Dynamic Tracing in Userspace

An introductory analysis of possible approaches with focus on DyninstAPI and GDB

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Agenda

Introduction

Aim

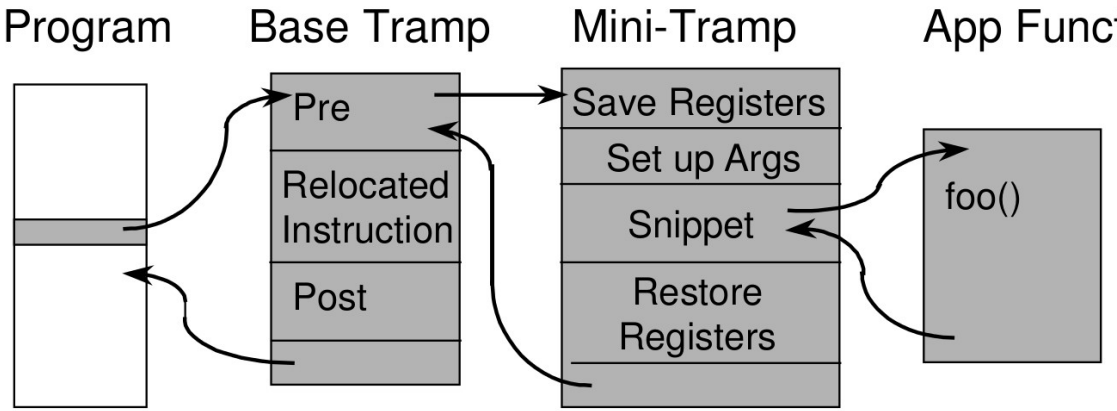
The goal is to investigate tools which can be of use to provide dynamic tracing with UST without compromising performance.

Some tools investigated recently

- Dyninst API for dynamic instrumentation
- GDB's fast tracing infrastructure

Dyninst

A *mutator* program mutates the target program (*mutatee*) by building and inserting code (*snippets*) during runtime



How Dyninst works

- BPatch object : `processCreate()`, `processAttach()`..
- Build snippets : `BPatch_arithExpr`, `BPatch_varExp`..
- Find points : `appImage->findFunction()`, `findPoint()`
- Insert Snippet : `appAddrSpace->insertSnippet()`

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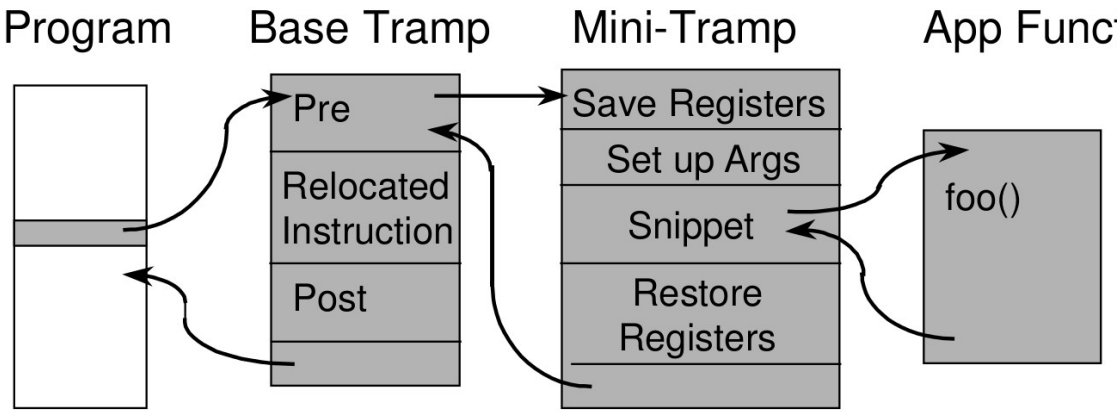

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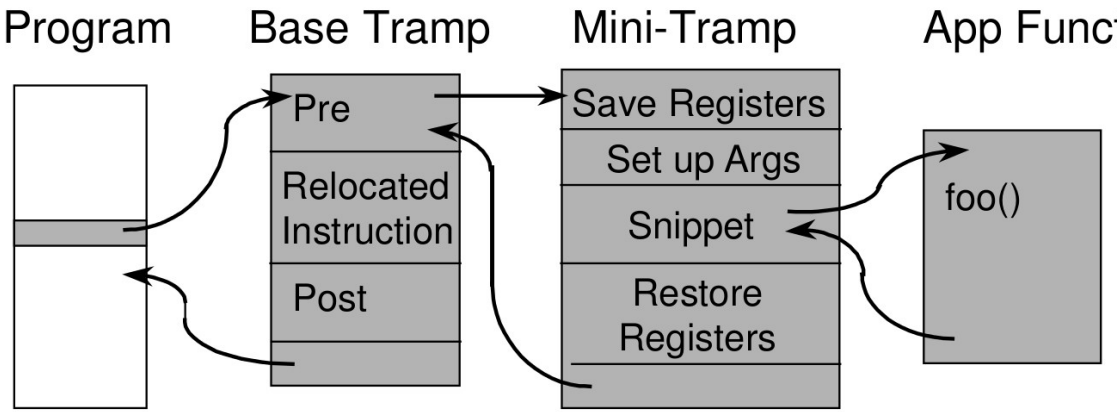

