

Using Microsoft Visual Studio 2008 for OpenMP Programming

Christian Terboven terboven@rz.rwth-aachen.de

Center for Computing and Communication RWTH Aachen University





PPCES 2009 March 24th, RWTH Aachen University Agenda

Project Management

The Microsoft C/C++ compiler

• The Intel C/C++ and Fortran compiler

Microsoft

compiler

Intel

compiler

OpenMP

Demo

Using OpenMP

Project

Management



2

o Demo



VS2008 Overview (1/2)

Introduction into using Visual Studio 2008

- Only text-mode programs are considered here, as HPC applications typically do not use GUIs
- VS2008 offers great support for GUI development on Windows
- VS2008 provides good support for Parallel Programming:
 - Support for OpenMP for Shared-Memory parallel compilation
 - Debugging of parallel programs: OpenMP and MPI
 - Architecture-specific compiler optimizations

Microsoft

compiler

Project

Management



3

Center for

 The first start of VS2008 may take a few minutes as the help system has to be updated. You are prompted to choose from several pre-defined sets of VS2008 configuration options: I typically choose the C++ settings.

Intel

compiler

OpenMP

Demo

4

AACHEN UNIV

Visual Studio 2008 for OpenMP Programming

24.03.2009 – C. Terboven

VS2008 Overview (2/2)

-	🖸 🕶 🕶 🚅 🚰 🛃 🐇 🖹 🛍 🖄 🕫 🖓 - 🔍 - 🚝 - 🖾 🕨 Debug 🛛 - Win32 🔹 🖄 🦉	🕨 🗉 🖬 🖨 🖓 🏝 🗍 Hex 🗞
		을 _
🎌 Toolbox 📇 Server Explorer	<pre>main.cpp (Global Scope)</pre>	Solution Explorer - Solution 'jacobi' (1 p Solution Tacobi' (1 project) Solution 'jacobi_omp Jacobi_omp Header Files Source Files Resource Files Source Files Source Files Main Copp Main Copp Main Copp
12	Code Definition Window - struct JacobiData (jacobi.h) 1 #ifndef _JACOBI_H 2 #define _JACOBI_H 3 4 Struct JacobiData 5 4	
	<pre> // input data int iRows; int iCols; j int iRowFirst; int iRowLast // input data // i</pre>	Solution Explore + Other Views

Visual Studio 2008 for OpenMP Programming

Visual Studio: Project Management (1/5)

• Everything that you do in Visual Studio will take place within the context of a *Solution*.

- A Solution is a higher-level container for other items, for example a *Project*. Any other kind of file type can also be added to a Solution, for example documentation items.
- A Solution can not contain another Solution.
- Solutions group and apply properties across projects.
- A *Project* maps one to one with a compiler target.

Microsoft

compiler

A Project organizes the code.

Project

Management



5

○ To start your work, a new Project has to be created with *File* → *New* → *Project*...

Intel

compiler

OpenMP

Demo



HENZ

AACHEN UNIVERSITY

Center for

Computing and

Communication

Visual Studio 2008 for OpenMP Programming

Project

Management

Microsoft

compiler

24.03.2009 – C. Terboven

Visual Studio: Project Management (2/5)

Project types: → Visual C++ → ATL → CLR → General → MFC → Win32 ↔ Other Languag	Implates: Implates: Visual Studio installed templates: Implates: Implates: Implates: Implates: Implates: Implates: Implates: Implates: Implates: Implates: Implates:	Win32 Console Application
A project for creat Name: Location:	vs2005-test02 C:\ct747764\tmp	<i>Name</i> of the Project, A Solution of the same name is created as well
Solution Na <u>m</u> e:	Vs2005-test02 Create <u>d</u> irectory for solution OK Cancel	<i>Location</i> where the folder structure is
Win32 (No GUI	<i>Console Application</i> : design support of Visual Studio enabled.	folder structure is created

Intel

compiler

OpenMP

Demo

7

Visual Studio 2008 for OpenMP Programming

24.03.2009 – C. Terboven

Visual Studio: Project Management (3/5)

• One might like or dislike wizards ...

Overview Application Settings	These are the current project settings: • Console application Click Finish from any window to accept the current settings. After you create the project, see the project's readme.txt file for information about the project features and files that are generated.
	< Previous Next > Finish Cancel

• Choose *Empty project* if you already have source files. Ο select Win32 Application Wizard - vs2005-test02 Empty Application Settings project. C:\ Application type: Add common header files for: Overview Windows application ATL **Application Settings** Console application MFC DLL Static library Additional options: Empty project Export symbols Precompiled header 'inHP³C 8 Finish < Previous Next >

Microsoft

compiler

Intel

compiler

OpenMP

Center for Computing and Communication

Visual Studio 2008 for OpenMP Programming

Project

Management

24.03.2009 – C. Terboven

?

