

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



July 2010

Outline

- Genesis and Objectives of GCC Resource Center
- Motivation behind the Workshop
- Philosophy and Pedogogy of the Workshop



Part 1

Genesis and Objectives of GRC

How Did It All Begin?

- An Informal Group
- A Desire



How Did It All Begin?

- An Informal Group
 - ▶ CSE faculty members at IITB: Uday Khedker
Amitabha Sanyal
Supratim Biswas
 - ▶ Reasonably long and deep experience of research in compilers
- A Desire



How Did It All Begin?

- An Informal Group

- ▶ CSE faculty members at IITB: Uday Khedker
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Supratim Biswas
- ▶ Reasonably long and deep experience of research in compilers

- A Desire

Performing research grounded in theory and corroborated by empirical evidence

- ▶ Exploring research issues in **real** compilers
- ▶ Demonstrating the relevance and effectiveness of our research in **real** compilers



A Modest Start in 2003...

- Our Tool of Experiment
- Our Guinea Pigs



A Modest Start in 2003...

- Our Tool of Experiment The GNU Compiler Collection
 - ▶ Compiler generation framework
Stable compiler generated for several dozen targets
 - ▶ Millions of users
- Our Guinea Pigs



A Modest Start in 2003...

- **Our Tool of Experiment** The GNU Compiler Collection
 - ▶ Compiler generation framework
 - Stable compiler generated for several dozen targets
 - ▶ Millions of users
- **Our Guinea Pigs**

Several unsuspecting M.Tech. students, external B.E. students, and project engineers



And Then in 2007...

Advanced GCC Workshop 2007 - Mozilla Firefox


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http://www.cse.iitb.ac.in/~uday/gcc-workshop/?file=intro

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Workshop on GCC Internals

Organised by
[Centre for Formal Design and Verification of Software](#) and
[Dept. of Computer Science & Engg.,](#)
[IIT Bombay.](#)



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Home

This workshop is a 3-day instructional workshop (and not a forum for contributed presentations) and involves lectures and laboratory exercises aimed at providing details of the internals of [GCC which is an acronym for GNU Compiler Collection](#). It is the de-facto standard compiler generation framework on GNU/Linux and many other variants of Unix/Linux on a wide variety of machines. In the last 20 years of its existence, it has seen a rapid growth and wide acceptability.

The [focus of this workshop](#) is different

News


(15 Aug 07). Our paper on [incremental construction of machine descriptions](#) has been accepted for presentation at the [GREPS 2007 workshop](#). This paper describes the methodology which was taught in our workshop at IIT Bombay.

(23 July 07). Slides and other workshop material is available at [the downloads page](#).

(10 July 07). There have been some delays in organizing the slides page and in sending certificates. I am tied up with a couple of deadlines. I hope to do the needful soon enough, perhaps on this week end. Will send a mail to all participants once this is done.

Applications Places System

Prof. Uday Khedkar Sun Jan 25, 8:33 PM



And then in 2008...

Thanks to small seed grants from IITB and IBM Faculty Award...



And then in 2008...

The screenshot shows the GCC Resource Center website in a Mozilla Firefox browser window. The browser's address bar displays `http://www.cse.iitb.ac.in/gcc`. The website has a green header with the IIT Bombay logo on the left, the text ".gccrc" and "GCC Resource Center Department of Computer Science & Engg." in the center, and a circular GCC logo on the right. A navigation menu on the left lists: Home, About GCC, Activities, GCC Internals Docs, GCC Related Links, Downloads, People, IIT Bombay, and CSE. The main content area features a welcome message: "Welcome to the GCC Resource Center at I.I.T. Bombay." followed by a paragraph explaining that GCC is an acronym for GNU Compiler Collection, the de-facto standard compiler generation framework for GNU/Linux and other Unix/Linux variants. It mentions that the source code is available for inspection and modification, and that the site aims to bridge the gap between conceptual structure and GCC implementation. Below this is a section titled "Interesting Aspects of GCC" which states that GCC was one of the first projects of the Free Software Foundation (FSF) to provide a free compiler for the GNU Operating System, starting as a C compiler and later supporting C++, Objective C, Java, and Fortran. The footer contains contact information (Email: `uday[AT]cse[AT]iitb[DOT]ac[DOT]in`), copyright notice (© 2008, GCC Resource Center), last update date (July 27, 2008), and the name of the professor (Prof. Uday Khedkar) with the date and time (Sun Jan 25, 7:50 PM). The browser's status bar at the bottom shows "Applications Places System".

