Introduction to Modeling parallelism

with Intel® Advisor XE

Data Driven Threading Design
Intel® Advisor XE – Threading Prototyping Tool for Architects

- Have you:
- Tried threading an app, but seen little performance benefit?
- Hit a “scalability barrier”? Performance gains level off as you add cores?
- Delayed a release that adds threading because of synchronization errors?

Breakthrough for threading design:

Quickly prototype multiple options

Project scaling on larger systems

Find synchronization errors before implementing threading

Separate design and implementation, design without disrupting development

Add Parallelism with Less Effort, Less Risk and More Impact

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Amdahl's Law

- (paraphrased) “The benefit from parallelism is limited by the computation which remains serial”
- If you perfectly execute ½ of your application in parallel you will achieve < 2x speedup
- The implication of this is that you must focus your attention where your application spends its time

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Agenda

- Survey
- Add Annotations
- Model Performance Suitability
- Check Correctness
- Add Parallel Framework
- Conclusion

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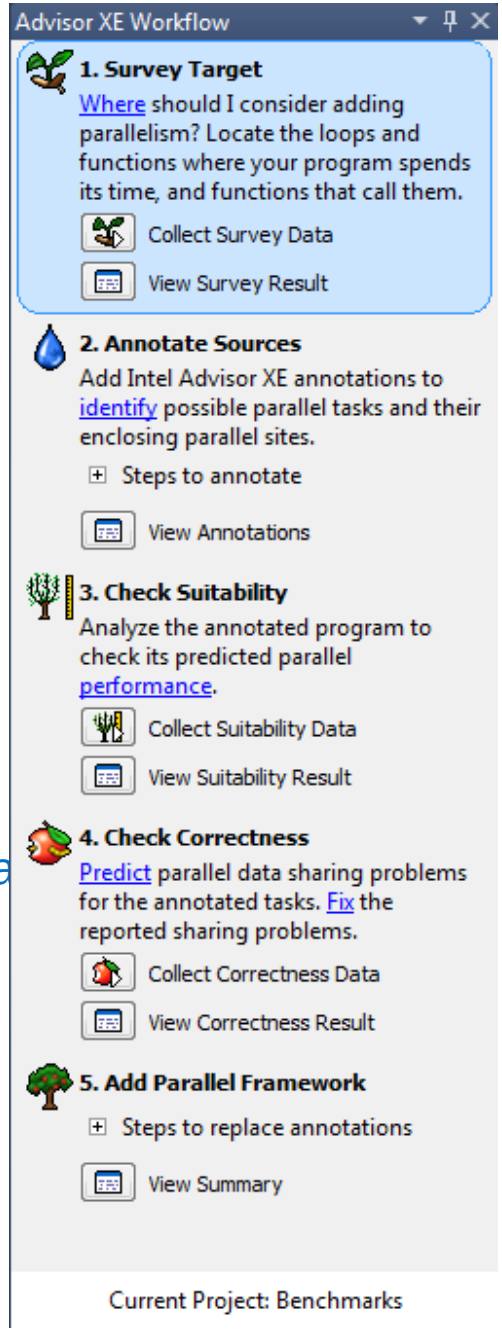
Intel® Advisor XE
Workflow

Transforming many serial algorithms into parallel form takes 5 easy high-level steps:

1. **Survey and Summary tools**: where to add parallelism
2. **Annotations**: experiment with parallel program structure
3. **Suitability tool**: predict and model program scalability
4. **Correctness tool**: discover potential synchronization problems
5. Manually convert annotations to **parallel framework** API (with a little help of Annotations/Summary)



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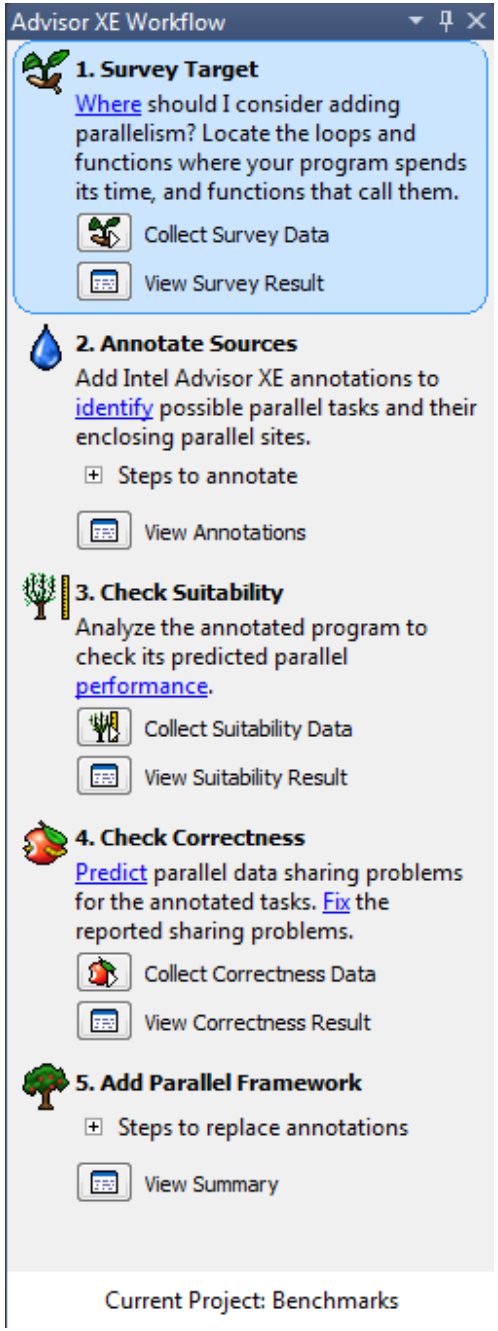
Intel® Advisor XE
Workflow

- Advisor XE guides you through these 5 steps
  - provides assisting tools
  - No auto-parallelization
- Model & evaluate potential return of parallelization investments.
- On your serial program

(Advisor XE toolbar)



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Intel® Advisor XE

Advantages of Advisor XE modeling

Serial modeling benefits:

1. Your application can't fail due to bugs caused by incorrect parallel execution (it's running serially)
2. You can easily experiment with several different proposals before committing to a specific implementation
3. All of your test suites should still pass when validating the correctness of your transformations

AND you can use Advisor XE on partially or completely parallelized code.

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Intel® Advisor XE

Advantages of Advisor XE modeling

Advisor XE modeling avoids the major design mistakes:

1. Measure performance, focus on hotspots.
2. Predict scalability, load balancing and overheads.
3. Predict data races

Automated analysis catches cases people miss.

Making good decisions early saves time.

