# #1 : Program Execution

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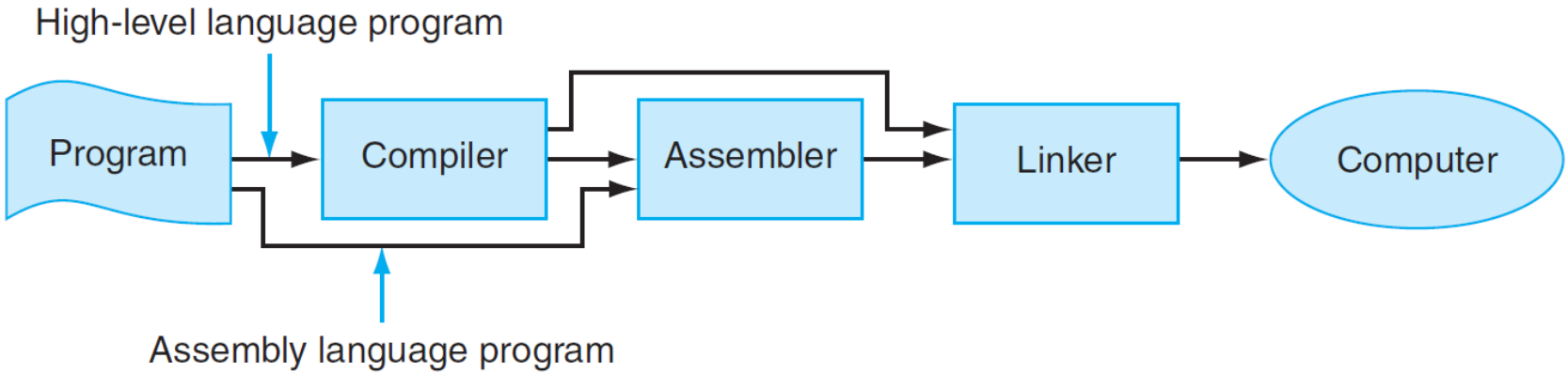
# Translating and Starting a Program

We can consider **four hierarchical steps** when transforming a C program in a file on disk into a process running on a computer:

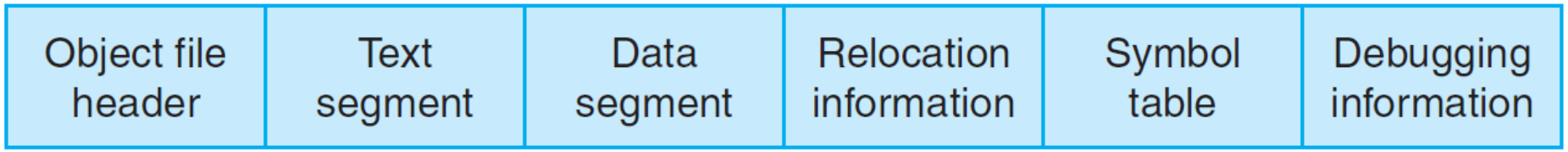
- **Compiler** transforms the high-level language program to an assembly language program, a symbolic form of what the machine understands
- **Assembler** turns the assembly language program into an object file, which includes machine code, data, and information needed to execute the program
- **Linker** combines independently object files and resolves all undefined labels into an executable file
- **Loader** places an executable file in main memory so that it is ready to execute



# Object Files

The object file for UNIX systems typically contains six distinct pieces:

