LRZ Workshop – 09.11.2022

Dynamic Debugging with Intel® Inspector

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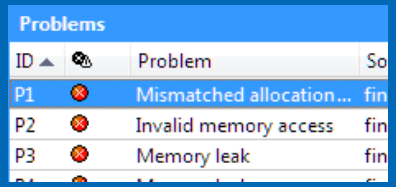
Agenda

- Introduction to Inspector
- GUI usage
- Command line usage
- Results
- Demo - Next steps

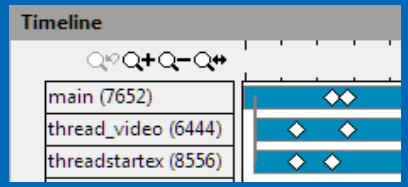
Motivation for Intel® Inspector

Memory Errors



- Invalid Accesses
- Memory Leaks
- Uninitialized Memory Accesses

Threading Errors



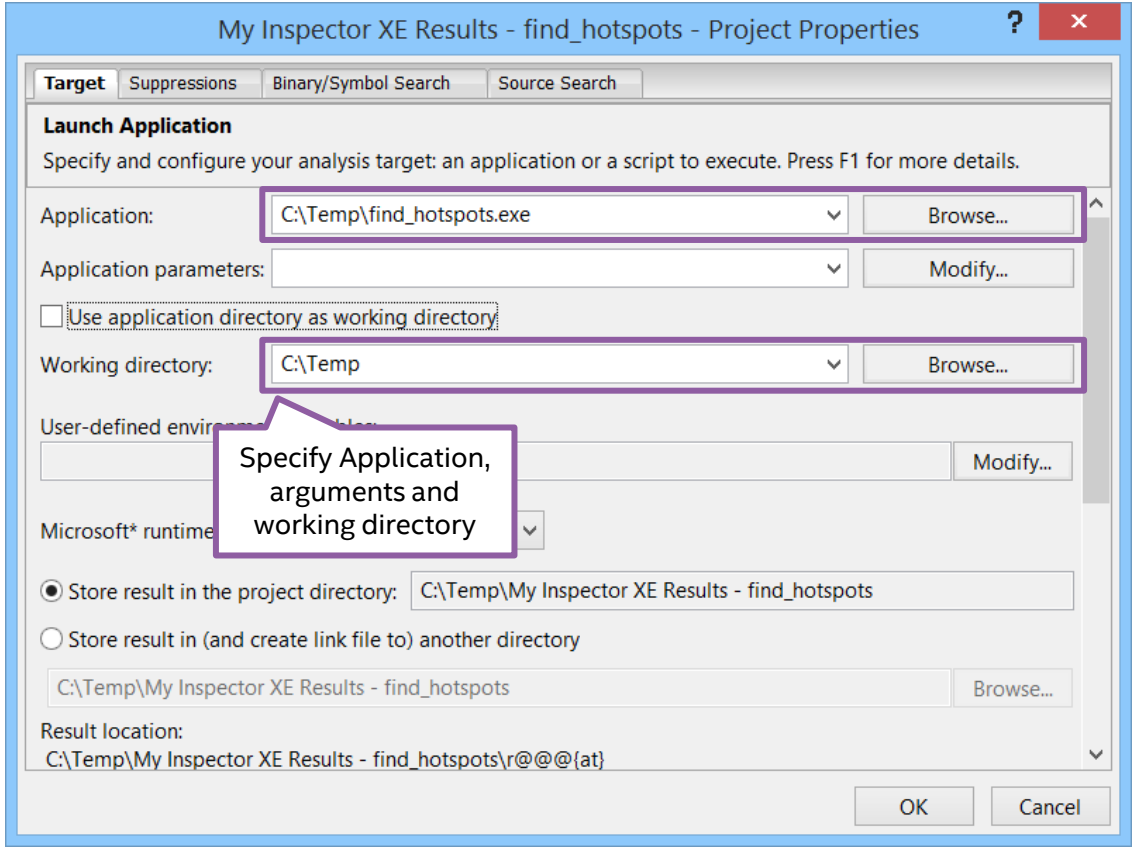
- Data Races
- Deadlocks
- Cross Stack References

