WASM Performance Benchmarking Efforts at Siemens Technology

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Who are we?

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- Siemens Technology is a research arm of the Siemens Corporation.
- We are divided into Technology Fields, that contains multiple research groups.
- I belong to Architecture and Verification of Intelligent Systems (AVI) research group under Systems and Software Processes Technology Field.
- We perform primarily three activities
  - Work on federal grants that align with the vision and roadmap of Siemens Business Units
  - Consulting and development activities for Siemens Business Units.
  - Internal research funded by Siemens Technology with strong alignment with Siemens Business Units

Motivation: Why it started?

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- As a part of the internal research, our group was looking for a lightweight replacement for the containers that can work in the embedded world.
- Chris Woods presented the first prototype in 2019 highlighting the main features of Webassembly (WASM).
  - Portable and Lightweight compilation target.
  - Sandboxed environment and memory safety.
- Siemens business units appreciated the USP of WASM and ask us the following (showing only the relevant ones):
  - What's performance overhead (clamp to clamp latency)?
  - What's the jitter?

Study #1: Latency and Jitter Analysis

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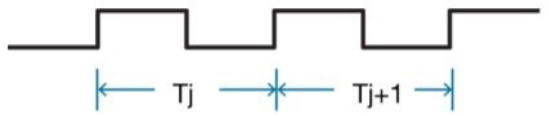
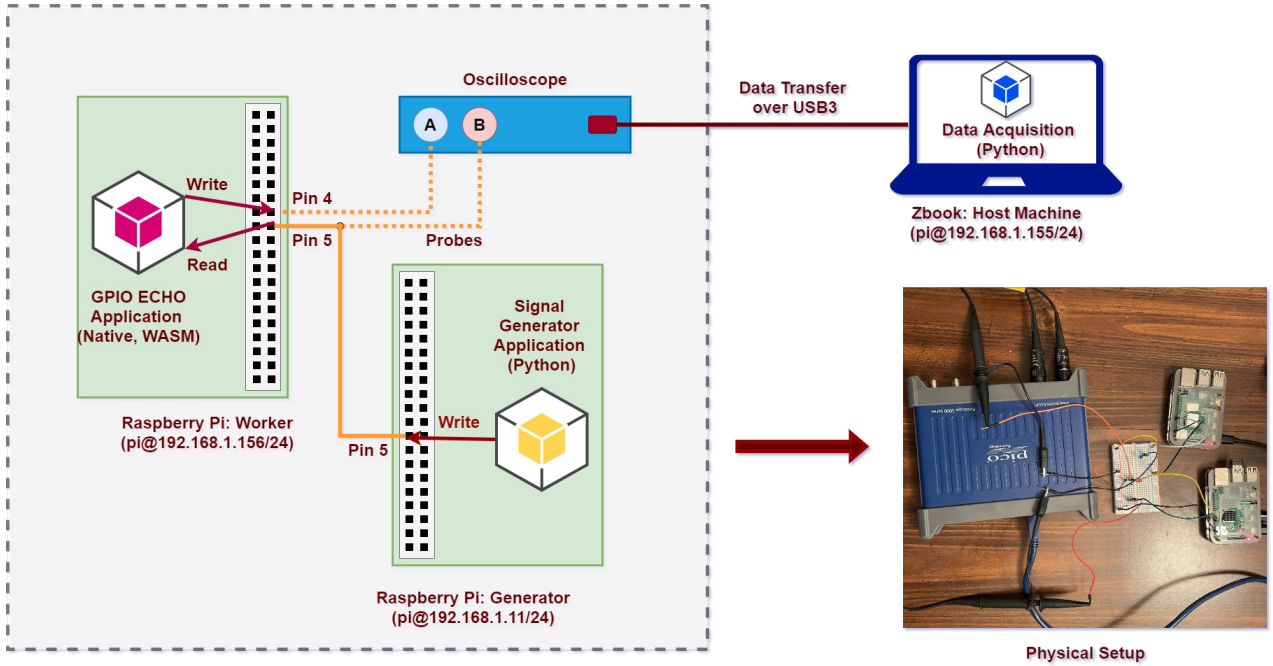
- In this experiment, a square wave produced at one GPIO pin and replicated at another pin.
- Clamp to clamp latency is measured as the time difference between the rising edges of the reference and replicated signals.
- Jitter is measured as the max deviation in the period of the replicated signal.
- Three major components of the experiment are
  - **Signal Generation**: Creates a square wave of 100 Hz that lasts 50 secs approx.
  - **Data Acquisition**: A streaming application is used that collects 10^7 samples with a sampling interval of 32 nsecs. The duration of capture in each experiment lasts 0.3 secs with 64 data points based on 100 Hz signal.
  - **GPIO state replication**: Two implementations are considered, *native and wasm*



$$Jcc = MAX \left| Tj - Tj+1 \right|, \text{ for all } j$$



Raspberry Pi 4B (2GB), with Debian 10 (Buster)
Kernel release and version: 4.19.71-rt24-v7l+ SMP PREEMPT RT
WiringPi library v 2.52, Picoscope 3205D

Study #2: Performance Overhead Analysis

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- **Benchmark Application Structure**:
  - Benchmark program should be deterministic.
  - Three associated workloads: small, medium, large.
  - Compiling, instantiating and executing the workload should be completed in order of seconds.
  - Benchmark program should only import WASI functions.
  - Input given through I/O and results reported through I/O.
  - Repeated executions (25) for good statistical analyses.

