Workshop on Essential Abstractions in GCC

GCC Configuration and Building

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

Department of Computer Science and Engineering,
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Outline

- Code Organization of GCC
- Configuration and Building
- Registering New Machine Descriptions
- Building a Cross Compiler
- Testing GCC

Part 1

GCC Code Organization

GCC Code Organization

Logical parts are:

- Build configuration files
- Front end + generic + generator sources
- Back end specifications
- Emulation libraries
  (eg. `libgcc` to emulate operations not supported on the target)
- Language Libraries (except C)
- Support software (e.g. garbage collector)

GCC Code Organization

Front End Code

- Source language dir: `$(SOURCE_D)/gcc/<lang dir>`
- Source language dir contains
  - Parsing code (Hand written)
  - Additional AST/Generic nodes, if any
  - Interface to Generic creation

  Except for C – which is the “native” language of the compiler

  C front end code in: `$(SOURCE_D)/gcc`

Optimizer Code and Back End Generator Code

- Source language dir: `$(SOURCE_D)/gcc`

Back End Specification

- `$(SOURCE_D)/gcc/config/<target dir>/`
  Directory containing back end code
- Two main files: `<target>.h` and `<target>.md`,
  e.g. for an i386 target, we have
  `$(SOURCE_D)/gcc/config/i386/i386.md` and
  `$(SOURCE_D)/gcc/config/i386/i386.h`
- Usually, also `<target>.c` for additional processing code
  (e.g. `$(SOURCE_D)/gcc/config/i386/i386.c`)
- Some additional files

Part 2

Configuration and Building: Basic Concepts

Configuration

Preparing the GCC source for local adaptation:

- The platform on which it will be compiled
- The platform on which the generated compiler will execute
- The platform for which the generated compiler will generate code
- The directory in which the source exists
- The directory in which the compiler will be generated
- The directory in which the generated compiler will be installed
- The input languages which will be supported
- The libraries that are required
- etc.

Pre-requisites for Configuring and Building GCC 4.6.0

- ISO C90 Compiler / GCC 2.95 or later
- GNU bash: for running configure etc
- Awk: creating some of the generated source file for GCC
- bzip/gzip/untar etc. For unzipping the downloaded source file
- GNU make version 3.8 (or later)
- GNU Multiple Precision Library (GMP) version 4.3.2 (or later)
- mpfr Library version 3.0.0 (or later)
  (multiple precision floating point with correct rounding)
- mpc Library version 0.8.2 (or later)
- Parma Polyhedra Library (ppl) version 0.11
- CLooG-PPL (Chunky Loop Generator) version 0.15.11
- jar, or InfoZIP (zip and unzip)
- libelf version 0.8.12 (or later) (for LTO)

Our Conventions for Directory Names

- GCC source directory : `$(SOURCE_D)`
- GCC build directory : `$(BUILD)`
- GCC install directory : `$(INSTALL)`
- Important
  - `$(SOURCE_D)` $\neq$ `$(BUILD)` $\neq$ `$(INSTALL)`
  - None of the above directories should be contained in any of the above directories

Commands for Configuring and Building GCC

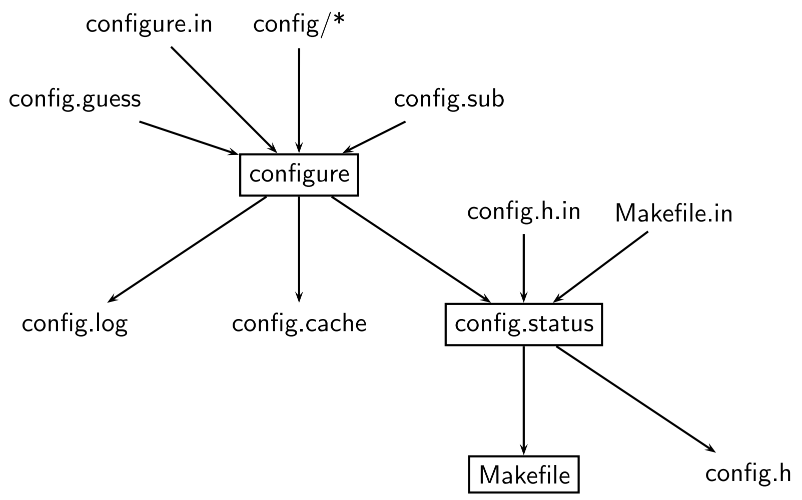
This is what *we* specify

- `cd $(BUILD)`
- `$(SOURCE_D)/configure <options>`
  `configure` output: customized `Makefile`
- `make 2> make.err > make.log`
- `make install 2> install.err > install.log`

Order of Steps in Installing GCC 4.6.0

- Building pre-requisites
  Build and install in the following order with `--prefix=/usr/local`
  Run `ldconfig` after each installation
  - GMP 4.3.2
    `CPPFLAGS=-fexceptions ./configure --enable-cxx ...`
  - mpfr 3.0.0
  - mpc 0.8.2
  - ppl 0.11
  - cloog-ppl 0.15.11
  - libelf 0.8.12
- Building gcc
  Follow the usual steps.

Configuring GCC



Steps in Configuration and Building

Usual steps for a other than GCC	Steps for GCC
• Download and untar the source	• Download and untar the source
• `cd $(SOURCE_D)`	• `cd $(BUILD)`
• `./configure`	• `$(SOURCE_D)/configure`
• `make`	• `make`
• `make install`	• `make install`

GCC generates a large part of source code during a build!

Building a Compiler: Terminology

- The sources of a compiler are compiled (i.e. built) on *Build system*, denoted BS.
- The built compiler runs on the *Host system*, denoted HS.
- The compiler compiles code for the *Target system*, denoted TS.

The built compiler itself runs on HS and generates executables that run on TS.

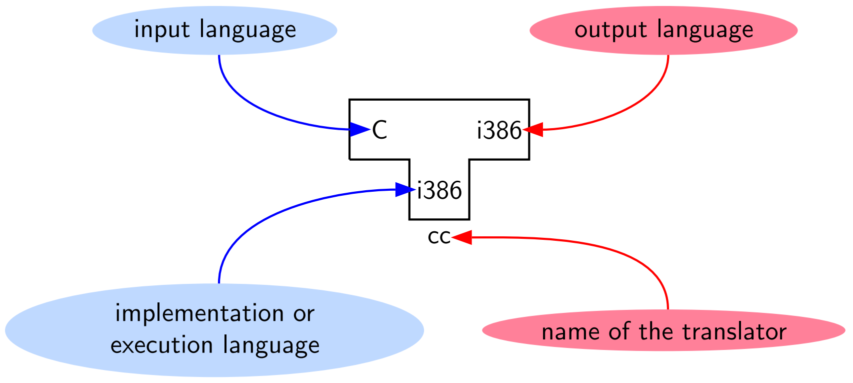
Variants of Compiler Builds

BS = HS = TS	Native Build
BS = HS ≠ TS	Cross Build
BS ≠ HS ≠ TS	Canadian Cross

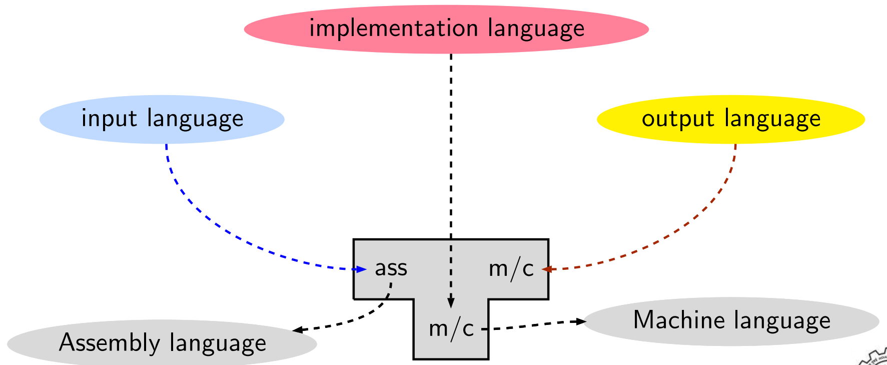
Example

Native i386: built on i386, hosted on i386, produces i386 code.
Sparc cross on i386: built on i386, hosted on i386, produces Sparc code.

