Motivation: Data-Oriented Programming (DOP) Attacks

- Memory unsafe languages are prone to memory corruption vulnerabilities
- DOP attacks corrupt non-control data to e.g. escalate privilege or leak information
- Existing security features including NX, ASLR, CFI are ineffective against these attacks
- Current practical DOP attacks rely on accessing out-of-scope variables

High-level Idea

- Enforcing variable visibility rules at run-time
- Challenge: Preventing DOP attacks requires mediating all memory accesses, cumbersome in software only
- Solution: Hardware-assisted enforcement through extensions to instruction set, processor and compiler
- Protects program data at run-time (e.g., control-data, local and global variables)
- Prevents out-of-scope memory accesses

Implementation

- Program code instrumented during compilation
  - Analyze variables used in C program functions
  - Instrument function prologues, epilogues and call-sites with HardScope instructions
- Hardware assisted run-time enforcement
  - Instrumented HardScope instructions maintain memory access rules during execution
  - Rules can be delegated on context switches
  - Rules enforced on each memory access

Storage Region Stack (SRS)

- Each SRS frame contains storage regions accessible from an execution context, i.e. code block
- Frames are pushed and popped to stack on context switches
- Permission to access memory from current context is checked on each load/store

Evaluation

- RISC-V instruction set extension, Spike simulator and Pulpino core hardware support
- Low performance overhead (~7%)
- Small area size in hardware implementation