File Edit View History Bookmarks Tools Help

http://www.cse.iitb.ac.in/gcc

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.gccrc **GCC Resource Center**
Department of Computer Science & Engg.

Search: GCC Docs

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IIT Bombay

CSE

Welcome to the GCC Resource Center at **I.I.T. Bombay**.

GCC is an acronym for GNU Compiler Collection. It is the de-facto standard compiler generation framework for a number on GNU/Linux and many other variants of Unix/Linux on a wide variety of machines and is one of the most dominant softwares in the free software community. Although it follows an **open, collaborative development methodology** and its source code is available to all for inspection and modification, not much effort has gone in bridging the gap between standard conceptual structure of a compiler and the GCC implementation.

This web site is an attempt to give you an insight into ideas and concepts that go behind a practical, industry strength compiler. Visit the **GCC Internals Documents** page for more information about the internal structure and operation of GCC that we have uncovered. We also plan to have other **activities** at the center.

Interesting Aspects of GCC

Historically, GCC has been one of the first projects of the **Free Software Foundation (FSF)** to provide a **free** compiler for its GNU Operating System. It started as C compiler, and was the acronym for "GNU C Compiler" in the early days. Over the years, it has been continuously upgraded to support a number of backend machines. Similarly, on the front end side, it has grown to support a number of front end languages like C++, Objective C, Java, and Fortran to name a few. As a consequence, it has been renamed as "GNU Compiler

Email: `uday[AT]cse[AT]iitb[DOT]ac[DOT]in` | © 2008, GCC Resource Center | Last Site Update: July 27, 2008

Prof. Uday Khedkar Sun Jan 25, 7:50 PM

Applications Places System



Finally in 2009...

A generous grant from the Department of Information Technology, Ministry of Communication and Information Technology, Gov. of India.

- National Resource Center for F/OSS, Phase II
- Participating agencies:
CDAC Chennai (coordinating agency), CDAC Mumbai, CDAC Hyderabad, [IIT Bombay](#), IIT Madras, Anna University
- IIT Bombay's focus: GCC



2009...



GCC Resource Center

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


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NEWS & EVENTS

- ▶ Course CS 715 (Design and Implementation of Gnu Compiler Generation Framework)
- ▶ Tutorial on GCC for Parallelization as part of ACM PPoPP 2010
- ▶ Workshop on Compiler Construction with Introduction to GCC (7th to 13th December 2009)
- ▶ Workshop on Essential Abstractions in GCC (3rd to 5th July 2009)

You are visitor number

000876

Welcome to GCC Resource Center at IIT Bombay



Participants in Workshop on Essential Abstractions in GCC held in July 2009.

About GCC

GCC is an acronym for GNU Compiler Collection. It is the de-facto standard compiler generation framework for all distros on GNU/Linux and many other variants of Unix on a wide variety of machines and is one of the most dominant softwares in the free software community. It supports several input languages for a variety of operating systems on more than 30 target processors. More back ends can be added by describing new target processors using the specification mechanism provided by GCC.

Novices may want to see the [Wikipedia introduction to GCC](#). For experts, the GCC page contains a wealth of information including installation instructions, reference manuals (which include users' guides as well as details of GCC internals), a set of frequently asked questions, a [wiki page](#) for the developers of GCC, additional reading material, and several mailing lists for more detailed issues and queries.