T Notation for a Compiler



Bootstrapping: The Conventional View



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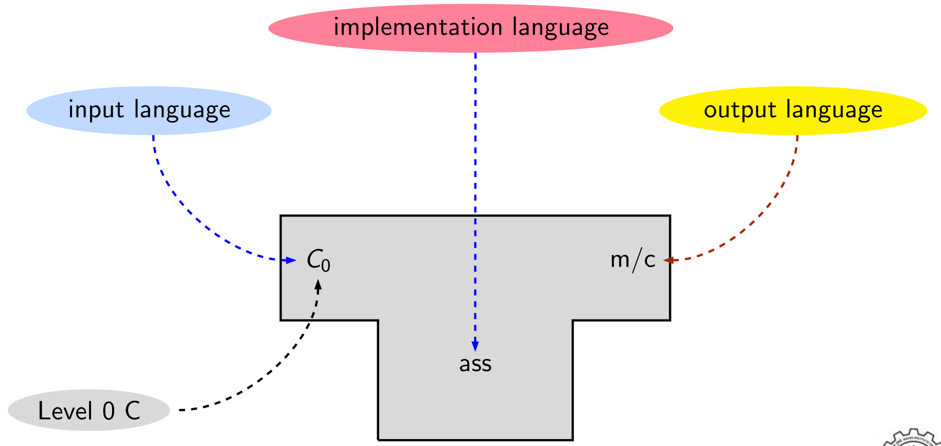

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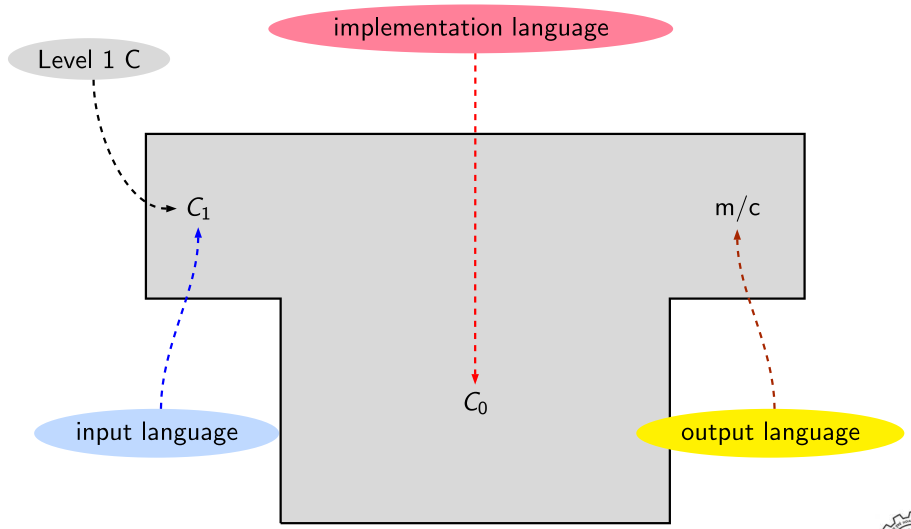

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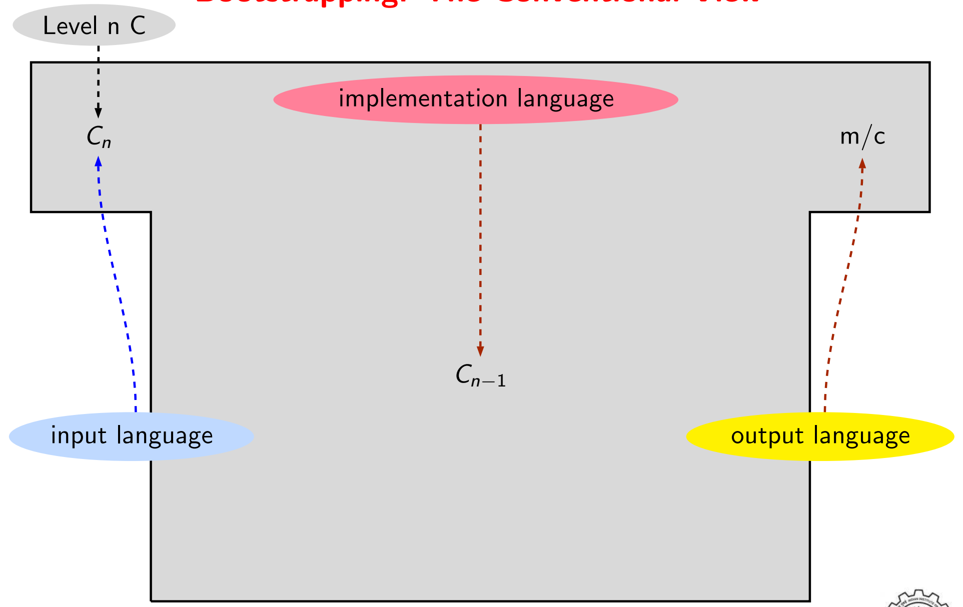
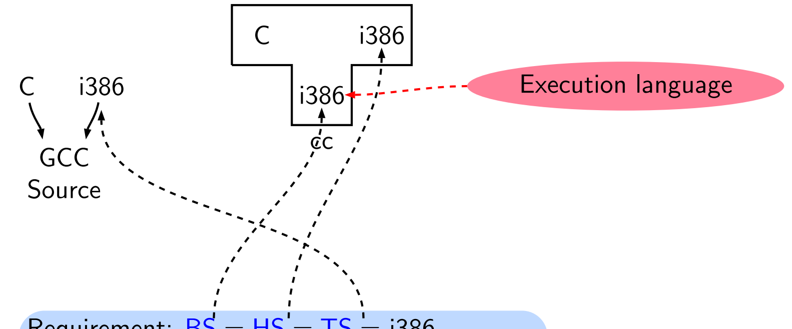


Bootstrapping: GCC View

- Language need not change, but the compiler may change
  Compiler is improved, bugs are fixed and newer versions are released
- To build a new version of a compiler given a built old version:
  - Stage 1: Build the new compiler using the old compiler
  - Stage 2: Build another new compiler using compiler from stage 1
  - Stage 3: Build another new compiler using compiler from stage 2
    Stage 2 and stage 3 builds must result in identical compilers

⇒ Building cross compilers stops after Stage 1!

