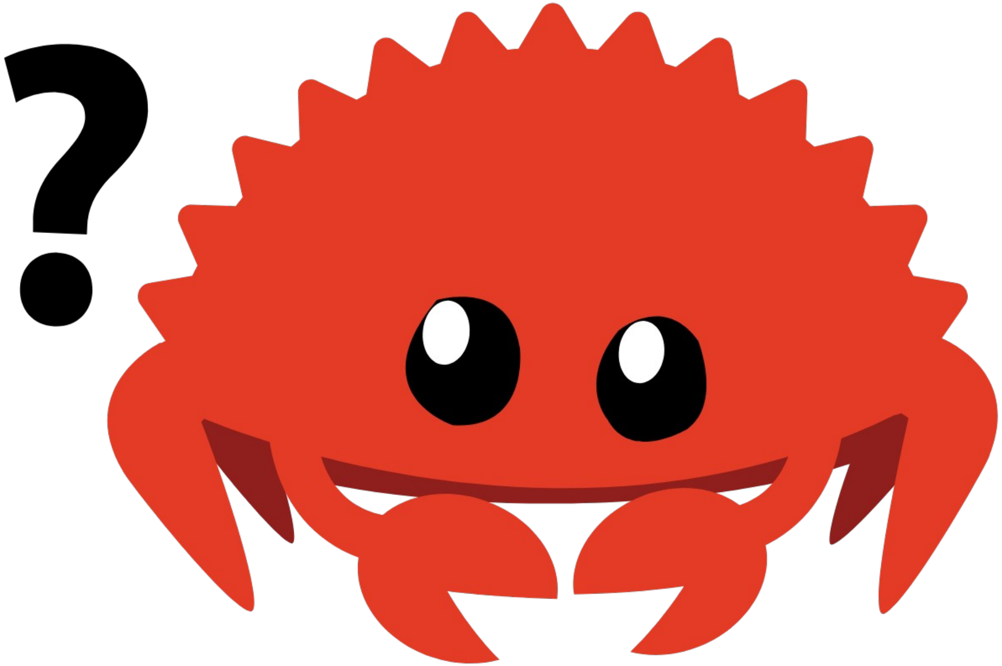
Mercurial refresher

- Version Control System started in 2005
- Written in Python (200k lines)
- Boosted by C extensions (45k lines), and now Rust (60k lines)
- Handles huge repos with millions of files and/or revisions
- Very powerful extension system

Why Rust?



Maintainability

Compared to C

- Better signal/noise ratio
- Better compile-time guarantees
- Standardized and modern tooling
- "Memory-safe" by default (<u>unsafe</u> blocks)

Performance

- It’s the main topic of this talk
- Compiled so no startup
- Little to no runtime
- “Zero-cost” abstractions
- Multithreading is a lot easier

Attacking the Python from both sides

- Build Rust extensions called from Python for hot paths
- Python ↔ Rust interop using the rust-cpython crate
- Wrap Python with a Rust executable for fast paths using PyOxydizer

The case of « hg status »

The « status » command

- Purpose: show the changed files in the working directory
- Possible values: modified, added...
- Has to compile the .hgignore patterns into one big regex
- Has to check every tracked file for changes and show untracked files (default)