Advisor XE increases parallelization ROI

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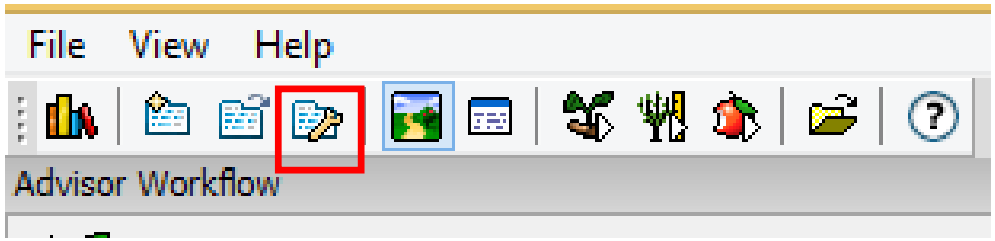
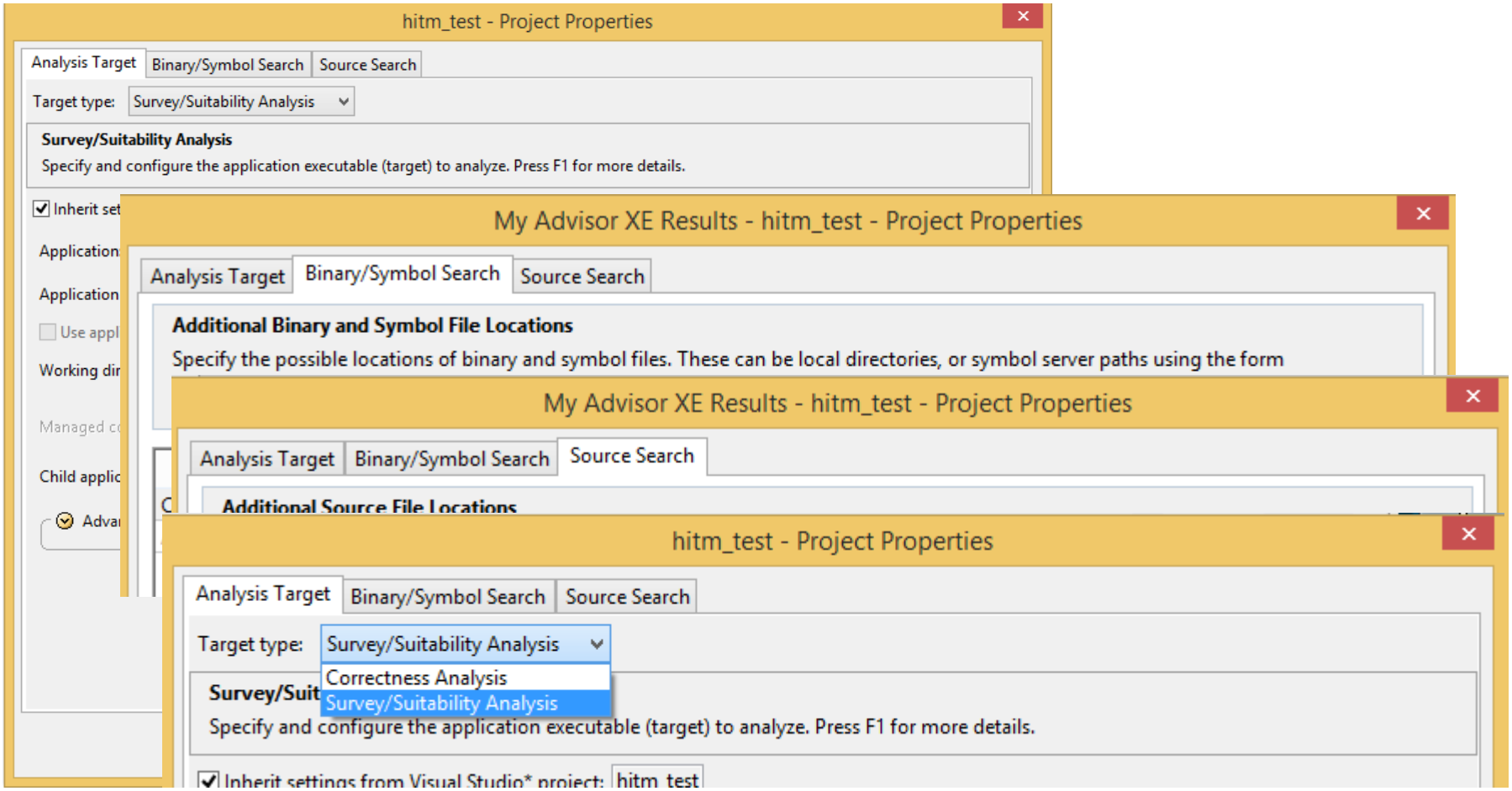
Project Set up





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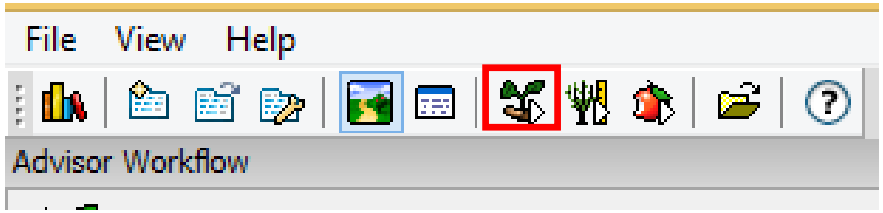
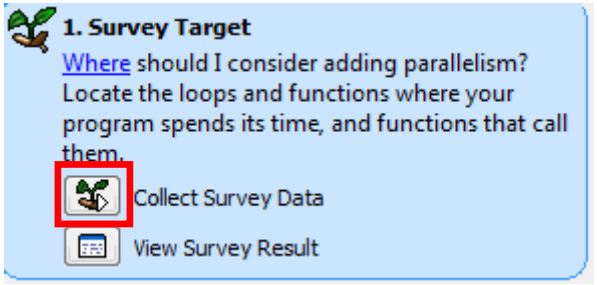
Step 1: Survey Target





hitm_test - e000 | util.c | hitm_test.c

Summary of predicted parallel behavior — Intel Advisor XE 2015

Summary | Survey Report | Annotation Report | Suitability Report | Correctness Report

Intel Advisor helps you choose where to add parallelism to your program

Intel Advisor tools help you choose possible parallel code regions, and predict their approximate parallel performance and data sharing problems. View the Advisor Workflow to guide you.

No Annotations found in your project source files.

After scanning 2 source files, 0 annotations have been found.

Top time-consuming loops

Consider adding parallel site and task annotations around these time-consuming loops found during Survey analysis.

Loop	Source Location	CPU Total Time
work	hitm_test.c:136	70.1988s
work	hitm_test.c:141	70.1988s
init_arrays	hitm_test.c:120	0.0745s

Collection Details

Survey

Collection started:	18 September 2014, 13:28:47
Collection finished:	18 September 2014, 13:29:09
Collection time:	00 min 22 sec
Finalization time:	00 min 02 sec
Elapsed time:	00 min 24 sec
Collection Log:	See log
Application Output:	See output
Collection Command Line:	See command line

Suitability (Not available)

Correctness (Not available)

Platform Information

Frequency:	1.90 GHz
Logical CPU Count:	4
Operating System:	Windows
Computer Name:	bbachmay-MOBL7.ger.corp.intel.com

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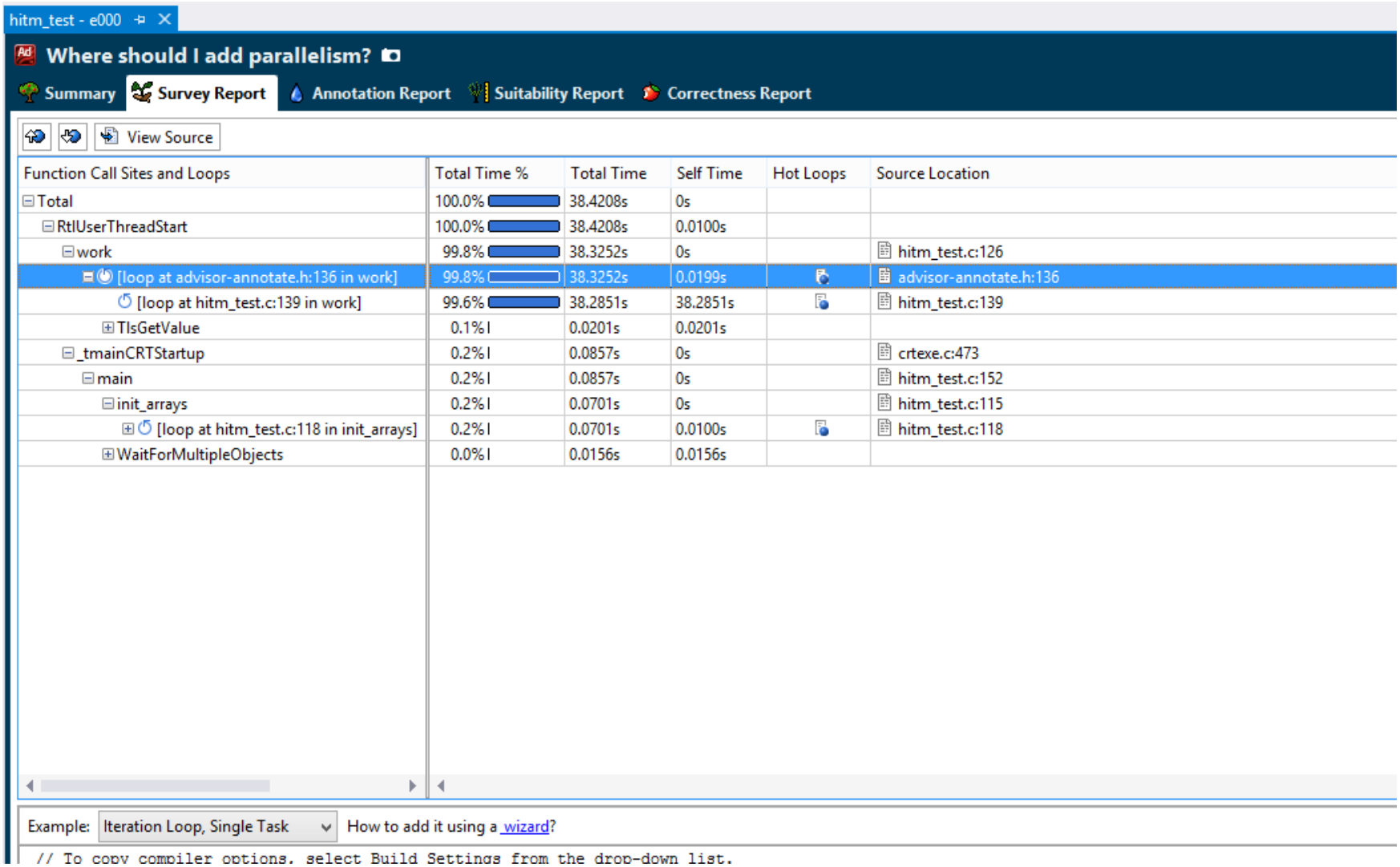
Survey Report