Cancel

Demo

X

Visual Studio: Project Management (4/5)

Make sure that *Precompiled header* is de-selected if you



Visual Studio: Project Management (5/5)

Microsoft

compiler



Project

Management

- In many cases, the shortest way to a desired operation can be found by right-clicking on a GUI element, using the context menu.
- Adding existing source code items (files) to a project: right-click on the Project (not the Solution !) and Add → Existing Item...
- Adding new items: right-click on the Project and Add → New Item...
- The folders (e.g. *Source Files*) do not have any other meaning than aiding you in structuring the files in a project. They do not map to physical folders. You can create your own folders.

OpenMP

Demo

Intel

compiler



'inHP³C

9

10

Visual Studio 2008 for OpenMP Programming

Directory layout of Visual Studio solutions

• The executable is created in the directory of the active configuration during the build process.

• Directory structure of a solution:

<top level> Given user directory

Microsoft

compiler

<project name> Created by VS2005 / VS2008

Debug Configuration: *Debug*

Release Configuration: Release

Platform: x64 (64bit for Amd64/Intel64)

OpenMP

Demo

Configuration: Debug

Configuration: Release

Intel

compiler



x64

Debug

Release

Project

Management

Agenda

Project Management

The Microsoft C/C++ compiler

• The Intel C/C++ and Fortran compiler

Microsoft

compiler

Intel

compiler

OpenMP

Demo

Using OpenMP

Project

Management



11

o Demo



Visual Studio Configurations (1/3)

The set of compiler options is managed in a *Configuration*.

- There are two configurations pre-defined: *Debug* and *Release*. Ο
 - Debug: typical options for debugging, no optimization.
 - Release: debugging still possible, some optimization options.
- The compile process can be triggered by right-clicking on the Ο project and choosing *Build*. Or from the menu: *Build* \rightarrow *Build* <projectname>.
- Build \rightarrow Build Solution builds all projects in the solution. Ο
- During and after the compile process compiler output Ο (informational messages, warnings, errors) is displayed in the tool window.

Microsoft

compiler

Project

Management

By double-clicking on such a message, the cursor jumps to the Ο corresponding place in the code.

Intel

compiler

OpenMP

Demo



12

nHP³C

13

24.03.2009 - C. Terboven

Visual Studio Configurations (2/3)

Right-clicking on a project and choosing Properties leads to Ο the project configuration dialog.

General Enable Intrinsic Functions No Debugging C/C++ Favor Size or Speed Neither Optimization Preprocessor No Enable Fiber-safe Optimizations No Preprocessor Code Generation Language Precompiled Heade Whole Program Optimization No Precompiled Heade E Output Files Browse Information Advanced Command Line Command Line Linker Manifest Tool XML Document Genera Optimization Select optimization; choose Custom to use specific optimization options. (/C/C/C/C/C/C/C/C/C/C/C/C/C/C/C/C/C/C/C	Cur Configuration	ptimiza line Fur Cur Platforn	sabled (/Od)
Debugging C/C++ General Optimization Preprocessor Code Generation Language Precompiled Heade Output Files Browse Information Advanced Command Line Uniker Manifest Tool XML Document Generat Build Events Custom Build Step Vice Declared in the second of the second optimization; choose Custom to use specific optimization options. (/C)	General	Enable Intrinsic Functions	No
Image: C/C++ Omit Frame Pointers No Image: Optimization Preprocessor Code Generation Image: Deprecember of Code Generation Language Precompiled Heade Image: Output Files Browse Information Advanced Image: Optimization Command Line Image: Optimization Image: Deprecember of Command Line Image: Optimization Image: Optimization Image: Deprecember of Command Line Image: Optimization Image: Optimization Image: Deprecember of Command Line Image: Optimization Image: Optimization Image: Deprecember of Command Line Image: Optimization Image: Optimization Image: Deprecember of Command Line Image: Optimization Image: Optimization Image: Deprecember of Command Line Image: Optimization Image: Optimization Image: Deprecember of Command Line Image: Optimization Image: Optimization Image: Deprecember of Command Line Image: Optimization Image: Optimization Image: Deprecember of Command Line Image: Optimization Image: Optimization Image: Deprecember of Command Line Image: Optimization Image: Optimization Image: Deprecember of Command Line Imag	Debugging	Favor Size or Speed	Neither
General Optimization Preprocessor Code Generation Language Precompiled Heade Output Files Browse Information Advanced Command Line Linker Manifest Tool Still Events Custom Build Step Custom Subscription Custom Subscr		Omit Frame Pointers	No
Optimization Whole Program Optimization No Preprocessor Code Generation Language Precompiled Heade Output Files Browse Information Advanced Command Line Command Line Manifest Tool Value Manifest Tool Optimization Bild Events Optimization Custom Build Step Value Whole Program Optimization; choose Custom to use specific optimization options. (/Communication)	General	Enable Fiber-safe Optimizations	No
Preprocessor Code Generation Language Precompiled Heade Output Files Browse Information Advanced Command Line Linker Manifest Tool XML Document Genera Browse Information Build Events Custom Build Step Vice Declare and the second optimization; choose Custom to use specific optimization options. (/C	Optimization	Whole Program Optimization	No
	Output Files Output Files Output Files Growse Information Advanced Command Line Output Files Manifest Tool Output Files Suite Tool Output Files Suite Tool Output Files Ou	Optimization Select option for code optimization: cho	pose Custom to use specific optimization options. (/C