QUICK LINKS

- [GCC Internals](#)
- [GCC Wiki \(internal link\)](#)
- [GCC FAQs](#)
- [GCC on Wikipedia](#)
- [GCC Internals on Wikipedia](#)

☐ GRC ☐ WWW

About GCC Resource Center

This Center has been established at IIT Bombay with the twin goals of (a) spreading the know-how of GCC by building suitable abstractions of GCC internals, and (b) improving GCC by introducing new technologies. It was initiated with a seed grant from IIT Bombay and an IBM Faculty Award for Prof. Uday Khedker. Currently, this center is supported by a generous grant from Department of Information Technology (DIT), Ministry of Communication and Information Technology (MCIT), Govt. of India, under the second phase of the National Resource Centre for Free/Open Source Software (NRCFOSS II).

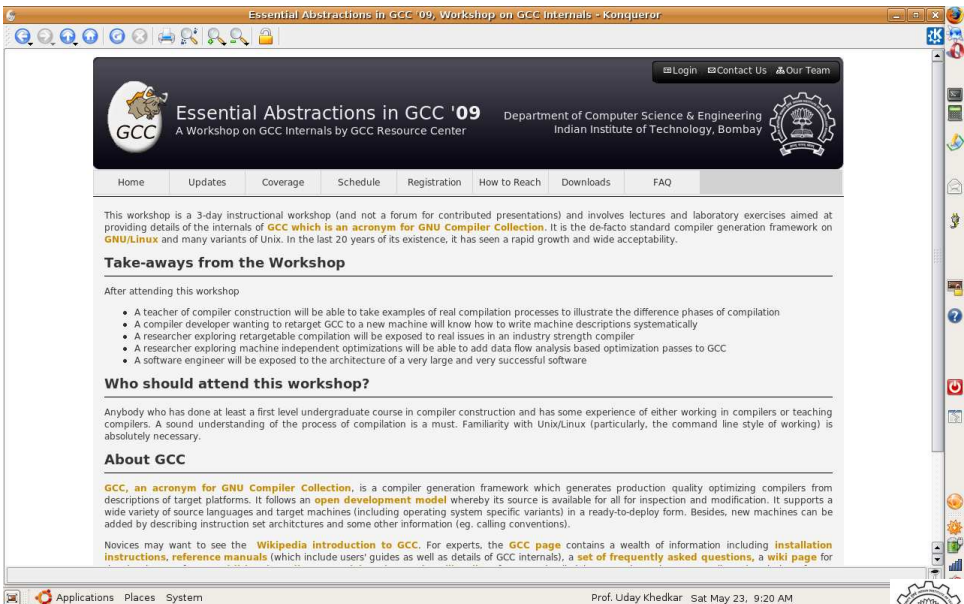
Interesting Aspects of GCC

Historically, GCC has been one of the first projects of the Free Software Foundation (FSF) to provide a free compiler for its GNU

Mon Jan 18, 12:09 AM



July 2009...



The screenshot shows a web browser window with the title "Essential Abstractions in GCC '09, Workshop on GCC Internals - Konqueror". The website has a dark header with the GCC logo, the title "Essential Abstractions in GCC '09", the subtitle "A Workshop on GCC Internals by GCC Resource Center", and the affiliation "Department of Computer Science & Engineering, Indian Institute of Technology, Bombay". Navigation links include Home, Updates, Coverage, Schedule, Registration, How to Reach, Downloads, and FAQ. The main content area describes the workshop as a 3-day instructional workshop involving lectures and laboratory exercises. It includes a section for "Take-aways from the Workshop" with a bulleted list of benefits for teachers, compiler developers, researchers, and software engineers. Another section, "Who should attend this workshop?", specifies the target audience. The "About GCC" section explains that GCC is an acronym for GNU Compiler Collection and describes its open development model. The footer of the website shows the application bar with "Applications", "Places", and "System" buttons, and the page information "Prof. Uday Khedkar Sat May 23, 9:20 AM".