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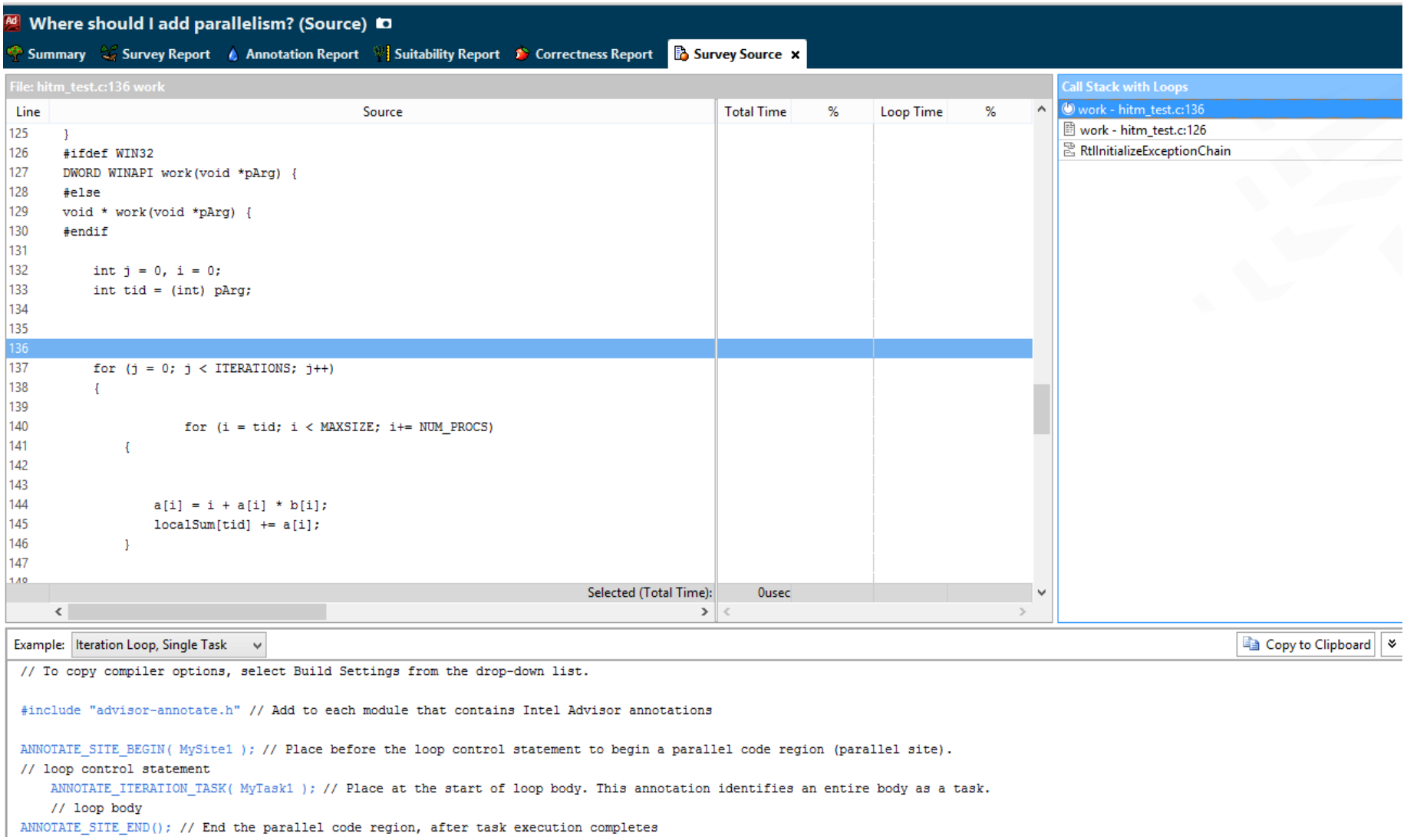
Drill down to Source Code in the hotspot



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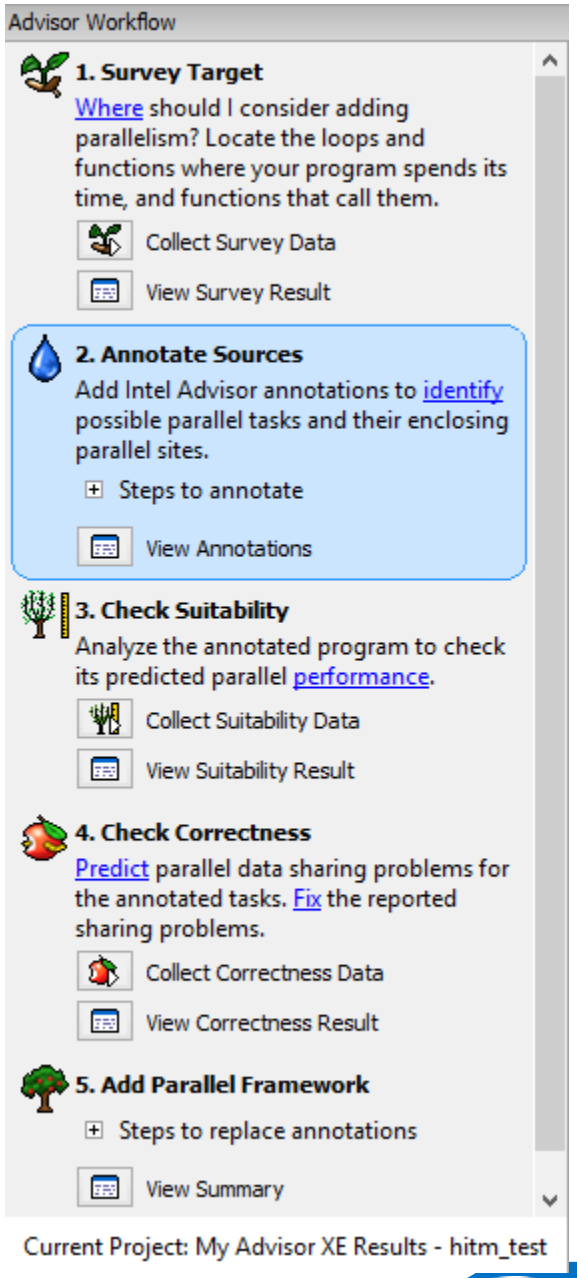
Advisor XE Annotation Concepts

Advisor XE uses 3 primary concepts to create a model

- **SITE**
  - A region of code in your application you want to transform into parallel code
- **TASK**
  - The region of code in a SITE you want to execute in parallel with the rest of the code in the SITE
- **LOCK**
  - Mark regions of code in a TASK which must be serialized