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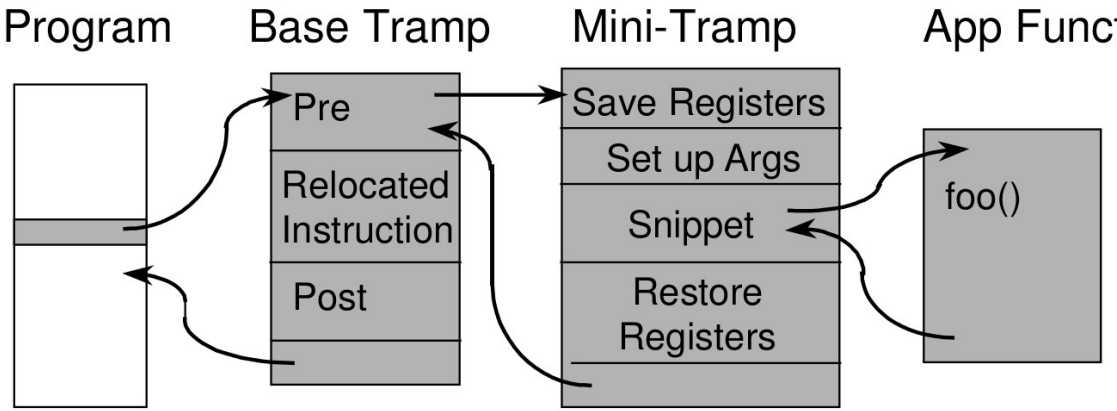

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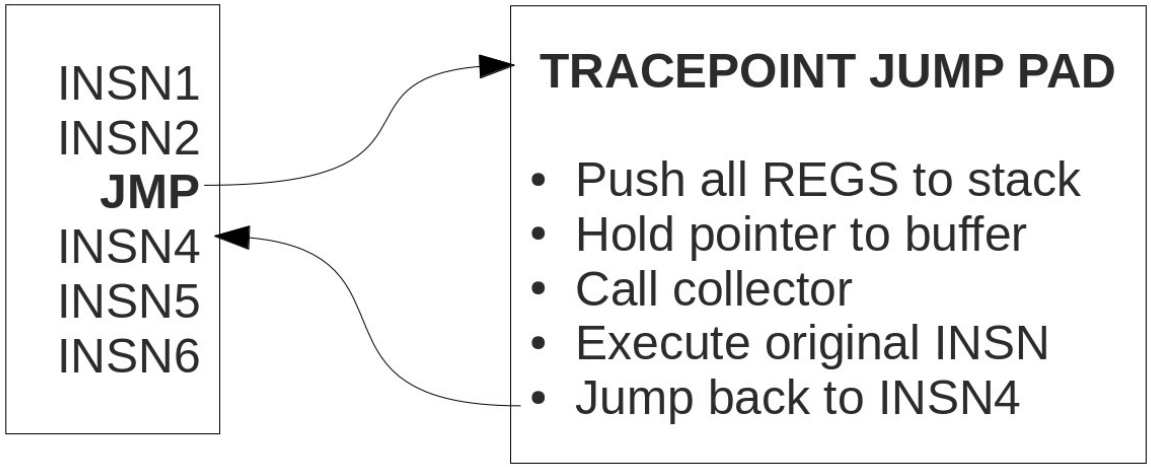
GDB's Tracing Infra

Fast Tracepoints : Similar approach by jumping to a small trampoline (*jump pad*). Faster than *normal* trap based tracepoints



How GDB's fast tracepoints work

- Can be placed only at instructions 5 bytes or longer (4 bytes on some targets)
- Needs In-process agent (IPA) library loaded in inferior process

Tests & Results

GDB and Dyninst elementary overhead analysis

Intel Core i5-3317U (1700Mhz x 4), 4GB RAM, Fedora 18 (3.8.1-201.fc18.x86_64)