Essential Abstractions in GCC '09, Workshop on GCC Internals - Konqueror

Home Updates Coverage Schedule Registration How to Reach Downloads FAQ

This workshop is a 3-day instructional workshop (and not a forum for contributed presentations) and involves lectures and laboratory exercises aimed at providing details of the internals of **GCC which is an acronym for GNU Compiler Collection**. It is the de-facto standard compiler generation framework on **GNU/Linux** and many variants of Unix. In the last 20 years of its existence, it has seen a rapid growth and wide acceptability.

Take-aways from the Workshop

After attending this workshop

- A teacher of compiler construction will be able to take examples of real compilation processes to illustrate the difference phases of compilation
- A compiler developer wanting to retarget GCC to a new machine will know how to write machine descriptions systematically
- A researcher exploring retargetable compilation will be exposed to real issues in an industry strength compiler
- A researcher exploring machine independent optimizations will be able to add data flow analysis based optimization passes to GCC
- A software engineer will be exposed to the architecture of a very large and very successful software

Who should attend this workshop?

Anybody who has done at least a first level undergraduate course in compiler construction and has some experience of either working in compilers or teaching compilers. A sound understanding of the process of compilation is a must. Familiarity with Unix/Linux (particularly, the command line style of working) is absolutely necessary.

About GCC

GCC, an acronym for GNU Compiler Collection, is a compiler generation framework which generates production quality optimizing compilers from descriptions of target platforms. It follows an **open development model** whereby its source is available for all for inspection and modification. It supports a wide variety of source languages and target machines (including operating system specific variants) in a ready-to-deploy form. Besides, new machines can be added by describing instruction set architectures and some other information (eg. calling conventions).

Novices may want to see the **Wikipedia introduction to GCC**. For experts, the **GCC page** contains a wealth of information including **installation instructions, reference manuals** (which include users' guides as well as details of GCC internals), a **set of frequently asked questions**, a **wiki page** for

Applications Places System Prof. Uday Khedkar Sat May 23, 9:20 AM

July 2010...



Essential Abstractions in GCC '10

A Workshop on GCC Internals by **GCC Resource Center**
July 5-8, 2010, IIT Bombay

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



[Home](#) [Prerequisites](#) [Schedule](#) [Registration](#) [How to Reach](#)
[FAQs](#)

This workshop is a 4-day instructional workshop (and not a forum for contributed presentations) and involves lectures and laboratory exercises aimed at providing details of the internals of GCC (GNU Compiler Collection). GCC is the de-facto standard compiler generation framework on GNU/Linux and many variants of Unix. In the last 20 years of its existence, it has seen a rapid growth and wide acceptability.

What is GCC?

GCC, an acronym for GNU Compiler Collection, is a compiler generation framework which generates production quality optimizing compilers from descriptions of target platforms. It follows an open development model whereby its source is available for all for inspection and modification. It supports a wide variety of source languages and target machines (including operating system specific variants) in a ready-to-deploy form. Besides, new machines can be added by describing instruction set architectures and some other information (eg. calling conventions).

Novices may want to see the Wikipedia introduction to GCC. For experts, the GCC page contains a wealth of information including installation instructions, reference manuals (which include users' guides as well as details of GCC internals), a set of frequently asked questions, a wiki page for the developers of GCC, additional reading material, and several mailing lists for more detailed issues and queries. An excellent description of GCC internals can also be found on Wikipedia. Some notes on GCC internals are available at Washington University.

Who should attend this workshop?

Anybody who has done at least a first level undergraduate course in compiler construction and has some experience of either working in compilers or teaching compilers. A sound understanding of the process of compilation is a must. Familiarity with Unix/Linux (particularly, the command line style of working) is absolutely necessary. We have identified some homework exercises to be done before the participants arrive for the workshop.