Multi-threading problems

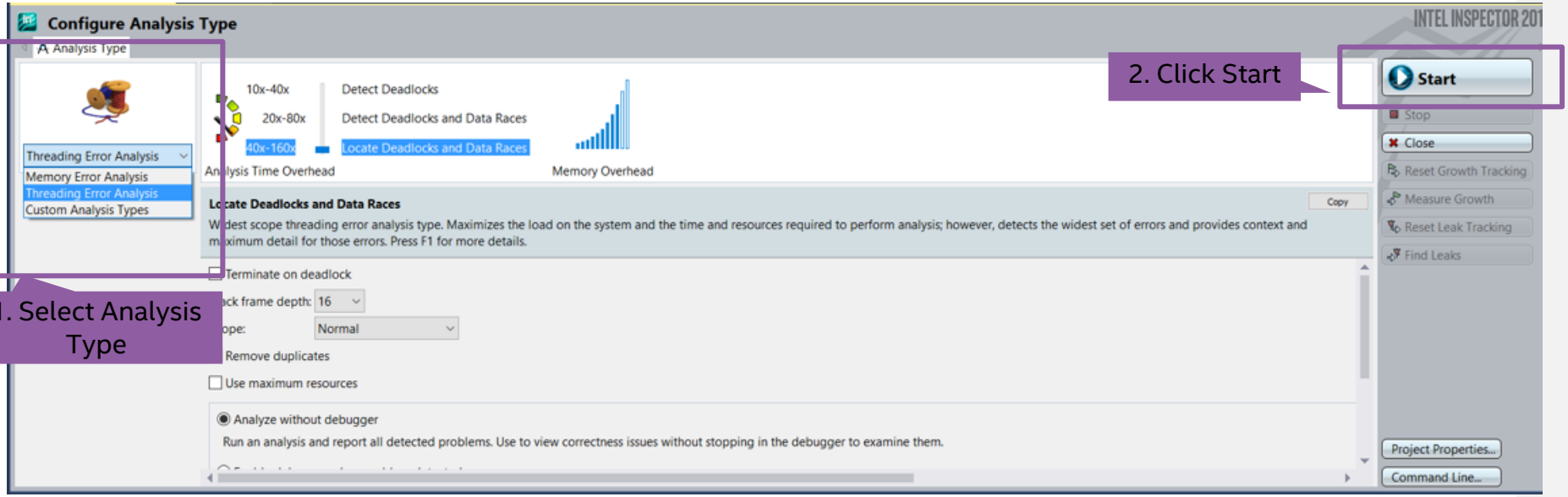
- Hard to reproduce,
- Difficult to debug
- Expensive to fix

