Data Race Detection on GNU* Project Debugger

Dr. Walfred Tedeschi

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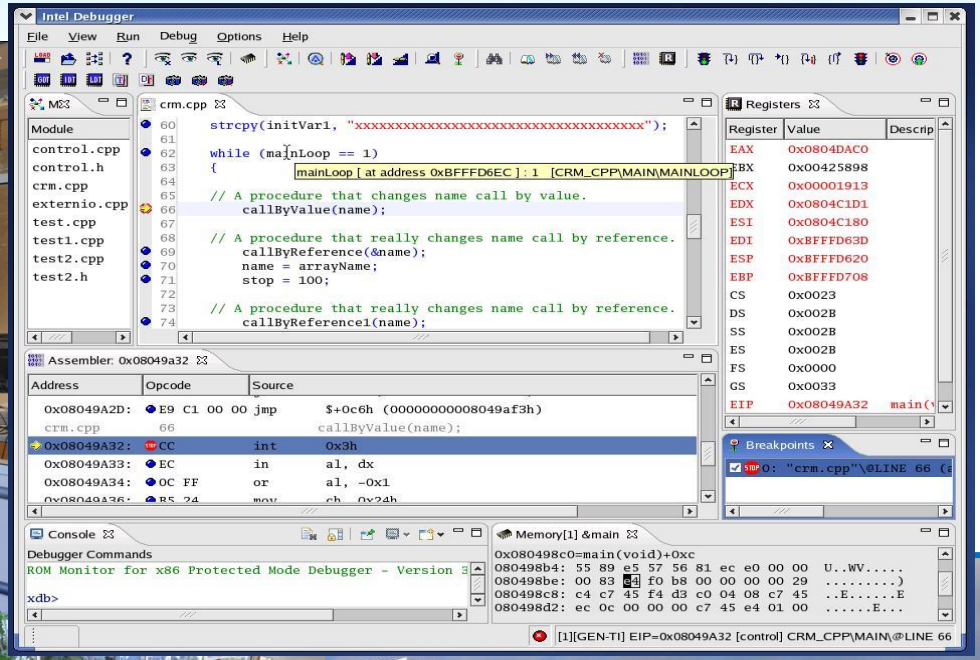
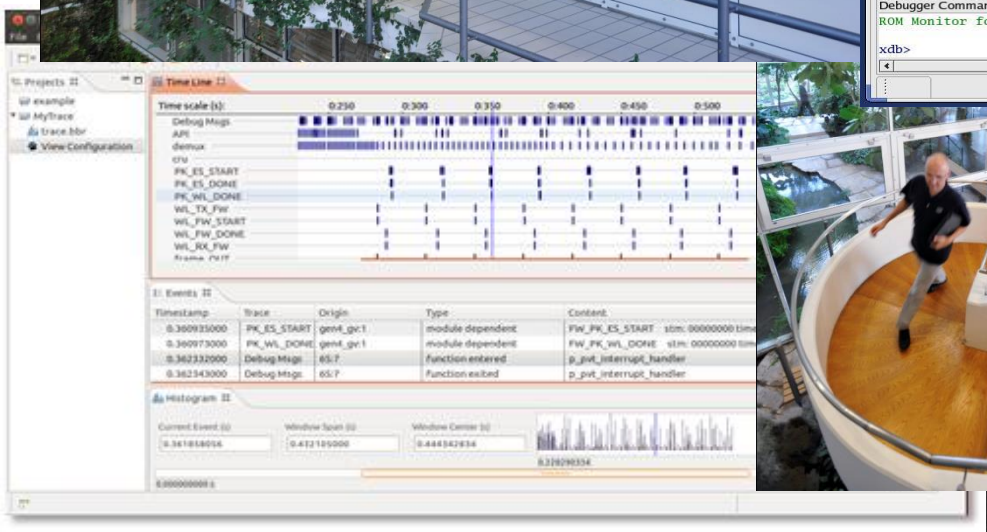
Intel GmbH - Ulm Site

– The Competence Center for Debugging Solutions





Projects

- **Owner of Intel® System Studio** software development tools for embedded IA
- **Development of Debuggers** - including GDB - for all Intel development products like **Intel® Parallel Studio**
- Unique Value:
  The **Ulm** site is the world wide **Intel Competence Center for Debugging on IA**

