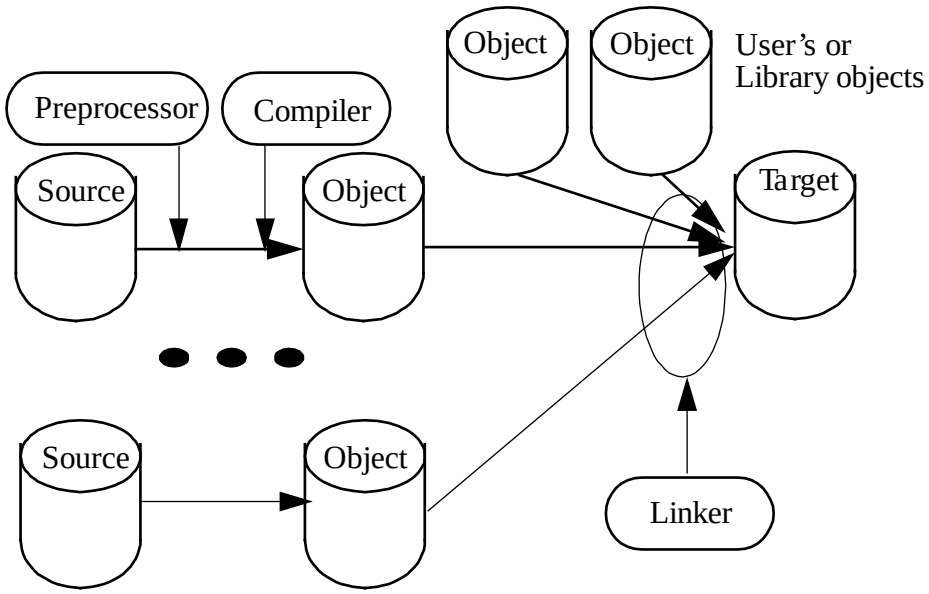
Review of Program Architecture in C

Modern Modular Compiler

- Multiple *sources*/*modules*, often worked on by different team members
    - Note difference between modules (linked together into single executable) and components accessed at runtime via agreed API.
- When each source/module is being complied, information about what to expect in the other modules in needed
    - Provided via *headers*
    - Older languages require the programmer to provide them, newer languages process implicit
    - Needed information on "what is exported" to other modules, that is what other modules can use
        - Functions
        - Variables
        - Classes
- Linker combines together references from multiple modules, user provided or libraries
    - *Externa linkage*
- A single source needs to link multiple internal elements
    - *Internal linkage*



- A larger project can be made of multiple targets communicating somehow via defined API

Source and Header

- *Source* - file containing some instructions or definitions, among other things, that have to be compiled.
  In the C language, it will have the extension `.c`
  Examples of what should go to source (in some languages this can be different)
  - Statements // typically must be in source
  - Function definitions // typically must be in source
  - Variable definitions // typically must be in source
  - Type definitions, macro definitions
    - should be in a source only if this source is the only one using this type or macro,
    - otherwise should be in a header file to be included in multiple sources
      - types definitions and macro definitions are not liked

  Source files should NOT be included (except for some linker optimization)

- *Header* file is a file (explicit or more recently implicit) containing only code that is informational or processed by the preprocessor
  In C, it will have the extension `.h`
  - `Typedef` // could be in source if for single source
  - Macros // could be in source if for single source
  - `extern` variables declarations (variable prototypes)
  - function prototypes
  - no variable definitions nor function definitions (other than inline)
  - **No variables** other than `extern`

Program Structure

- Any nontrivial project will be developed in multiple files and by multiple people
- `main()` should be one application source typically by itself
- The remaining code (functions, variables) are implemented in different sources based on how they fit together
  - *Cohesion* (internal match) and *coupling* (external match)
  - Generally code/functions operating on the same data go into the same source
    - Object-oriented languages push this further by making such functions methods of a class and placing the data in the same class
  - So a source is once function (class) or a group of related functions such as functions designed to manipulate the same data
- Another way to create architecture
  - Start will all functions needed to accomplish the objectives
  - Start with one function per file
  - Combine some functions into same file
    - Functions operate on the same data

        - Functions need helpers that are not be linked/exposed to other files
            - These are static functions/global variables in the source but NOT prototyped in header
        - Functions will communicate with each other using global data hidden from other files
    - Decide on any data that needs to have global external linkage
        - Data needs to be placed in some source and declarations need to be placed in the corresponding header file
- File name reflects the contents of the file
    - Could be the name of the function (class)
- Generally, each source has a header file with the same name
    - `source.c` -> `source.h`
    - The header file `source.h` will have
        - Multiple inclusion prevention
        - List of functions prototypes and variable declarations that are exported out of the source (have *external linkage*)
    - Exceptions
        - The source containing `main()` will generally not export anything and thus will not have header
        - There may be headers without sources, such as containing macros or `typedef`

Multiple Inclusion Prevention

- Assume header file *`filename`*`.h`

```
#ifndef FILENAME_H
#define FILENAME_H

// the needed contents

#endif
```

Linkage, Internal vs. External

- Elements at the global level in a source (function, global variable) can be made available to other sources
    - *external linkage*
        - Header file declares these elements, does not provide the actual linkage
        - Linker provides actual linkage
        - Declarations are important for proper compilation is proper linkage
    - `static` keyword prevents external linkage and makes *internal linkage* (available in this source only)

- this is used for "helper" functions and variables, that is functions and variables needed in this file only and not available to other sources

Example: Program architecture

Assume `main()`, `f1()`, `f2()`, `int x`, and structure type `node_t` needed. Assume each function implemented in separate separate, `x` goes in the file with `f2()`, and interfaces as shown.

Note

- Source can include its own header file for cross-checking, not shown
- Multiple inclusion prevention mechanism not shown.

node.h

```
typedef struct
{ // members

} node_t;
```

appl.c

```
//include system
#include "node.h"
#include "f1.h"
#include "f2.h"
main()
{ node_t *p;
   p=f1();
   f2(p);
   x=1;
}
```

f1.c

```
#include "node.h"
#include "f2.h"

 node_t *f1()
 {
    f2(...);
 }
```

f2.c

```
#include "node.h"


 int x;
 void f2(node_t*p)
 { // something
 }
```

f1.h

```
#include "node.h"

node_t *f1();
```

f2.h

```
#include "node.h"

extern int x;
void f2(node_t*);
```

```
> gcc appl.c f1.c f2.c
```