A Native Build on i386



Requirement: BS = HS = TS = i386

- Stage 1 build compiled using cc
- Stage 2 build compiled using gcc
- Stage 3 build compiled using gcc
- Stage 2 and Stage 3 Builds must be identical for a successful native build

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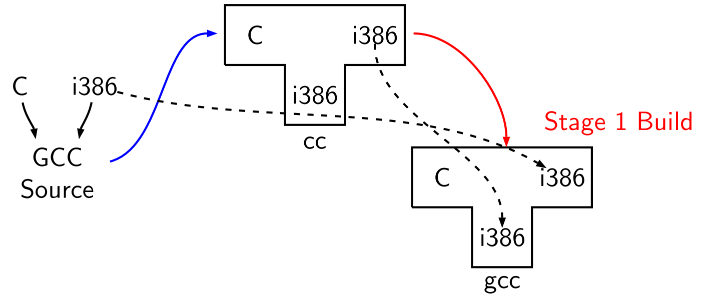

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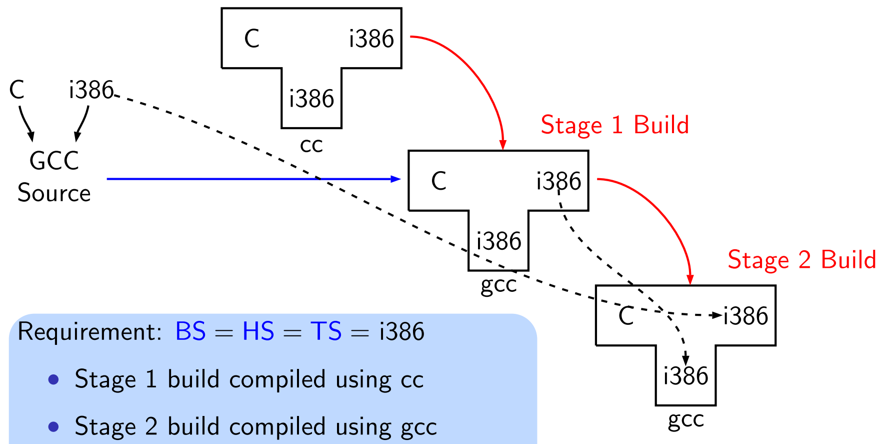

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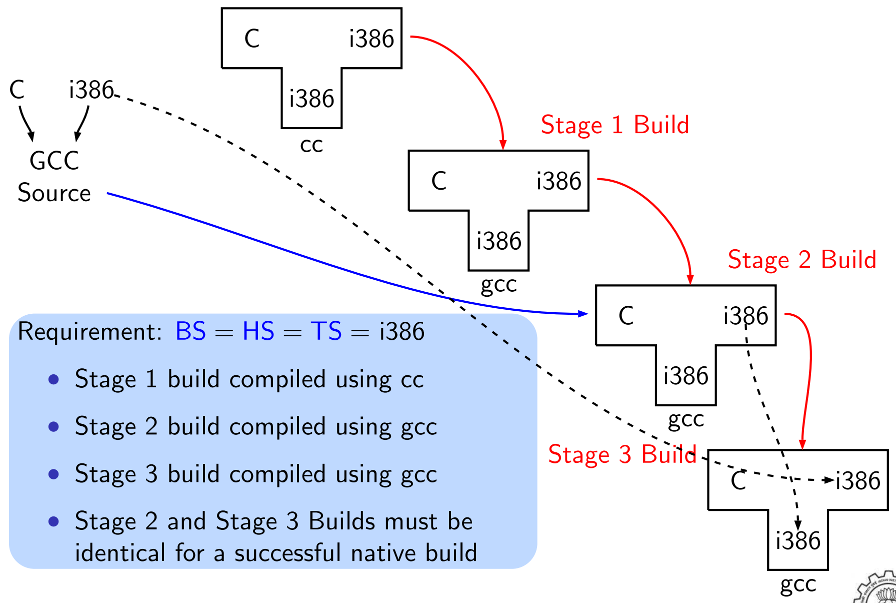

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- Stage 1 build compiled using cc
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Commands for Configuring and Building GCC Revisited

This is what *we* specify

- `cd $(BUILD)`
- `$(SOURCE_D)/configure <options>`
  configure output: customized `Makefile`
- `make 2> make.err > make.log`
- `make install 2> install.err > install.log`

Build for a Given Target

This is what actually happens!

- Generation
  - Generator sources (`$(SOURCE_D)/gcc/gen*.c`) are read and generator executables are created in `$(BUILD)/gcc/build`
  - MD files are read by the generator executables and back end source code is generated in `$(BUILD)/gcc`
- Compilation
  Other source files are read from `$(SOURCE_D)` and executables created in corresponding subdirectories of `$(BUILD)`
- Installation
  Created executables and libraries are copied in `$(INSTALL)`

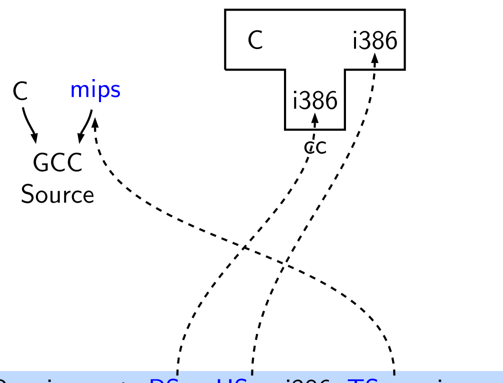
```
genattr
gencheck
genconditions
genconstants
genflags
genopinit
genpreds
genattrtab
genchecksum
gencondmd
genemit
gengenrtl
genmddeps
genoutput
genrecog
genautomata
gencodes
genconfig
genextract
gengtype
genmodes
genpeep
```

Examining the Build Process

Use the *Build Browser* `bb.py`

- Currently, it can only handle `make cc1`
- Reads the log post-facto and collects dependency information
- One can give queries interactively
- We will use it in the lab session

Building a MIPS Cross Compiler on i386



Requirement: BS = HS = i386, TS = mips

- Stage 1 build compiled using cc
- Stage 2 build compiled using gcc
  Its HS = mips and not i386!

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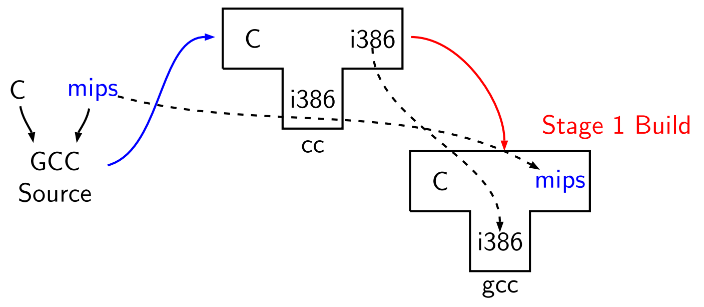

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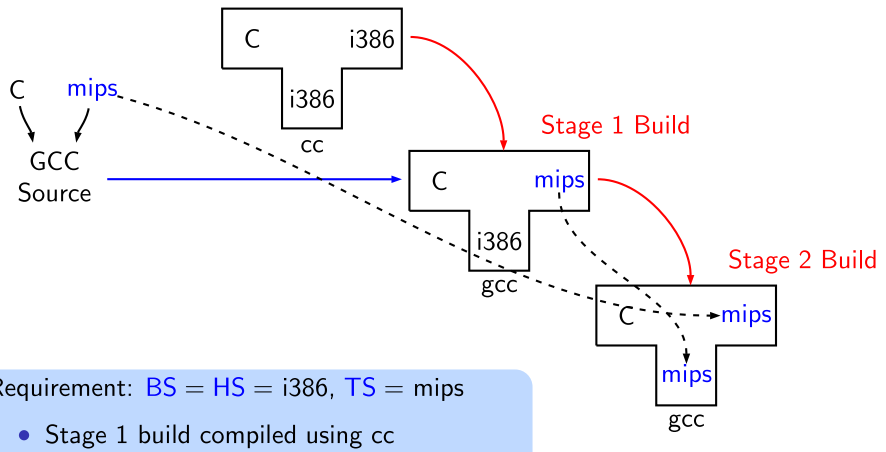