NOTE

- All of these regions may be nested
- You may create more than one SITE
- Just macros, so work with any C/C++ compiler



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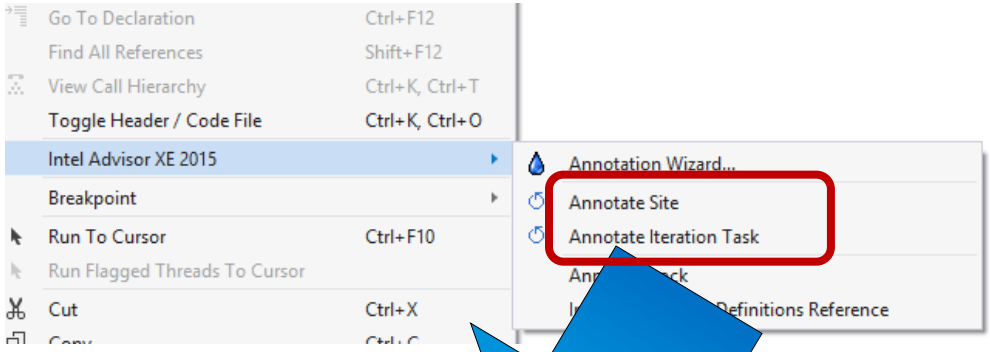
Candidate: ADD Annotation
48% Work::start

```
DWORD WINAPI work(void *pArg) {
#else
void * work(void *pArg) {
#endif

    int j = 0, i = 0;
    int tid = (int) pArg;



    for (j = 0; j < ITERATIONS; j++)
    {

        for (i = tid; i < MAXSIZE; i+= NUM_PROCS)
        {
            a[i] = i + a[i] * b[i];
            localSum[tid] += a[i];
        }


    }

    return 0;
}
```




```
void * work(void *pArg)
#endif

    int j = 0, i = 0;
    int tid = (int) pArg;
    ANNOTATE_SITE_BEGIN( MySite5 );


    for (j = 0; j < ITERATIONS; j++)
    {
        ANNOTATE_ITERATION_TASK( MyTask9 );
        for (i = tid; i < MAXSIZE; i+= NUM_PROCS)
        {
            a[i] = i + a[i] * b[i];
            localSum[tid] += a[i];
        }


    }
    ANNOTATE_SITE_END();
    return 0;
}
```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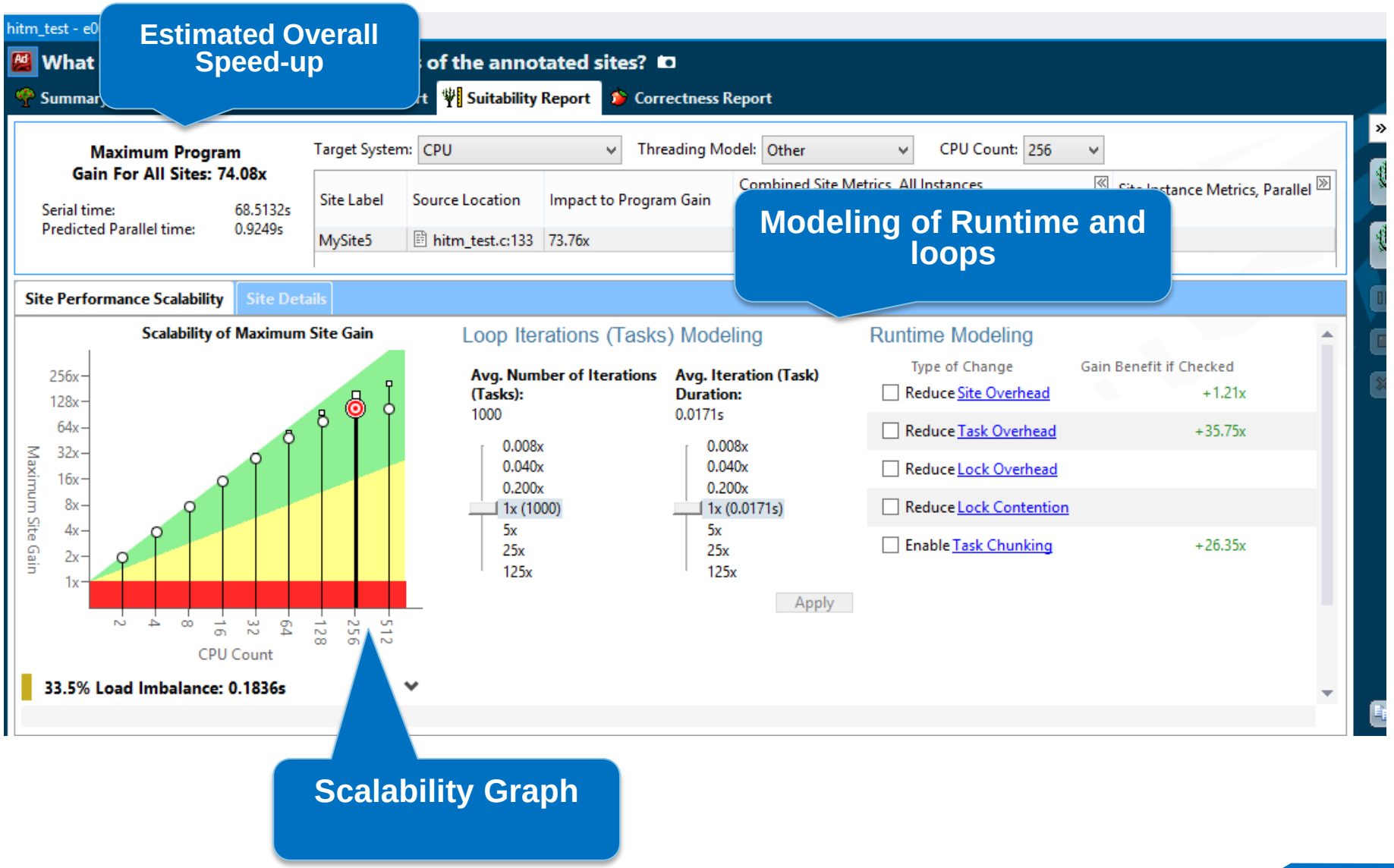
Step 3:



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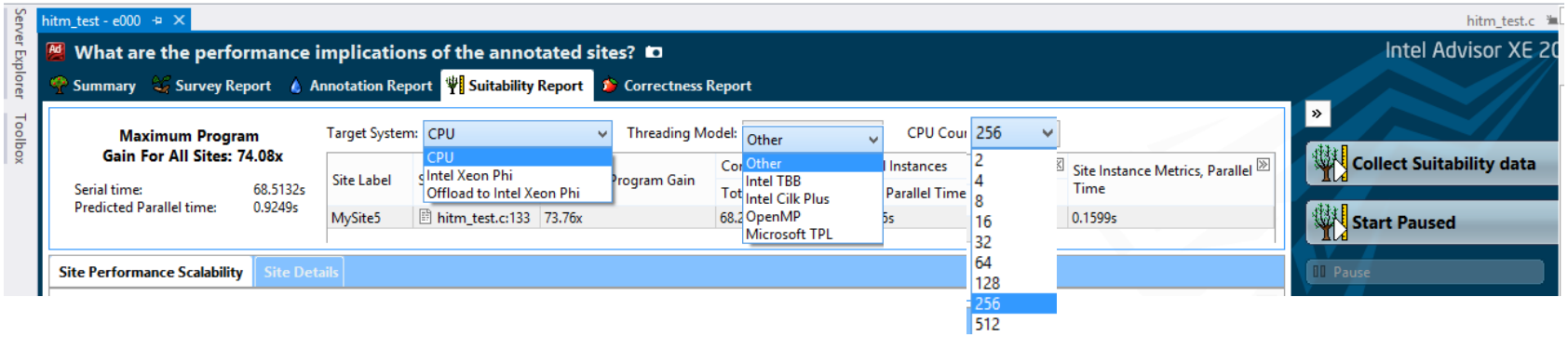
Adjustable: Target architecture, threading models and number of CPU



To set up data collection determine the target architecture, threading model and number of CPU's

Collect the Scalability data, and determine how it differs between the architectures and threading models.

