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

Part 1

Genesis and Objectives of GRC

Outline

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

How Did It All Begin?

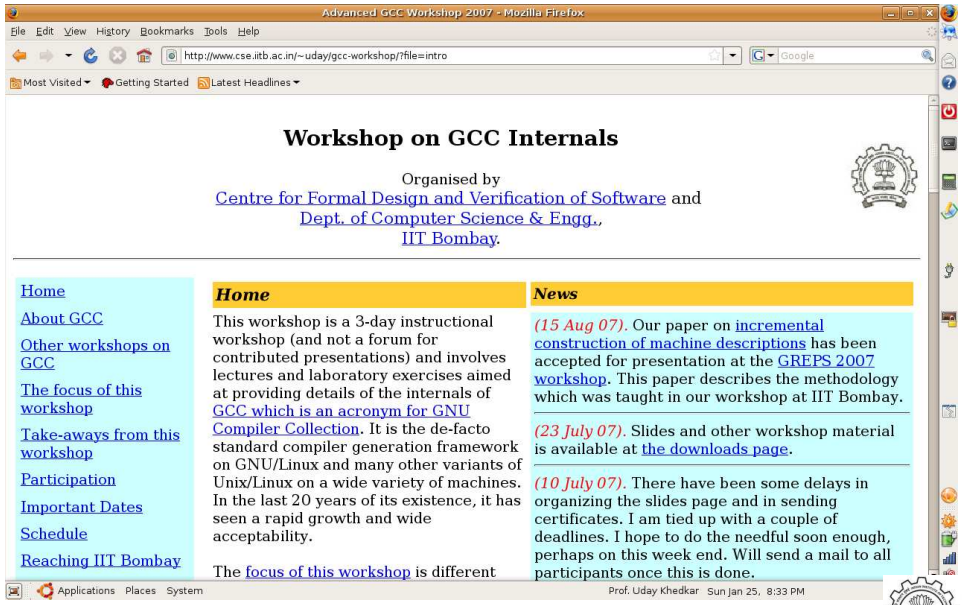
- An Informal Group
  - CSE faculty members at IITB: Uday Khedker
    Amitabha Sanyal
    Supratim Biswas
  - Reasonably long and deep experience of research in compilers
- A Desire

  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 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

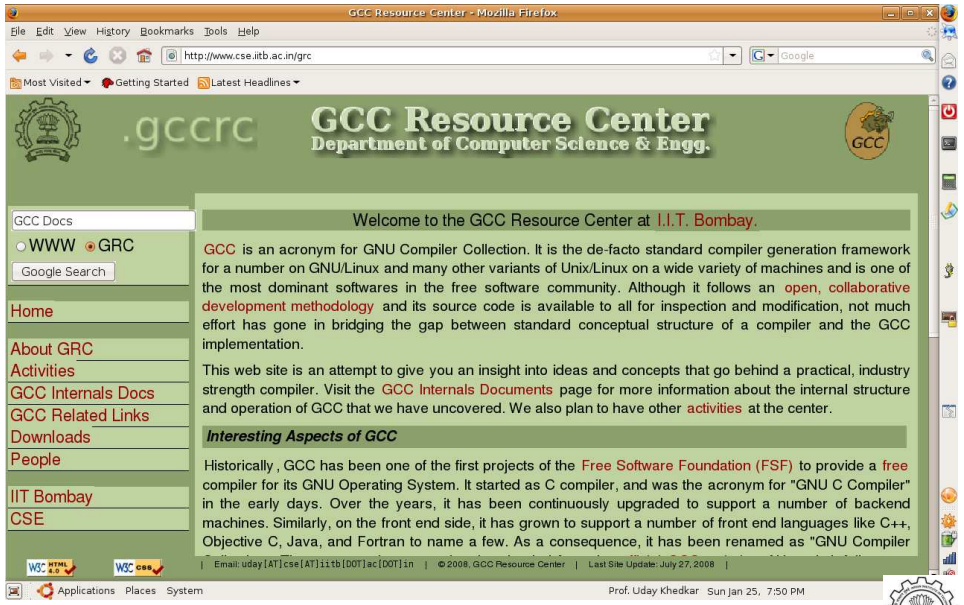
And Then in 2007...