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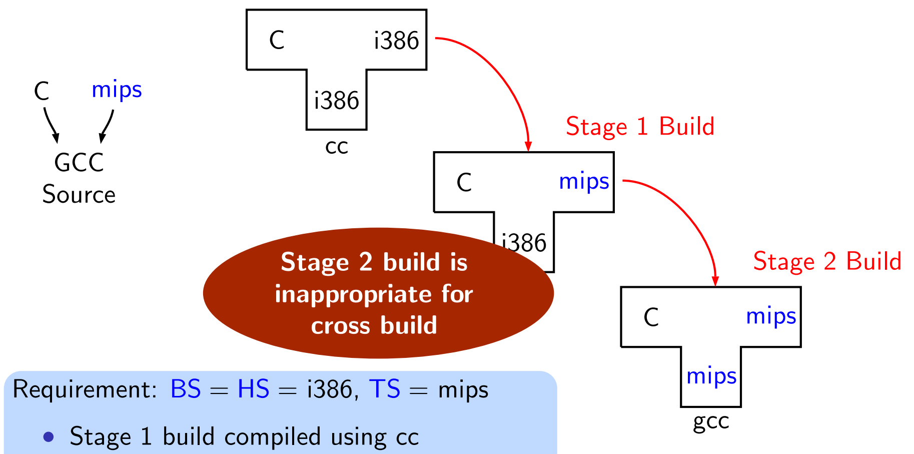
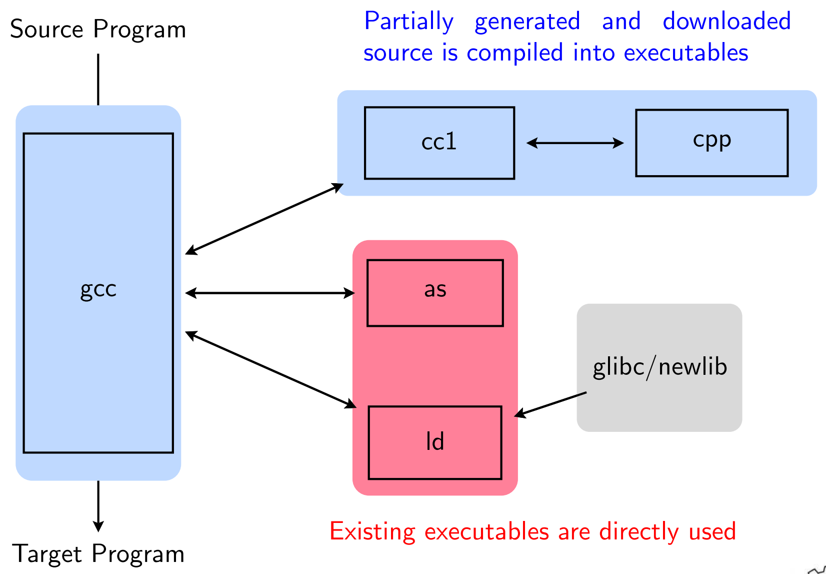


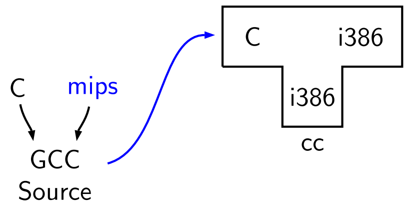
Requirement: BS = HS = i386, TS = mips

- Stage 1 build compiled using cc
- Stage 2 build compiled using gcc
  Its HS = mips and not i386!

A More Detailed Look at Building


Source Program
Partially generated and downloaded source is compiled into executables
gcc
cc1
cpp
as
ld
glibc/newlib
Existing executables are directly used
Target Program

Building a MIPS Cross Compiler on i386: A Closer Look



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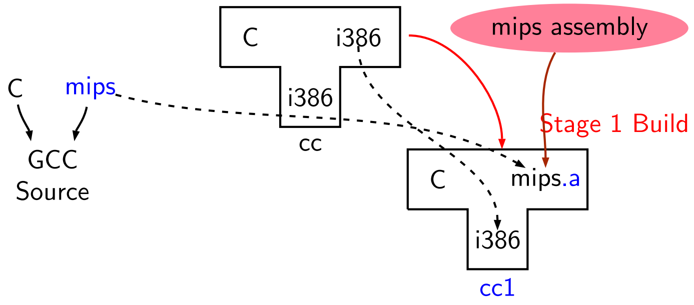
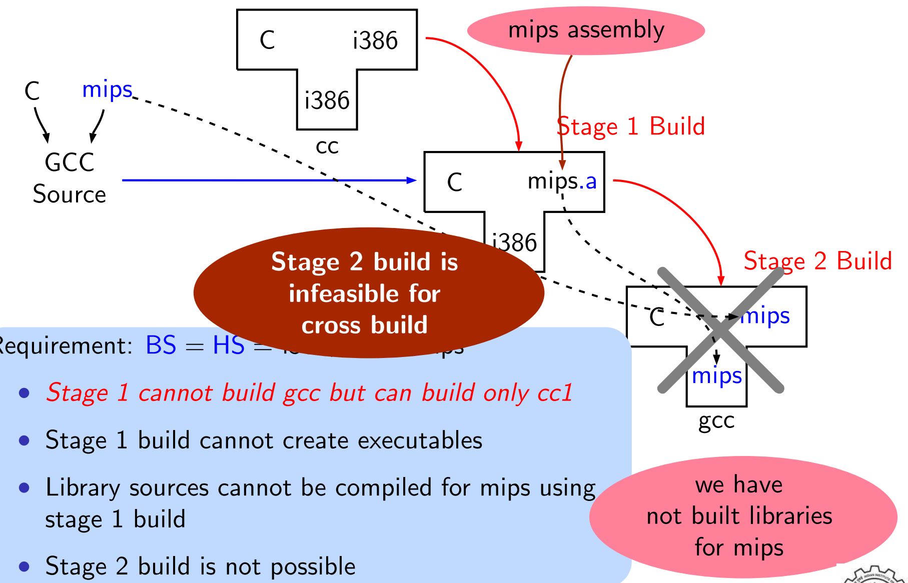


Requirement: BS = HS = i386, TS = mips

- *Stage 1 cannot build gcc but can build only cc1*
- Stage 1 build cannot create executables
- Library sources cannot be compiled for mips using stage 1 build

we have not built libraries for mips

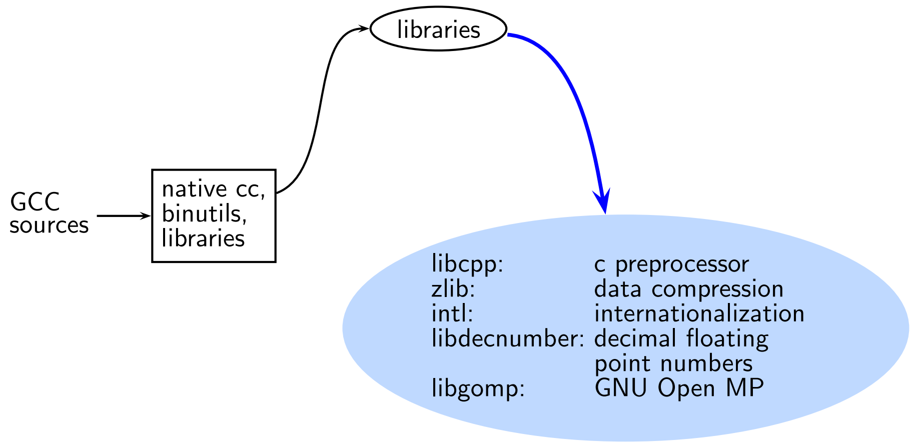
Building a MIPS Cross Compiler on i386: A Closer Look