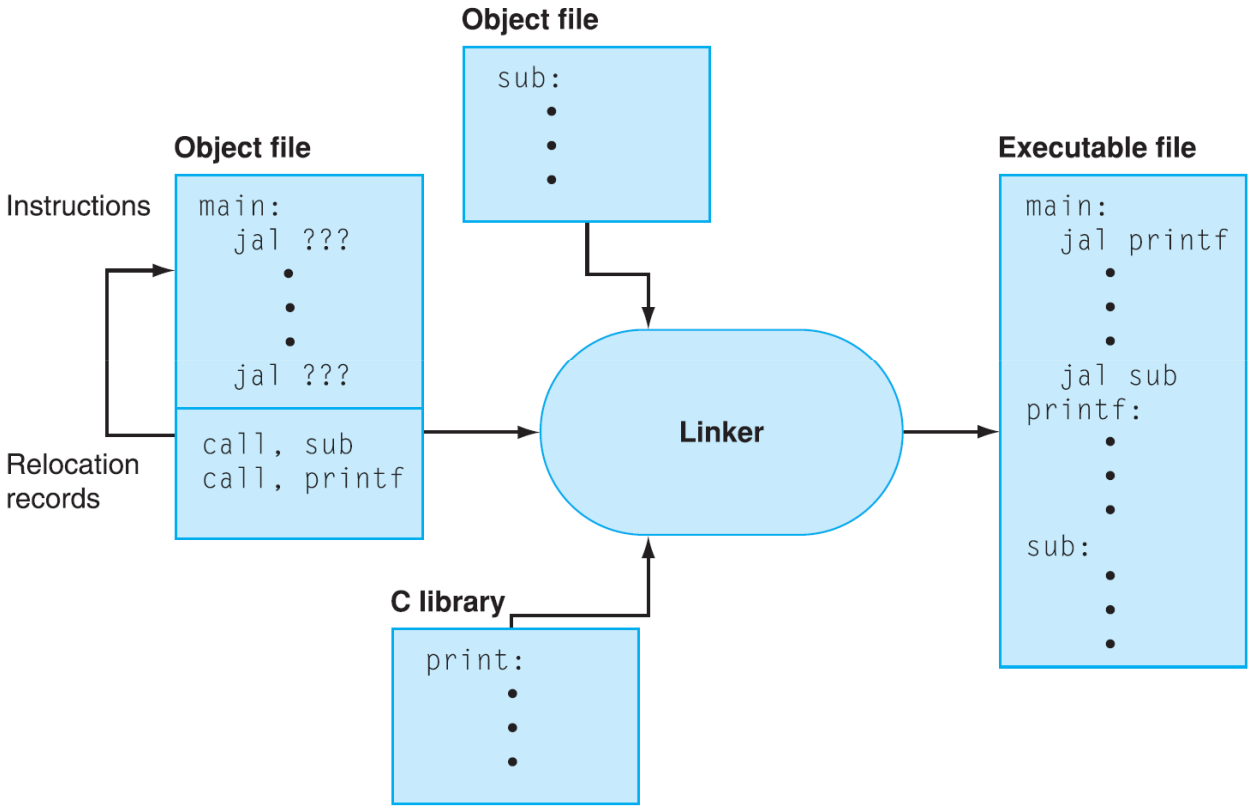
- **Object file header** describes the size and position of the other 5 pieces
- **Text segment** contains the machine language code
- **Static data segment** contains data allocated for the life of the program
- **Relocation information** identifies instructions and data words that depend on absolute addresses when the program is loaded into memory
- **Symbol table** contains the remaining labels that are not defined, such as global definitions and external references
- **Debugging information** contains a concise description of how the modules were compiled so that a debugger can associate machine instructions with C source files and make data structures readable



# Linking Object Files

The linker uses the relocation information and symbol table in each object module to resolve all undefined labels.

- Such references occur in branch/jump instructions and data addresses
- The linker produces an executable file that has the same format as an object file, except that it contains no unresolved references or relocation information



# Dynamic Linking

Static linking has a few disadvantages:

- The library becomes part of the executable code and, if a new library version is released, the statically linked program keeps using the old version
- It loads all routines in the library even if those calls are not executed

These disadvantages lead to **dynamically linked libraries (DLLs)** where **each library routine is loaded only when it is needed**:

- Initially, the main routine is loaded into memory and executed
- When a routine calls another routine, the calling routine first checks to see whether the other routine has been loaded and, if not, a **relocatable linking loader** is called to load the desired routine into memory
- A **stub** is included in the binary program for each library routine reference that indicates how to locate the appropriate library routine and load it

