Workshop on Essential Abstractions in GCC

Introduction and Opening Remarks

GCC Resource Center
(www.cse.iitb.ac.in/grc)

Department of Computer Science and Engineering,
Indian Institute of Technology, Bombay

30 June 2011

Outline

• About GCC Resource Center
• Workshop Plan

Objectives of GCC Resource Center

1. To support the open source movement
   Providing training and technical know-how of the GCC framework
to academia and industry.

2. To include better technologies in GCC
   Whole program optimization, Optimizer generation, Tree tiling
   based instruction selection.

3. To facilitate easier and better quality deployments/enhancements of
   GCC
   Restructuring GCC and devising methodologies for systematic
   construction of machine descriptions in GCC.

4. To bridge the gap between academic research and practical
   implementation
   Designing suitable abstractions of GCC architecture
30 June 2011 Introduction: About GCC Resource Center

### Broad Areas of Interests

- Program Analysis and Optimization
- Translation Validation
- Retargetable compilation
- Parallelization and Vectorization for SIMD and MIMD Architectures

*General explorations applied in the context of GCC*

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30 June 2011 Introduction: About GCC Resource Center

### Broad Research Goals of GCC Resource Center

- **Using GCC as a means**
  - Adding new optimizations to GCC
  - Adding flow and context sensitive analyses to GCC (In particular, pointer analysis)
  - Translation validation of GCC

- **Using GCC as an end in itself**
  - Changing the retargetability mechanism of GCC
  - Cleaning up the machine descriptions of GCC
  - Systematic construction of machine descriptions
  - Facilitating optimizer generation in GCC

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30 June 2011 Introduction: About GCC Resource Center

### GRC Training Programs

<table>
<thead>
<tr>
<th>Title</th>
<th>Target</th>
<th>Objectives</th>
<th>Mode</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Workshop on Essential Abstractions in GCC</td>
<td>People interested in deploying or enhancing GCC</td>
<td>Explaining the essential abstractions in GCC to ensure a quick ramp up into GCC Internals</td>
<td>Lectures, demonstrations, and practicals (experiments and assignments)</td>
<td>Three days</td>
</tr>
<tr>
<td>Tutorial on Essential Abstractions in GCC</td>
<td>People interested in knowing about issues in deploying or enhancing GCC</td>
<td>Explaining the essential abstractions in GCC to ensure a quick ramp up into GCC Internals</td>
<td>Lectures and demonstrations</td>
<td>One day</td>
</tr>
<tr>
<td>Workshop on Compiler Construction with Introduction to GCC</td>
<td>College teachers</td>
<td>Explaining the theory and practice of compiler contraction and illustrating them with the help of GCC</td>
<td>Lectures, demonstrations, and practicals (experiments and assignments)</td>
<td>Seven days</td>
</tr>
<tr>
<td>Tutorial on Demystifying GCC Compilation</td>
<td>Students</td>
<td>Explaining the translation sequence of GCC through gray box probing (i.e. by examining the dumps produced by GCC)</td>
<td>Lectures and demonstrations</td>
<td>Half day</td>
</tr>
</tbody>
</table>

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Essential Abstractions in GCC

GCC Resource Center, IIT Bombay
CS 715: The Design and Implementation of GNU Compiler Generation Framework

- 6 credits semester long course for M.Tech. (CSE) students at IIT Bombay
- Significant component of experimentation with GCC
- Introduced in 2008-2009

Motivation Behind this Workshop

- To understand GCC well :-)  
- Reasonably quickly

Philosophy and Pedagogy

Twin goals of this workshop:

- Learning how to learn GCC
  Our focus will be on
  - giving you some core information
  - showing you how to discover more information

- Striking a balance between theory and practice
  Our focus will be on showing you how to
  - discover concepts in a large code base and build abstractions
  - take concepts and update a large code base
  - relate the classroom concepts of compilers to an industry strength compiler
Our Canvas

- Version: GCC 4.6.0
- Language: C
- Targets: i386, spim (mips simulator)

Philosophy and Pedagogy

- We will
  - Explain configuration and building of GCC
  - Explain essential abstractions related to compilation
    - The key intermediate representations and their manipulations
  - Explain essential abstractions related to program analysis in GCC
  - Explain essential abstractions related to generation of a compiler
    - The machine descriptions and their influence on compilation
- You will
  - Build and run GCC
  - Examine various IR dumps produced by GCC
  - Add passes to GCC
  - Add a new machine description and systematically enhance it

Takeaways from this Workshop

- A programmer will get a better compiler
- A compiler professional will be able to deploy and enhance GCC much more easily.
- A compiler researcher will be able to use GCC for research much better.
- A compiler teacher will be able to strike a better balance between theory and practice.
- A compiler student will be exposed to issues in real compilers.