Requirement: BS = HS =

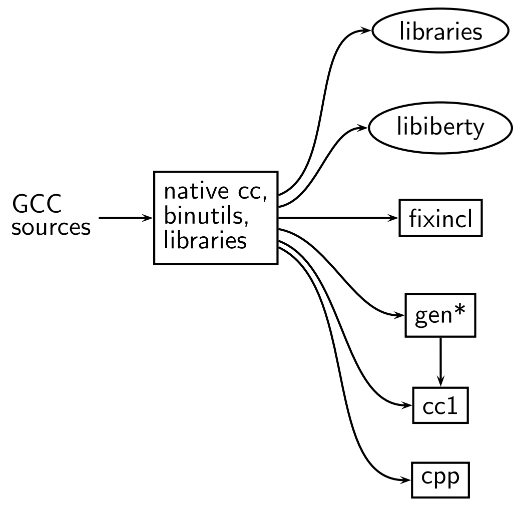
- *Stage 1 cannot build gcc but can build only cc1*
- Stage 1 build cannot create executables
- Library sources cannot be compiled for mips using stage 1 build
- Stage 2 build is not possible

A Closer Look at an Actual Stage 1 Build for C



libcpp:	c preprocessor
zlib:	data compression
intl:	internationalization
libdecnumber:	decimal floating point numbers
libgomp:	GNU Open MP

A Closer Look at an Actual Stage 1 Build for C



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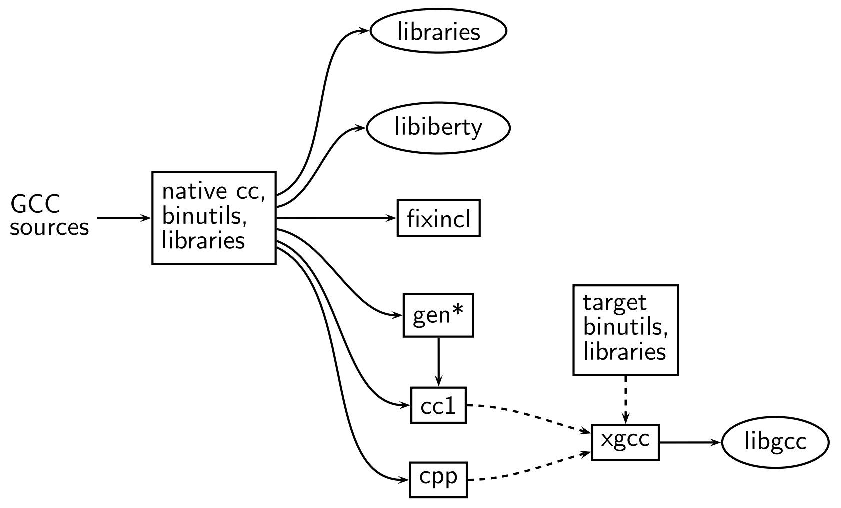
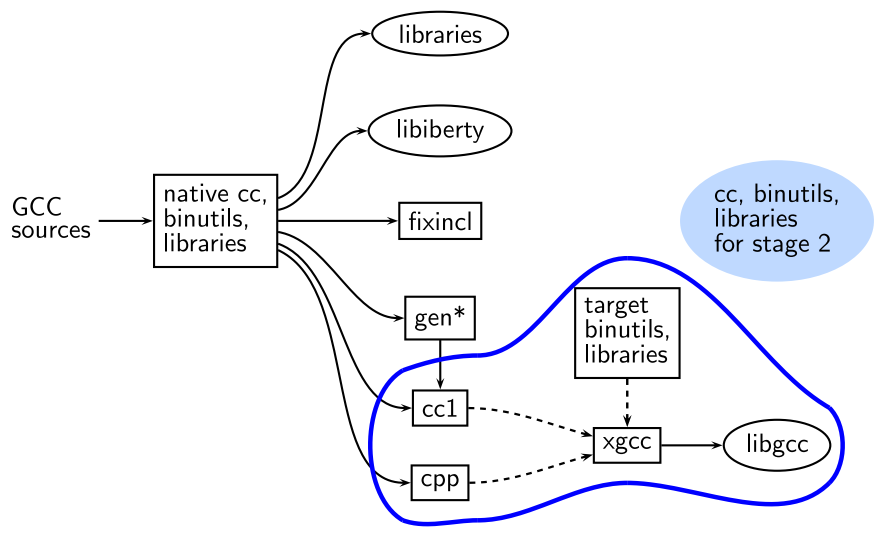


A Closer Look at an Actual Stage 1 Build for C

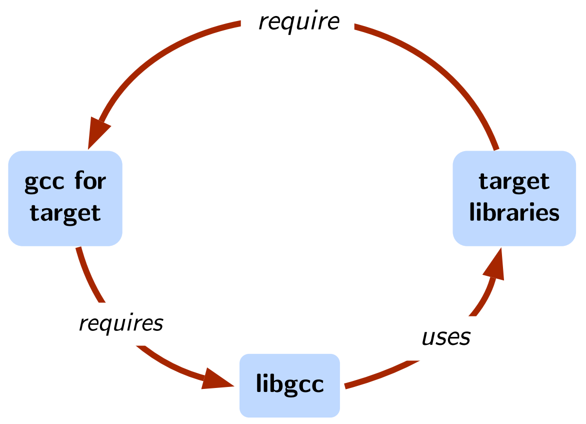

GCC sources
native cc, binutils, libraries
libraries
libiberty
fixincl
gen*
cc1
cpp
target binutils, libraries
xgcc
libgcc
cc, binutils, libraries for stage 2

A Closer Look at an Actual Stage 1 Build for C

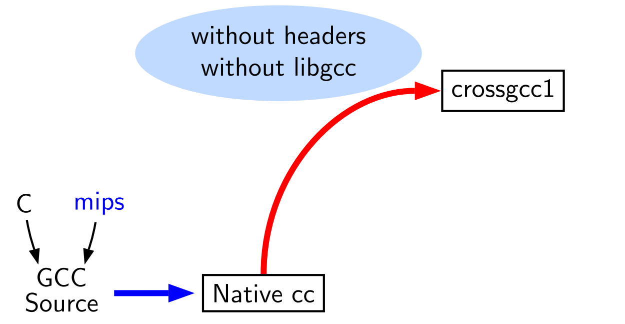
Generated Compiler Executable for All Languages

Main driver	`$BUILD/gcc/xgcc`
C compiler	`$BUILD/gcc/cc1`
C++ compiler	`$BUILD/gcc/cc1plus`
Fortran compiler	`$BUILD/gcc/f951`
Ada compiler	`$BUILD/gcc/gnat1`
Java compiler	`$BUILD/gcc/jc1`
Java compiler for generating main class	`$BUILD/gcc/jvgenmain`
LTO driver	`$BUILD/gcc/lto1`
Objective C	`$BUILD/gcc/cc1obj`
Objective C++	`$BUILD/gcc/cc1objplus`

Difficulty in Building a Cross Compiler



Building a MIPS Cross Compiler on i386



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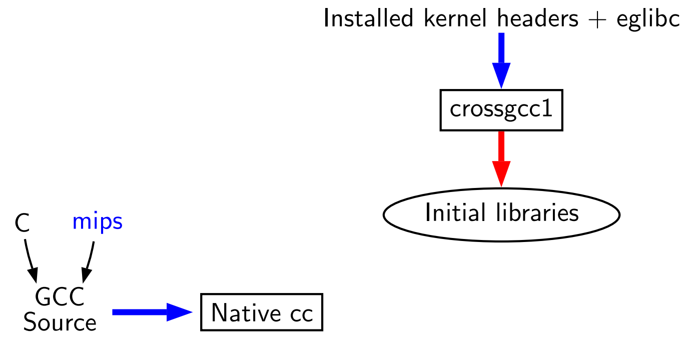