hg status example

```
$ hg st
A new-file
M modified-file
? unknown-file
```

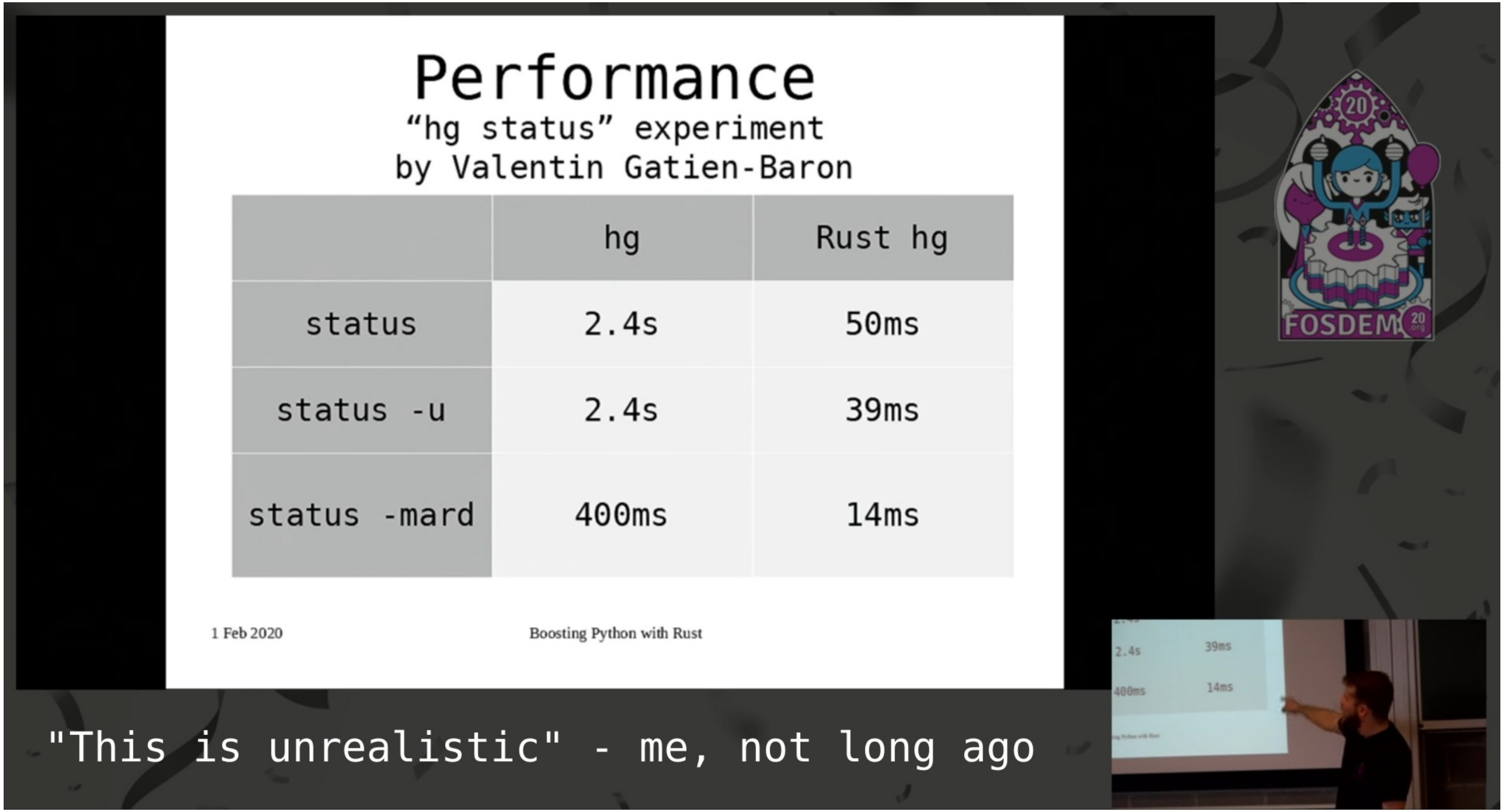
Last year

- Re-implemented parts of the dirstate in Rust
- Used multithreading in traversal for a considerable speedup
- Created and used shared Rust+Python iterators

Previous milestones

- Up to 4x faster with Rust extension
- Available in CentOS and Gentoo
- Used on foss.heptapod.net
- Google employees showing strong interest