AACHENL

24.03.2009 – C. Terboven

Visual Studio Configurations (3/3)

Active solution configuration: Debug Debug Release <new> <edit></edit></new>	Active solution glatform: Win32 r deploy): Platform Build Win32 Win32 Vin32 Vin32 Vin32 Vin32 Vin32 Vin32 Vin	x64 are supported, not Itanium.
	Configuration Manager Active solution configuration: Active Release Conversion of the second seco	solution platform: >
	Project New Solution Platform c-ser Type or select the new glatform: x64 Copy settings from: Win32 Image: Section of the new project platforms	Image: state
You can create your own configurations.		Cancel

CANTHAACHEN UNIVERSITY



15

Ο Active(Debug) Configuration: C/C++ General Optimization Preprocessor Code Generation Language Precompiled Headers Output Files Browse Information Advanced Command Line Linker General Input Manifest File Debugging System Optimization Embedded IDL Advanced Command Line

Visual Studio 2008 for OpenMP Programming

Important General Settings:

Microsoft C/C++-specific settings

- − C/C++ \rightarrow General
 - Addition Include Directories: Include Path
- − Linker \rightarrow General
 - Additional Library Directories: Library Path
- Linker \rightarrow Input
 - Additional Dependencies: Libraries to be used
- Important Optimization Settings:
 - − C/C++ \rightarrow Optimization
 - Optimization: General Optimization Level
 - Inline Function Expansion: Inlining
 - − C/C++ \rightarrow Code Generation
 - Enable Enhanced Instruction Set: Vectorization



Project Management Microsoft compiler

Intel compiler

OpenMP

Demo

24.03.2009 – C. Terboven

Agenda

Project Management

• The Microsoft C/C++ compiler

The Intel C/C++ and Fortran compiler

Using OpenMP



16

o Demo



Project	
Management	

Microsoft compiler



Intel compiler

OpenMP

Demo

Visual Studio 2008 for OpenMP Programming

Using the Intel C/C++ compiler

- Create a (Win32) project using the Microsoft C/C++ compiler
- 2. Right-click on the Solution or on the Project
- 3. Intel Parallel Studio Installed (cluster-win-beta + -lab): Intel Parallel Composer → Use Intel C++

Intel

compiler

OpenMP

Demo

4. Intel Parallel Studio Not Installed (cluster-win): Use Intel(R) C++



Solution or Project can be converted back to use Microsoft C/C++ as well.

Microsoft

compiler

Project

Management



Ο

Intel C/C++-specific settings

 \circ Most settings are the same as with Microsoft C/C++, but:

- Additional Optimization Settings: Ο
 - $C/C++ \rightarrow Optimization$
 - Generate Alternate Code Path and/or Use Intel(R) Processor • Extensions: Optimization for specific CPU
 - Parallelization: Ask the compiler for automatic parallelization
 - $C/C++ \rightarrow Language$

Project

Management

- Recognize the Restrict Keyword: Enable C99 restrict (Tuning!)
- Enable C++0x Support: Enable first C++0x features

Microsoft

compiler

- Add to C/C++ \rightarrow Command Line and Linker \rightarrow Command Line:
 - /Qtcheck: Enable source instrumentation for Thread Checker
 - /Qtprofile: Enable source instrumentation for Thread Profiler

Intel

compiler

OpenMP

Demo



18



Project

Management

Using the Intel Fortran compiler

- 1. Open the Project Creation dialog via $File \rightarrow New \rightarrow Project...$
- 2. Select *Intel(R) Fortran* as project type

New Project						?
Project types:		:	Templates:		.NET Framework 3.5	▼ 000 0-0
Visual C++			Visual Studio installed te	mplates		
CLR			Empty Project	Main Pr	ogram Code	
General MFC			My Templates			
Smart Dev Test	/ice		Search Online Templates			
Win32 Intel(R) Fortr	-					
Console A	pplication					
Library						
QuickWin	Application					
Windowin	g Application					
COM Serv	er					
Database Pro	jects	_				
Other Langua	nes		1			
A project for crea	ting a command-l	ne app	plication			
<u>N</u> ame:	Console 1					
Location:	H:\				•	Browse
Solution Name:	Console 1			Create directo	ory for solution	
					ОК	Cancel

OpenMP

Demo



19

3. Typically select *Empty Project* as best-suited option

Microsoft

compiler

Remaining project handling does not differ from C/C++!

