

1 Background & Motivation

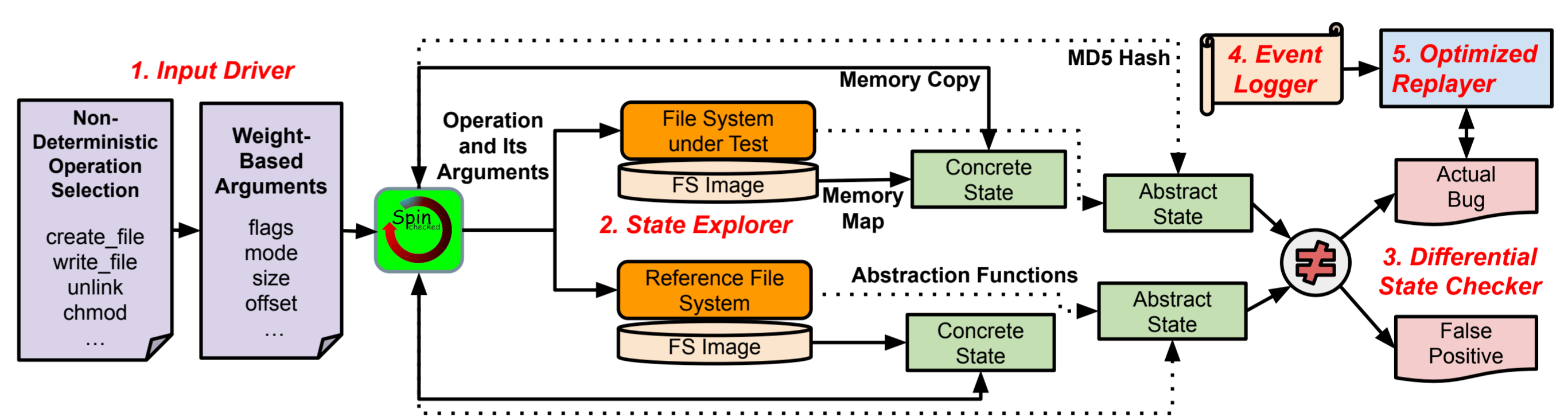
- File system bugs have serious consequences
- Existing testing methods for file systems
 - Regression testing; Model checking; Fuzzing; Automatic test generation; Static analysis
 - Limited **input** and **state** space coverage
 - Other restrictions:
 - Creation of an abstract model or a checker
 - Kernel instrumentation or modification
 - Scalability & bug reproduction

