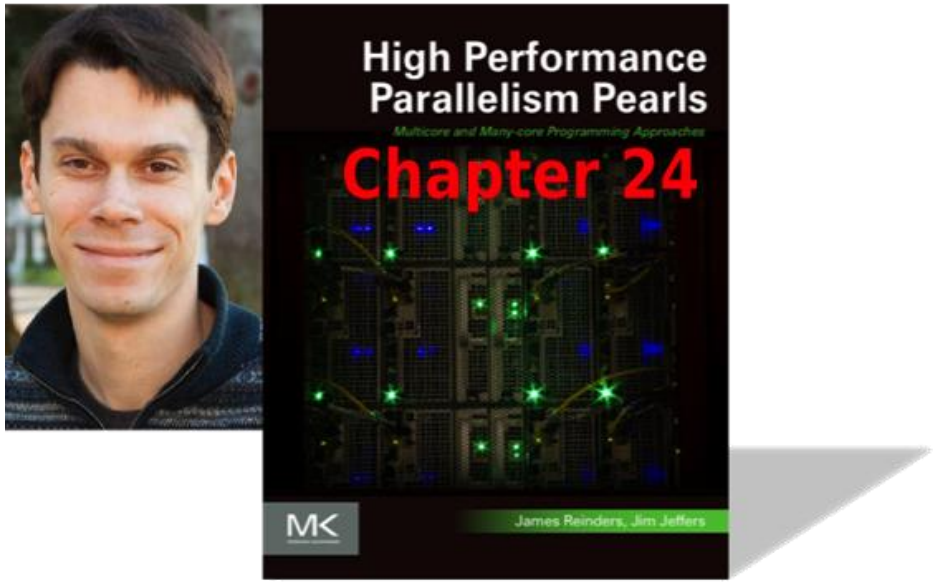
Hands-on “modernization of an application using Intel Advisor”

Matrix Transposition

- This Hands-on is based on chapter 24 (“Profiling-Guided Optimization”) - “High Performance Parallelism Pearls” book;

- This chapter exploits the use of Intel® VTune™ Amplifier XE reports to understand where to apply optimization on matrix transposition.



Agenda

- Speedup Estimation Analysis
  - Create Advisor Project
  - Collect Survey Data
  - Include Annotations
  - Collect Suitability Data

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- ;

Intel Advisor

- Intel® Advisor XE is a shared memory threading designing and prototyping tool for C, C++, C# and Fortran.

- This tool provides a mechanism called annotation which is used to inform the regions of the code which can be parallelized. Based on such annotations a model is built in order to compare the performance scaling of different threading designs without the cost and disruption of implementation.

- In this part of Hands-on you will execute the following steps in order to perform threading prototyping:

✓ Create project;
✓ Survey data: Discover opportunities for parallelization;
✓ Annotate sources: include annotations on source code to check scalability;
✓ Check suitability: evaluate the performance of annotated loops in different architectures and frameworks.