Take-aways from the workshop

After attending this workshop

- A teacher of compiler construction will be able to take examples of real compilation processes to illustrate the difference phases of compilation
- A compiler developer wanting to retarget GCC to a new machine will know how to write machine descriptions systematically
- A researcher exploring machine independent optimizations will be able to add data flow analysis based optimization passes to GCC
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Structure of the workshop

This offering of the workshop has a lot of new material and all the material has been upgraded to **GCC 4.5.0**. Besides, based on the feedback from

UPDATES

- **June 8, 2010:** A detailed schedule of the workshop is now available.
- **June 1, 2010:** The first list of selected candidates has been put up.

Past updates...



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)
 - ▶ 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



GRC Training Programs

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



GRC Training Programs

Title	Target	Objectives	Mode	Duration
Workshop on Essential Abstractions in GCC	People interested in knowing about GCC 3, 4, and 5 July, 2009 IIT Bombay, Mumbai	Explaining the essential abstractions in GCC to help a quick ramp up to GCC Internals	Lectures, demonstrations, and practicals (experiments and assignments)	Three days
Tutorial on Essential Abstractions in GCC	People interested in knowing about GCC (modified version) 9 Jan 2010 ACM PPOPP, Bangalore	Explaining the essential abstractions in GCC	Lectures and demonstrations	One day
Workshop on Compiler Construction with Introduction to GCC	College teachers 7-13 Dec 2009, IIT Bombay, Mumbai	Explaining the theory and practice of compiler construction and helping them with the help of GCC	Lectures, demonstrations, and practicals (experiments and assignments)	Seven days
Tutorial on	Students	Explaining the translation	Lectures and	Half day
20 Jan 2010, Cummins College, Pune	20 Feb 2010, IIITDM, Jabalpur	06 March 2010, SGGS IET, Nanded	27 March 2010, RSCoE, Pune	25 Apr 2010, Punjabi Univ., Patiala



GRC Training Programs

Title	Target	Objectives	Mode	Duration
Workshop on Essential Abstractions in GCC	People interested in GCC 3, 4, and 5 July, 2009 IIT Bombay, Mumbai	Explaining the essential abstractions in GCC and a quick GCC Internals	Lectures, demonstrations, and assignments)	Three days
Tutorial on Essential Abstractions in GCC	People interested in knowing about issues in deploying or enhancing GCC (modified version) 9 Jan 2010 ACM PPOPP, Bangalore	Explaining the essential	Lectures and demonstrations	One day
Workshop on Compiler Construction with Introduction to GCC	College teachers 7-13 Dec 2009, IIT Bombay, Mumbai	Explaining the theory and practice of compiler construction and helping them with the help of GCC	Lectures, demonstrations, and assignments)	Seven days
Tutorial on	Students	Explaining the translation	Lectures and	Half day
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GRC Training Programs

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



Part 2

Workshop Plan

Motivation Behind this Workshop

- To understand GCC well :-)



Motivation Behind this Workshop

- To understand GCC well :-)
- Reasonably quickly



Philosophy and Pedogogy

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 4.5.0
- Language: C
- Targets: i386, spim (mips simulator)



Philosophy and Pedogogy

- We will
- You will



Philosophy and Pedogogy

- 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 Pedogogy

- 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 (Monday 5 July 2010)

09:45 to 10:00	Inaguration, Welcome note by the Head, CSE	
10:00 to 10:30	<i>Theme:</i> Introduction <i>Topic:</i> Introductory remarks, Workshop plan	Lecture
10:30 to 11:00	<i>Theme:</i> Introduction <i>Topic:</i> An overview of compilation and GCC	Lecture
11:00 to 11:30	Tea break	
11:30 to 13:00	<i>Theme:</i> An external view of GCC <i>Topic:</i> First level gray box probing of GCC	Lecture
13:00 to 14:00	Lunch	
14:00 to 15:30	<i>Theme:</i> An external view of GCC <i>Topic:</i> Gray box probing for machine independent optimizations	Lecture
15:30 to 16:00	Tea break	
16:00 to 17:30	<i>Theme:</i> An external view of GCC <i>Topic:</i> Gray box probing of GCC	Lab
TBD	Optional: ctags, cscope, ddd, shell, make, screen, patch files	
<i>Participants can continue to do the lab work until dinner (20:00)</i>		