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Introduction: GDB

Features added / worked on by Intel:

- Data Race Detection
- Intel® Many integrated Core Architecture
- Intel® Memory Protection Extensions
- Intel® Advanced Vector Extensions 512
- Fortran support like Variable Length Array
- Pointer Checker

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Agenda

- Data Race Conditions
- Usage
- Configuration Options
- Filter (Set) Options
- Overhead Management
- Selective Enabling
- Summary

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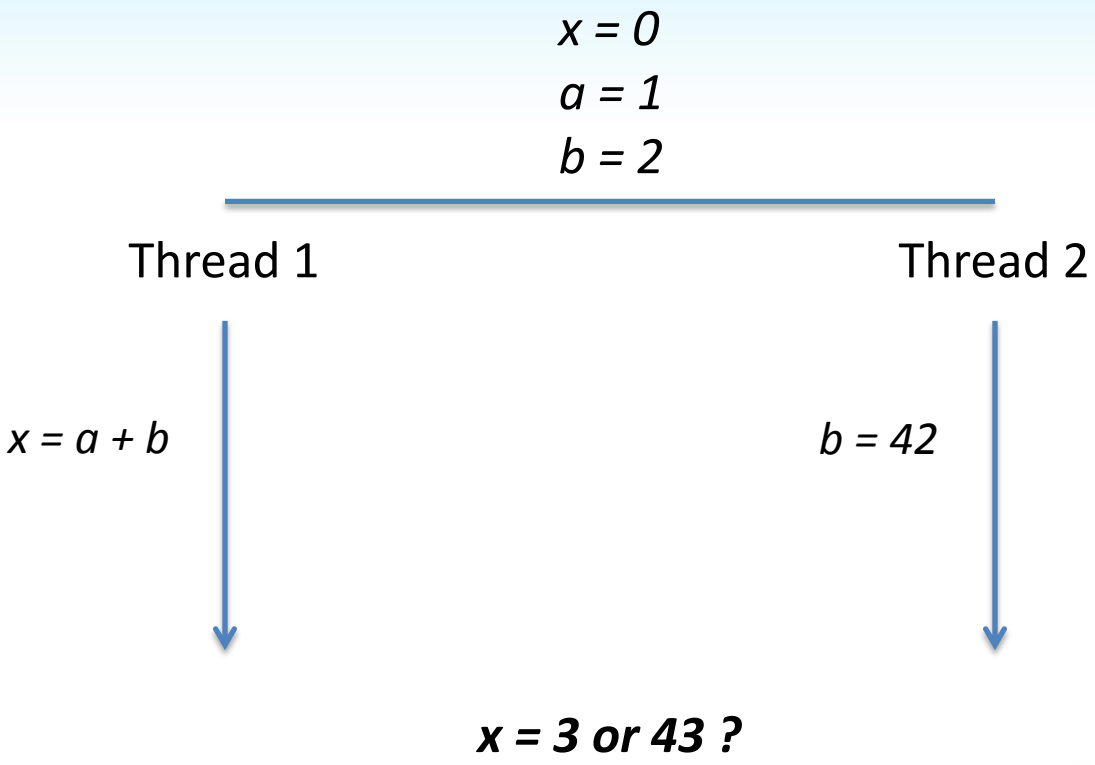
Data Race Conditions



x = 3 or 43 ?