- **Testbed Configuration**:
  - Linux kernel: 5.15.65-rt49 #1 SMP PREEMPT_RT
  - Arch: x86_64
  - OS: Ubuntu 22.04.1 LTS
  - CPU performance scaling using performance governor
  - Processor: Core-i5
  - RAM: 16 GB

```
66  int main(int argc, char *argv[])
67  {
68      // SETUP
69      statement 1;
70      statement 2;
71      statement 3;
72
73      // BENCHMARK
74      bench_start();
75      for (int i = 0; i < ITERATIONS; i++) {
76          bench_program(parametes);
77      }
78      bench_end();
79
80      // TEARDOWN
81      statement 4;
82      statement 5;
83  }
84
```

Study #2: Benchmarking Applications

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Test	Matrix Multiplication	Memory Allocation	Travelling Salesperson	Merge Sort	Graph Traversal DFS	Inheritance
Description	Multiplies two square matrices	Allocate and de-allocate linear heap in a fixed pattern	Solves a travelling salesperson problem	Sorts a list using merge sort (statically defined)	Performs a DFS on a binary tree	Iterate over the inheritance tree
Input & Scale	**Matrix Size** 10x10 100x100 1000x1000	**Allocation** (initial heap) 110% 120% 130%	**Distance Matrix** 6x6 10x10 15x15	**List** 100 1000 10000	**Graph Size** 64 128 256	**Inheritance Tree** 5x5 10x10 15x15

Study #2: Toolchain Overview & More Test Combinations

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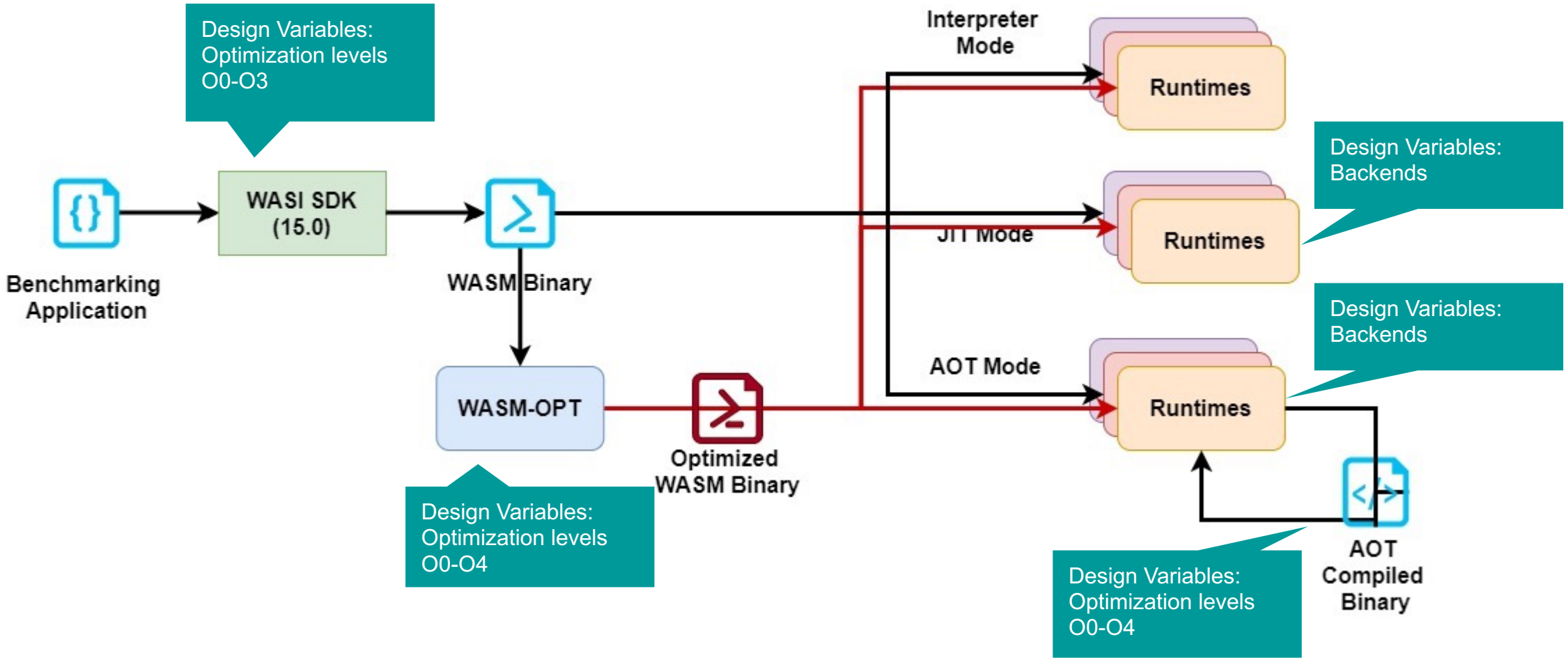