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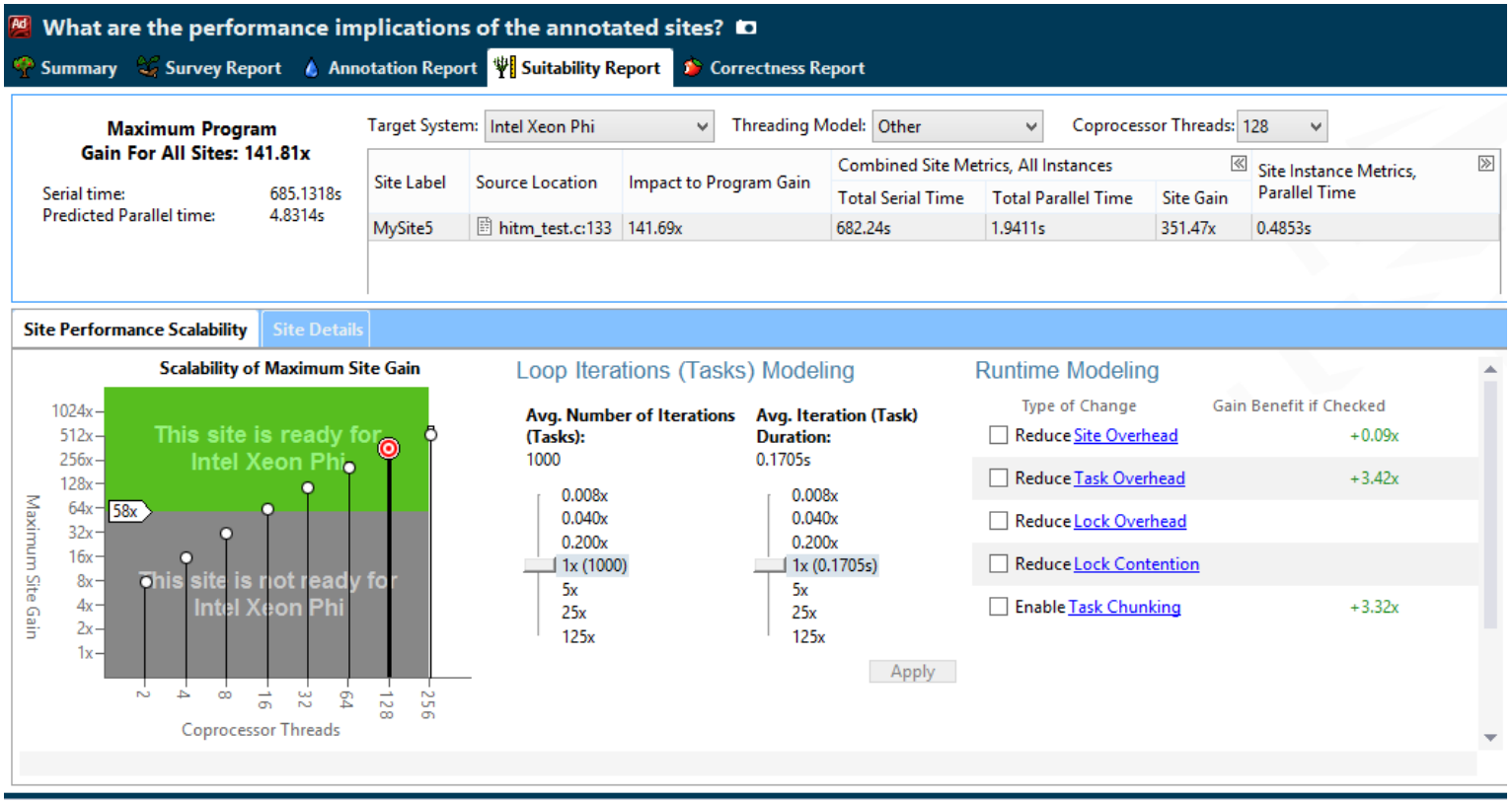
After collecting data change your view



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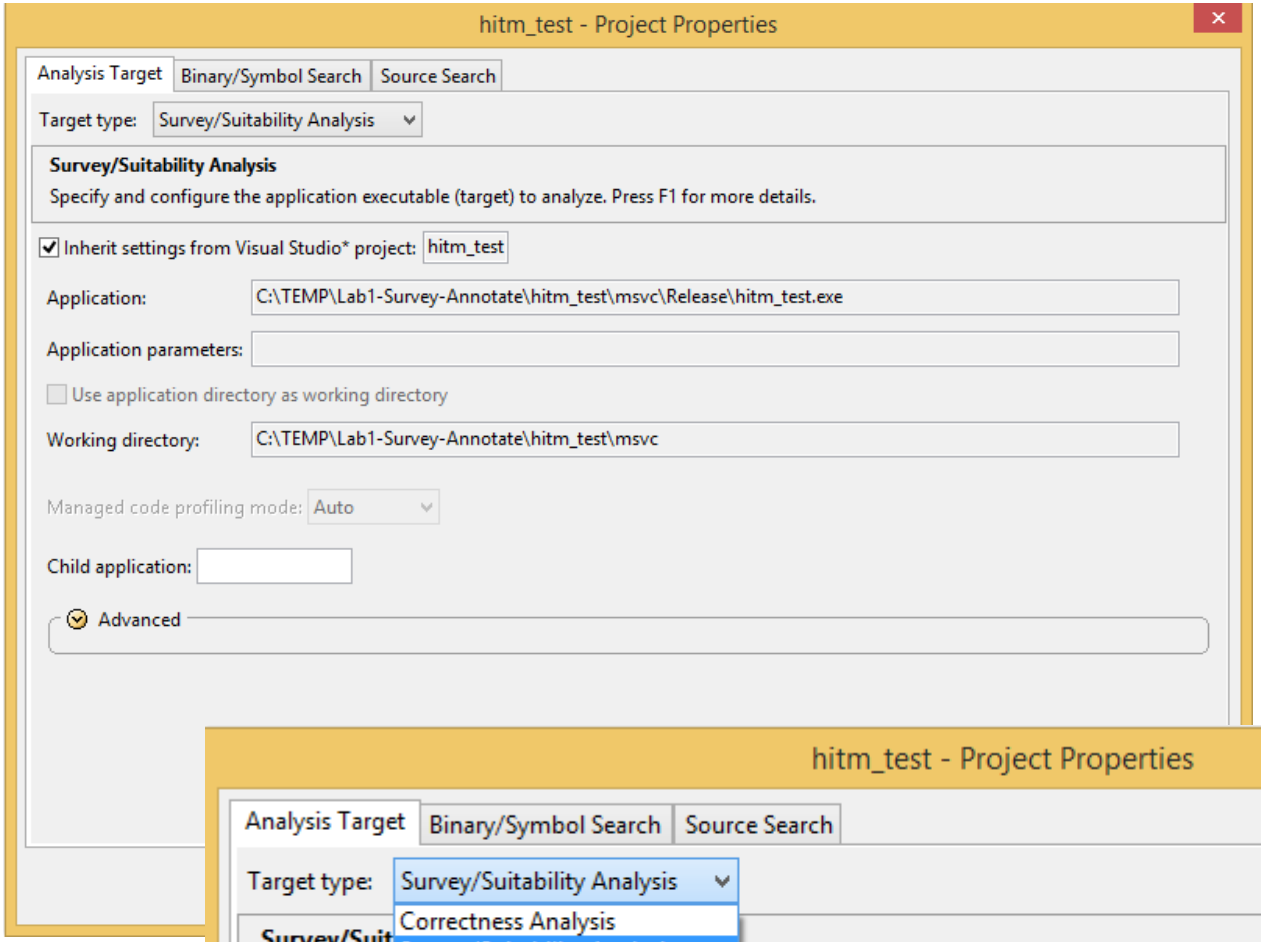
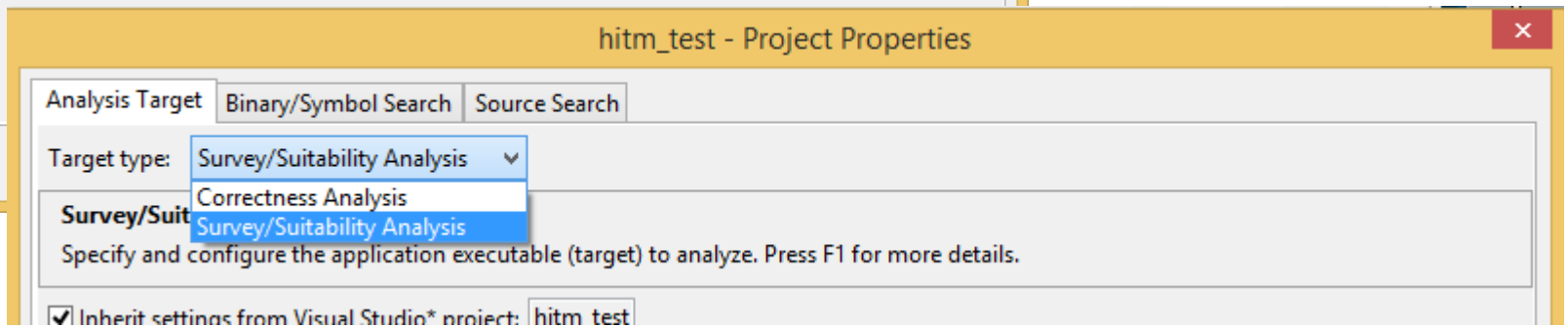
Lab 1: Survey, Annotate, Suitability