2 File System Inputs & States

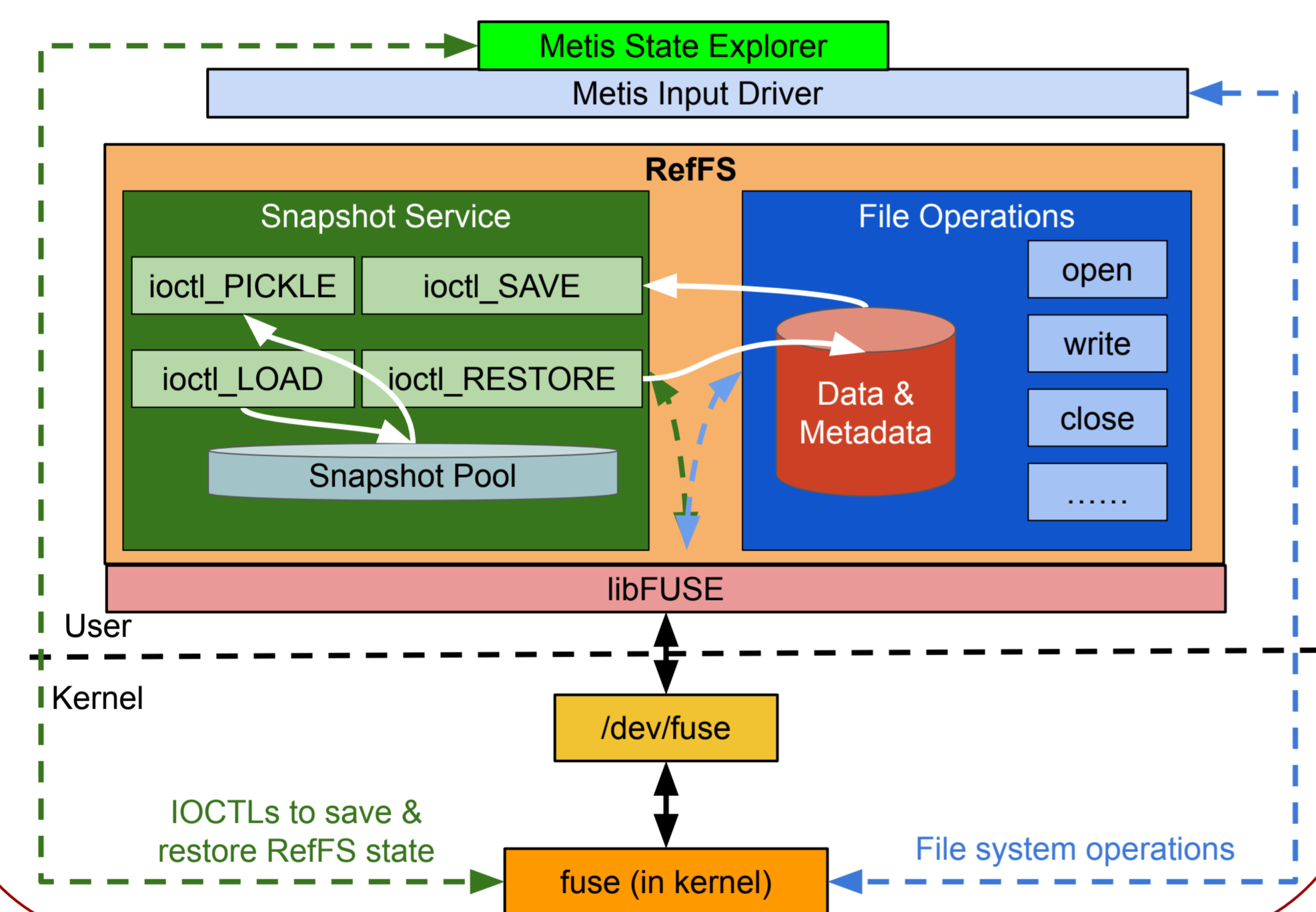
- Executing various inputs under different states
- File System Test Inputs
 - File system syscalls: huge argument space
 - Input space partitioning
 - Identifiers, bitmaps, numeric, categorical, etc.
- File System States
 - File system's content, status, and context
 - State definition: tradeoff between integrity and efficiency
 - Avoid testing duplicate states

3 Metis Design and Implementation

- Combination of *model checking* and *differential testing*
 - Generation of versatile inputs
 - State exploration on both file systems
 - Comparing abstract states for bugs
 - Logging operations and discrepancies
 - Simplified bug replay