Intel

compiler



Agenda

Project Management

The Microsoft C/C++ compiler

• The Intel C/C++ and Fortran compiler

Microsoft

compiler

Intel

compiler

OpenMP

Demo

Using OpenMP

Project

Management



20

o Demo



21

Visual Studio 2008 for OpenMP Programming

24.03.2009 – C. Terboven

Enabling OpenMP (1/3)

• OpenMP support has to be enabled in a configuration:

⊡ Common Properties	Disable Language Extensions	No	complicis.
- Configuration Properties	Default Char Unsigned	No	
General	Treat wchar_t as Built-in Type	Yes	• VS2005 C/C+
Debugging	Force Conformance In For Loop Scope	Yes	
⊡ C/C++	Enable Run-Time Type Info	Yes	
General	OpenMP Support	Yes (/openmp)	• VS2008 C/C+
Code Generation Canguage Precompiled Headers Output Files Browse Information Advanced Command Line Cinker Command Line Command For Content Generator Commant Generator Comman	OpenMP Support		• Intel C/C++ • Intel FORTRA

Project

Management

Enabling OpenMP (2/3)

Known problem with Visual Studio 2005 / 2008 and OpenMP:

c-omp.exe	e - Unable To Locate Component	×
8	This application has failed to start because vcompd.dll was not found. Re-installing the application may fix this proble	m.
	OK]	

 The message appears if an OpenMP program has been compiled with OpenMP support enabled, but omp.h had not been included.



22

• Solution: include omp.h in at least one file per project.

Intel

compiler

OpenMP

Demo

Microsoft

compiler



Visual Studio 2008 for OpenMP Programming

24.03.2009 – C. Terboven

Enabling OpenMP (3/3)

• Setting the number of threads for debugging of OpenMP programs: set environment variable OMP_NUM_THREADS.

	E Common Properties	Debugger to launch:				
	E Configuration Properties	Local Windows Debugger				
	General					
	Debugging	Command	\$(TargetPath)			
		Command Arguments				
	General	Working Directory				
	Optimization	Attach	No			
	Preprocessor	Debugger Type	Auto		_	
		Environment				
	Precompiled Headers	Merge Environment	res			
	Output Files	SQL Debugging	No			
	- Browse Information					
	Advanced	Environment	? ×			
	+ browse information					
	i∎- Build Events i∎- Custom Build Step i∎- Web Deployment	Ĕ	in	g environment.		
IP ³ C	i - Build Events		in T	g environment.		
IP ³ C	i - Build Events	E	in 	g environment.		
IP ³ C	Build Events Custom Build Step B: Web Deployment		in Marros >>	g environment.		
IP ³ C	Build Events Custom Build Step Build Events Web Deployment	E S	in <u>Macros>></u>	g environment.		
IP ³ C	Build Events Custom Build Step Build Events Web Deployment C. (WINDOWS\WINDSSTAted_Incoment 'C: \WINDOWS\SysW0W64\msvch 'C: \WINDOWS\WinDsS\x86_Mic	E di rosc	Macros>> =	g environment. Cancel Apply TOEPTOC (MSOCTOOD CTT), ww66b81908\vcompd.dll		
HP ³ C	Build Events Custom Build Step Build Events Web Deployment Custom Systems 2000-inco 'C:\WINDOWS\SysWOW64\msvch 'C:\WINDOWS\WinSxS\x86_Mic 'C:\WINDOWS\SysWOW64\user3	E C C C C C C C C C C C C C C C C C C C	Macros>> OK Cancel	g environment. Cancel Apply Troeprocement and a ww_66b81908\vcompd.dll		

Agenda

Project Management

The Microsoft C/C++ compiler

• The Intel C/C++ and Fortran compiler

Microsoft

compiler

Intel

compiler

OpenMP

Demo

Using OpenMP

Project

Management



24

o **Demo**



Project

Management

Microsoft

compiler

24.03.2009 – C. Terboven

Demo

Jacobi-C++-omp

Intel

compiler

OpenMP

Demo



25



The End

Thank you for your attention!

Questions?



26