Previously at FOSDEM 2020



Not so unrealistic

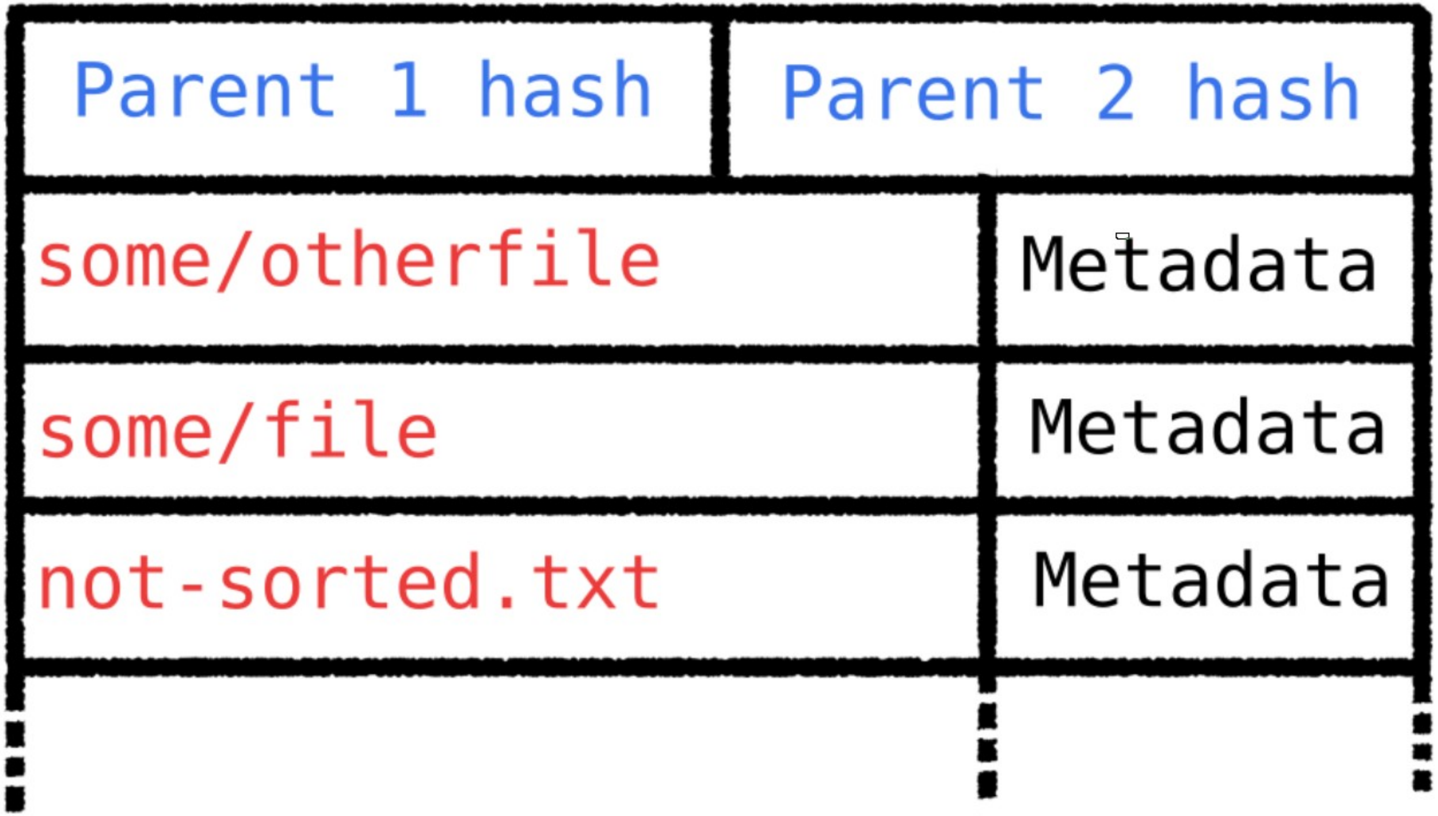
	hg	Experiment	New Rust
Mozilla clean	1.151s	73ms	44ms
Mozilla dirty	2.129s	203ms	64ms
Pathological	7.334s	973ms	53ms

How « status » works

The dirstate

- Very naive approach: open all tracked files and compare the content with the Mercurial store
- Better: store the size, exec bit, mtime and state (added, removed, etc.). This is called the **dirstate**
- Has not been changed since 2005, has a flat structure

Current dirstate structure



Old algorithm

- Walk and check the working directory respecting ignore rules, yielding the results of any file encountered
- Check if any files in the dirstate that were not seen on disk: they were deleted, ignored, under a symlink.

