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Assembler vs compiler vs linker

This document briefly describes what happens when you compiler and run a program. More details can be found in compilers, principles, techniques, and tools by Deer, Seti, and Ullman (Book CSE 401) and Appendix A of Organization and Computer Design by Peterson & Hennessy (CSE Book 378). Compile an app when you type cc in the command line a lot of issues happen. There are four entities involved in the formulation process: preprocessor, compiler, smomer, linker (see Figure 1). Figure 1: Cc interiors. First, cpp preprocessor C extends all those definitions of macros and includes statements (and anything else that #شروع with a #شروع) and passes the result to the actual compiler. Preprocessing is not so interesting because it just replaces some of the short slices you used in your code with more code. The cpp output is only code C; The preprocessor does not require any knowledge of the target architecture. If you had the correct containing files, you could use your C files on a preprocessed Linux machine and output to the training machine and pass that to cc. to see the output of a preprocessed file from cc-E. The compiler effectively translates the preprocessed C code into the assembly code and performs various optimizations along the way as well as the allocation of registration. Since a assembly code compiler specially produces a specific architecture, you can't use the CC assembly output of an Intel Pentium machine on one of the training machines (alpha digital machines). Compilers are very interesting to see that one of the reasons why the department offers a full course in compilers (CSE 401). Use cc-S to see the assembly code generated by the compiler. The smobly code generated by the editing stage is then transferred to the smobler which translates it into machine code; The resulting file is called the object file. In training machines, both cc and gcc use native smoblers as provided by UNIX. You can write an assembly language program and pass it directly as and even to cc (that's what we do in Project 2 with sys.s). An object file is a binary view of your program. The smobler is a memory place to each variable and training; It also lists all unresolved references that will likely be defined in other object files or libraries, such as printf. A typical object file includes the program text (instructions) and data (constants and strings), information about instructions and data that depends on absolute addresses, a symbolic table of unresolved references, and possibly some debugging information. nm UNIX command allows you to look at symbols (both defined and unresolved) in Object file. Since an object file will be associated with other object files and libraries to generate a program, the assembler cannot assign absolute memory locations to all the instructions and data in a file. Rather, it writes some notes in the object file about how it assumes everything was placed. It works from Linker to use these notes to assign absolute memory locations to everything and resolve any unresolved resources. Again, both cc and cc on the training machines use native linker, ld. Some compilers chose to have their own linkers, so that optimizations can be done at the time of the link, one of these optimizations is the method of aligning the boundaries of the page. Linker generates a binary run that can run from the command interface. Note that you can cite each of the steps above by hand. Since it is annoying to each section separately as well as passing the correct flags and files, cc does this for you. For example, you can run the whole process by hand, citing lib/cpp and then cc-S and then /bin/as, and finally ld. If you think it's easy, try compiling a simple program that way. Running a program when you type a.out in the command line, a bunch of things have to happen before your program actually runs. The loader magically does these things for you, in Unix systems, the loader creates a process. This includes reading the file and creating address space for the process. Page table entries are created for instructions, data and app stacks, and the registration suite is initial. The loader then runs a jump instruction to the first instructions in the app. This generally causes the page fault and the front page of your instructions is brought to memory. On some systems the loader is a little more interesting. For example, on systems like Windows NT that provide support for dynamic loaded libraries (DLLs), loaders must resolve references to such libraries similar to how a linker performs. Memory Figure 2 shows a typical layout for the program's memory. It does loader to map the app, static data (including worlds and strings) and stacks to physical addresses. Note that the stack is mapped and down to the top addresses, and the program and data are mapped to the lower addresses. The tag stack area is where your data is placed through the assigned malloc. Calling malloc may use the sbrk system recall to add more physical pages to the program's address space (see male pages for more information about Malloc, Free and sbrk). Figure 2: Memory layout. Contact Conventions Procedure is a method of a field switch in your application. Just like any other field switch, some states must be saved by the caller method, or the caller, so that when the procedure is called, or the caller returns the caller, it may be without distraction to Continue. To enable Compiling, a compiler must follow a set of rules for using registrations when calling procedures. This procedural call convention may vary across compilers (does cc and gcc use the same call convention?) which is why object files created by a compiler cannot always be associated with another compiler. A typical call convention involves action on behalf of the caller and the caller. The place caller argued to the caller in some agreement on the location; This location is usually a few