And then in 2008...

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

And then in 2008...

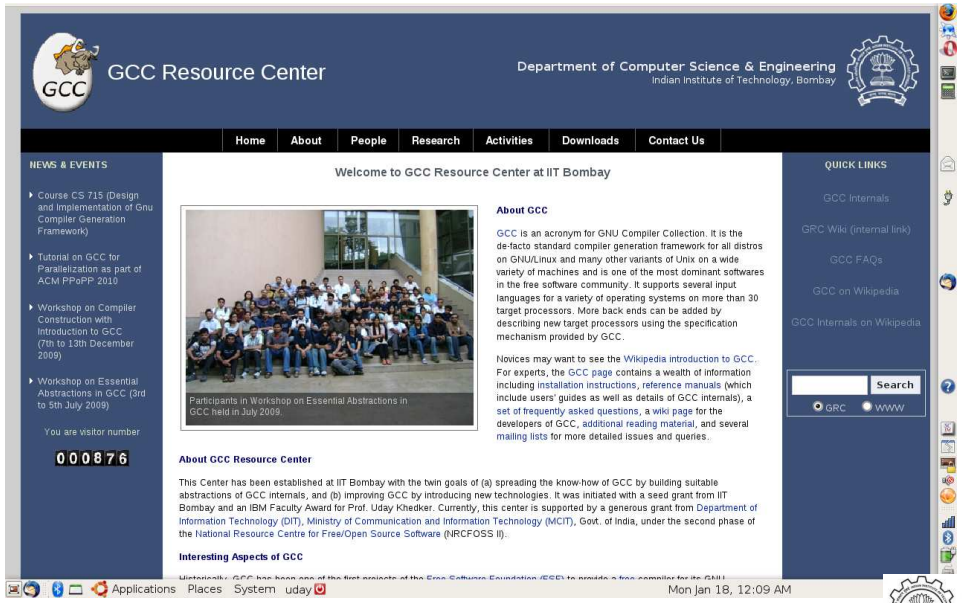


Finally in 2009...

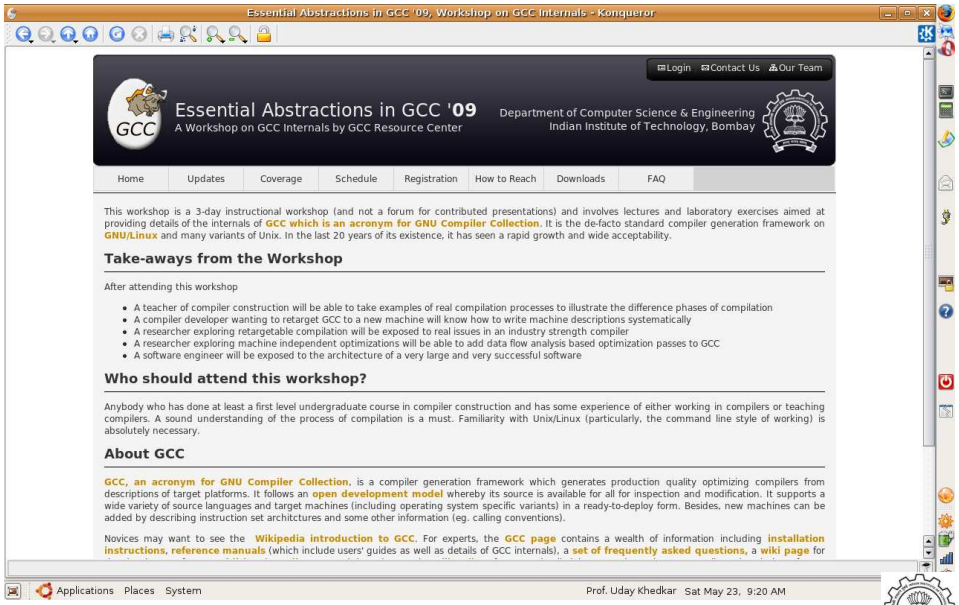
A generous grant from the Department of Information Technology, Ministry of Communication and Information Technology, Gov. of India.