Day 1 Schedule (Thursday 30 June 2011)

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>09:45 to 10:00</td>
<td>Introductory remarks, Workshop plan</td>
<td>Lecture</td>
</tr>
<tr>
<td>10:00 to 10:30</td>
<td>An overview of compilation and GCC</td>
<td>Lecture</td>
</tr>
<tr>
<td>10:30 to 11:00</td>
<td>An external view of GCC</td>
<td>Lecture</td>
</tr>
<tr>
<td>11:00 to 11:30</td>
<td>Tea break</td>
<td></td>
</tr>
<tr>
<td>11:30 to 12:15</td>
<td>First level gray box probing of GCC</td>
<td>Lecture</td>
</tr>
<tr>
<td>11:30 to 12:15</td>
<td>Gray box probing for machine independent optimizations</td>
<td>Lecture</td>
</tr>
<tr>
<td>13:00 to 14:00</td>
<td>Lunch</td>
<td></td>
</tr>
<tr>
<td>14:00 to 15:30</td>
<td>Gray box probing of GCC</td>
<td>Lab</td>
</tr>
<tr>
<td>15:30 to 15:45</td>
<td>Tea break</td>
<td></td>
</tr>
<tr>
<td>15:45 to 16:15</td>
<td>Gray box probing of GCC</td>
<td>Lab</td>
</tr>
<tr>
<td>16:15 to 17:15</td>
<td>Configuration and building</td>
<td>Lecture</td>
</tr>
<tr>
<td>17:15</td>
<td>High Tea</td>
<td></td>
</tr>
<tr>
<td>Optional</td>
<td>ctags, cscope, ddd, shell, make, screen, patch files</td>
<td>Demo</td>
</tr>
<tr>
<td>20:30</td>
<td>Dinner</td>
<td></td>
</tr>
</tbody>
</table>

Participants can continue to do the lab work until dinner.
Day 2 Schedule (Friday 1 July 2011)

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>09:30 to 11:00</td>
<td>Module Binding Mechanisms in GCC</td>
</tr>
<tr>
<td>11:00 to 11:30</td>
<td>Tea break</td>
</tr>
<tr>
<td>11:30 to 13:00</td>
<td>Adding Passes to GCC: Manipulating GIMPLE and RTL IRs</td>
</tr>
<tr>
<td>13:00 to 14:00</td>
<td>Lunch</td>
</tr>
<tr>
<td>14:00 to 15:30</td>
<td>Adding GIMPLE interprocedural and intraprocedural passes</td>
</tr>
<tr>
<td>15:30 to 15:45</td>
<td>Tea break</td>
</tr>
<tr>
<td>15:45 to 17:15</td>
<td>Adding GIMPLE interprocedural and intraprocedural passes</td>
</tr>
<tr>
<td>17:15</td>
<td>High Tea</td>
</tr>
<tr>
<td>20:30</td>
<td>Dinner</td>
</tr>
</tbody>
</table>

Participants can continue to do the lab work until dinner

Day 3 Schedule (Saturday 2 July 2011)