Day 2 (Tuesday 6 July 2010)

09:30 to 10:00	<i>Theme:</i> Generating a compiler from GCC <i>Topic:</i> Configuration and building	Lecture
10:00 to 10:30	<i>Theme:</i> Generating a compiler from GCC <i>Topic:</i> Building a cross compiler	Lecture
10:30 to 11:00	<i>Theme:</i> An internal view of GCC <i>Topic:</i> GCC control flow and plugins	Lecture
11:00 to 11:30	Tea break	
11:30 to 12:00	<i>Theme:</i> An internal view of GCC <i>Topic:</i> GCC control flow and plugins	Lecture
12:00 to 13:00	<i>Theme:</i> An internal view of GCC: <i>Topic:</i> Manipulating GIMPLE and RTL IRs.	Lecture
13:00 to 14:00	Lunch	
14:00 to 15:30	<i>Theme:</i> Intermediate representations in GCC <i>Topic:</i> Adding GIMPLE interprocedural pass	Lab
15:30 to 16:00	Tea break	
16:00 to 17:30	<i>Theme:</i> Intermediate representations in GCC <i>Topic:</i> Adding RTL pass	Lab



Day 3 (Wednesday 7 July 2010)

09:30 to 10:15	<i>Theme:</i> Program analysis and optimization <i>Topic:</i> Introduction to data flow analysis	Lecture
10:15 to 11:00	<i>Theme:</i> Program analysis and optimization <i>Topic:</i> Introduction to GDFA	Lecture
11:00 to 11:30	Tea break	
11:30 to 12:15	<i>Theme:</i> Program analysis and optimization <i>Topic:</i> Introduction to parallelization and vectorization	Lecture
12:15 to 13:00	<i>Theme:</i> Program analysis and optimization <i>Topic:</i> Parallelization and vectorization in GCC	Lecture
13:00 to 14:00	Lunch	
14:00 to 15:00	<i>Theme:</i> Program analysis and optimization <i>Topic:</i> Parallelization and vectorization in GCC	Lecture
15:00 to 15:30	<i>Theme:</i> Program analysis and optimization <i>Topic:</i> Using GDFA	Lab
15:30 to 16:00	Tea break	
16:00 to 17:30	<i>Theme:</i> Program analysis and optimization <i>Topic:</i> Parallelization and vectorization in GCC	Lab



Day 4 (Thursday 8 July 2010)

09:30 to 10:15	<i>Theme:</i> Retargetability issues <i>Topic:</i> Introduction to machine descriptions	Lecture
10:15 to 11:00	<i>Theme:</i> Retargetability issues <i>Topic:</i> spim machine descriptions levels 0 and 1	Lecture
11:00 to 11:30	Tea break	
11:30 to 12:15	<i>Theme:</i> Retargetability issues <i>Topic:</i> spim machine descriptions levels 2, 3, 4	Lecture
12:15 to 13:00	<i>Theme:</i> Retargetability issues <i>Topic:</i> Advanced issues in machine descriptions and retargetability model of GCC	Lecture
13:00 to 14:00	Lunch	
14:00 to 15:30	<i>Theme:</i> Retargetability issues <i>Topic:</i> spim machine descriptions	Lab
15:30 to 16:00	Tea break	
16:00 to 17:00	<i>Theme:</i> Concluding session <i>Activity:</i> Summarization, interactive session, distribution of certificates	



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

- Tea at 17:30
- Dinner and breakfast arrangements
 - ▶ Breakfast available in the hostels
 - ▶ Dinner: Mon, Tue, Wed: Available at 20:00 in foyer



Announcements and Questions

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



Announcements and Questions

- Receipts of payments
 - ▶ If you have sent the DD earlier, your receipt may be ready.
 - ▶ Please collect from Nisha on Thursday 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