Create a project

Set up project properties

Annotate the Code

Get the suitability report

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Review of of Lab 1
Survey, Annotate, Suitability

What would be the best target architecture for this code?

Does loop scale well?

At how many iterations would you want to use Xeon Phi coprocessors instead of CPU's

Does the Threading model make a difference in the scalability?

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Correctness Simulation

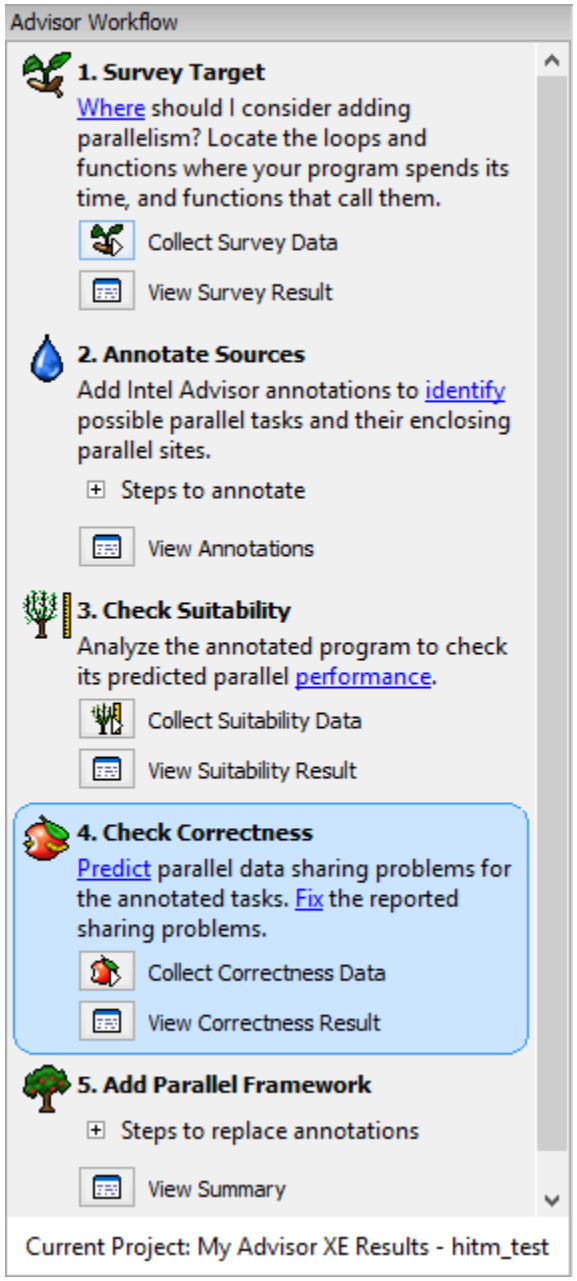
Find data sharing problems prior to implementation

- Data Sharing
- Data races

Intel Advisor XE provides a list of errors:

- shows a snippet of the code at all the related code locations

- Correctness Analysis watches the annotated sites for data sharing problems



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Correctness Analysis – Set up

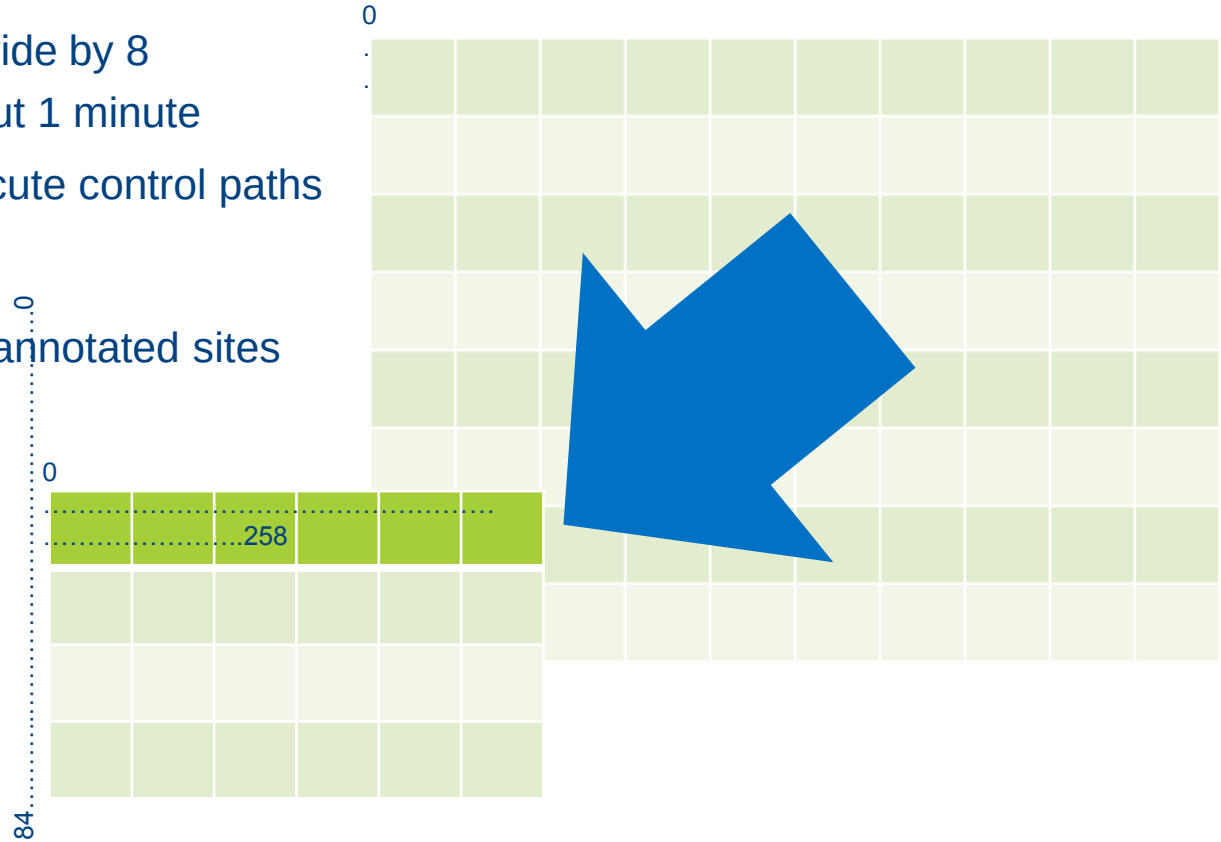
Build a target executable using debug configuration build

Choose a reduced data set that allows execution of all control paths

- Reduce data set size – divide by 8
  - 258x84 executes about 1 minute
- Be sure to thoroughly execute control paths