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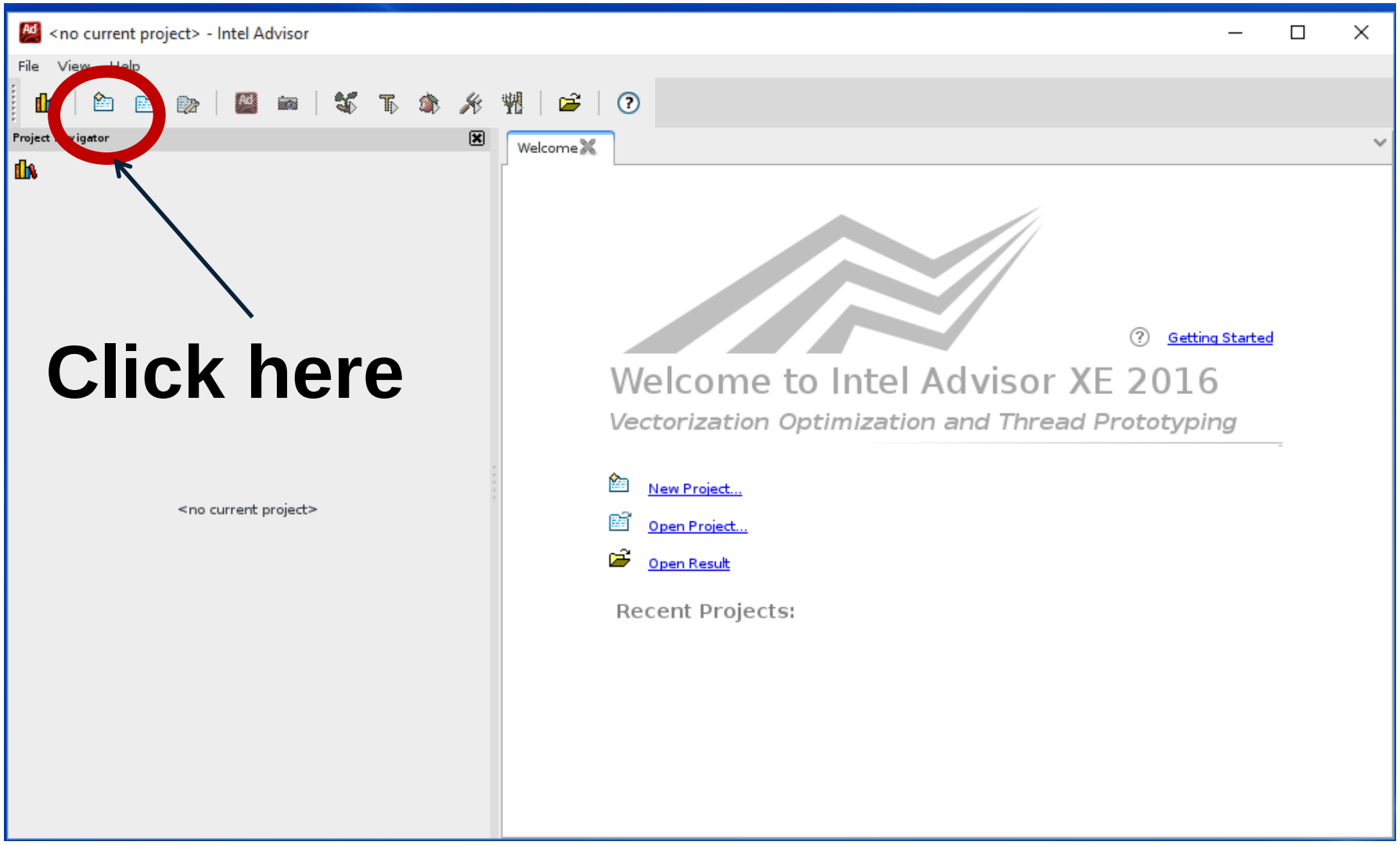
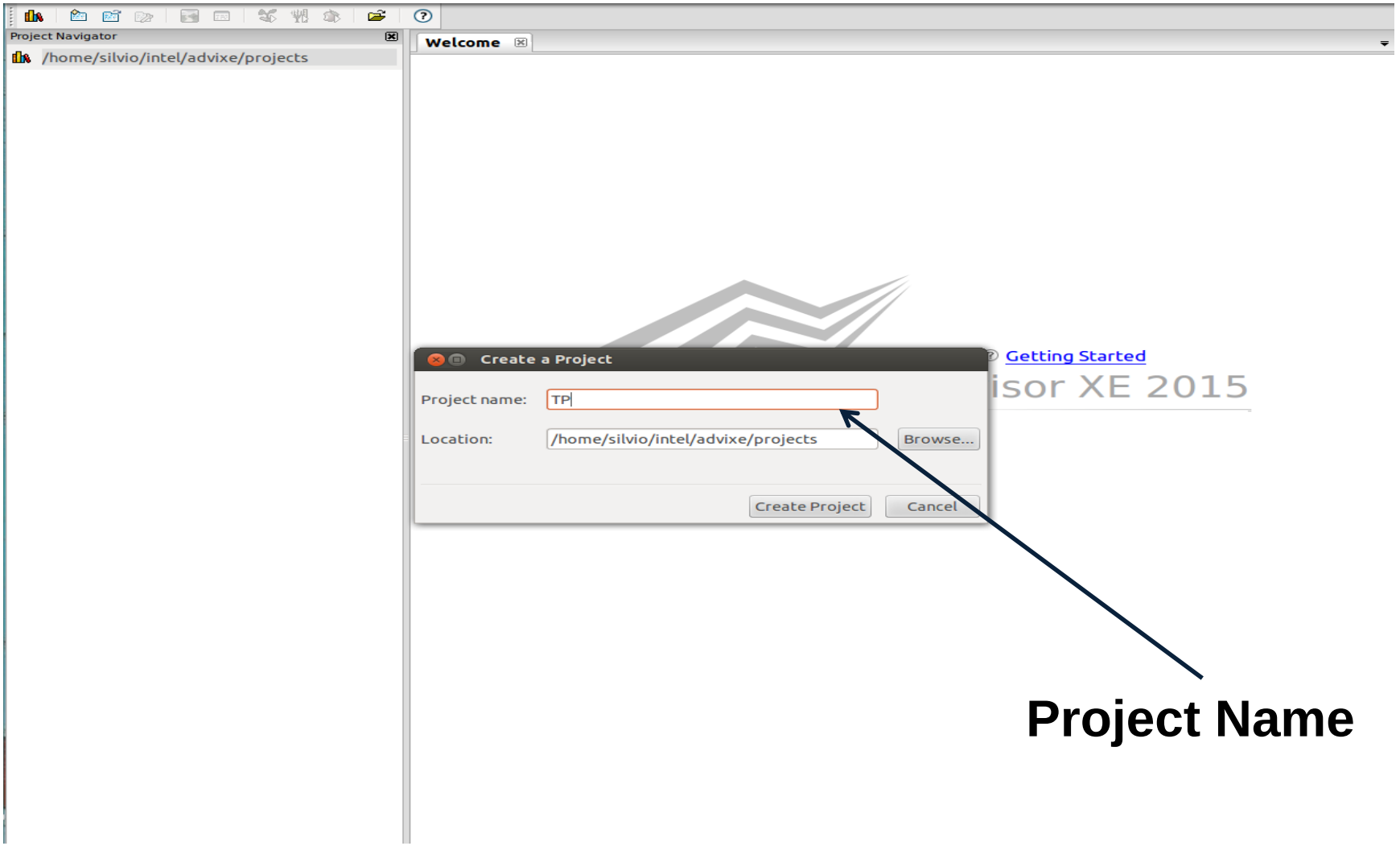
Intel Advisor – Create New Project

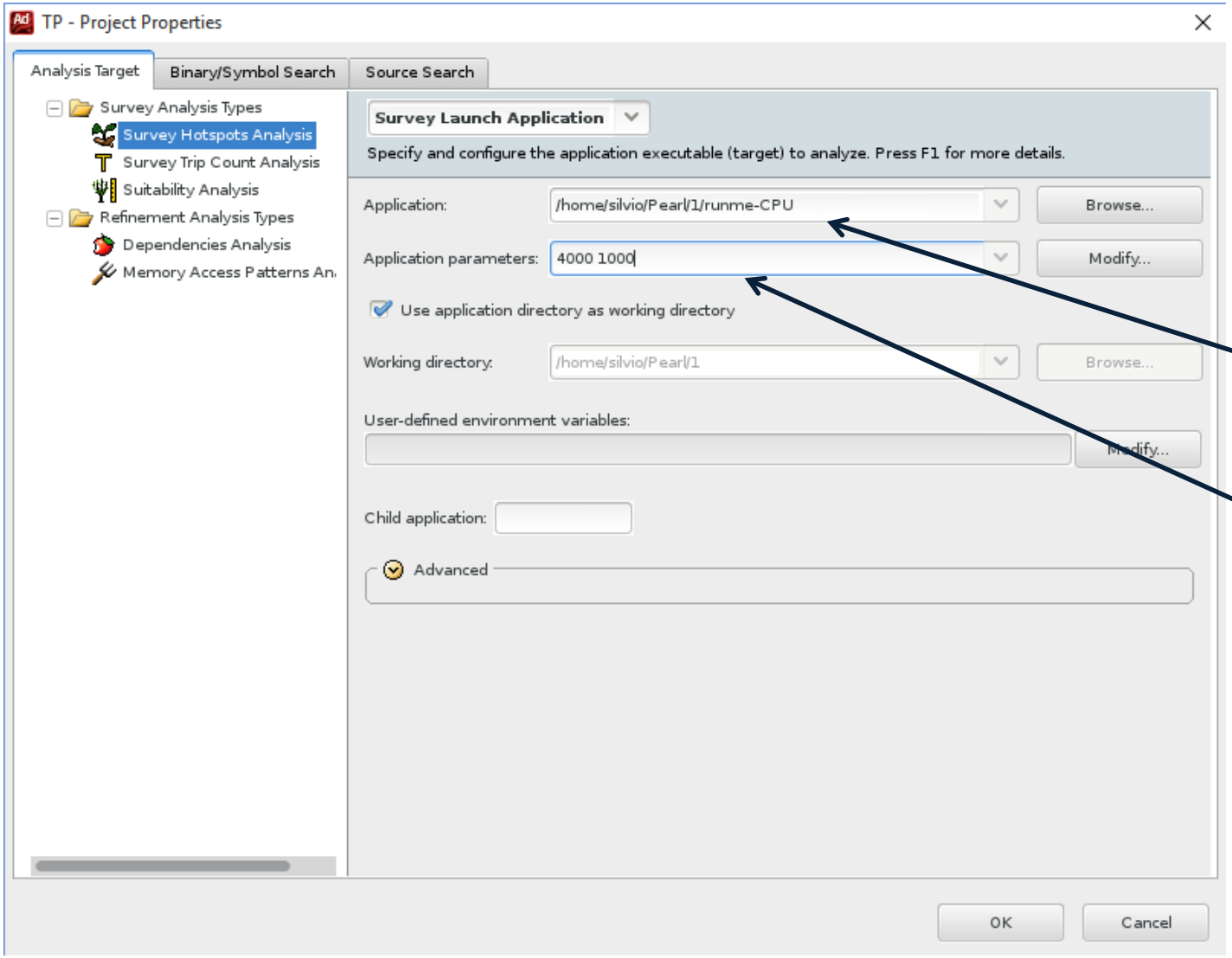
- Execute Intel Advisor on terminal: advixe-gui
- create new Advisor project:
  - name: TP
  - application: ~/hands-on/Pearl/1/runme-CPU
  - application parameters: 3000 100
  - Source Folder: ~/hands-on/Pearl/1/


