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

29 June 2013
Outline

- About GCC Resource Center
- Workshop Plan
Part 1

About GCC Resource Center
National Resource Center for F/OSS, Phase II

GCC Resource Center is a part of NRCFOSS (II)

- Sponsored by Department of Information Technology (DIT), Ministry of Information and Communication Technology

- CDAC Chennai is the coordinating agency of NRCFOSS (II)

- Participating agencies
  CDAC Chennai, CDAC Mumbai, CDAC Hyderabad, IIT Bombay, IIT Madras, Anna University,

- Project investigators of GCC Resource Center

  Uday Khedker: Professor, Dept. of CSE, IIT Bombay
  Supratim Biswas: Professor, Dept. of CSE, IIT Bombay
  Amitabha Sanyal: Professor, Dept. of CSE, IIT Bombay
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
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
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)
  ▶ Automatic validation of GCC translation

• 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
Our Deliverables: Research and Development

- Technologies:

- Tools:

- Methodologies:

- Concepts:
Our Deliverables: Research and Development

- **Technologies:**
  Precise Pointer Analysis, Optimizer Generation, specRTL for Simplifying Machine Descriptions

- **Tools:**
  Build browser, compilation browser

- **Methodologies:**
  Gray box probing, Incremental construction of machine descriptions

- **Concepts:**
  Essential abstractions in GCC
Our Deliverables: Human Resource Development

- Teaching material
- Outreach programmes
- Formal courses
Our Deliverables: Human Resource Development

• **Teaching material**
  ▶ The official GCC HOWTO pages have a link to our training material
  ▶ Request by GCC developer community for videos of our lectures
  ▶ Designed suitable abstractions of GCC architecture
  ▶ Devised useful methodologies and built tools to understand GCC

• **Outreach programmes**
  ▶ Conducted annual workshops and tutorials in India
  ▶ Conducted tutorials in prestigious international conferences
  ▶ Projects for external students

• **Formal courses**
  ▶ Designed and taught Master’s course on GCC
  ▶ Designed GCC related lab assignments for UG compiler course
Part 2

Workshop Plan
Motivation Behind this Workshop

- To understand GCC well :-)

Essential Abstractions in GCC

GCC Resource Center, IIT Bombay
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 class room concepts of compilers to an industry strength compiler
Our Canvas

- Version: GCC 4.7.2
- Language: C, C++
- Targets: i386, spim (mips simulator)
Philosophy and Pedagogy

- We will

- You will
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
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.
Schedule on All Days

- 09:30. Commencement of the pre-lunch session
- 11:00. Tea Break
- 13:00. Lunch Break
- 14:00. Commencement of the post-lunch session
- 15:30. Tea Break
- 17:15. High Tea (Formal sessions end. Participants can continue to work on the assignments)
- 20:30. Dinner
Coverage

- A day wise coverage follows
- The big picture of coverage and logical connections between the topics?
Coverage

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- The big picture of coverage and logical connections between the topics?

Will be clear after the technical overview
## Coverage on Day 1 (Saturday 29 June 2013)

<table>
<thead>
<tr>
<th>Lecture Topics</th>
<th>Lab Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Introductory remarks, Workshop plan</td>
<td>• Gray box probing of GCC</td>
</tr>
<tr>
<td>• An overview of compilation and GCC</td>
<td>• Adding intraprocedural GIMPLE passes</td>
</tr>
<tr>
<td>• Gray box probing of GCC</td>
<td></td>
</tr>
<tr>
<td>• Adding passes to gcc</td>
<td></td>
</tr>
<tr>
<td>• (Optional) make, byobu, ctags, ddd, cscope, patch files</td>
<td></td>
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</tbody>
</table>
## Coverage on Day 2 (Sunday 30 June 2013)

<table>
<thead>
<tr>
<th>Lecture Topics</th>
<th>Lab Topics</th>
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</thead>
<tbody>
<tr>
<td>• Module binding mechanisms in GCC</td>
<td>• Adding interprocedural GIMPLE passes</td>
</tr>
<tr>
<td>• Gcc control flow</td>
<td>• Configuration and building</td>
</tr>
<tr>
<td>• Manipulating GIMPLE IR</td>
<td></td>
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<tr>
<td>• Link time optimization (LTO)</td>
<td></td>
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<tr>
<td>• Configuration and building</td>
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</tbody>
</table>
## Coverage on Day 3 (Monday 1 July 2013)

<table>
<thead>
<tr>
<th>Lecture Topics</th>
<th>Lab Topics</th>
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</thead>
<tbody>
<tr>
<td>• Introduction to machine descriptions</td>
<td>Machine Descriptions</td>
</tr>
<tr>
<td>• Spim machine descriptions</td>
<td></td>
</tr>
<tr>
<td>• The retargetability mechanism of GCC</td>
<td></td>
</tr>
</tbody>
</table>
### Coverage on Day 4 (Tuesday 2 July 2013)

<table>
<thead>
<tr>
<th>Lecture Topics</th>
<th>Lab Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Introduction to Parallelization and Vectorization</td>
<td></td>
</tr>
<tr>
<td>• Parallelization and Vectorization in GCC</td>
<td>Parallelization and Vectorization</td>
</tr>
</tbody>
</table>
## Coverage on Day 5 (Wednesday 3 July 2013)

<table>
<thead>
<tr>
<th>Lecture Topics</th>
<th>Lab Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nothing :-)</td>
<td>Complete remaining assignments</td>
</tr>
</tbody>
</table>
Optional Coverage

• If you are keen on knowing about the following
  ▶ Data flow analysis in GCC, pointer analysis in GCC
  ▶ Context sensitive interprocedural analysis
  ▶ Optimizer generation
  ▶ specRTL based machine descriptions

• May lead to possible collaboration with us
Lecture and Lab Schedule

- Lab and lectures will be interleaved
- Flexible schedule
- Duration, time, sequencing may be changed dynamically based on how well things are being received
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: Sat, Sun, Mon, Tue: Available at 20:30 in foyer

- We need to know who all would like to stay back for
  - dinner on Tuesday night
  - the Wednesday morning session (including the lunch)

- Important requirement from the security:
  Please continue to wear your name badge throughout the IITB campus
Announcements and Questions

- Receipts of payments
  - Most receipts should be ready
  - Please collect from Nisha on Tuesday during the lunch time
Announcements and Questions

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- 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 Organizing Team

1. Amitkumar Patil
2. Amitabha Sanyal
3. Aniket Deole
4. Avantika Gupta
5. Barnali Basak
6. Himanshu Sharma
7. Kalyani Zope

8. Mayank Gupta
9. Mahendra Kaklij
10. Mukta Joglekar
11. Nisha Biju
12. Pritam Gharat
13. Rohan Padhye
14. Sheweta Tharani

15. Swati Rathi
16. Sudakshina Das
17. Supratim Biswas
18. Sumit Jamgade
19. Uday Khedker
20. Vini Kanvar
21. Vinit Deodhar