Issues with this approach

- Expensive mapping to compare it to the dirstate, itself expensive to build (tens of ms)
- Expensive ignore and security check
- Iterating more than once over the dirstate

A better datastructure

Let’s build a tree instead to mirror the working directory:

- Allows for a unified iteration
- More efficient ignore rules
- Symlink substitution and nested .hg are very cheap to ignore
- Status in a directory comes for free

Implementing a new dirstate

Components of the Tree

Disk data containing full nodes

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struct Vault<'a> {

Reference

Vec of full paths

}

Components of the Tree

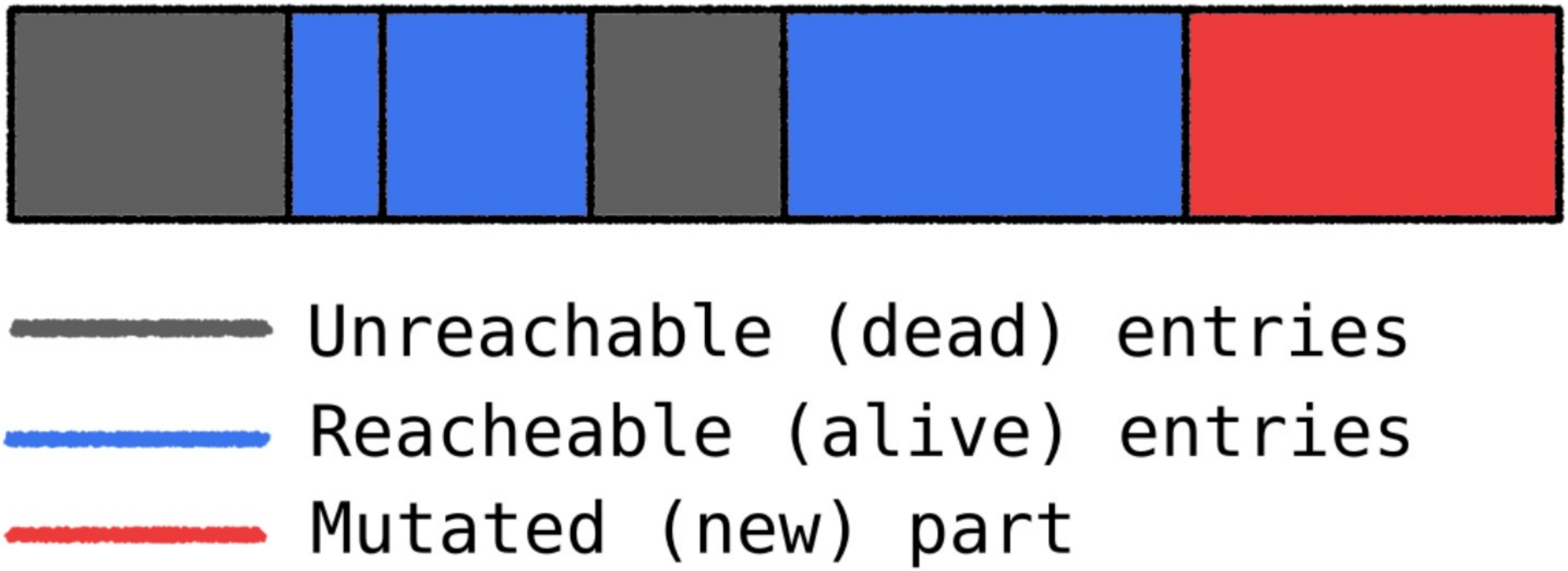
Disk data containing full nodes

```
struct Vault<'a> {
    Reference
    Vec of full paths
}
```

```
struct OnDiskNode {
    start: VaultKey,
}
```

```
struct InMemoryNode {
    path: VaultedPath,
    children, state, etc.
}
```