<no current project> - Intel Advisor
File View Help
Project Navigator
Welcome
Click here
<no current project>
Getting Started
Welcome to Intel Advisor XE 2016
Vectorization Optimization and Thread Prototyping
New Project...
Open Project...
Open Result
Recent Projects:

Intel Advisor – Create New Project



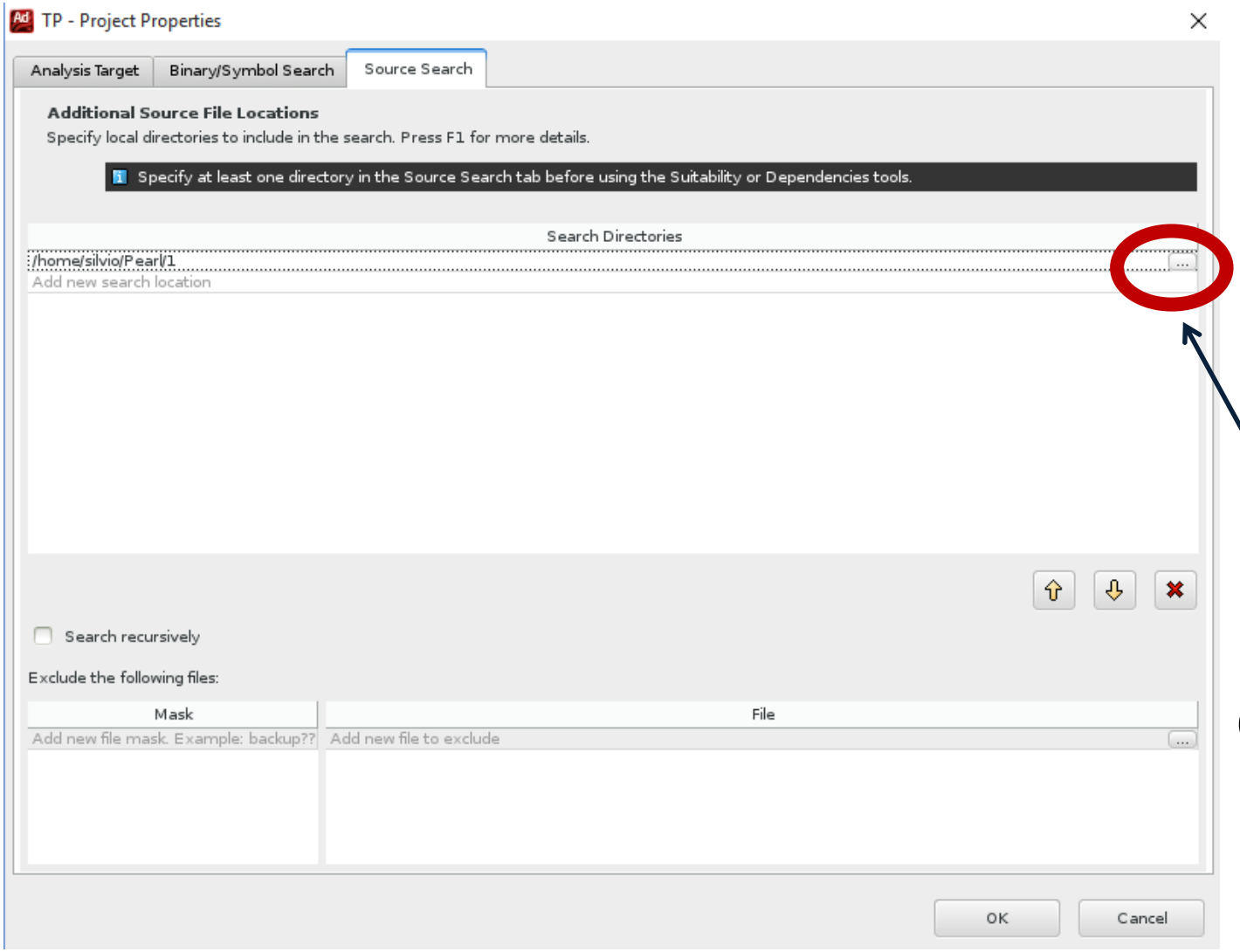
Intel Advisor – Create New Project



Application

Application Parameters

Intel Advisor – Source Search



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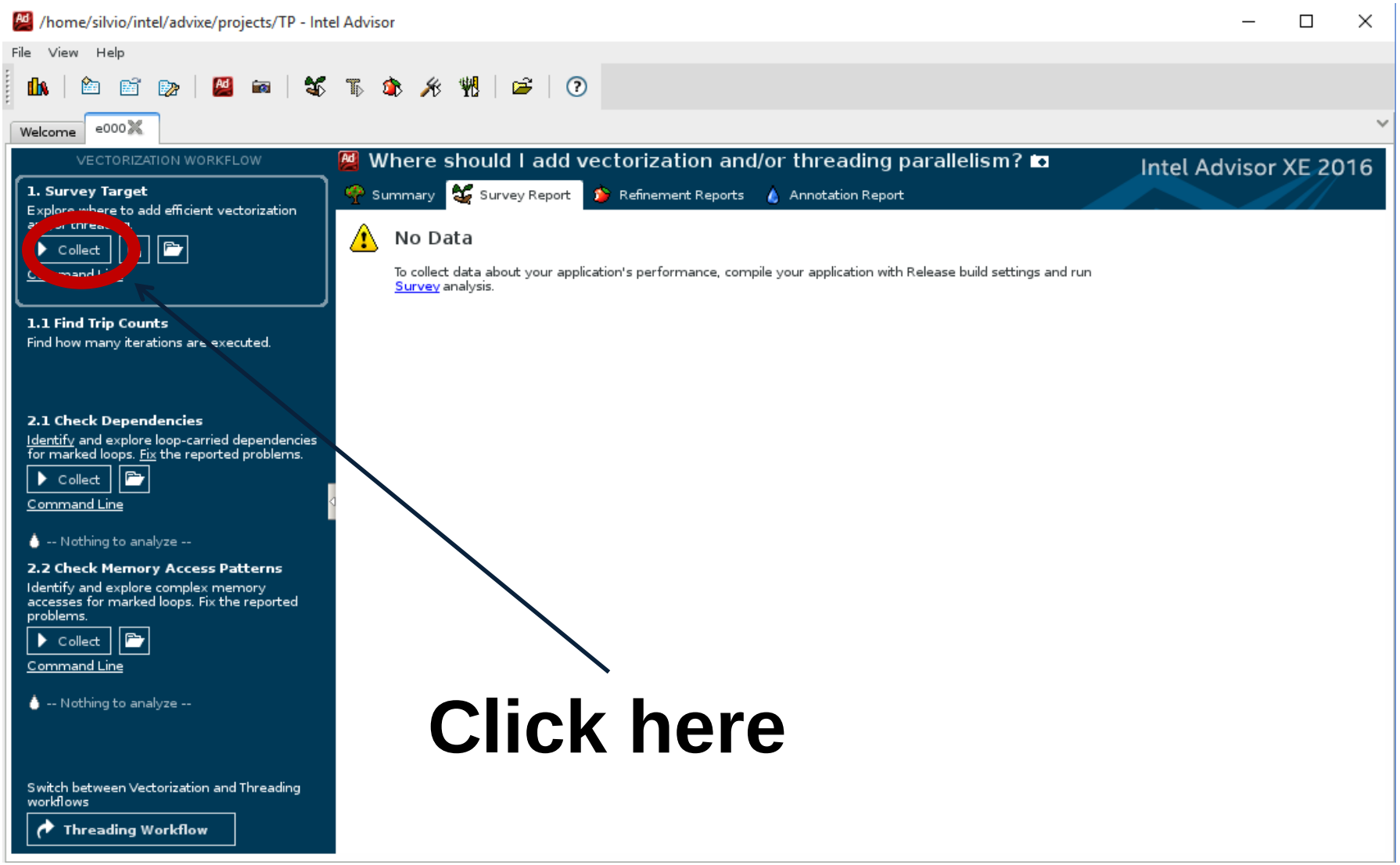
Intel Advisor - collect survey data



Intel Advisor - survey data results

Higher instruction set architecture (ISA) available

Consider recompiling your application using a higher ISA.

Loops	Vector Issues	Self Time	Total Time	Loop Type	Why No Vectorization?	Vectorized Loops: Vector ISA	Vectorized Loops: Gain Estimate	Vectorized Loops: VL (Vector Length)	Vectorized Loops: Compiler Estimated Gain	Instruction Set Analysis: Traits	Instruction Set Analysis: Data Types	Advanced	Location
[loop in Transpose at Transpose.cc:20]		40.470s	40.470s	Vectorized (B...		SSE	3.43x	2; 4	3.43x		Float32; Float64	Unrolled by 4	Transpose.cc:
[loop in Transpose at Transpose.cc:20]		40.470s	40.470s	Vectorized (B...		SSE		2; 4	3.43x		Float32; Float64	Unrolled by 4	Transpose.cc:
[loop in __kmp_launch_thread at kmp_runtime.c:5900]		24.499s	24.820s	Scalar									kmp_runtime
[loop in VerifyTransposed at Main.cc:24]	1 Data type conversions present	0.171s	0.171s	Vectorized (B...		SSE2	2.73x	2; 4	2.73x	Type Conv...	Float32; Float64; Int32	Unrolled by 4	Main.cc:24
[loop in VerifyTransposed at Main.cc:24]	1 Data type conversions present	0.171s	0.171s	Vectorized (B...		SSE2		2; 4	2.73x	Type Conv...	Float32; Float64; Int32	Unrolled by 4	Main.cc:24
[loop in Transpose at Transpose.cc:20]	**1 Ineffective peeled/remainder loop ...**	**0.080s**	**0.080s**	**Vectorized ...**		**SSE**	**1.86x**	**2; 4**	**1.86x**		**Float32; Float64**		**Transpose.**
[loop in Transpose at Transpose.cc:20]		0.050s	0.050s	Vectorized (R...		SSE		2; 4	1.86x		Float32; Float64		Transpose.cc:
[loop in Transpose at Transpose.cc:20]		0.030s	0.030s	Remainder									Transpose.cc:
[loop in Transpose at Transpose.cc:17]		0.030s	40.500s	Scalar	inner loop was al...								Transpose.cc:
[loop in start_thread]		0.000s	24.820s	Scalar									
[loop in __libc_start_main]		0.000s	40.670s	Scalar									
[loop in main at Main.cc:74]		0.000s	40.600s	Scalar	loop with multipl...						Float32; Float64		Main.cc:74
[loop in VerifyTransposed at Main.cc:23]		0.000s	0.171s	Scalar						Unpacks	Float32; Float64; Int32; Int64		Main.cc:23
[loop in [OpenMP worker] at z_Linux_util.c:786]		0.000s	24.820s	Scalar									z_Linux_util.c

Source | Top Down | Loop Assembly | Recommendations | Compiler Diagnostic Details

File: Transpose.cc:20 Transpose

Line	Source	Total Time	%	Loop Time	%	Traits
7	// You are free to use, modify and distribute this code as long as you acknowledge					
8	// the above mentioned publication.					
9	// (c) Colfax International, 2013					
10						
11	#include "Transpose.h"					
12	#include <cstdlib>					
13						
14						
15	void Transpose(FTYPE* const A, const int n) {					
16						
17	for (int i = 0; i < n; i++) {			40.499s		
18						
19						
20	for (int i = 0; i < i; i++) {	0.280s		40.550s		
21						
22	const FTYPE c = A[i*n + j];	29.950s				
23	A[i*n + j] = A[j*n + i];	10.180s				
24	A[j*n + i] = c;	0.190s				
25	}					
26						
27	}					
28						
29	}					
30						