Dyninst Overhead Analysis

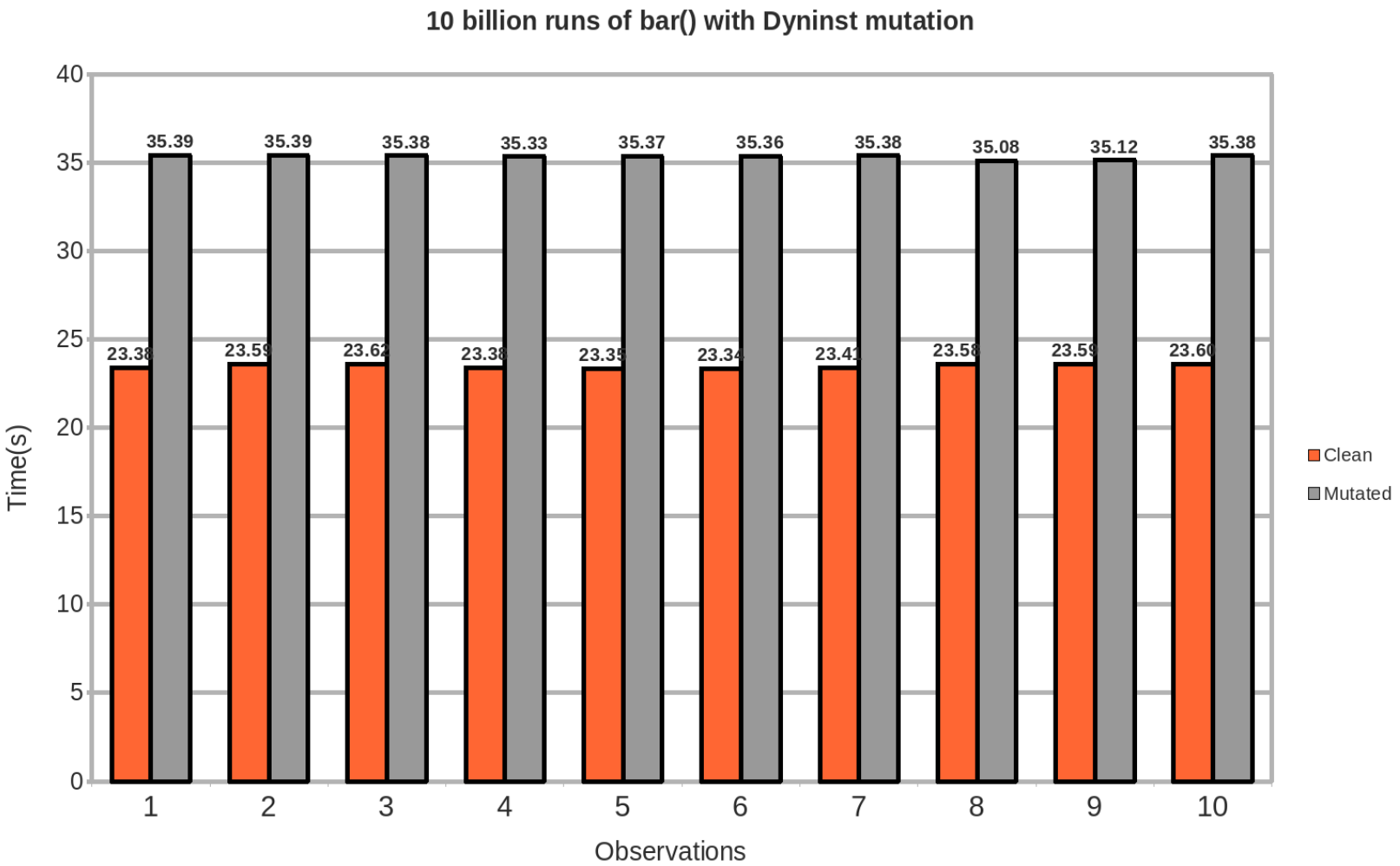
Test Scenario : Consists of a *dummy* program and a *mutator* program mutating it. It instruments the function `bar()` in dummy. The function `bar()` originally just increments a variable by 1.

```
void bar(){ ch=ch+1; }
```

The mutator builds a snippet to initialize another variable with zero and inserts this snippet during *dummy* runtime. Time for 10 billion runs of `bar()` is observed using `clock_gettime()` for a clean vs mutated run