Execution order is not guaranteed unless synchronization constructs are used

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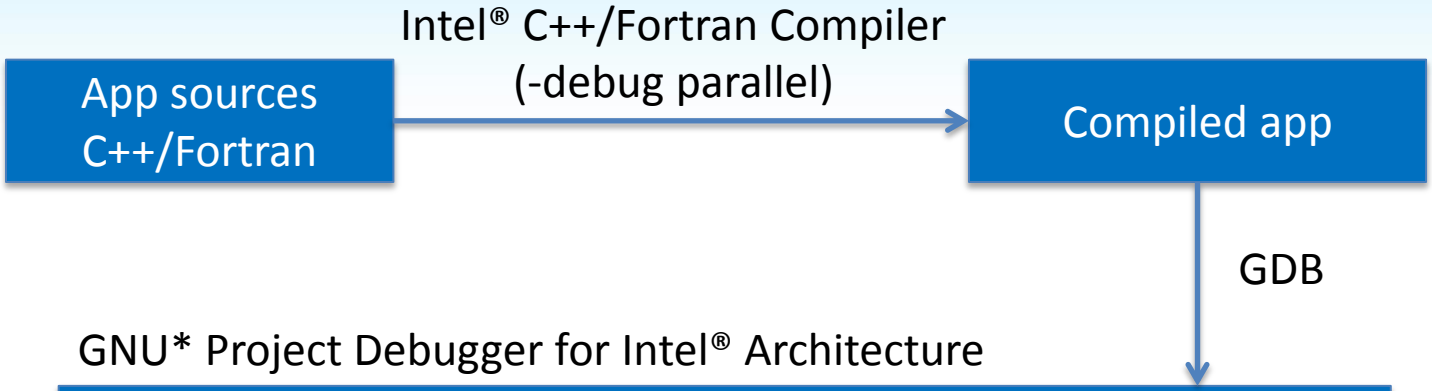
Data Race Conditions

Usual Symptoms:

- Random clobbered results
- Unpredictable lost updates
- Sporadic memory corruption

How to debug this kind of random behavior?

Usage




```
(gdb) pdbx enable
(gdb) run
data race detected
1: write b, 4 bytes from foo.c:36
3: read b, 4 bytes from foo.c:40
Breakpoint, 0x401515 in foo () at foo.c:36
36 b = 42;
(gdb)
```

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Usage

Pre requisites

- Intel® C++ or Fortran Compiler
  - Compile with *–debug parallel* option
  - Link with data race analyzer library
- Supported threading models: POSIX* threads and OpenMP*
- Supported processors: Intel® Core™, Xeon®, Atom™ and Xeon Phi™
- Python* 2.6+

Workflow

- Start application in Intel® GDB
- Configure data race analysis
- Debugger breaks in the context of a data race

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Usage

```
$ icc –g –debug parallel –o foo foo.c
```

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Usage

```
$ icc –g –debug parallel –o foo foo.c
$ gdb foo
GNU gdb (GDB) ...
Reading symbols from foo...done.
(gdb) pdbx enable
```

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Usage

```
$ icc -g -debug parallel -o foo foo.c
$ gdb foo
GNU gdb (GDB) ...
Reading symbols from foo...done.
(gdb) pdbx enable
(gdb) run
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Configuration Options

- Fine-tune the data race analysis through Filters
  - Ignore specified regions (suppress)
  - Consider only specified regions (focus)
  - Ignore all read accesses
- Filters can be added/modified at any time
- Setting filters similar to breakpoints/watchpoints
- Filters are organized in filter sets

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Filter Operations

- `pdbx filter line foo.c:36` `# Line`
- `pdbx filter code 0x40518-0x40524` `# Code range`
- `pdbx filter var answer` `# Variable`
- `pdbx filter data 0x60f48-0x60f50` `# Data range`
- `pdbx filter reads` `# All reads`

- Filter defines code or data region in debuggee
- Filter expressions evaluated when filter is set

Filter Set Operations

```
• pdbx fset new my_fset          # set creation
• pdbx fset suppress/focus       # filter meaning

• pdbx fset list                 # list filter sets
• pdbx fset show                 # list filters in set
• pdbx fset select other_fset    # switch between sets

• pdbx fset remove 4             # remove filter number 4
• pdbx fset disable 2-6          # disable filters from 2 to 6
• pdbx fset enable 8             # enable 8th filter
• pdbx fset evaluate             # re-evaluate filter expr

• pdbx fset import other:3-8     # import
```

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Example

```
(gdb) pdbx enable
(gdb) run
data race detected
1: write b, 4 bytes from foo.c:36
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Breakpoint -11, 0x401515 in foo () at foo.c:36
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Example

```
(gdb) pdbx enable
(gdb) run
data race detected
1: write b, 4 bytes from foo.c:36
3: read b, 4 bytes from foo.c:40
Breakpoint -11, 0x401515 in foo () at foo.c:36
36 b = 42;
(gdb) pdbx filter var b
(gdb) continue
Program exited normally.
```

