

CSE-425: Compiler Design

Assignment #1: Compilation pipeline and its different components

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i. Run gcc compiler using `'gcc -Wall --verbose --save-temps -o first-exec test.c'`. Find the name of different components of the compiler and highlight them in the submission.

// test.c

```
1 #include <stdio.h>
2
3 int main() {
4     int num1, num2, sum;
5
6     // Get input from the user
7     printf("Enter the first number: ");
8     scanf("%d", &num1);
9
10    printf("Enter the second number: ");
11    scanf("%d", &num2);
12
13    // Perform addition
14    sum = num1 + num2;
15
16    // Display the result
17    printf("The sum of %d and %d is %d.\n", num1, num2, sum);
18
19    return 0;
20 }
```

\$ gcc -Wall --verbose --save-temps -o first-exec test.c

Using built-in specs.

COLLECT_GCC=gcc

COLLECT_LTO_WRAPPER=/usr/lib/gcc/x86_64-linux-gnu/11/lto-wrapper

OFFLOAD_TARGET_NAMES=nvptx-none:amdgc-n-amdhsa

OFFLOAD_TARGET_DEFAULT=1

Target: x86_64-linux-gnu

Configured with: ../src/configure -v --with-pkgversion='Ubuntu 11.3.0-1ubuntu1~22.04.1'

--with-bugurl=file:///usr/share/doc/gcc-11/README.Bugs

--enable-languages=c,ada,c++,go,brig,d,fortran,objc,obj-c++,m2 --prefix=/usr

--with-gcc-major-version-only --program-suffix=-11 --program-prefix=x86_64-linux-gnu-

```

--enable-shared --enable-linker-build-id --libexecdir=/usr/lib --without-included-gettext
--enable-threads=posix --libdir=/usr/lib --enable-nls --enable-bootstrap
--enable-clocale=gnu --enable-libstdcxx-debug --enable-libstdcxx-time=yes
--with-default-libstdcxx-abi=new --enable-gnu-unique-object --disable-vtable-verify
--enable-plugin --enable-default-pie --with-system-zlib
--enable-libphobos-checking=release --with-target-system-zlib=auto --enable-objc-gc=auto
--enable-multiarch --disable-werror --enable-cet --with-arch-32=i686 --with-abi=m64
--with-multilib-list=m32,m64,mx32 --enable-multilib --with-tune=generic
--enable-offload-targets=nvptx-none=/build/gcc-11-aYxV0E/gcc-11-11.3.0/debian/tmp-nvpt
x/usr,amdgc- amdhsa=/build/gcc-11-aYxV0E/gcc-11-11.3.0/debian/tmp-gcn/usr
--without-cuda-driver --enable-checking=release --build=x86_64-linux-gnu
--host=x86_64-linux-gnu --target=x86_64-linux-gnu --with-build-config=bootstrap-lto-lean
--enable-link-serialization=2
Thread model: posix
Supported LTO compression algorithms: zlib zstd
gcc version 11.3.0 (Ubuntu 11.3.0-1ubuntu1~22.04.1)
COLLECT_GCC_OPTIONS='-Wall' '-v' '-save-temps' '-o' 'first-exec' '-mtune=generic'
'-march=x86-64' '-dumpdir' 'first-exec'

```

- Preprocessor starts

```

/usr/lib/gcc/x86_64-linux-gnu/11/cc1 -E -quiet -v -imultiarch x86_64-linux-gnu test.c
-mtune=generic -march=x86-64 -Wall -fpch-preprocess -fasynchronous-unwind-tables
-fstack-protector-strong -Wformat-security -fstack-clash-protection -fcf-protection -o
first-exec-test.i

```

```

ignoring nonexistent directory "/usr/local/include/x86_64-linux-gnu"
ignoring nonexistent directory "/usr/lib/gcc/x86_64-linux-gnu/11/include-fixed"
ignoring nonexistent directory
"/usr/lib/gcc/x86_64-linux-gnu/11/../../../../x86_64-linux-gnu/include"
#include "..." search starts here:
#include <...> search starts here:
/usr/lib/gcc/x86_64-linux-gnu/11/include
/usr/local/include
/usr/include/x86_64-linux-gnu
/usr/include
End of search list.