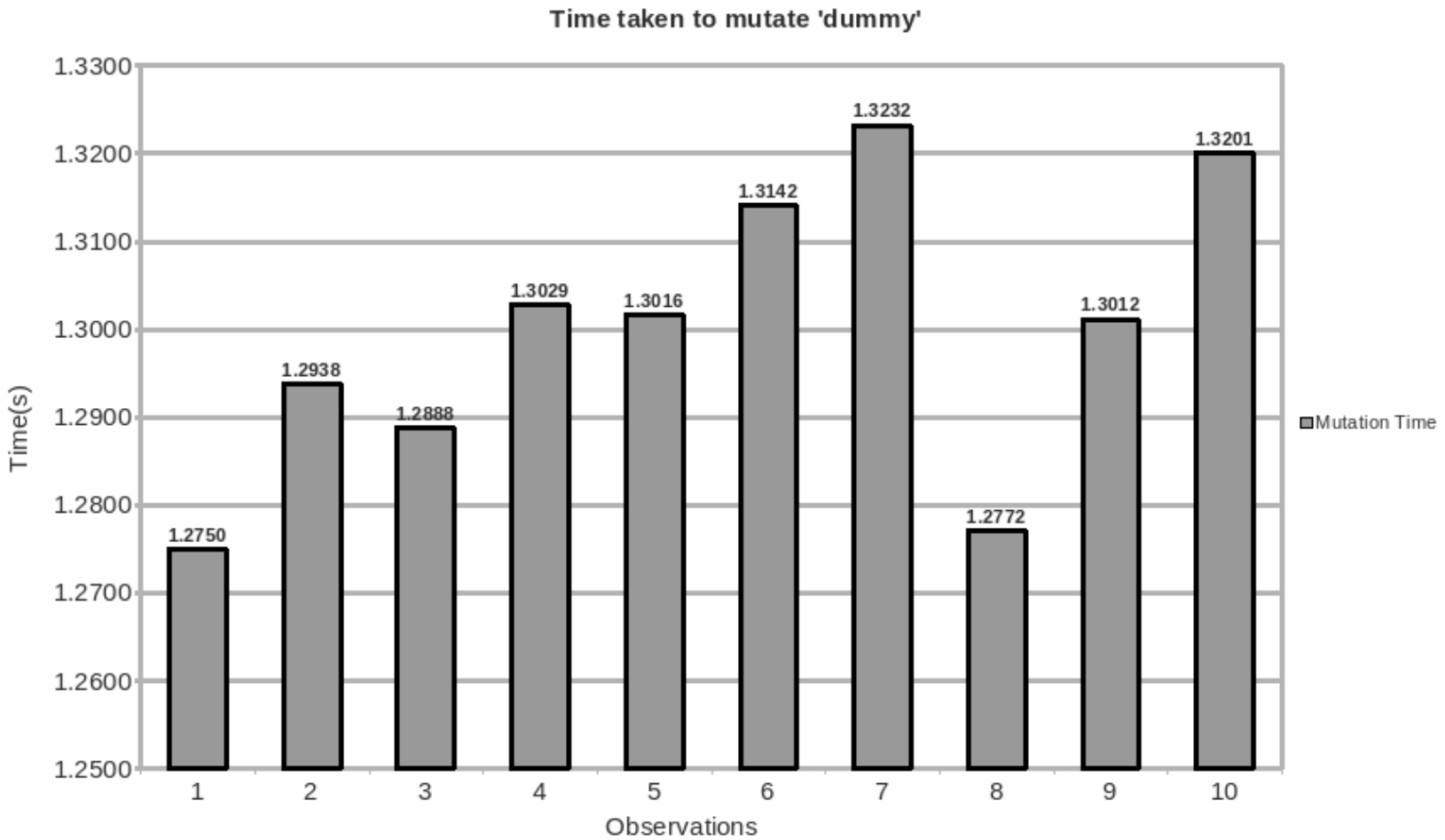
```
a = appAddrSpace->malloc(*appImage->findType("int"));
BPatch_arithExpr initSnippet(BPatch_assign, *a, zero);
appAddrSpace->insertSnippet(initSnippet, *functionEntry);
```