→ Let the tool do it for you

Workflow: setup project



Workflow: select analysis and start



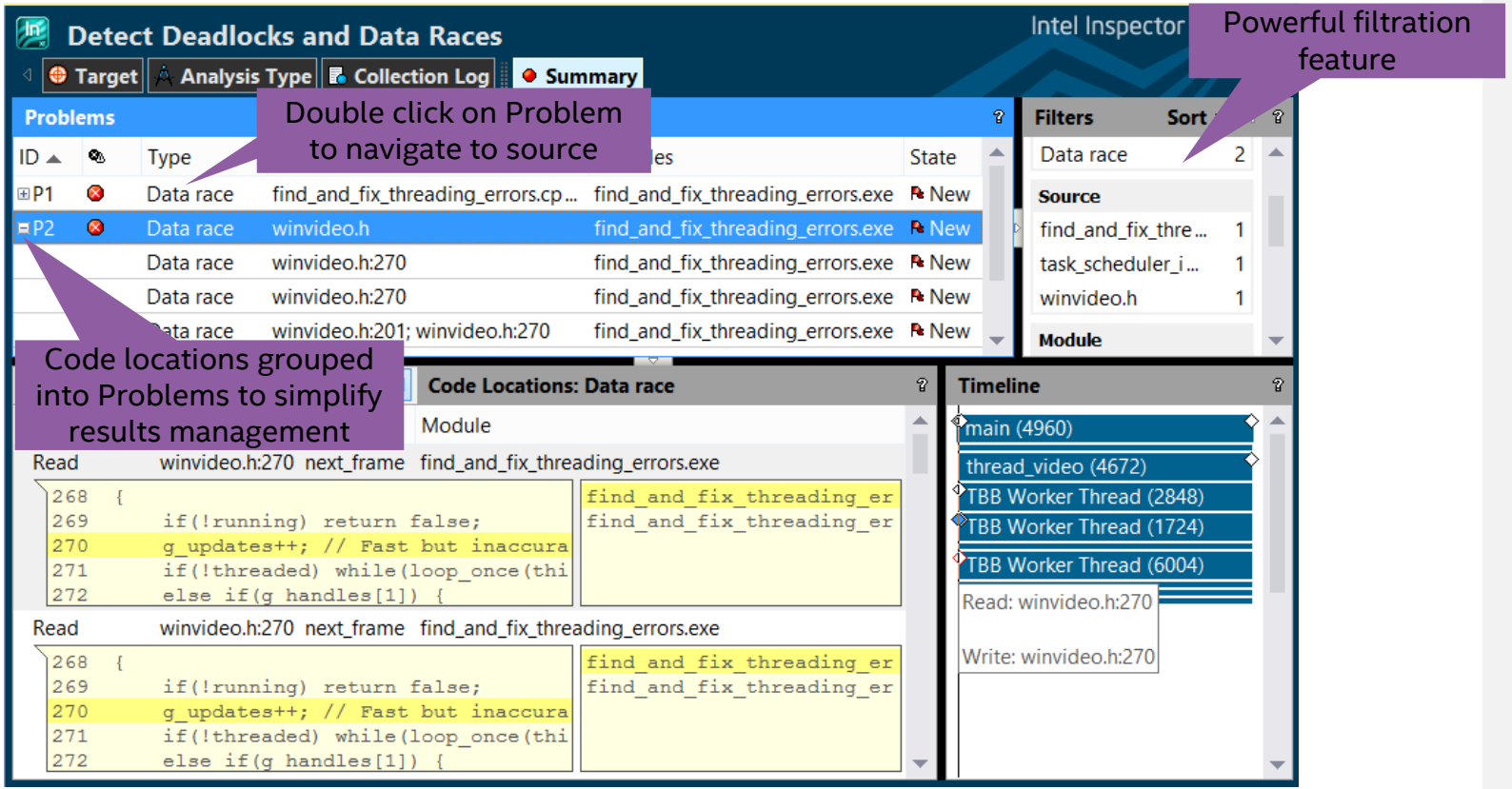
Command Line Interface

- Start analysis
  - *Memory:* inspxe-cl -c mi3 -- <app> [app_args]
  - *Threading:* inspxe-cl -c ti3 -- <app> [app_args]
- View results
  - inspxe-cl -report=problems -report-all –r <result-dir>
  - To open result in GUI, type:
    inspxe-gui <result folder>