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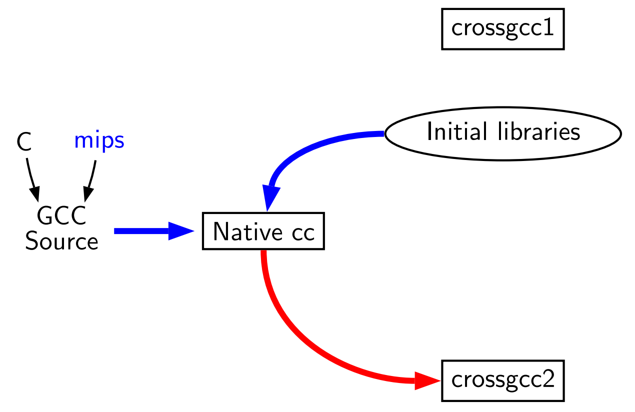

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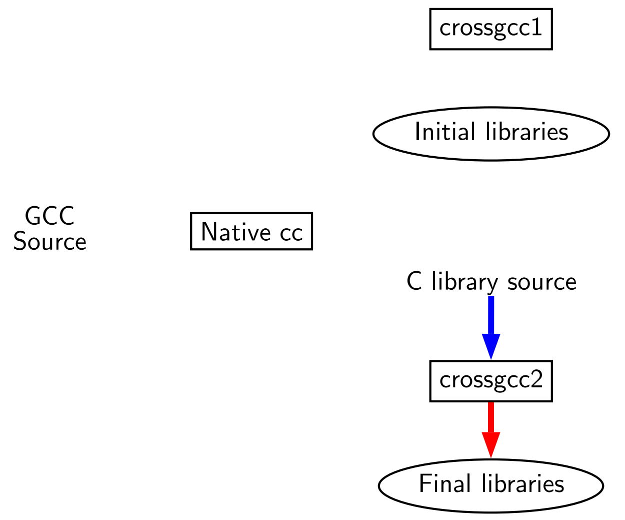

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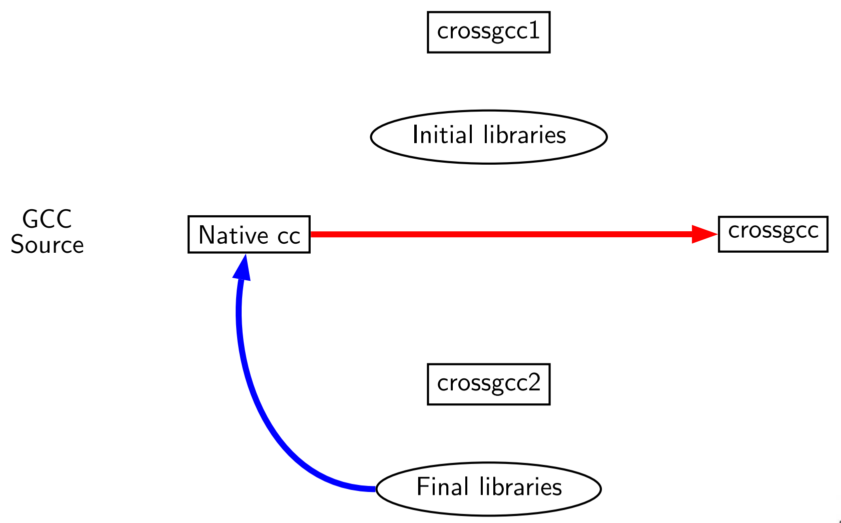

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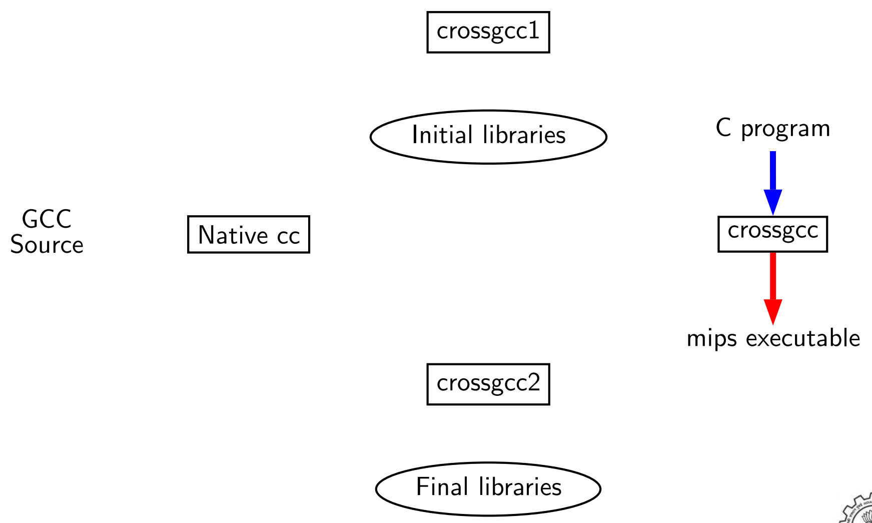

Problem with Native Build in Ubuntu 11.04

- GCC expects `asm` directory in `/usr/include`
- In Ubuntu 11.04, it is present in `/usr/include/i386-linux-gnu` and not in `/usr/include`
- Installing `gcc-multilib` using synaptic package manager creates the required symbolic links

Common Configuration Options

`--target`

- Necessary for cross build
- Possible `host-cpu-vendor` strings: Listed in `$(SOURCE_D)/config.sub`

`--enable-languages`

- Comma separated list of language names
- Default names: `c`, `c++`, `fortran`, `java`, `objc`
- Additional names possible: `ada`, `obj-c++`, `treelang`

`--prefix=$(INSTALL)`
`--program-prefix`

- Prefix string for executable names

`--disable-bootstrap`

- Build stage 1 only

Building `cc1` Only

- Add a new target in the `Makefile.in`

```
.PHONY cc1:
cc1:
     make all-gcc TARGET-gcc=cc1$(exeext)
```

- Configure and build with the command `make cc1`.

Configuring and Building GCC – Summary

- Choose the source language: C (`--enable-languages=c`)
- Choose installation directory: (`--prefix=<absolute path>`)
- Choose the target for non native builds: (`--target=sparc-sunos-sun`)
- Run: `configure` with above choices
- Run: `make` to
  - generate target specific part of the compiler
  - build the entire compiler
- Run: `make install` to install the compiler

Tip

Redirect all the outputs:

```
$ make > make.log 2> make.err
```

Build failures due to Machine Descriptions

Incomplete MD specifications	$\Rightarrow$	Unsuccessful build
Incorrect MD specification	$\Rightarrow$	Successful build but run time failures/crashes (either ICE or `SIGSEGV`)

Part 3

Registering New Machine Descriptions

Registering New Machine Descriptions

- Define a new system name, typically a triple.
  e.g. `spim-gnu-linux`
- Edit `$(SOURCE_D)/config.sub` to recognize the triple
- Edit `$(SOURCE_D)/gcc/config.gcc` to define
  - any back end specific variables
  - any back end specific files
  - `$(SOURCE_D)/gcc/config/<cpu>` is used as the back end directory

  for recognized system names.

Tip

Read comments in `$(SOURCE_D)/config.sub` &
`$(SOURCE_D)/gcc/config/<cpu>`.