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>09:30 to 10:00</td>
<td>Introduction to Machine Descriptions</td>
</tr>
<tr>
<td>10:00 to 10:30</td>
<td>Spim machine descriptions Levels 0, 1</td>
</tr>
<tr>
<td>10:30 to 11:00</td>
<td>Machine description assignments</td>
</tr>
<tr>
<td>11:00 to 11:30</td>
<td>Tea break</td>
</tr>
<tr>
<td>11:30 to 13:00</td>
<td>Machine description assignments</td>
</tr>
<tr>
<td>13:00 to 14:00</td>
<td>Lunch</td>
</tr>
<tr>
<td>14:00 to 14:30</td>
<td>Spim machine descriptions Levels 2, 3, 4</td>
</tr>
<tr>
<td>14:30 to 15:00</td>
<td>Advanced issues in machine descriptions</td>
</tr>
<tr>
<td>15:00 to 15:30</td>
<td>Machine description assignments</td>
</tr>
<tr>
<td>15:30 to 15:45</td>
<td>Tea break</td>
</tr>
<tr>
<td>15:45 to 16:45</td>
<td>Machine description assignments</td>
</tr>
<tr>
<td>16:45 to 17:15</td>
<td>The Retargetability Mechanism of GCC</td>
</tr>
<tr>
<td>17:15</td>
<td>High Tea</td>
</tr>
<tr>
<td>20:30</td>
<td>Dinner</td>
</tr>
</tbody>
</table>

Participants can continue to do the lab work until dinner

Day 4 Schedule (Sunday 3 July 2011)

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>09:30 to 10:15</td>
<td>Introduction to Parallelization and Vectorization</td>
</tr>
<tr>
<td>10:15 to 11:00</td>
<td>Parallelization and Vectorization in GCC</td>
</tr>
<tr>
<td>11:00 to 11:30</td>
<td>Tea break</td>
</tr>
<tr>
<td>11:30 to 13:00</td>
<td>Parallelization and Vectorization in GCC</td>
</tr>
<tr>
<td>13:00 to 14:00</td>
<td>Lunch</td>
</tr>
<tr>
<td>14:00 to 15:30</td>
<td>Parallelization and Vectorization in GCC</td>
</tr>
<tr>
<td>15:30 to 15:45</td>
<td>Tea break</td>
</tr>
<tr>
<td>15:45 to 17:15</td>
<td>Concluding Session</td>
</tr>
<tr>
<td>17:15</td>
<td>High Tea</td>
</tr>
</tbody>
</table>

Participants can continue to do the lab work until dinner

Announcements and Questions

Lecture and lab schedule
- Flexible
- Duration, time may be changed dynamically based on how well things are being received
- Lab and lectures may be interchanged too
Announcements and Questions

Lab arrangements:
- Assignments have to be done in groups of two.
  - Please use the tea time to finalize your group
  - A sheet will be circulated after the tea for group details
  - If you need a laptop, we will issue it during lunch. You will need to return it in the evening.
- Doing the assignments.
  - Do all exercises on your laptop, or
  - Use your laptop and log into our servers,
  - Use our laptop and log into our servers.
- How to connect to server?
  Separate information sheet has been provided.
- Teaching assistants will help you in doing the assignments

Announcements and Questions

Dinner and breakfast arrangements
- Breakfast available in the hostels
- Tea: Available in the foyer
- Dinner: Thu, Fri, Sat: Available at 20:30 in foyer
- Important requirement from the security:
  Please continue to wear your name badge throughout the IITB campus

Announcements and Questions

Receipts of payments
- If you have sent the DD earlier, your receipt may be ready.
- Please collect from Nisha on Saturday during the lunch time.

Concluding session
- Informal discussions
- Brief (10 minute) presentations by participating organizations/individuals
  If you are interested, please contact me today or latest tomorrow
- Feedback forms
- Announcement of best Teaching Assistant

The Workshop Team

1. Aboli Ajit Aradhya
2. Ankita Mathur
3. Amit Kulkarni
4. BalKrishna Jeph
5. Dhritiman Das
6. Harbaksh Chhabra
7. Gokul Ramaswamy
8. Jubi Taneja
9. Mradul Maheshwari
10. Netra Shetty
11. Nisha Biju
12. Prachee Yogi
13. Prashant Singh Rawat
14. Prateek Sharma
15. Prerna Budhkar
16. Rahul Agrawal
17. Sayali Vilas Borawake
18. Soumya Prasad Ukil
19. Sreenivas M N
20. Swati Rath
21. Vineet Singh
22. Vini Kanvar

Overall coordination: Uday Khedker, Supratim Biswas, Amitabh Sanyal