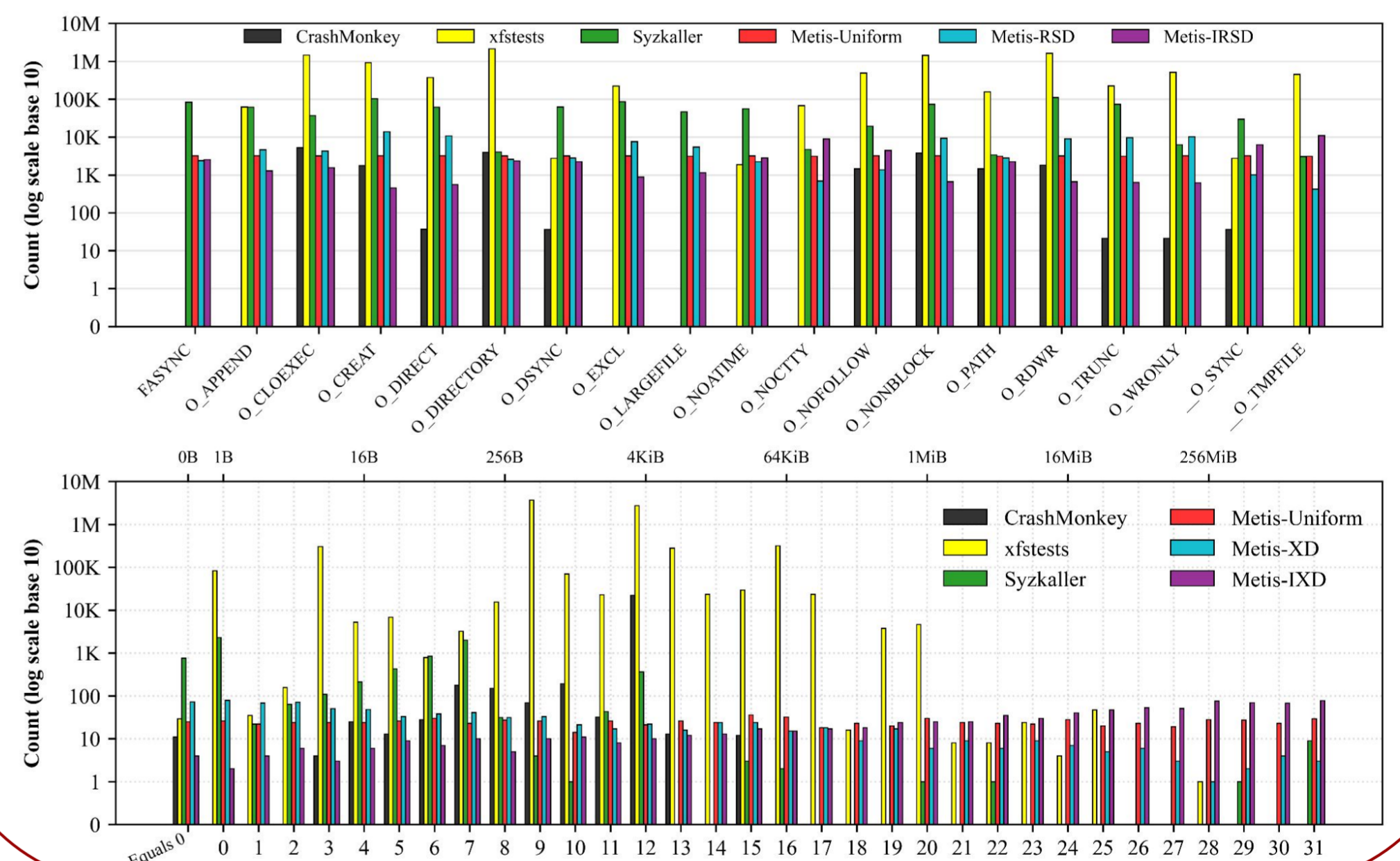


4 RefFS: Reference File System

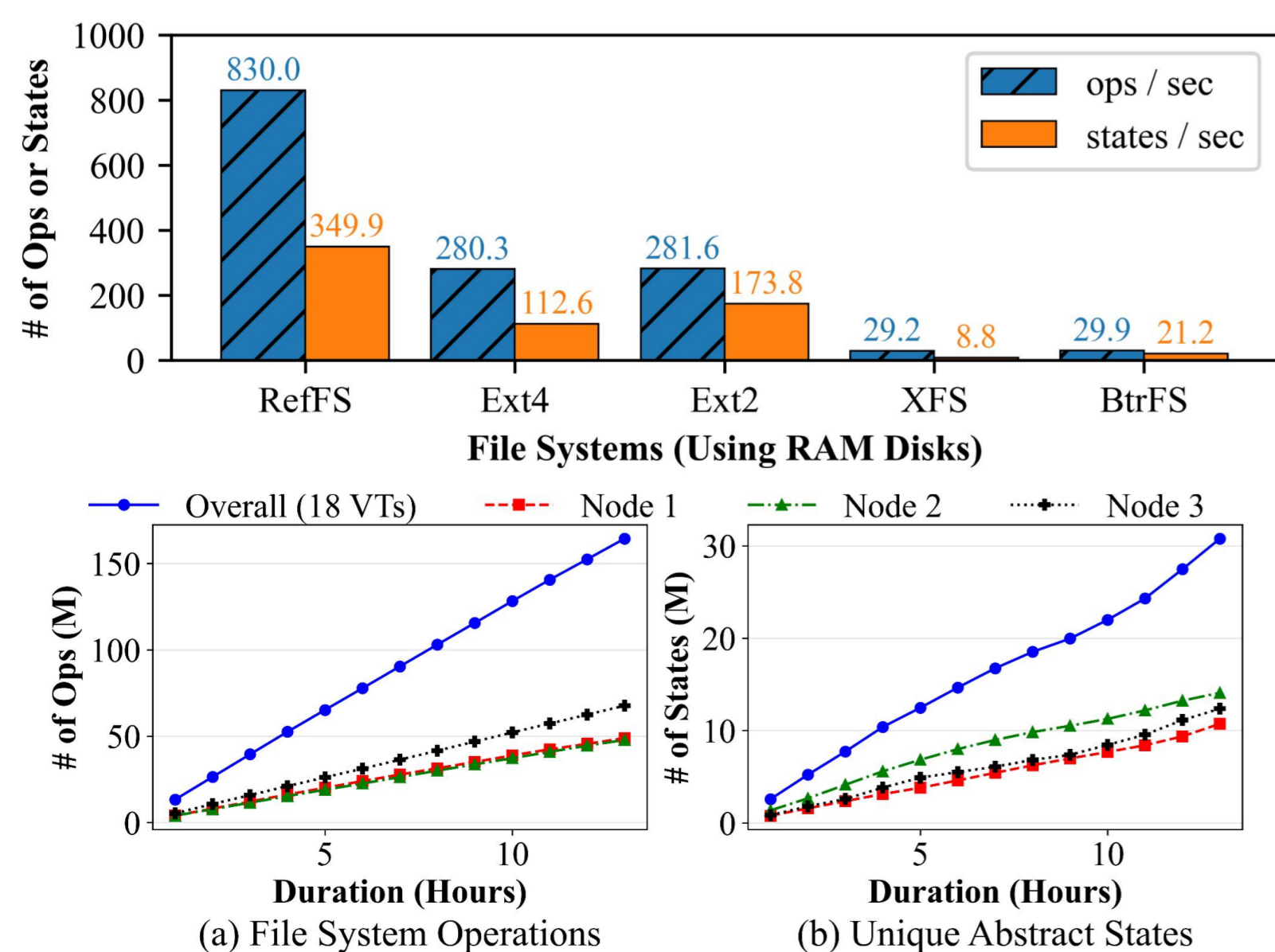


5 Evaluation: Test Input Coverage

- Completeness & Versatility (40 mins)



6 Eval: RefFS & Metis Performance



RefFS: 3–28X perf improvement vs. existing file systems
Swarm: scales state exploration nearly linearly across nodes

7 Bug Finding & Future Work

- Found and fixed 11 RefFS bugs using Ext4 as reference
- Bug Finding for Existing File Systems
 - Used RefFS as the reference for Metis
 - Checked nine other file systems; identified bugs in seven
 - BetrFS, F2FS, JFFS2, JFS, NILFS2, NOVA, PMFS
 - Found 15 bugs: six confirmed and 13 previously unknown
 - Behavioral discrepancies, kernel crashes, deadlocks, etc.
- Future Work
 - Crash-consistency & concurrency bugs
 - Fault injection & controlled file-system corruptions

- Artifacts Available, Artifacts Functional, Results Reproduced
- Metis and RefFS are open-sourced at:

<https://github.com/sbu-fsl/Metis> and <https://github.com/sbu-fsl/RefFS>