Registering Spim with GCC Build Process

We want to add multiple descriptions:

- Step 1. In the file `$(SOURCE_D)/config.sub`
  Add to the `case $basic_machine`
  - `spim*` in the part following
    `# Recognize the basic CPU types without company name.`
  - `spim*-*` in the part following
    `# Recognize the basic CPU types with company name.`

Registering Spim with GCC Build Process

- Step 2a. In the file `$(SOURCE_D)/gcc/config.gcc`

  In `case ${target}` used for defining `cpu_type`, i.e. after the line

  `# Set default cpu_type, tm_file, tm_p_file and xm_file ...`

  add the following case

```
spim*-*-*)
     cpu_type=spim
     ;;
```

  This says that the machine description files are available in the directory `$(SOURCE_D)/gcc/config/spim`.

Registering Spim with GCC Build Process

- Step 2b. In the file `$(SOURCE_D)/gcc/config.gcc`

  Add the following in the `case ${target}` for
  `# Support site-specific machine types.`

```
spim*-*-*)
     gas=no
     gnu_ld=no
     file_base="`echo ${target}| sed 's/-.*$//'`"
     tm_file="${cpu_type}/${file_base}.h"
     md_file="${cpu_type}/${file_base}.md"
     out_file="${cpu_type}/${file_base}.c"
     tm_p_file="${cpu_type}/${file_base}-protos.h"
     echo ${target}
     ;;
```

Building a Cross-Compiler for Spim

- Normal cross compiler build process attempts to use the generated `cc1` to compile the emulation libraries (`LIBGCC`) into executables using the assembler, linker, and archiver.
- We are interested in only the `cc1` compiler.
- Use `make cc1`

Part 4

Building A Cross Compiler

Overview of Building a Cross Compiler

1. crossgcc1. Build a cross compiler with certain facilities disabled
2. Initial Library. Configure the C library using crossgcc1. Build some specified C run-time object files, but not rest of the library. Install the library's header files and run-time object file, and create dummy libc.so
3. crossgcc2. Build a second cross-compiler, using the header files and object files installed in step 2
4. Final Library. Configure, build and install fresh C library, using crossgcc2
5. crossgcc. Build a third cross compiler, based on the C library built in step 4

Downloading Source Tarballs

Download the latest version of source tarballs

Tar File Name	Download URL
gcc-4.6.0.tar.gz	gcc.cybermirror.org/releases/gcc-4.6.0/
binutils-2.20.tar.gz	ftp.gnu.org/gnu/binutils/
Latest revision of EGLIBC	svn co svn://svn.eglibc.org/trunk eglibc
linux-2.6.33.3.tar.gz	www.kernel.org/pub/linux/kernel/v2.6/

Setting Up the Environment for Cross Compilation

- Create a folder 'crossbuild' that will contain the crossbuilt compiler sources and binaries.

```
$.mkdir crossbuild
$.cd crossbuild
```

- Create independent folders that will contain the source code of gcc-4.6.0, binutil, and eglibc.

```
crossbuild$.mkdir gcc
crossbuild$.mkdir eglibc
crossbuild$.mkdir binutils
```

Setting Up the Environment for Cross Compilation

- Create a folder that will contain the cross toolchain.

```
crossbuild$.mkdir install
```

- Create a folder that will have a complete EGLIBC installation, as well as all the header files, library files, and the startup C files for the target system.

```
crossbuild$.mkdir sysroot
```

sysroot $\equiv$ standard linux directory layout

Setting the Environment Variables

Set the environment variables to generalize the later steps for cross build.

```
crossbuild$.export prefix=<path_to crossbuild/install>
crossbuild$.export sysroot=<path_to crossbuild/sysroot>
crossbuild$.export host=i686-pc-linux-gnu
crossbuild$.export build=i686-pc-linux-gnu
crossbuild$.export target=mips-linux OR
            export target=powerpc-linux
crossbuild$.export linuxarch=mips OR
            export linuxarch=powerpc
```

Building Binutils

- Change the working directory to binutils.

```
crossbuild$. cd binutils
```

- Untar the binutil source tarball here.

```
crossbuild/binutils$. tar -xvf binutils-2.20.tar.gz
```

- Make a build directory to configure and build the binutils, and go to that dicrectory.

```
crossbuild/binutils$. mkdir build
crossbuild/binutils$. cd build
```

Building Binutils

- Configure the binutils:

```
crossbuild/binutils/build$. ../binutils-2.20/configure
--target=$target --prefix=$prefix --with-sysroot=$sysroot
```

- Install the binutils:

```
crossbuild/binutils/build$. make
crossbuild/binutils/build$. make install
```

- Change the working directory back to crossbuild.

```
crossbuild/binutils/build$. cd ~/crossbuild
```

Building First GCC

- Change the working directory to gcc.

```
crossbuild$. cd gcc
```

- Untar the gcc-4.6.0 source tarball here.

```
crossbuild/gcc$. tar -xvf gcc-4.6.0.tar.gz
```

- Make a build directory to configure and build gcc, and go to that directory.

```
crossbuild/gcc$. mkdir build
crossbuild/gcc$. cd build
```

libgcc and other libraries are built using libc headers. Shared libraries like 'libgcc_s.so' are to be compiled against EGLIBC headers (not installed yet), and linked against 'libc.so' (not built yet). We need configure time options to tell GCC not to build 'libgcc_s.so'.

Building First GCC

- Configure gcc:

```
crossbuild/gcc/build$. ../gcc-4.6.0/configure
--target=$target  --prefix=$prefix  --without-headers
--with-newlib --disable-shared  --disable-threads
--disable-libssp --disable-libgomp  --disable-libmudflap
--enable-languages=c
```

'--without-headers' ⇒ build libgcc without any headers at all. '--with-newlib' ⇒ use newlib header while building other libraries than libgcc.
Using both the options together results in libgcc being built without requiring the presence of any header, and other libraries being built with newlib headers.

Building First GCC

- Install gcc in the install folder:

```
crossbuild/gcc/build$. PATH=$prefix/bin:$PATH make all-gcc
crossbuild/gcc/build$. PATH=$prefix/bin:$PATH make
install-gcc
```

- change the working directory back to crossbuild.

```
crossbuild/gcc/build$. cd ~/crossbuild
```

Installing Linux Kernel Headers

Linux makefiles are target-specific

- Untar the linux kernel source tarball.

```
crossbuild$.tar -xvf linux-2.6.33.3.tar.gz
```

- Change the working directory to linux-2.6.33.3

```
crossbuild$.cd linux-2.6.33.3
```

- Install the kernel headers in the sysroot directory:

```
crossbuild/linux-2.6.33.3$.PATH=$prefix/bin:$PATH  make
headers_install  CROSS_COMPILE=$target-
INSTALL_HDR_PATH=$sysroot/usr ARCH=$linuxarch
```

- change the working directory back to crossbuild.

```
crossbuild/linux-2.6.33.3$.cd ~/crossbuild
```

Installing EGLIBC Headers and Preliminary Objects

Using the cross compiler that we have just built, configure EGLIBC to install the headers and build the object files that the full cross compiler will need.

- Change the working directory to eglibc.

```
crossbuild$. cd eglibc
```

- Check the latest eglibc source revision here.

```
crossbuild/eglibc$. svn co svn://svn.eglibc.org/trunk
eglibc
```

- Some of the targets are not supported by glibc (e.g. mips). The support for such targets is provided in the 'ports' folder in eglibc. We need to copy this folder inside the libc folder to create libraries for the new target.

```
crossbuild/eglibc$. cp -r eglibc/ports eglibc/libc
```

Installing EGLIBC Headers and Preliminary Objects

- Make a build directory to configure and build eglibc headers, and go to that directory.

```
crossbuild/eglibc$. mkdir build
crossbuild/eglibc$. cd build
```

- Configure eglibc:

```
crossbuild/eglibc/build$. BUILD_CC=gcc
CC=$prefix/bin/$target-gcc  AR=$prefix/bin/$target-ar
RANLIB=$prefix/bin/$target-ranlib ../eglibc/libc/configure
--prefix=/usr  --with-headers=$sysroot/usr/include
--build=$build  --host=$target  --disable-profile
--without-gd  --without-cvs  --enable-add-ons
```

EGLIBC must be configured with option '--prefix=/usr', because the EGLIBC build system checks whether the prefix is '/usr', and does special handling only if that is the case.