Results



- Mean difference of 11.83s and an overhead of 50.38%

Results



- Mean mutation time : 1.29s

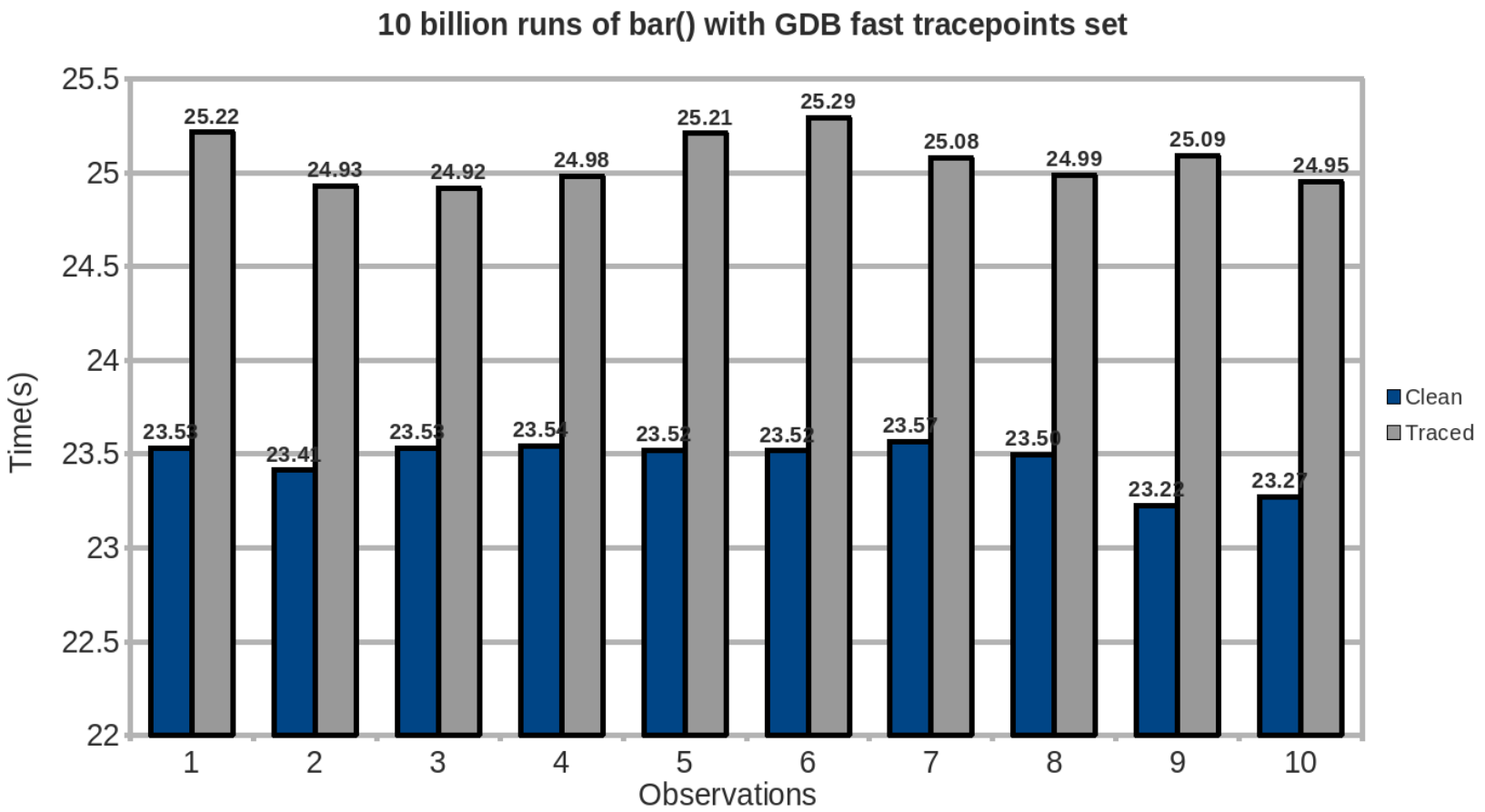
GDB Overhead Analysis

Test Scenario : Consists of a *dummy* program with a function `bar()`. The function `bar()` originally just increments a variable by 1. The *dummy* application is started with GDBserver while pre-loading the IPA library.

```
gdbserver --wrapper env LD_PRELOAD=/usr/lib64/libinproctrace.so
:2222 dummy
```

Through GDB, fast tracepoint is set at beginning of `bar()` and trace experiment is conducted without any 'actions'. Time for 10 billion runs of `bar()` is observed using `clock_gettime()` for a clean vs traced run

Results



- Mean difference of 1.60s and an overhead of 6.83%

What Next?

- Run more rigorous and real life tests on multiple test setups
- Analyze pros and cons for each dynamic instrumentation candidate
- Investigate ways to utilize GDB's dynamic tracing infra for UST
- A glance at other tools - DynamoRIO, Pin

Long Term Vision

The long term goal now is eventually merging the functionality of tracing, profiling and debugging in an integrated tool.

Questions and Suggestions?

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suchakra on #lttng