- 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

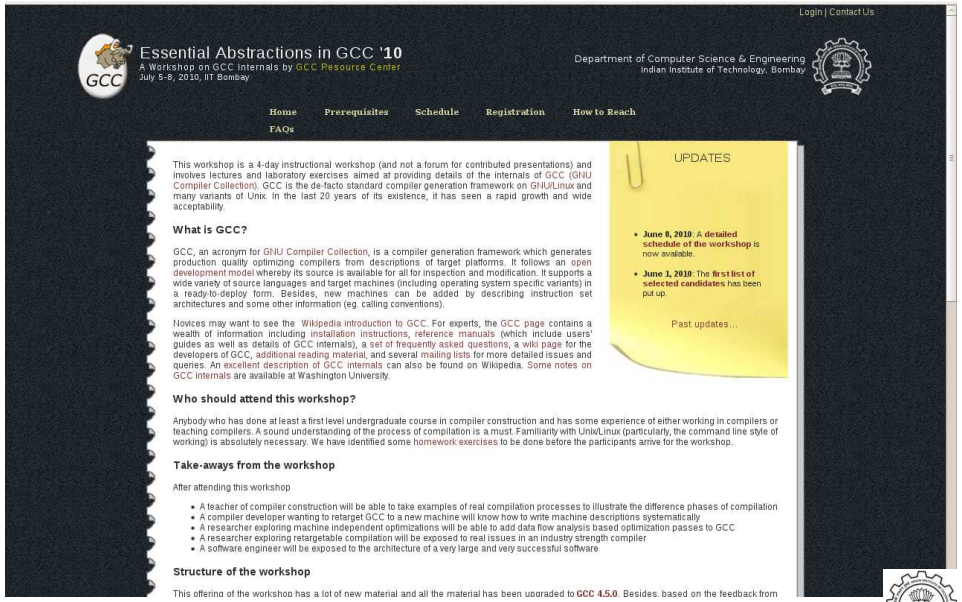
2009...



July 2009...



July 2010...



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 (experiements 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 contruction and illustrating them with the help of GCC	Lectures, demonstrations, and practicals (experiements 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

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Tutorial on Essential Abstractions in GCC	People interested in knowing about issues in deploying or enhancing GCC	Explaining the essential	Lectures and demonstrations	One day
Workshop on Compiler Construction with Introduction to GCC	College teachers	Explaining the theory and practice of compiler and implementing them with help of GCC	Lectures, and assignments)	Seven days
Tutorial on	Students	Explaining the translation	Lectures and	Half day

3, 4, and 5 July, 2009, IIT Bombay, Mumbai

5-8 July, 2010, IIT Bombay, Mumbai

(modified version) 9 Jan 2010, ACM PPoPP, Banglore

7-13 Dec 2009, IIT Bombay, Mumbai

10-15 July 2010, MIT, Pune

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

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 :-)
- 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 complilers to an industry strength compiler

Our Canvas

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

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

Day 2 (Tuesday 6 July 2010)

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

Day 3 (Wednesday 7 July 2010)

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

Day 4 (Thursday 8 July 2010)

09:30 to 10:15	*Theme*: Retargetability issues *Topic*: Introduction to machine descriptions	Lecture
10:15 to 11:00	*Theme*: Retargetability issues *Topic*: spim machine descriptions levels 0 and 1	Lecture
11:00 to 11:30	Tea break	
11:30 to 12:15	*Theme*: Retargetability issues *Topic*: spim machine descriptions levels 2, 3, 4	Lecture
12:15 to 13:00	*Theme*: Retargetability issues *Topic*: Advanced issues in machine descriptions and retargetability model of GCC	Lecture
13:00 to 14:00	Lunch	
14:00 to 15:30	*Theme*: Retargetability issues *Topic*: spim machine descriptions	Lab
15:30 to 16:00	Tea break	
16:00 to 17:00	*Theme*: Concluding session Activity 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 arrangments
  - 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.
- 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