Installing EGLIBC Headers and Preliminary Objects

- We can now use the 'install-headers' makefile target to install the headers:

```
crossbuild/eglibc/build$. make install-headers
install_root=$sysroot install-bootstrap-headers=yes
```

  'install-bootstrap-headers' variable requests special handling for certain tricky header files.

  (`autoconf` 2.13 causes some problems. Get version 2.50 or later)

- There are a few object files that are needed to link shared libraries. We will build and install them by hand:

```
crossbuild/eglibc/build$. mkdir -p $sysroot/usr/lib
crossbuild/eglibc/build$. make csu/subdir_lib
crossbuild/eglibc/build$. cd csu
crossbuild/eglibc/build/csu$. cp crt1.o  crti.o  crtn.o
$sysroot/usr/lib
```

Installing EGLIBC Headers and Preliminary Objects

- Finally, 'libgcc_s.so' requires a 'libc.so' to link against. However, since we will never actually execute its code, it doesn't matter what it contains. So, treating '/dev/null' as a C souce code, we produce a dummy 'libc.so' in one step:

```
   crossbuild/eglibc/build/csu$. $prefix/bin/$target-gcc
-nostdlib -nostartfiles -shared -x c /dev/null -o
$sysroot/usr/lib/libc.so
```

- change the working directory back to crossbuild.

```
crossbuild/gcc/build$. cd ~/crossbuild
```

Building the Second GCC

With the EGLIBC headers and the selected object files installed, build a GCC that is capable of compiling EGLIBC.

- Change the working directory to build directory inside gcc folder.

```
crossbuild$. cd gcc/build
```

- Clean the build folder.

```
crossbuild/gcc/build$. rm -rf *
```

- Configure the second gcc:

```
   crossbuild/gcc/build$. ../gcc-4.6.0/configure
--target=$target --prefix=$prefix --with-sysroot=$sysroot
--disable-libssp --disable-libgomp --disable-libmudflap
--enable-languages=c
```

Building the Second GCC

- install the second gcc in the install folder:

```
crossbuild/gcc/build$. PATH=$prefix/bin:$PATH make
crossbuild/gcc/build$. PATH=$prefix/bin:$PATH make install
```

- change the working directory back to crossbuild.

```
crossbuild/gcc/build$. cd ~/crossbuild
```

Building Complete EGLIBC

With the second compiler built and installed, build EGLIBC completely.

- Change the working directory to the build directory inside eglibc folder.

```
crossbuild$. cd eglibc/build
```

- Clean the build folder.

```
crossbuild/eglibc/build$. rm -rf *
```

- Configure eglibc:

```
   crossbuild/eglibc/build$. BUILD_CC=gcc
CC=$prefix/bin/$target-gcc AR=$prefix/bin/$target-ar
RANLIB=$prefix/bin/$target-ranlib ../eglibc/libc/configure
--prefix=/usr --with-headers=$sysroot/usr/include
--build=$build --host=$target --disable-profile
--without-gd --without-cvs --enable-add-ons
```

Building Complete EGLIBC

- install the required libraries in $sysroot:

```
crossbuild/eglibc/build$. PATH=$prefix/bin:$PATH make
crossbuild/eglibc/build$. PATH=$prefix/bin:$PATH make
install install_root=$sysroot
```

- change the working directory back to crossbuild.

```
crossbuild/gcc/build$. cd ~/crossbuild
```

At this point, we have a complete EGLIBC installation in '$sysroot', with header files, library files, and most of the C runtime startup files in place.

Building fully Cross-compiled GCC

Recompile GCC against this full installation, enabling whatever languages and libraries you would like to use.

- Change the working directory to build directory inside gcc folder.

```
crossbuild$. cd gcc/build
```

- Clean the build folder.

```
crossbuild/gcc/build$. rm -rf *
```

- Configure the third gcc:

```
crossbuild/gcc/build$. ../gcc-4.6.0/configure
--target=$target --prefix=$prefix --with-sysroot=$sysroot
--disable-libssp --disable-libgomp --disable-libmudflap
--enable-languages=c
```

Building fully Cross-compiled GCC

- Install the final gcc in the install folder:

```
crossbuild/gcc/build$. PATH=$prefix/bin:$PATH make
crossbuild/gcc/build$. PATH=$prefix/bin:$PATH make install
```

- change the working directory back to crossbuild.

```
crossbuild/gcc/build$. cd ~/crossbuild
```

Maintaining $sysroot Folder

Since GCC's installation process is not designed to help construct sysroot trees, certain libraries must be manually copied into place in the sysroot.

- Copy the libgcc_s.so files to the lib folder in $sysroot.

```
crossbuild$.cp -d $prefix/$target/lib/libgcc_s.so*
$sysroot/lib
```

- If c++ language was enabled, copy the libstdc++.so files to the usr/lib folder in $sysroot.

```
crossbuild$.cp -d $prefix/$target/lib/libstdc++.so*
$sysroot/usr/lib
```

At this point, we have a ready cross compile toolchain in $prefix, and EGLIBC installation in $sysroot.

Part 5

Testing

Testing GCC

- Pre-requisites - `Dejagnu`, `Expect` tools
- Option 1: Build GCC and execute the command

  `make check`

  or

  `make check-gcc`
- Option 2: Use the configure option `--enable-checking`
- Possible list of checks
  - Compile time consistency checks
    `assert`, `fold`, `gc`, `gcac`, `misc`, `rtl`, `rtlflag`, `runtime`, `tree`, `valgrind`
  - Default combination names
    - `yes`: `assert`, `gc`, `misc`, `rtlflag`, `runtime`, `tree`
    - `no`
    - `release`: `assert`, `runtime`
    - `all`: all except `valgrind`

GCC Testing framework

- `make` will invoke `runtest` command
- Specifying `runtest` options using `RUNTESTFLAGS` to customize torture testing

  `make check RUNTESTFLAGS="compile.exp"`
- Inspecting testsuite output: `$(BUILD)/gcc/testsuite/gcc.log`

Interpreting Test Results

- PASS: the test passed as expected
- XPASS: the test unexpectedly passed
- FAIL: the test unexpectedly failed
- XFAIL: the test failed as expected
- UNSUPPORTED: the test is not supported on this platform
- ERROR: the testsuite detected an error
- WARNING: the testsuite detected a possible problem

GCC Internals document contains an exhaustive list of options for testing

Testing a Cross Compiler

Sample input file test.c:

```
#include <stdio.h>
int main ()
{
        int a, b, c, *d;
        d = &a;
        a = b + c;
        printf ("%d", a);
        return 0;
}
```

```
$. $prefix/bin/$target-gcc -o test test.c
```

Testing a Cross Compiler

For a powerpc architecture,

```
$. $prefix/bin/powerpc-unknown-linux-gnu-gcc -o test test.c
```

Use readelf to verify whether the executable is indeed for powerpc

```
$. $prefix/bin/powerpc-unknown-linux-gnu-readelf -lh test
```

```
ELF Header:
  Magic:   7f 45 4c 46 01 02 01 00 00 00 00 00 00 00 00 00
  ...
  Type:                              EXEC (Executable file)
  Machine:                           PowerPC
  ...
Program Headers:
  ...
      [Requesting program interpreter: /lib/ld.so.1]
  ...
```