registrations and extras are transferred onto the stack (the stack pointer may need to be updated). Then the caller saves the value of each registration it will need after the call and jump to the callee's first instructions. The callee then assigns memory for its stack frame and saves any registration that values are guaranteed through a procedural call, as such as the return address, unchanged. When the caller is ready to return, it will place the return value, if any, on a special registration and return the registers stored with the caller. He then jumps the stack frame and jumps to the return address. Original version of CSE451, fall 1996. Modified by wolman@cs.washington.edu, fall 1997. It's good to press a programmer who has a sleek green play button at the top of Visual Studio and will see your app run on the current device. But, what kind of magic is hidden under that button? This blog is a gentle overview of the process behind the consolidated/running work based on my curiosity on the topic; Four Horsemen do not understand our computer C++ or any other language, except for machine code. Machine code is a sequence of instructions written binaryally that can run directly from the processor. So, how does our C++ program be able to run if it's not written in machine code? If we are able to run our program thanks to four main tools: compiler, smomer, linker and loader. A short overview of the building process is depicted in the figure below. A preprocessing step occurs before our source files are given to the compiler. At this point, the preprocessor deals with files, conditional editing instructions and macros, and produces a file that is then given to the compiler. Header files are not #include .cpp compiler; Let's do a little test test.h #ifndef TEST_H #define TEST_H // A test class, containing two functions and a integer member. class Test{ public: Test(); Test(int value); int getMember(const; void setMember(int value); Private: member int; }; #endif test.cpp #include Test.h //Test class implementation Test::Test(): member(0) {} Test::Test(int value) :member(value) {} void Test::setMember(int value) { member = value; } int const { return member; } main.cpp #include <iostream>#include Test.h int main() { Test test; <t; the= int= member= is= currently= => <t; test.getmember()=> <t; test.setmember(10);= std::cout> <t; the= int= member= is= currently= => <t; test.getmember()=> <t; return 0; } Now let's open the command line and use g++ to see what is the preprocessor output (you can use whatever C++ compiler you like). The command to use is g++ -E Test.cpp -o preprocessed_test.ii which will only preprocess (-E) our Test.cpp file and put the result into preprocessed_test.ii (-o flag). The extension .ii is not casual: according to the gnu documentation, ii files are (C++) files that do not need to be preprocessed. If you open preprocessed_test.ii, it will look like this. If we want to preserve our comments, just add the -C flag to the previous command. Let's do the same for our main file, with g++ -E main.cpp -o preprocessed_main.ii Examining preprocessed_main.ii we can see a very long file, which is the result of including iostream header file. The compiler is fed with the preprocessed file we just generated and, in turn, it creates assembly code. In our experiment, we can use g++ -S preprocessed_test.ii -o assembly_test.s g++ -S preprocessed_main.ii -o assembly_main.s to generate the assembly code. The extension .s denotes assembler code. Assembly_test.s will look like this This is the end of the proper "compiling" stage, as we reached assembly code. Assembler The assembler aim is to build an object file. An object file is basically our source file translated in binary format. To assemble our test, run g++ -c assembly_test.s -o object_test.o g++ -c assembly_main.s -o object_main.o With the -c flag, we are telling g++ to just compile (in this case to just assemble) our input, skipping the linking step, which will be discussed in the next section. An object file can come in different forms, such as ELF (Executable and Linking Format) on Linux systems and COFF (Common Object File Format) on Windows. An object file is made of sections, containing executable code, data, dynamic linking information, symbol tables, relocation information and much more. If we want to inspect what an object file is and what it contains, we can use tools such as objdump or readelf. On my macbook I have installed the macports version of objdump, gobjdump, used for our example. gobjdump -all-headers object_test.o Will give us human-readable information about the object files: What are all those sections and what is their meaning? Some of them are described below. .text section contains the executable code; this section is the one affected by compiler optimizations; .bbs section stores un-initialized global and static variables; .data part is responsible to store initialized global and static variables; .rdata contains constant and string literal; .reloc holds the relocation information of return 0;.= now= let's= open= the= command= line= and= use= g++= to= see= what= is= the= preprocessor= output= (you= can= use= whatever= c++= compiler= you= like).= the= command= to= use= is= g++= -e= test.cpp= -o= preprocessed_test.ii= which= will= only= preprocess= (-e)= our= test.cpp= file= and= put= the= result= into= preprocessed_test.ii= (-o= flag).= the= extension=.ii= is= not= casual := according= to= the= gnu= documentation,=.ii= files= are= (c++)= files= that= do= not= need= to= be= preprocessed.= if= you= open= preprocessed_test.ii.= it= will= look= like= this.= if= we= want= to= preserve= our= comments,= just= add= the= -c= flag= to= the= previous= command.= let's= do= the= same= for= our= main= file.= with= g++= -e= main.cpp= -o= preprocessed_main.ii= examining= preprocessed_main.ii= we= can= see= as= very= long= file.= which= is= the= result= of= including= iostream= header= file.