```

```

COLLECT_GCC_OPTIONS='-Wall' '-v' '-save-temps' '-o' 'first-exec' '-mtune=generic'
'-march=x86-64' '-dumpdir' 'first-exec'

```

- Preprocessor ends

// test.i main function (Preprocessed)

```
739
740 # 3 "test.c"
741 int main() {
742     int num1, num2, sum;
743
744     printf("Enter the first number: ");
745     scanf("%d", &num1);
746
747     printf("Enter the second number: ");
748     scanf("%d", &num2);
749
750
751     sum = num1 + num2;
752
753
754     printf("The sum of %d and %d is %d.\n", num1, num2, sum);
755
756     return 0;
757 }
758 }
```

- Compiler starts

```
/usr/lib/gcc/x86_64-linux-gnu/11/cc1 -fpreprocessed first-exec-test.i -quiet -dumpdir first-exec-  
-dumpbase test.c -dumpbase-ext .c -mtune=generic -march=x86-64 -Wall -version  
-fasynchronous-unwind-tables -fstack-protector-strong -Wformat-security -fstack-clash-protection  
-fcf-protection -o first-exec-test.s
```

GNU C17 (Ubuntu 11.3.0-1ubuntu1~22.04.1) version 11.3.0 (x86_64-linux-gnu)
compiled by GNU C version 11.3.0, GMP version 6.2.1, MPFR version 4.1.0, MPC
version 1.2.1, isl version isl-0.24-GMP

GGC heuristics: --param ggc-min-expand=100 --param ggc-min-heapsize=131072
GNU C17 (Ubuntu 11.3.0-1ubuntu1~22.04.1) version 11.3.0 (x86_64-linux-gnu)
compiled by GNU C version 11.3.0, GMP version 6.2.1, MPFR version 4.1.0, MPC
version 1.2.1, isl version isl-0.24-GMP

GGC heuristics: --param ggc-min-expand=100 --param ggc-min-heapsize=131072

Compiler executable checksum: e13e2dc98bfa673227c4000e476a9388
COLLECT_GCC_OPTIONS='-Wall' '-v' '-save-temps' '-o' 'first-exec' '-mtune=generic'
'-march=x86-64' '-dumpdir' 'first-exec'

- **Compiler ends**

```
1      .file      "test.c"
2      .text
3      .section   .rodata
4 .LC0:
5      .string   "Enter the first number: "
6 .LC1:
7      .string   "%d"
8 .LC2:
9      .string   "Enter the second number: "
10 .LC3:
11     .string   "The sum of %d and %d is %d.\n"
12     .text
13     .globl    main
14     .type     main, @function
15 main:
16 .LFB0:
17     .cfi_startproc
18     endbr64
19     pushq    %rbp
20     .cfi_def_cfa_offset 16
21     .cfi_offset 6, -16
22     movq     %rsp, %rbp
23     .cfi_def_cfa_register 6
24     subq     $32, %rsp
25     movq     %fs:40, %rax
26     movq     %rax, -8(%rbp)
27     xorl     %eax, %eax
28     leaq     .LC0(%rip), %rax
29     movq     %rax, %rdi
30     movl     $0, %eax
```

- **Assembler starts**

as -v --64 -o first-exec-test.o first-exec-test.s

- **Assembler ends**

- **Linker starts**

GNU assembler version 2.38 (x86_64-linux-gnu) using BFD version (GNU Binutils for Ubuntu) 2.38

COMPILER_PATH=/usr/lib/gcc/x86_64-linux-gnu/11:/usr/lib/gcc/x86_64-linux-gnu/11:/usr/lib/gcc/x86_64-linux-gnu:/usr/lib/gcc/x86_64-linux-gnu/11:/usr/lib/gcc/x86_64-linux-gnu/

LIBRARY_PATH=/usr/lib/gcc/x86_64-linux-gnu/11:/usr/lib/gcc/x86_64-linux-gnu/11/../../x86_64-linux-gnu:/usr/lib/gcc/x86_64-linux-gnu/11/../../lib:/usr/lib/x86_64-linux-gnu:/usr/lib/./usr/lib/x86_64-linux-gnu:/usr/lib/./lib:/usr/lib/gcc/x86_64-linux-gnu/11/../../lib:/usr/lib/

COLLECT_GCC_OPTIONS='-Wall' '-v' '-save-temps' '-o' 'first-exec' '-mtune=generic' '-march=x86-64' '-dumpdir' 'first-exec.'

/usr/lib/gcc/x86_64-linux-gnu/11/collect2 -plugin

/usr/lib/gcc/x86_64-linux-gnu/11/liblto_plugin.so

-plugin-opt=/usr/lib/gcc/x86_64-linux-gnu/11/lto-wrapper -plugin-opt=-fresolution=first-exec.res

-plugin-opt=-pass-through=-lgcc -plugin-opt=-pass-through=-lgcc_s -plugin-opt=-pass-through=-lc

-plugin-opt=-pass-through=-lgcc -plugin-opt=-pass-through=-lgcc_s --build-id --eh-frame-hdr -m

elf_x86_64 --hash-style=gnu --as-needed -dynamic-linker /lib64/ld-linux-x86-64.so.2 -pie -z now

-z relro -o first-exec /usr/lib/gcc/x86_64-linux-gnu/11/../../x86_64-linux-gnu/Scrt1.o

