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FloatZone: Accelerating Memory Error Detection using the Floating Point Unit

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A Artifact Appendix

A.1 Abstract
In this artifact we provide the means to reproduce our main results. Specifically, we show that our memory sanitizer, FloatZone, can detect memory errors, and that FloatZone’s performance is higher than traditional comparison-based solutions. We have validated the artifact using an Intel i9-13900K CPU running Ubuntu 22.04 with a stock v5.15 Linux kernel. Our source code is available at: github.com/vusec/floatzone.

A.2 Description & Requirements

A.2.1 Security, privacy, and ethical concerns
We require the evaluators to obtain the SPEC CPU benchmarking suites themselves, since we cannot distribute the licensed software. As a memory sanitizer, FloatZone poses no risks to the security of the target machine.

A.2.2 How to access
The files for the artifact evaluation are available at: https://github.com/vusec/floatzone/releases/tag/ae-final.

A.2.3 Hardware dependencies
While FloatZone has no strict hardware requirements (we assume x86-64), we highly recommend using a modern Intel CPU, since FloatZone’s performance depends on the throughput of the floating point unit. We have ran benchmarking experiments on various CPUs (see Figure 6 for more information).

A.2.4 Software dependencies
Some packages from the Ubuntu package manager are required to be installed to accommodate for the build process of FloatZone (e.g., for building LLVM). These are described in the Set-up section.

A.2.5 Benchmarks
For this artifact we benchmark using the SPEC CPU2006 benchmarking suite.

A.3 Set-up
We recommend using a bare-metal desktop system with 32GB of RAM, running Ubuntu 22.04, glibc 2.35, and a stock v5.15 Linux kernel.

A.3.1 Installation
1. Obtain the artifact source:
   git clone \
   https://github.com/vusec/floatzone.git \
   --recurse-submodules
   cd floatzone

2. Install some standard dependencies:
   sudo apt install ninja-build cmake gcc-9 \
   autoconf2.69 bison build-essential flex \
   texinfo libtool zlib1g-dev

3. Configure the FloatZone environment by editing the env.sh file and modifying the FLOATZONE_TOP variable to reflect the working directory of the system, and then run:
   source env.sh

4. Install the FloatZone infrastructure by running:
   ./install.sh

NOTE: installing LLVM can take up a lot of RAM when using multiple cores. If the compilation process crashes, use the ninja -j <cores> parameter inside install.sh to use less cores.
A.3.2 Basic Test

To test the functionality of FloatZone, we provide a test case in the example directory. Run `make` to obtain three versions of the buggy binary: uninstrumented, instrumented by FloatZone, and instrumented by ASan. The program contains a buffer of size 16, and the command line argument is used as an index in this array. Confirm that executing:

```
./buggy_floatzone_run_base 16
```

results in an error report containing a faulting address, while using index 15 does not. See the README on GitHub for the exact expected output format.

A.4 Evaluation workflow

A.4.1 Major Claims

(C1): FloatZone can detect spatial and temporal memory errors bounded by its security guarantees (as described in Section 5). This is proven by experiment E1.

(C2): FloatZone provides high performance in terms of runtime and memory overhead (see Sections 7.3 and 7.4). This is proven by experiment E2.

A.4.2 Experiments

(E1): [1 human-hour]: Confirming memory error detection.

**How to:** The Juliet Test Suite can be used to confirm that FloatZone detects memory errors. This suite contains test cases for spatial and temporal memory errors.

**Preparation:** Make sure that SEGFAULTS are reported: in the runtime directory, edit `wrap.c` and ensure that `CATCH_SEGFAULT` is set to 1. Run `make` inside this directory to ensure the shared object file is up-to-date. No further preparation is required if the `env.sh` and `install.sh` scripts have been used. If interested, FloatZoneExt (with partial overflow detection capabilities, see Section 5 and Figure 5) can be tested by modifying the `FLOATZONE_MODE` variable to also contain the term `just_size` in `env.sh`.

**Execution:**

```
pip3 install psutil terminaltables
```

Then, since some of the SPEC binaries contain false positives (see Table 3), in the runtime directory, edit `wrap.c` and ensure that `SURVIVE_EXCEPTIONS` is set to 1. Run `make` inside this directory to ensure the shared object file is up-to-date. As can be seen in the `wrap.c` source file, this only ensures that exceptions do not abort, and the program continues executing where it left off.

**Results:**

To obtain the results from the SPEC CPU2006 runs, we again make use of the `run.py` script. Find the corresponding output folder in the `results` directory that matches the start timestamp (e.g.: `results/run.2023-06-19.13-56-59`). Then execute the following command, replacing the directory with the one just obtained:

```
python3 run.py report spec2006 \
results/run.2023-06-19.13-56-59 \
--aggregate geomean --field runtime:median \
mmaxrss:median
```

The output of this command can then be used to calculate the runtime and memory overheads for each individual binary, as well as for the geomean. As reported in Table 4: if ran on the i9-13900K machine, the expected runtime overhead for FloatZone is 36.4%, and 77.8% for ASan, while the memory overhead is expected to be 182% and 237%, for FloatZone and ASan, respectively.

A.5 Version

Based on the LaTeX template for Artifact Evaluation V20220926. Submission, reviewing and badging methodology followed for the evaluation of this artifact can be found at [https://secartifacts.github.io/usenixsec2023/](https://secartifacts.github.io/usenixsec2023/).