Append-only on-disk storage



Append-only on-disk storage

- Used in Mercurial since the beginning (Revlog)
- Also works with dynamic sized entries
- Once the unreachable parts become too large, re-write everything (vaccuum)

Transactionality

- There are two files per storage
- A small atomic « docket » file keeps track of metadata (generation, size, root node offset, etc.)
- A data file with a unique name per vacuum cycle

Memory mapping

- Memory usage stays the same with multiple processes
- Append-only: don’t have to worry about truncation
- Basically removes read time

Removing « build time »

- Mmap is basically free most of the time
- Keep the full paths, don’t compress the roots: no allocation needed
- Only new nodes are allocated

Other optimizations

Fast directory traversal

- Recursive implementation with 1 task per directory (naive)
- Iterative walk is more complicated and will probably not be useful
- Using rayon’s threadpool: easy
- crossbeam-channel for the results

Mtime caching

- Compare the mtime of directories with the cached version
- If different: need to read the dir, otherwise just stat the children, then recurse
- Can even cache unknown/ignored files

Mtime caching

- Only works with certain OS/filesystem pairs
- Needs to be properly invalidated (parents changes, moved in FS, new ignore rule, etc.)

Let’s recap

Building the tree

- Open the docket and read it
- Mmap the corresponding data file
- The Vault already knows how to access the data, it does not need to be read first
- The root node is given by the docket

Checking the working copy

- Iterate over both the dirstate and the working copy
- Check for any relevant differences
- Directory → symlink checks are free when using mtime caching
- Send the results with a channel from all threads

Performance (POC)

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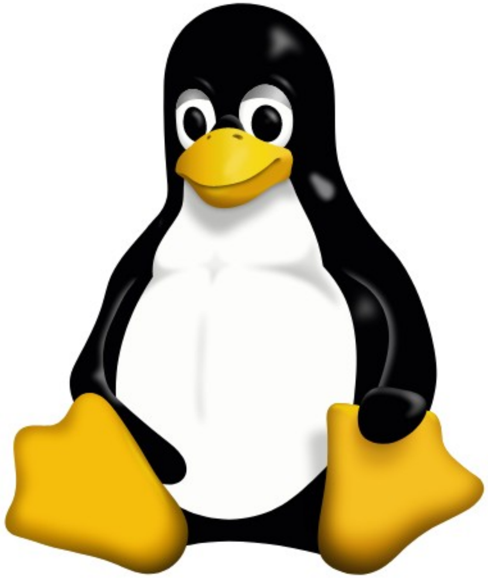
Dirstate is used in many commands

- Commit
- Diff
- Update
- Purge
- Files
- etc.

Linux is the simpler platform



Paths, filesystems, IO

- Paths are just plain bytes in Linux
- Great filesystems like BTRFS
- On MacOS: unicode normalization issues, case sensitivity
- Windows, above issues + file IO is very slow and has more footguns with transactionality

Linux is faster, but could be faster still?

- Using getdents64 directly instead of the (most likely) slower opendir/readdir loop/closedir
- A lot of our time is spent in system instead of user
- Is fstatat/openat faster because it doesn’t have to re-walk the tree?

Mercurial
is always getting faster

Other Rust endeavors

- Ancestor iteration (up to 3x perf in discovery)
- Copytracing (up to 20x speedup)
- Nodemap (up to 2000x speedup in index lookups!)
- hg cat (more than 10x speedup)
- hg files (more than 10x speedup)

Non-Rust endeavors

- Cloning needs 40 % less RSS memory
- Sparse-revlog (up to 99 % reduction of manifest size)
- New revlog format (fewer files, better information)
- New branch cache, etc.

Keep an eye out
In the next few months

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Thank you!

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