Intel Advisor - survey data results

Loops		Vector Issues	Self Time▾	Total Time	Loop Type	Why No Vectorization?	Vectorized Loops				Instruction Set Analysis		Advanced	Location
							Vector ISA	Gain Estimate	VL (Vector Length)	Compiler Estimated Gain	Traits	Data Types		
[loop in Transpose at Transpose.cc:20]			40.470s	40.470s	Vectorized (B...		SSE	3.43x	2; 4	3.43x		Float32; Float64	Unrolled by 4	Transpose.cc:
[loop in Transpose at Transpose.cc:20]			40.470s	40.470s	Vectorized (B...		SSE		2; 4	3.43x		Float32; Float64	Unrolled by 4	Transpose.cc:
[loop in __kmp_launch_thread at kmp_runtime.c:5900]			24.499s	24.820s	Scalar									kmp_runtime
[loop in VerifyTransposed at Main.cc:24]		1 Data type conversions present	0.171s	0.171s	Vectorized (B...		SSE2	2.73x	2; 4	2.73x	Type Conv...	Float32; Float64; Int32	Unrolled by 4	Main.cc:24
[loop in VerifyTransposed at Main.cc:24]		1 Data type conversions present	0.171s	0.171s	Vectorized (B...		SSE2		2; 4	2.73x	Type Conv...	Float32; Float64; Int32	Unrolled by 4	Main.cc:24
[loop in Transpose at Transpose.cc:20]		**1 Ineffective peeled/remainder loop ...**	**0.080s**	**0.080s**	**Vectorized ...**		**SSE**	**1.86x**	**2; 4**	**1.86x**		**Float32; Float64**		**Transpose.**
[loop in Transpose at Transpose.cc:20]			0.050s	0.050s	Vectorized (R...		SSE		2; 4	1.86x		Float32; Float64		Transpose.cc:
[loop in Transpose at Transpose.cc:20]			0.030s	0.030s	Remainder									Transpose.cc:
[loop in Transpose at Transpose.cc:17]			0.030s	40.500s	Scalar	inner loop was al...								Transpose.cc:
[loop in start_thread]			0.000s	24.820s	Scalar									
[loop in __libc_start_main]			0.000s	40.670s	Scalar									
[loop in main at Main.cc:74]			0.000s	40.600s	Scalar	loop with multipl...						Float32; Float64		Main.cc:74
[loop in VerifyTransposed at Main.cc:23]			0.000s	0.171s	Scalar						Unpacks	Float32; Float64; Int32; Int64		Main.cc:23
[loop in [OpenMP worker] at z_Linux_util.c:786]			0.000s	24.820s	Scalar									z_Linux_util.c

Source | Top Down | Loop Assembly | Recommendations | Compiler Diagnostic Details

Function Call Sites and Loops	Total Time %	Total Time	Self Time	Loop Type	Why No Vectorization?	Vectoriz...		Instruction Set Analysis		Advanced	Location
						Vec...	VL ...	Traits	Data Types		
Total	100.0%	65.490s	0s								
__libc_start_main	62.1%	40.670s	0s								
[loop in __libc_start_main]	62.1%	40.670s	0s	Scalar							
[Unknown stack frame(s)]	62.0%	40.600s	0s								
main	62.0%	40.600s	0s								Main.cc:38
[loop in main at Main.cc:74]	62.0%	40.600s	0s	Scalar	loop with multiple exits cannot be vectorized unless it meets search loop idiom criteria				Float32; Float64		Main.cc:74
Transpose	62.0%	40.600s	0.0200s								Transpose.cc:15
[loop in Transpose at Transpose.cc:17]	61.8%	40.500s	0.0300s	Scalar	inner loop was already vectorized						Transpose.cc:17
[loop in Transpose at Transpose.cc:20]	61.8%	40.470s	0s								Transpose.cc:20
[loop in Transpose at Transpose.cc:20]	61.8%	40.470s	40.4696s	Vectorized (Body)		SSE	2; 4		Float32; Float64	Unrolled by 4	Transpose.cc:20
[loop in Transpose at Transpose.cc:20]	0.1%	0.080s	0s								Transpose.cc:20
[loop in Transpose at Transpose.cc:20]	0.1%	0.050s	0.0500s	Vectorized (Remainder)		SSE	2; 4		Float32; Float64		Transpose.cc:20
[loop in Transpose at Transpose.cc:20]	0.0%	0.030s	0.0300s	Remainder							Transpose.cc:20
main	0.1%	0.070s	0s								Main.cc:38
__clone	37.9%	24.820s	0s								

Intel Advisor - survey data results

- What lines are the hot spots in this code?

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Intel Advisor – Include Annotations

- Include the annotations on “~/hands-on/Pearl/1/transpose.cc” in the following way:
  - **#include "advisor-annotate.h“**: include header file
  - **ANNOTATE_SITE_BEGIN(id)**: before beginning of loop;
  - **ANNOTATE_ITERATION_TASK(id)**: first line inside the loop;
  - **ANNOTATE_SITE_END()**: after end of loop;

Intel Advisor – Include Annotations

```
#include "Transpose.h"
#include <cstdlib>


void Transpose(FTYPE* const A, const int n) {

 for (int j = 0; j < n; j++) {


  for (int i = 0; i < j; i++) {

     const FTYPE c = A[i*n + j];
     A[i*n + j] = A[j*n + i];
     A[j*n + i] = c;
    }

  }

}
```

```
#include "Transpose.h"
#include <cstdlib>
#include "advisor-annotate.h"

void Transpose(FTYPE* const A, const int n) {
  ANNOTATE_SITE_BEGIN( MySite1 );
  for (int j = 0; j < n; j++) {
    ANNOTATE_ITERATION_TASK( MyTask1 );
    ANNOTATE_SITE_BEGIN( MySite2 );
    for (int i = 0; i < j; i++) {
      ANNOTATE_ITERATION_TASK( MyTask2 );
      const FTYPE c = A[i*n + j];
      A[i*n + j] = A[j*n + i];
      A[j*n + i] = c;
    }
    ANNOTATE_SITE_END();
  }
  ANNOTATE_SITE_END();
}
```

Intel Advisor – Include Annotations

- Red Lines shows the lines that has to be included in original source code;
- After include these lines recompile application:
  - Cd ~/hands-on/Pearl/1/
  - rm –rf runme-CPU
  - Make
- Check your annotations on “view annotations” options;