Moving forward: Performance Analysis as a Service

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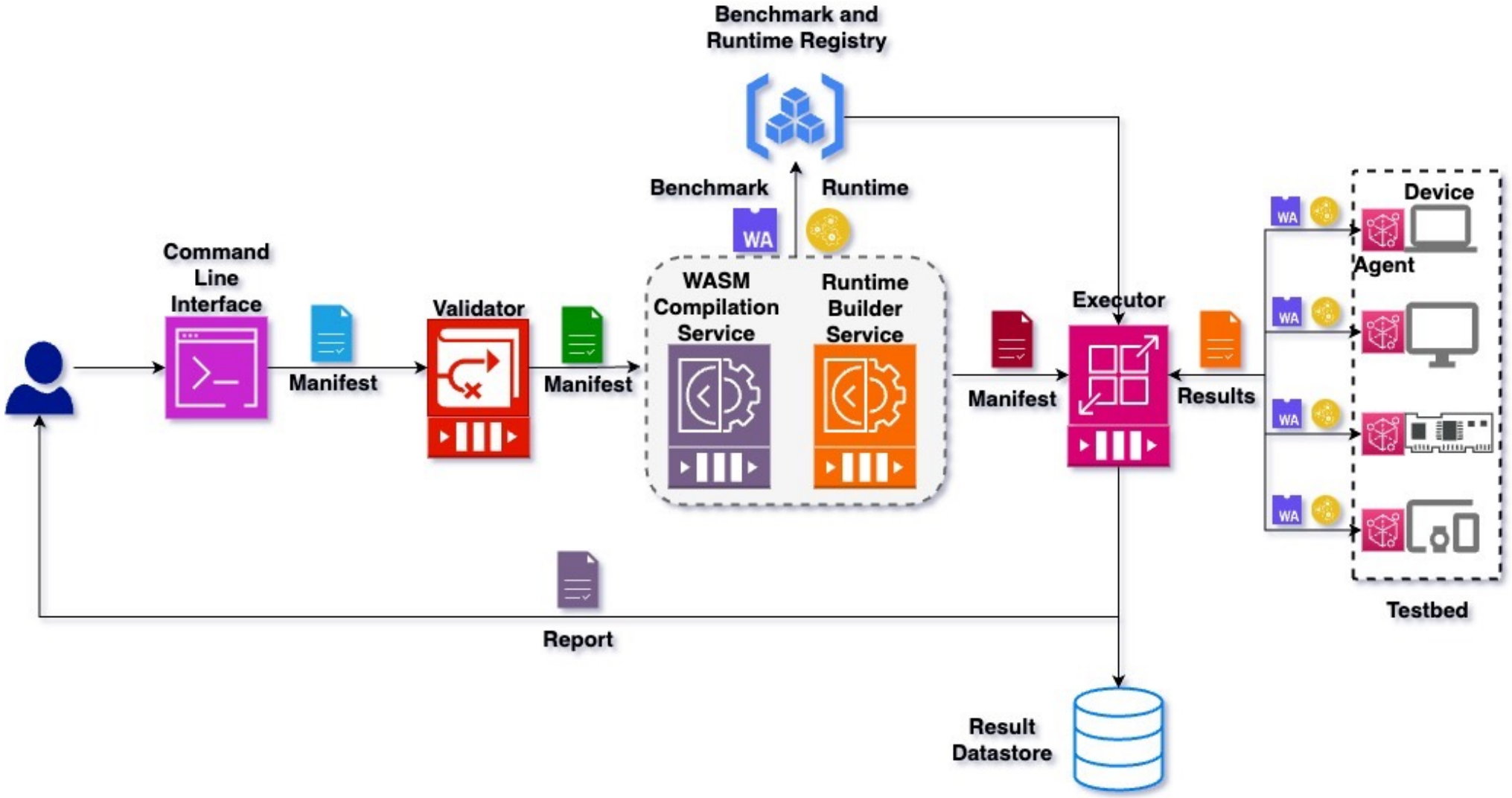

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