

# Assignment 1– LLVM Playground (Part 1)

HSS  
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The goal of this assignment is to get your hands dirty using LLVM and gain experience developing static analysis and dynamic instrumentation techniques that can work on real-world code. In this part, your goal is to understand different LLVM IR instructions and how they are produced from C code.

Logistics:

- **LLVM Primer:** Please make sure that you have skimmed the LLVM Primer presentation (access it from the course webpage) to know the capabilities of LLVM.
- **Setup Repo:** I have created a `github` repo with all the necessary scripts to install LLVM, Z3 and starter code to write a pass. You can access it at: <https://github.com/HolisticSoftwareSecurity/hssllvmsetup>. The repo has examples of analysis (i.e., the passes that do not modify the IR) and instrumentation (i.e., the passes that modify the IR) passes.
- **Development Environment:** I use CLion (<https://www.jetbrains.com/clion/>) while working with LLVM and strongly suggest you to use it. You can get unlimited access using your `@purdue.edu` email.

## 1 Generating Bitcode file

You can generate a bitcode file for a given C file by following the below instructions:

```
clang -c -emit-llvm <your_c_file> -o <path_to_output_bitcode>
```

Example:

```
clang -c -emit-llvm simple_log.c -o simple_log.bc
```

The file `simple_log.bc` will be in binary format. You can get human readable bitcode file from the binary format using the following command:

```
llvm-dis <path_to_bitcode_file>
```

Example:

```
llvm-dis simple_log.bc
```

The above command will generate `simple_log.ll` which is a text file containing human-readable LLVM IR.

You can generate bitcode for your entire project (i.e., multiple C files) using `wllvm` [1].

## Part 1 - Understanding the LLVM IR

### Repo

<https://github.com/HolisticSoftwareSecurity/LLVMPlayground>

### Step 1

Study the LLVM Primer from the course webpage to understand the structure of the LLVM IR. The primer shows how to run LLVM on a sample C program to generate the corresponding LLVM IR program. You can use the `part1_learningir/` directory in the repo for this purpose:

```
cd test
clang -emit-llvm -S -fno-discard-value-names -c simple0.c
```

### Step 2

Write by hand the C programs corresponding to the LLVM IR programs under the `part1_learningir/ir_programs` directory and place them under the `part1_learningir/c_programs/` directory. Ensure that running the above command on your hand-written C programs generates the exact LLVM IR programs provided as we will auto-grade them. You can do so by using the `diff` command-line utility to check if your files are the same. As shown in the following example:

```
cd part1_learningir/c_programs
clang -emit-llvm -S -fno-discard-value-names -c test1.c
diff test1.ll ../ir_programs/test1.ll
```

## 2 Submission

Run the below command to produce file `submission.zip` and submit that file to brightspace.

```
make submit
mkdir -p submission
rm -rf submission/*
cp -r c_programs submission
zip -r submission.zip submission/ 2 >&1>/dev/null
```

## References

[1] <https://github.com/travitch/whole-program-llvm>.