= the= compiler= is= fed= with= the= preprocessed= file= we= just= generated= and.= in= turn,= it= creates= assembly= code.= in= our= experiment,= we= can= use= g++= -s= preprocessed_test.ii= -o= assembly_test.s= g++= -s= preprocessed_main.ii= -o= assembly_main.s= to= generate= the= assembly= code.= the= extension=.s= denotes= assembler= code.= assembly_test.s= will= look= like= this= is= the= end= of= the= proper= "compiling"= stage.= as= we= reached= assembly= code.= assembler= the= assembler= aim= is= to= build= an= object= file.= an= object= file= is= basically= our= source= file= translated= in= binary= format.= to= assemble= our= test,= run= g++= -c= assembly_test.s= -o= object_test.o= g++= -c= assembly_main.s= -o= object_main.o= with= the= -c= flag.= we= are= telling= g++= to= just= compile= (in= this= case= to= just= assemble)= our= input.= skipping= the= linking= step.= which= will= be= discussed= in= the= next= section.= an= object= file= can= come= in= different= forms,= such= as= elf= (executable= and= linking= format)= on= linux= systems= and= coff= (common= object= file= format)= on= windows.= an= object= file= is= made= of= sections,= containing= executable= code.= data.= dynamic= linking= information.= symbol= tables.= relocation= information= and= much= more.= if= we= want= to= inspect= what= an= object= file= is= and= what= it= contains.= we= can= use= tools= such= as= objdump= or= readelf.= on= my= macbook= i= have= installed= the= macports= version= of= objdump.= gobjdump.= used= for= our= example.= gobjdump= -all-headers= object_test.o= will= give= us= human-readable= information= about= the= object= files.= what= are= all= those= sections= and= what= is= their= meaning?= some= of= them= are= described= below.= .text= section= contains= the= executable= code.= this= section= is= the= one= affected= by= compiler= optimizations.= .bbs= section= stores= un-initialized= global= and= static= variables.= .part= is= responsible= to= store= initialized= global= and= static= variables.= .rdata= contains= constant= and= string= literal.= .reloc= holds= the= required= relocation= information= of= return 0; } Now let's open the command line and use g++ to see what is the preprocessor output (you can use whatever C++ compiler you like). 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As the word shows, the backlink links all object files together and allows for separate editing. In short, The Linker calculates the final address of the code and resolves all external references present in each object file. In our example, we have two files, the original.cpp and the test.cpp; in our main function there are some references to the functions defined in the test.cpp so we need to connect those two files somehow. Linker takes as input of our object files and other compiled source code (such as libraries) and gives us an executable as output, resolving all resources between files. In order to complete your work, Linker uses displacement records and icon tables: displacement records are used to find the addresses of the symbol referred to in an object file, for example if we call the Test setMember function in our original, we will have a displacement record for it in main.o so that the linker can replace the actual instruction from test.o; Let's see how this works briefly. Run objdumb with object_main.o as input and search for the symbol table (or, alternatively use the Sims flag), we can see that some symbols are not defined. These symbols refer to functions that are .cpp. Actually, if object_test.o, the same symbols will be defined, take the setMember function as an example. To generate our executive run: g++ object_main.o object_test.o -o program if we already review the program with objdump, we will have all the defined symbols. Thanks, Linker! Displacement of the main effects of linker displacement generates final addresses for the tags present in our application. That is, the addresses assigned before the link stage are temporary and relative. Displacement can be divided into two following tasks: merge section and insert section. First simply a matter of merging the same sections present in our object file into the executable. That is, in our file, the .text and .data sections will be the result of merging the same sections into object files; Inserting a section to set the memory address is the start in which all addresses must be pointed out; they are usually 0 relative to the address, but after the placement of all addresses are moved by the start index. The image below, taken from this page, will summarize and visualize the movement in a great way. Linker & </symbol,address>.In our code, libraries and pre-compiled code can be included, i.e. The Linker must also consider the library to produce our executable. We can define a library as a set of object files, which can be used in external applications. With the static link, all files are linked over the link time, resulting in a file executing. All symbols and information required by the program are known before running our code. Because we need all the information stored before the run time, the static link generates large files. Another option is to use dynamic link. In this case, Linker inserts information into the executable to let the loader know where to find the library, which is limited in run time, just before the program is run; So why should dynamic linking be used? Dynamic link makes the executable size smaller; A library can be updated without reconnection; Loader after we came up with an executable file, we could run it on our car. The first step is loading the app in memory (RAM) and this task is performed by the loader. Primarily, the loader validates the program with the calculations required by memory and check its data type, instruction set, etc.; The final operation is the implementation of the main function. The app is currently running on our car. Sources: Motor Game by Jason Gregory Gregory

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