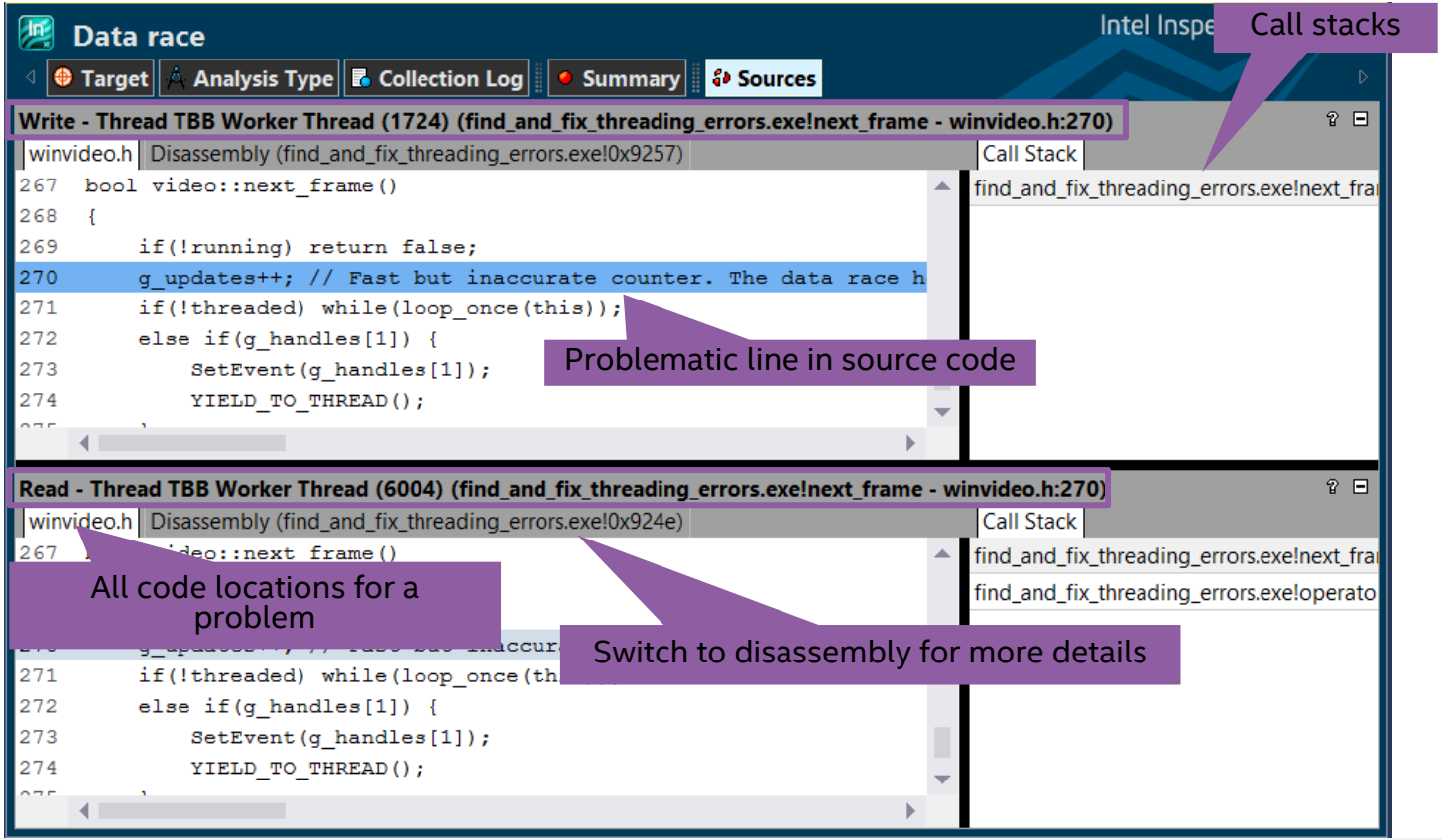
Command Line Interface – Intel MPI

- Use gtool flag or environment variable:
  - *flag: $ mpirun –gtool* “inspxe-cl -c mi3 –r <result_dir>:0” –n N <app> [app_args]
  - *env:* $ export I_MPI_GTOOL=“inspxe-cl -c mi3 –r <result_dir>:0”
- Gtool inserts tool on selected ranks
  - Analysis only on rank 0: use “:0”
  - Analysis on selected ranks: use “:m-n”
  - Analysis on all ranks: use “:all”
- In most cases it should be sufficient to do analysis on single rank!

