

# Verifying filesystems in ACL2

Towards verifying file recovery tools

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# Overview

1. Why we need a verified filesystem
2. Our approach
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# Why we need a verified filesystem

- ▶ Filesystems are everywhere.
- ▶ Yet they're poorly understood - especially by people who should.
- ▶ Modern filesystems have become increasingly complex, and so have the tools to analyse and recover data from them.
- ▶ It might be nice, it might be nice to verify that the filesystems and the tools actually provide the guarantees they claim to provide.

# Our approach

- ▶ Build a series of models, each providing a minimal set of operations and proofs of correctness of these operations.
- ▶ Per Ghemawat et al in SOSP 2003, a minimal set of operations can suffice - create, delete, open, close, read, and write files.
- ▶ Increasing the complexity of these operations with each model while proving equivalence with the previous model as we go would make the proofs tractable.
- ▶ There are many properties that could be considered for correctness, but the read-over-write theorems from the first-order theory of arrays seem like a good place to start.
  1. Reading from a location after writing to the same location should yield the data that was written.
  2. Reading from a location after writing to a different location should yield the same result as reading before writing.

# Progress so far

- ▶ We've built three models, with the operations read, write, and delete.
  1. In the first model, we represent the filesystem as a tree, allow for text files (stored as strings) and directories only, and store no metadata.
  2. In the second model, we add some metadata to our tree representation - namely, file length. We introduce a rudimentary fsck and prove that our operations of writing and deleting preserve correctness under fsck.
  3. In the third model, we retain the tree but also introduce an unlimited "disk" of fixed-length character blocks. We do away with the explicit strings holding the contents of text files and instead store lists of block indices in the tree.
- ▶ For each of these models, we have proofs of correctness of the two read-after-write properties, based on the proofs of equivalence between each model and its successor.

# Future work

- ▶ Add the create operation, and possibly open and close with the introduction of file descriptors in future models.
- ▶ In the next model, finitise the length of the disk and garbage collect disk blocks that are left unused after a write or a delete operation.
- ▶ In future models, linearise the tree, leaving only the disk.
- ▶ Eventually emulate the CP/M filesystem as a convincing proof of concept, and move on to fsck and file recovery tools.