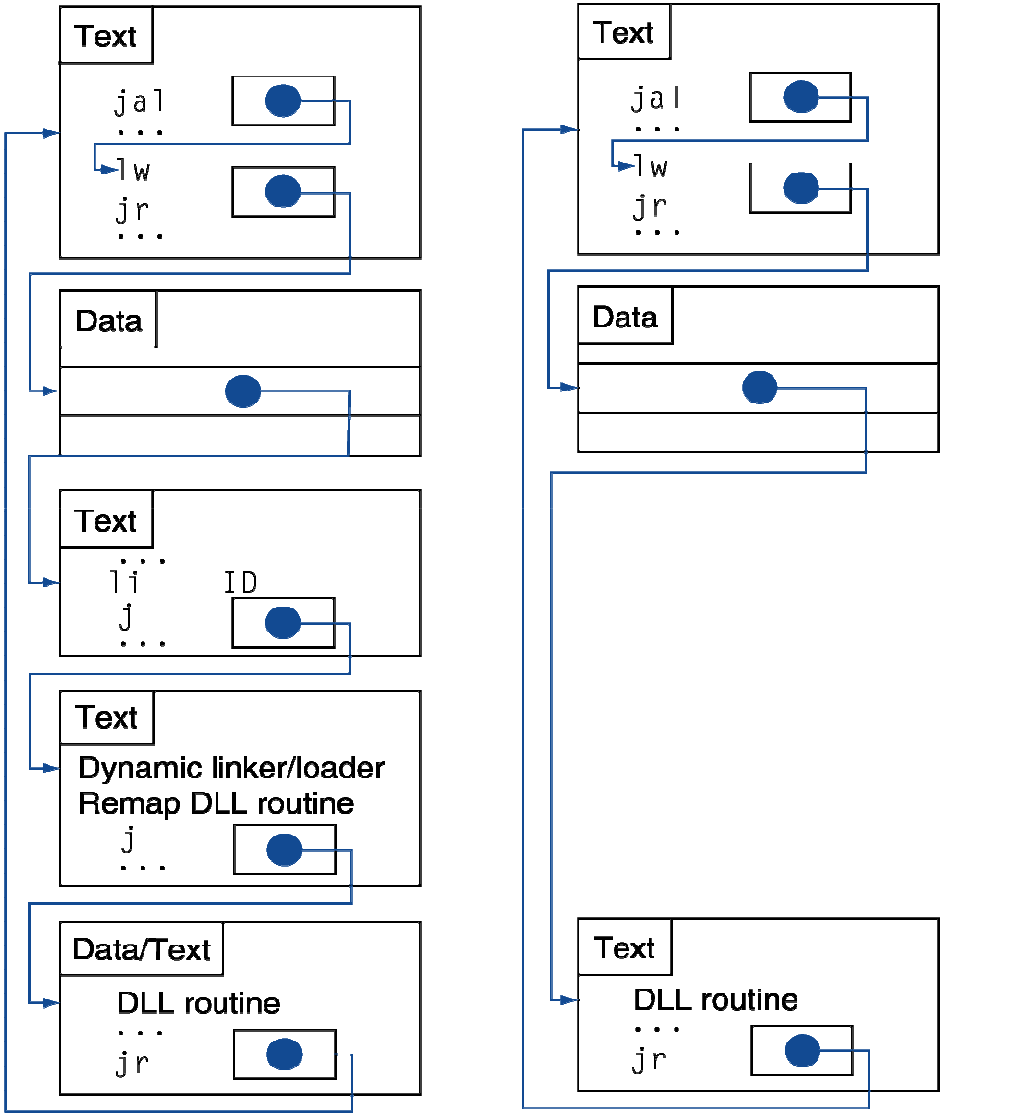
# Dynamic Linking

**Indirection table**

**Stub: loads routine ID and jumps to linker/loader**

**Linker/loader code**

**DLL code**




a. First call to DLL routine

b. Subsequent calls to DLL routine