Annotate your program

- Correctness only looks at annotated sites



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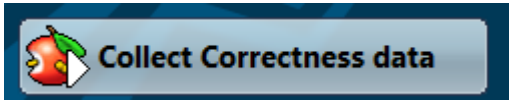
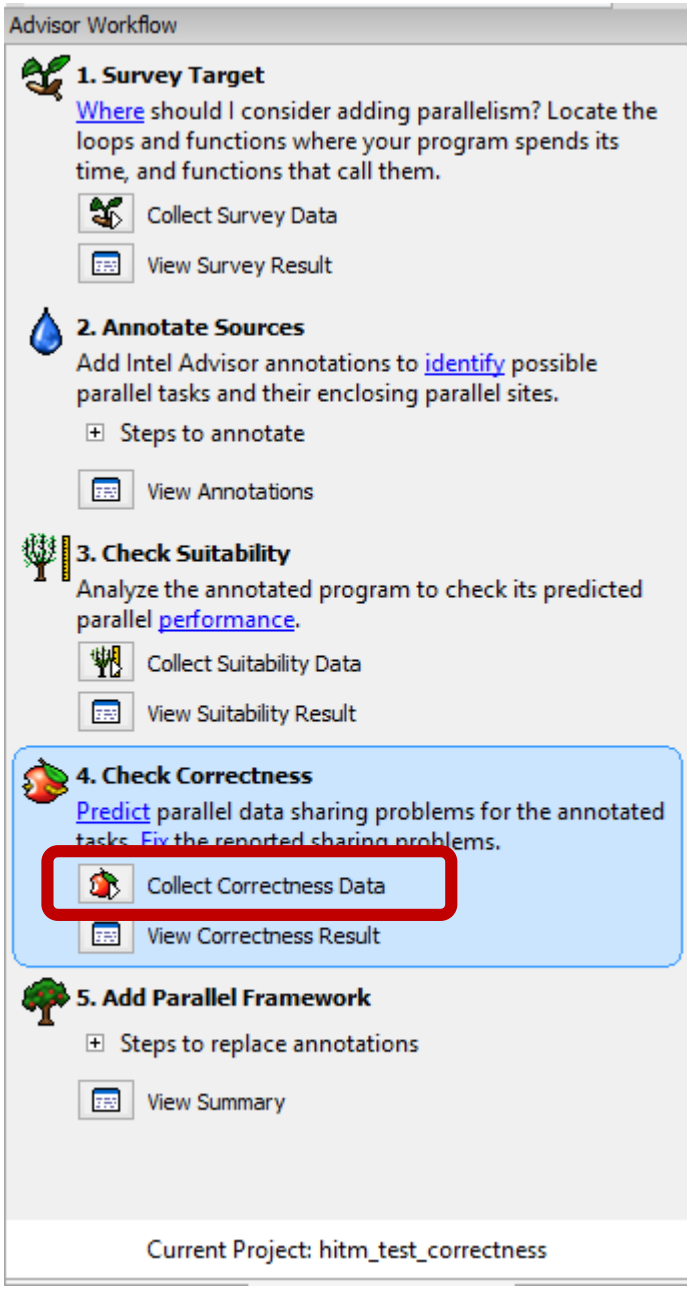
Check Correctness

Recompile using Debug

Execute your program using



Execution will take longer as the code is executing in debug and the annotations in the code



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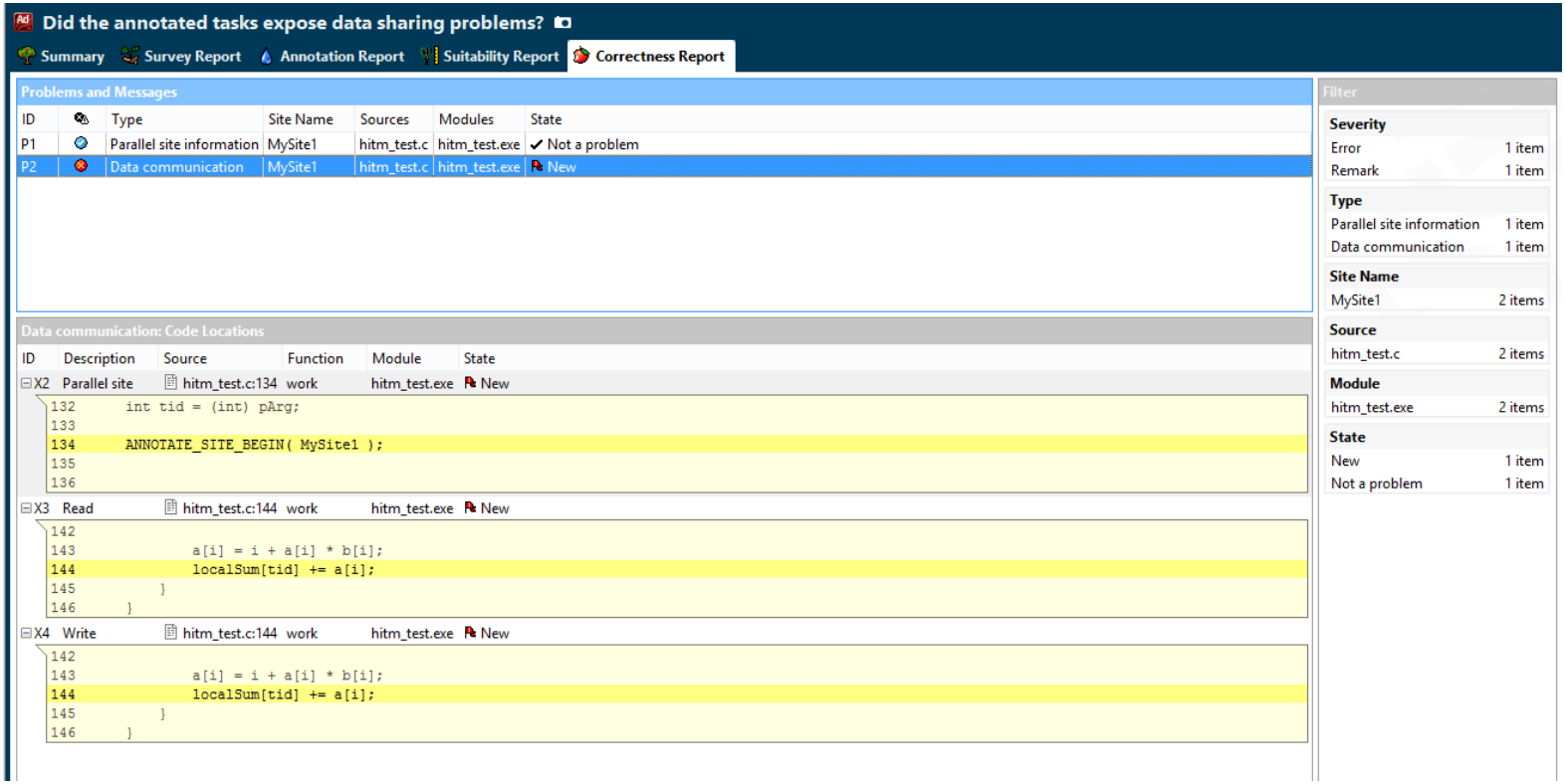
Correctness Report