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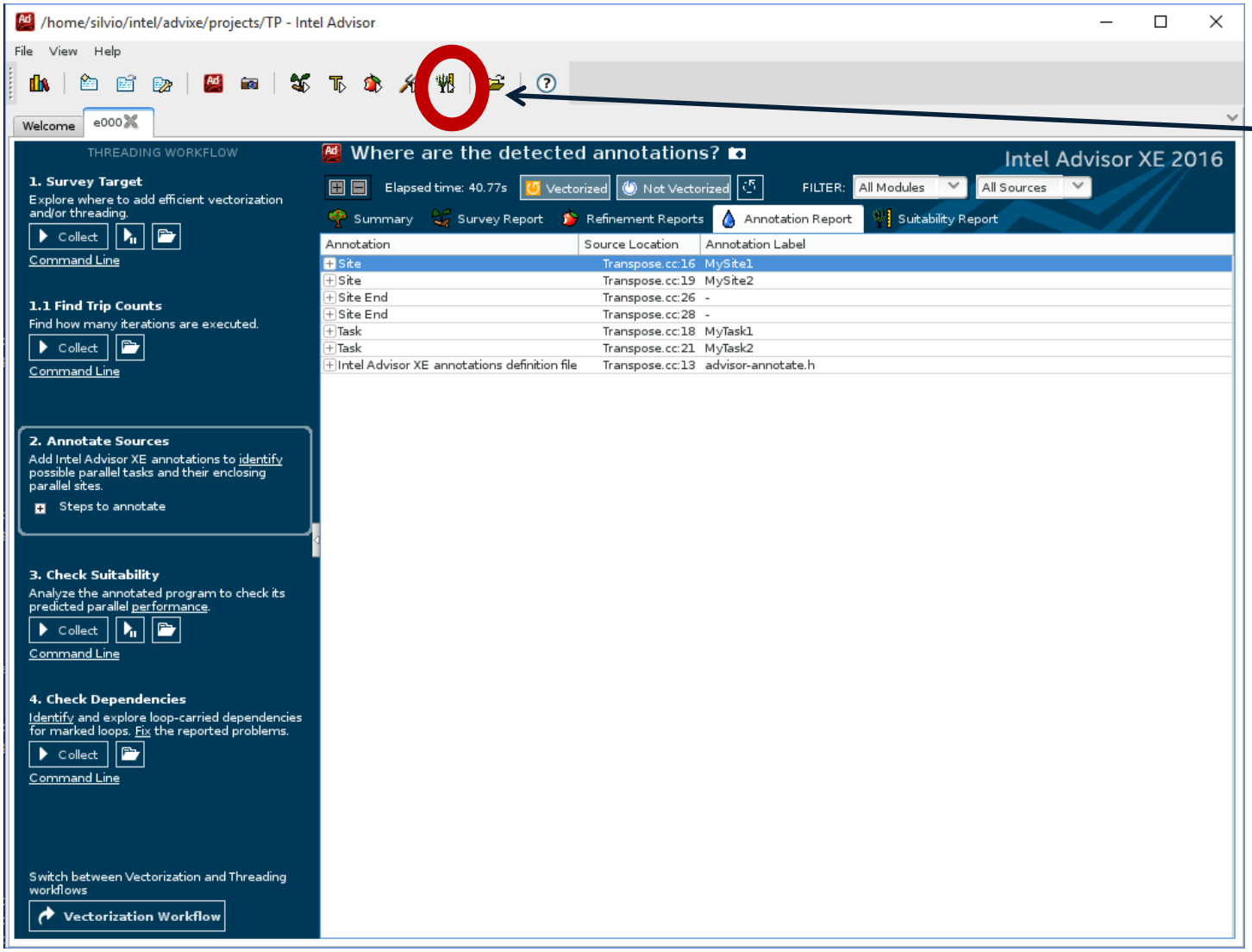