/usr/lib/gcc/x86_64-linux-gnu/11/../../x86_64-linux-gnu/crti.o

/usr/lib/gcc/x86_64-linux-gnu/11/crtbeginS.o -L/usr/lib/gcc/x86_64-linux-gnu/11

-L/usr/lib/gcc/x86_64-linux-gnu/11/../../x86_64-linux-gnu

-L/usr/lib/gcc/x86_64-linux-gnu/11/../../lib -L/lib/x86_64-linux-gnu -L/lib/./lib

-L/usr/lib/x86_64-linux-gnu -L/usr/lib/./lib -L/usr/lib/gcc/x86_64-linux-gnu/11/../../

first-exec-test.o -lgcc --push-state --as-needed -lgcc_s --pop-state -lc -lgcc --push-state --as-needed

-lgcc_s --pop-state /usr/lib/gcc/x86_64-linux-gnu/11/crtendS.o

/usr/lib/gcc/x86_64-linux-gnu/11/../../x86_64-linux-gnu/crtn.o

- **Linker ends**

COLLECT_GCC_OPTIONS='-Wall' '-v' '-save-temps' '-o' 'first-exec' '-mtune=generic' '-march=x86-64' '-dumpdir' 'first-exec.'

The compilation process generates the following intermediate files:

- **`test.i`**: This is the preprocessed file produced after the Preprocessor operates on the `test.c` file.
- **`test.s`**: This contains the assembly code generated by the compiler when processing the preprocessed `test.i` file.
- **`test.o`**: This stores the object code created by the assembler when processing the assembly code from `test.s`.

Finally, the linker acts on the `test.o` object code to generate the final executable.

ii.

PL/I Source Code:

```
EX02: PROC OPTIONS (MAIN);  
DCL A BIT(16) INIT('101'B);  
DCL B BIT(16) INIT('1010'B);  
DCL C BIT(16) INIT('111'B);  
DCL D BIT(16);  
D = A ! B & C;  
END EX02;
```

```
vicky@pop-os:~/linux-pli-compiler-master$ ./run.sh all  
Removing old files...  
Running make  
_____k o m p p l . e x e          g e n e r a t i o n_____  
gcc -o kompl.exe kompl.c
```

```
-----k o m p a s s r . e x e      g e n e r a t i o n_____  
gcc -o kompassr.exe kompassr.c
```

```
Compiling .pli file  
трансляция завершена успешно  
Building object file  
успешное завершение трансляции
```

Below is the shell script provided to execute various components of the compilation pipeline:

```
# /bin/sh
if [ $# -lt 1 ]; then
    echo 'Usage: ./run.sh [clean] [make] [run] [all]'
    exit 0
fi
if [ "$1" = "clean" -o "$1" = "all" ]; then
    echo 'Removing old files...'
    rm *.exe
    rm *.ass
    rm *.tex
fi
if [ "$1" = "make" -o "$1" = "all" ]; then
    echo 'Running make'
    make
fi
if [ "$1" = "run" -o "$1" = "all" ]; then
```

Compiler starts

```
echo 'Compiling .pli file'
./komppl.exe task2.pli
```

Compiler ends

Assembler starts

```
echo 'Building object file'
./kompassr.exe task2.ass
cp task2.tex examppl.tex
```

Assembler ends

```
fi
```



```

1 # /bin/sh
2 if [ $# -lt 1 ]; then
3     echo 'Usage: ./run.sh [clean] [make] [run] [all]'
4     exit 0
5 fi
6 if [ "$1" = "clean" -o "$1" = "all" ]; then
7     echo 'Removing old files...'
8     rm *.exe
9     rm *.ass
10    rm *.tex
11 fi
12 if [ "$1" = "make" -o "$1" = "all" ]; then
13     echo 'Running make'
14     make
15 fi
16 if [ "$1" = "run" -o "$1" = "all" ]; then
17     echo 'Compiling .pli file'
18     ./komppl.exe task2.pli
19     echo 'Building object file'
20     ./kompassr.exe task2.ass
21     cp task2.tex exampl.tex
22 #     echo 'Running debugger'
23 #     ./absloadm.exe spis.mod
24 fi

```

The intermediate files produced are as follows:

- **task2.ass**: This contains the assembly code generated by the compiler when processing the **task2.pli** file.
- **task2.tex**: This stores the object code generated by the assembler when processing the assembly code from **task2.ass**.

***** Please note that the IBM compiler is designed to work exclusively on the AIX operating system, which is not compatible with Intel systems. However, we came across a GitHub repository for a PL/I compiler tailored for Linux. It is worth mentioning that this particular compiler omits the intermediate components of Preprocessing and Linker from its compilation pipeline. *****