Analyze your annotations to see if you made a correct choice

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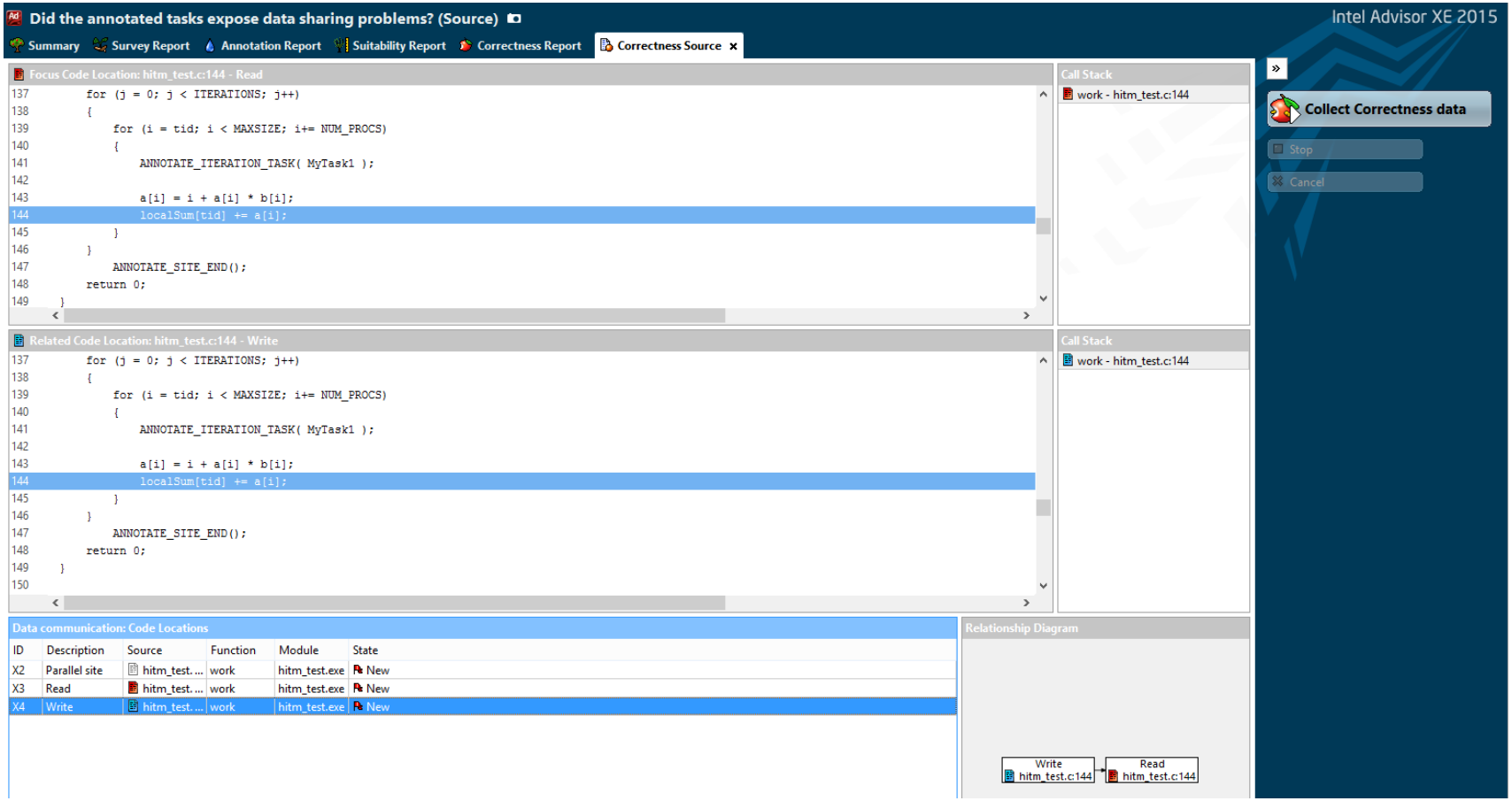
Drill down to source code to get more information



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Fix the issues shown in Advisor and then Repeat…

You do not have to choose the perfect answer the first time, so you can go back and modify your choices

Iterative refinement will either

- Create a suitable and correct annotation proposal
- Conclude no viable sites are possible

Efficiently arriving at either answer is valuable

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Lab 2: Check Correctness

Reduce the size of the data set

Recompile with Debug

Start a project

Set up project properties

Check correctness

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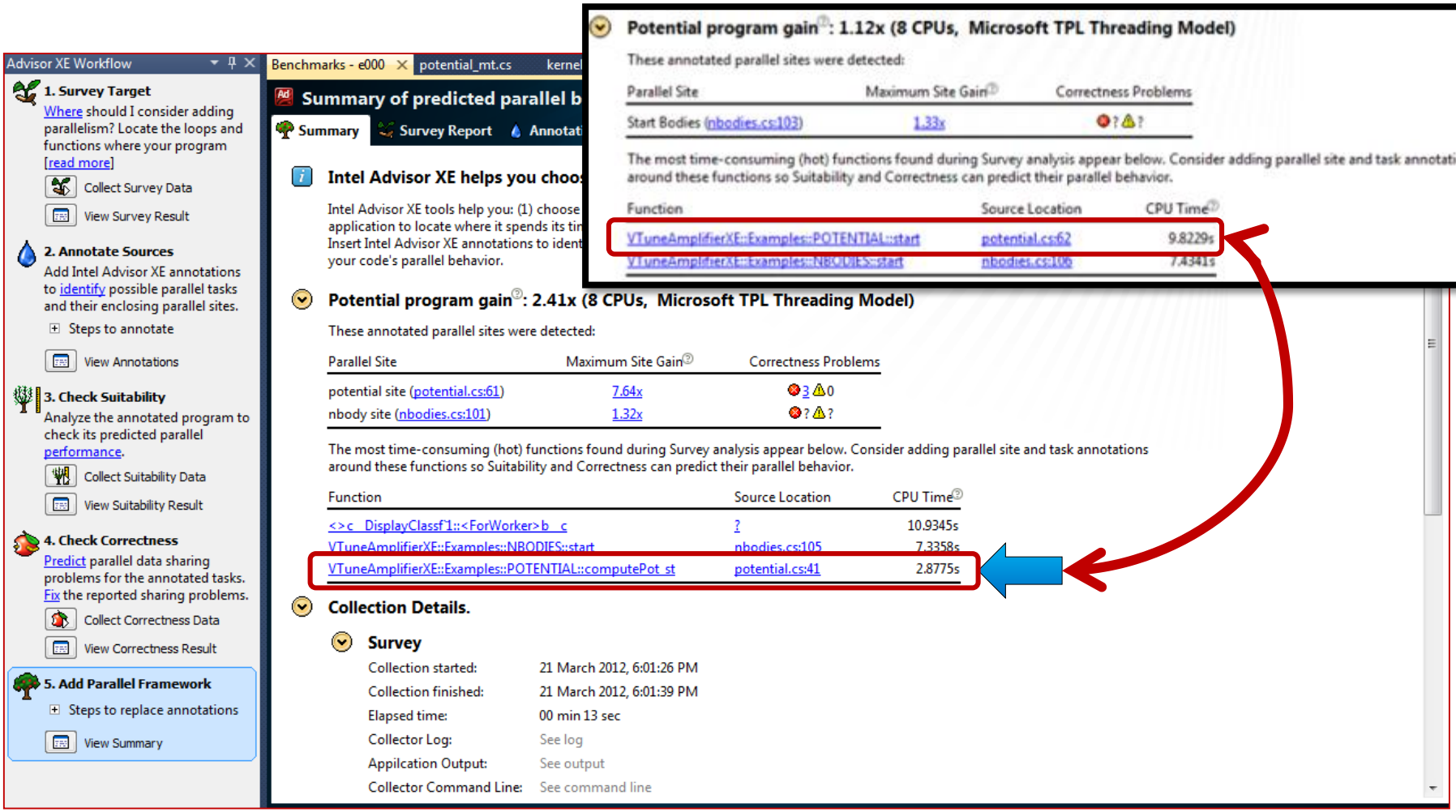
Add Parallel Framework



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Summary

The Intel Advisor XE is a unique tool

- assists you to work smarter though detailed modeling
- guides you through the necessary steps
- leaves you in control of code and architectural choices
- lets you transform serial algorithms into parallel form faster

The parallel modeling methodology

- maintains your original application's semantics and behavior
- helps find the natural opportunities to exploit parallel execution

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Top 10 Questions

1. Why we do not just insert the correct code at a push of the button

Answer : the technology for parallelism is not quite there. See slide 5.

2. Do you run on Xeon Phi coprocessor

Answer: no, we run on Xeon and then use heuristics and what we know about the data size of the operations to model the behavior if the code is run natively on Xeon Phi or run in offload to Xeon Phi.

3 How do Advisor and Amplifier results compare.

4

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Intel® Parallel Studio XE

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