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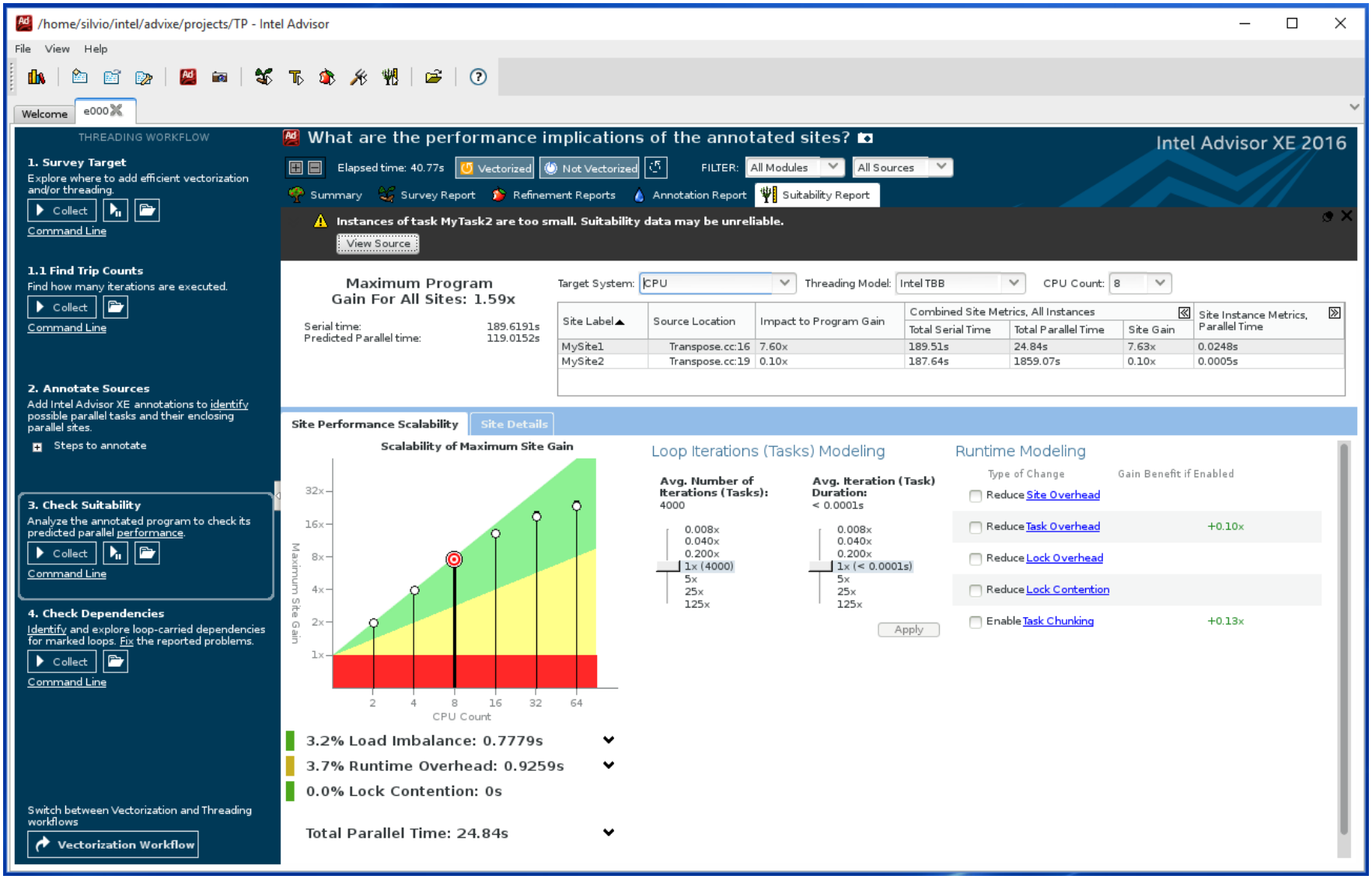
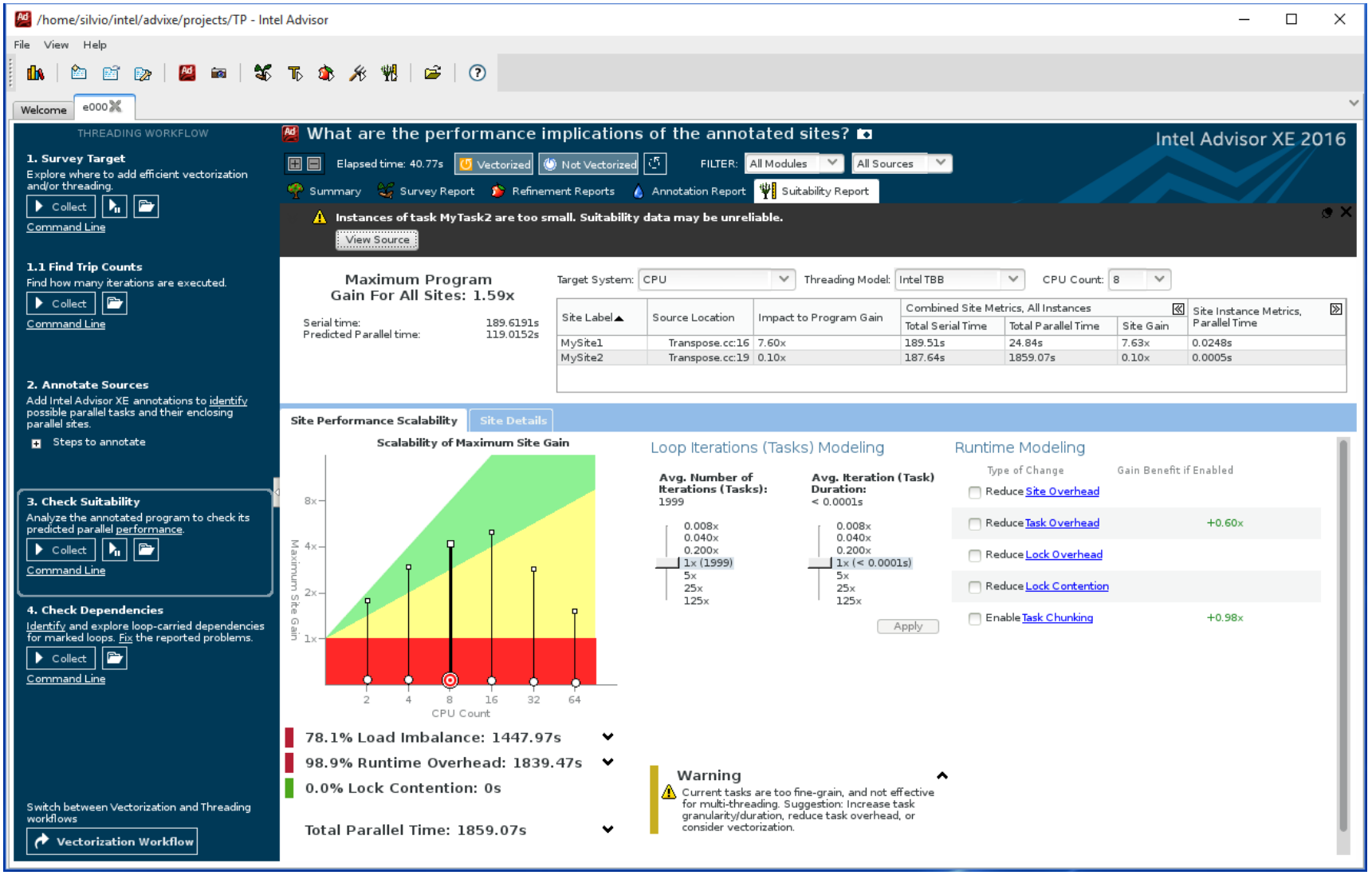
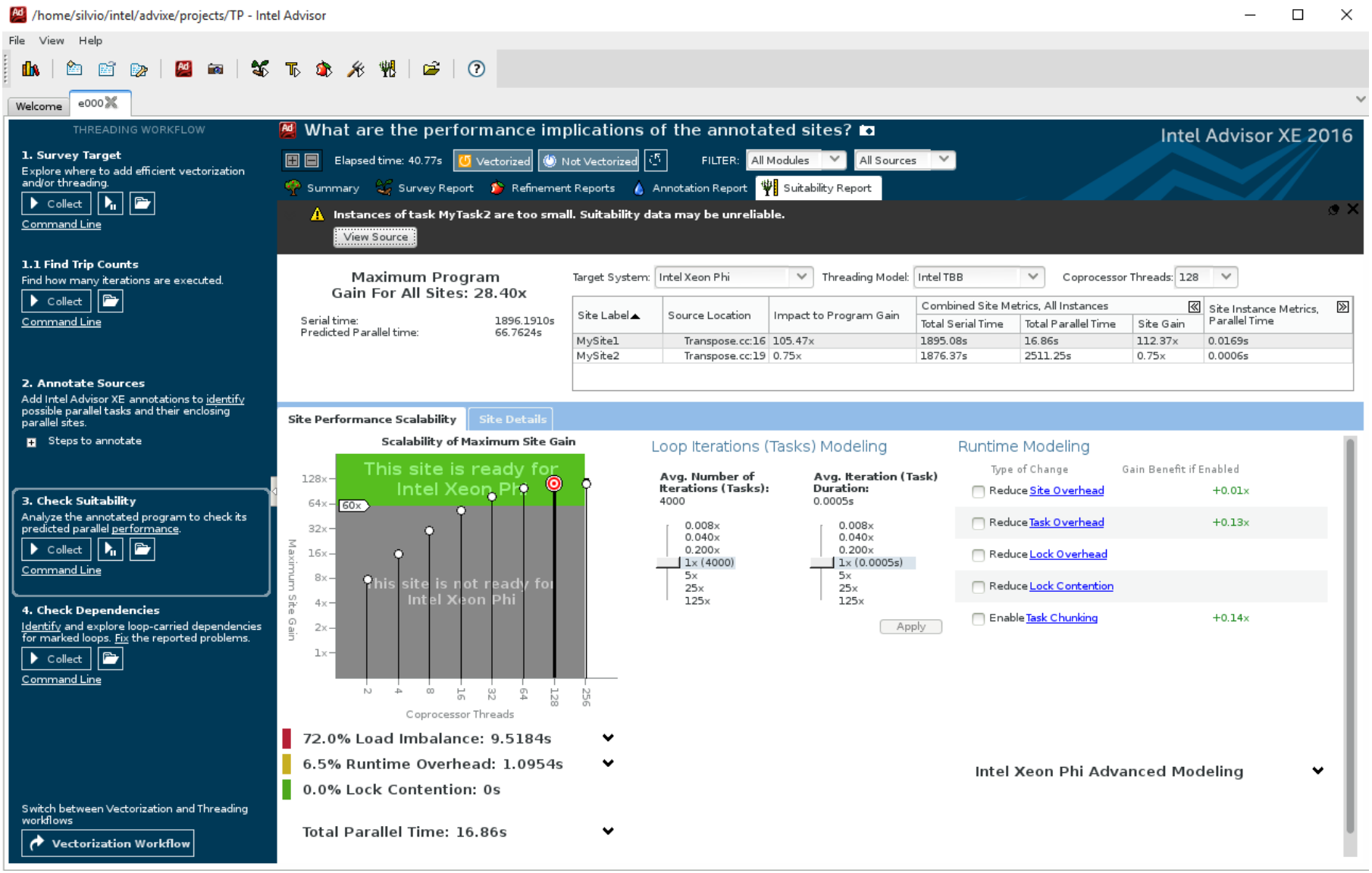
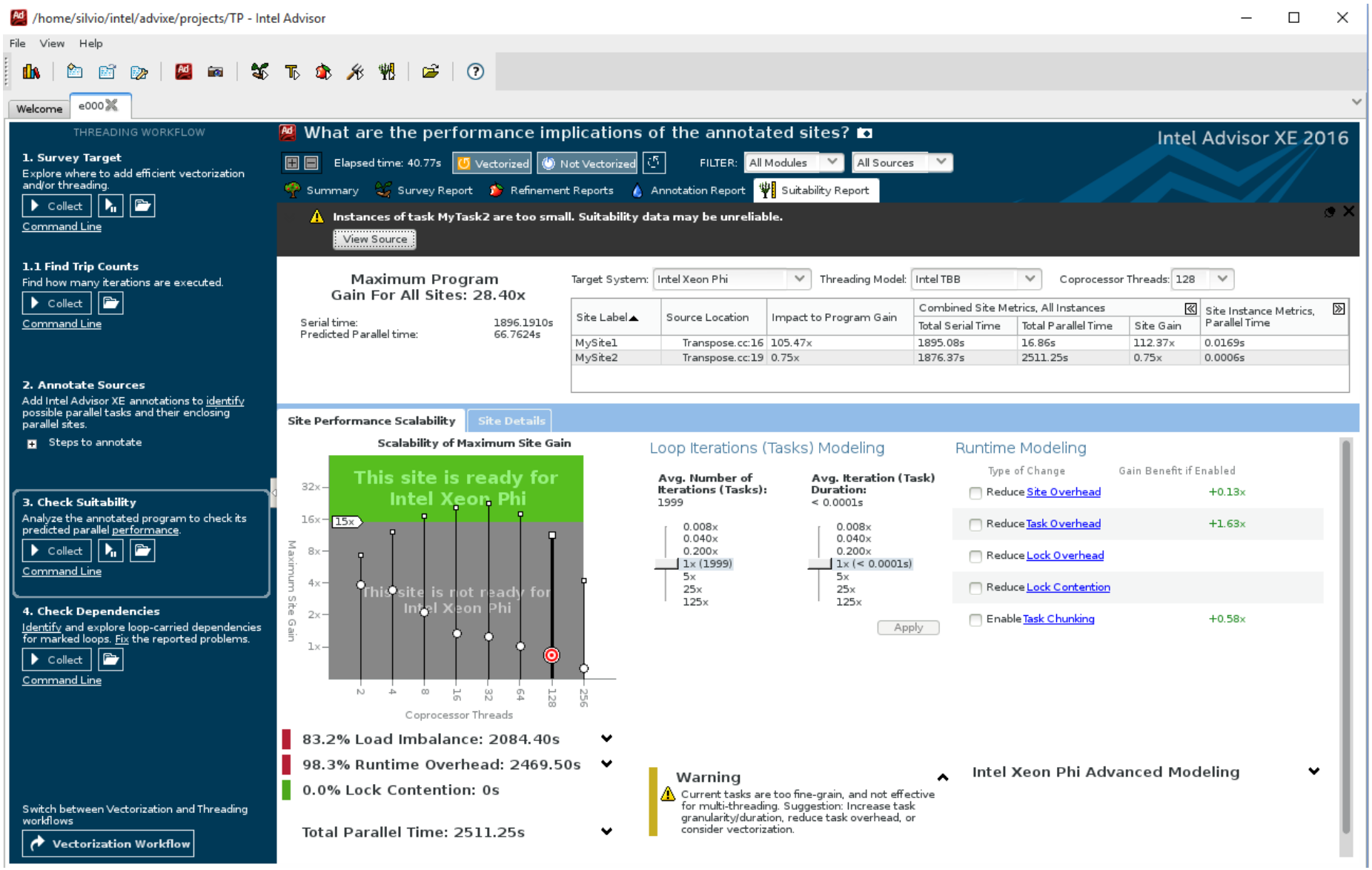
Check Suitability Expected Results (Intel Xeon) Site 1



Check Suitability Expected Results (Intel Xeon) Site 2



Check Suitability Expected Results (Intel Xeon Phi) Site 1



Check Suitability Expected Results (Intel Xeon Phi) Site 2