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Overhead Management

- Manage overhead effectively through
  - Focus filter sets
  - Global filter on reads
  - Selective enabling
- Allows fast and focused debugging of data race bugs
- Allows data race detection under resource constraints

Interactive data race debugging

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Selective Enabling

```
(gdb) pdbx disable
(gdb) pdbx reset # discards memory access logs
(gdb) break foo
Breakpoint 1 at 0x4006e8: file foo.c, line 30
(gdb) continue
Breakpoint 1, foo () at foo.c:30
(gdb) pdbx enable
```

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Selective Enabling

```
(gdb) continue
data race detected
1: write b, 4 bytes from foo.c:36
3: read b, 4 bytes from foo.c:40
Breakpoint -11, 0x401515 in foo () at foo.c:36
36 b = 42;
```

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Summary

- Interactive debugging of data races in GDB
- Configurable analysis scope to manage performance
- Use well known GDB syntax

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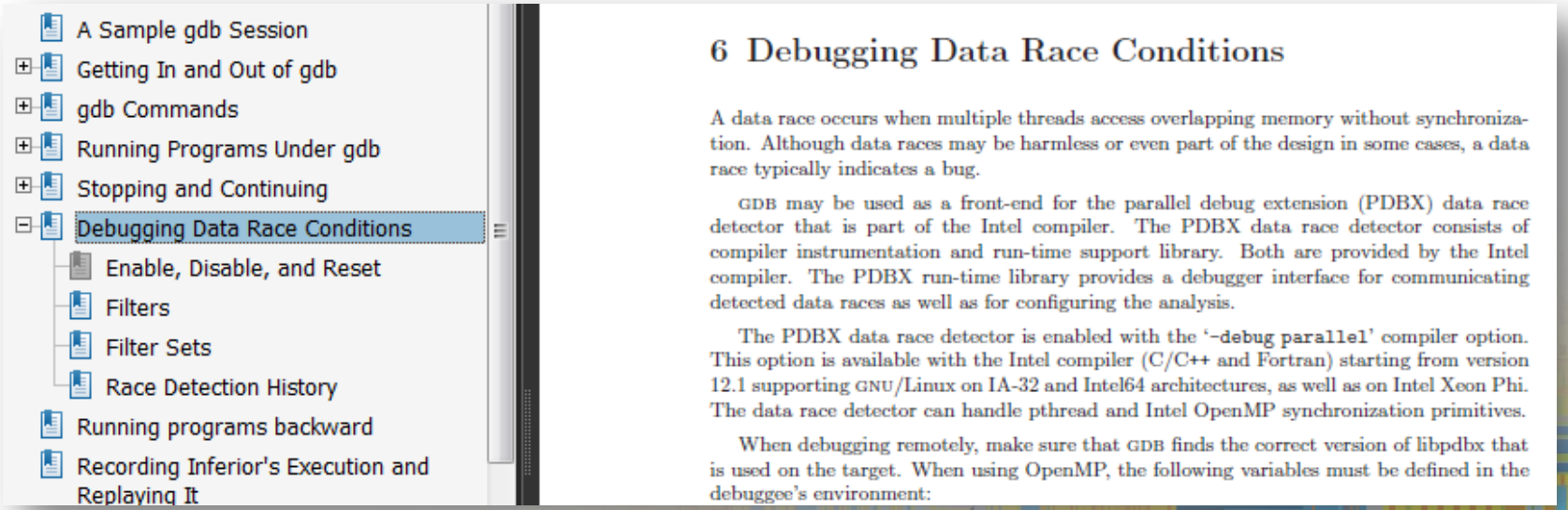
Learn More

- Learn more: [GDB - The GNU* Project Debugger for Intel® Architecture]
- The GNU* Project Debugger for Intel® Architecture Documentation:



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Where to find (Linux)

For Intel® Atom™:

Intel® System Studio

For Intel® Core™, Atom™ and Xeon Phi™:

Intel® Composer XE 2013 SP1

Intel® Parallel Studio XE 2013 SP1

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Thank You

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