Workflow: manage results



Workflow: navigate to sources



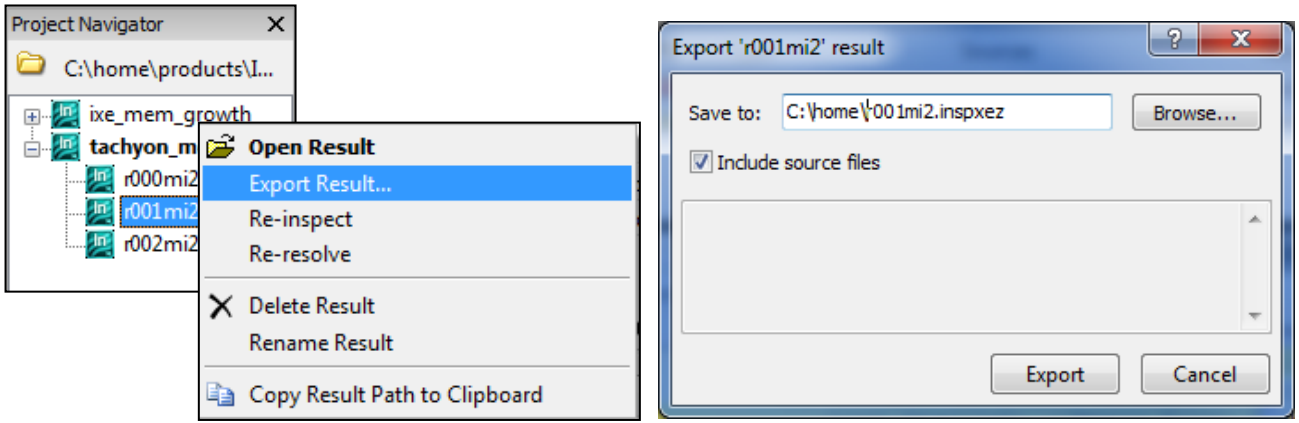
Exporting results

Save results with sources – copy and browse anywhere without setting search paths

CLI:

```
inspxe-cl -export -archive-name r000mi2.inspxez
   -include-sources -result-dir r000mi2
```

GUI:



Work on remote computer

- Working with GUI on remote system might be not possible
- Result generated by CLI on remote system can be exported to archive (plain file)
- Transfer archive from remote system to local desktop/laptop with local Inspector installation. Linux results can be analyzed by Windows Inspector

Demo – Hands on

- Try Inspector on DevCloud or local system
- Playbook will provide some sample command lines on DevCloud: **/data/comp/workshop/Playbook_Inspector.txt**
- More information:

  https://www.intel.com/content/www/us/en/developer/tools/oneapi/inspector.html

- Video:

  https://www.intel.com/content/www/us/en/developer/videos/introduction-to-intel-inspector.html

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Backup

Additional information

Using the Intel® Inspector with MPI (mpich etc)

- Use the command-line tool under the MPI run scripts to gather report data

```
mpirun -n 4 inspxe-cl –-result-dir insp_results
   -collect mi1 -- ./insp_example.exe
```

- Output is: a results directory for each MPI rank in the job

`ls | grep inspector_results` on Linux

- Launch the GUI and view the results for each particular rank

`inspxe-gui inspector_results.<rank#>` on Linux

Memory problems

- **Memory leak**
  - a block of memory is allocated
  - never deallocated
  - not reachable (there is no pointer available to deallocate the block)
  - Severity level = (Error)

```
// Memory leak

char *pStr = (char*) malloc(512);
return;
```

- **Memory not deallocated**
  - a block of memory is allocated
  - never deallocated
  - still reachable at application exit (there is a pointer available to deallocate the block).
  - Severity level = (Warning)

```
// Memory not deallocated

static char *pStr = malloc(512);
return;
```

- **Memory growth**
  - a block of memory is allocated
  - not deallocated, within a specific time segment during application execution.
  - Severity level = (Warning)

```
// Memory growth

// Start measuring growth
static char *pStr = malloc(512);
// Stop measuring growth
```

Memory problems

- **Uninitialized memory access**
  - Read of an uninitialized memory location

- **Invalid Memory Access**
  - Read or write instruction references memory that is logically or physically invalid

- **Kernel Resource Leak**
  - Kernel object handle is created but never closed

- **GDI Resource Leak**
  - GDI object is created but never deleted

```
// Uninitialized Memory Access

void func()
{
   int a;
   int b = a * 4;
}
```

```
// Invalid Memory Access

char *pStr = (char*) malloc(20);
free(pStr);
strcpy(pStr, "my string");
```

```
// Kernel Resource Leak

HANDLE hThread = CreateThread(0,
      8192, work0, NULL, 0,
NULL);
return;
```

```
// GDI Resource Leak

HPEN pen = CreatePen(0, 0, 0);
return;
```

Data race

```
CRITICAL_SECTION cs;              // Preparation
int *p = malloc(sizeof(int)); // Allocation Site
*p = 0;
InitializeCriticalSection(&cs);
```

Write -> Write Data Race

Thread #1

```
*p = 1; // First Write
```

Thread #2

```
EnterCriticalSection(&cs)
;
*p = 2; // Second Write
LeaveCriticalSection(&cs)
;
```

Read -> Write Data Race

Thread #1

```
int x;
x = *p; // Read
```

Thread #2

```
EnterCriticalSection(&cs)
;
*p = 2; // Write
LeaveCriticalSection(&cs)
;
```


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