7. Structuring Code

- Separate compilation
- Header files
- Examples

Separate compilation

- So far, when using *gcc* we have translated a source program to an executable code file.
- Actually, this has involved 4 separate programs:
  - *cpp* to pre-process the source file
  - *gcc* to translate C to assembly language
  - *as* to translate assembly language to a relocatable binary *object code* file
  - *ld* to link your code with the library code and build an executable code file

Separate compilation (cont'd)

- If we pass a `-c` flag to *gcc* it stops after the third step
- Output is a *relocatable object module*
  - Binary code plus:
    - a table of all locations that need to be changed when the code is moved in memory during linking
    - a table of all locations that reference externally defined symbols (e.g. calls to *printf*)
    - a table of all locations that define externally-referenceable symbols (e.g. callable functions)

Example

- Suppose we have a source code file *silly.c*:

```
int myVeryUsefulFunction(int arg)
{
     return arg;
}
```

- Then could compile with:

```
gcc -c $CFLAGS silly.c -o silly.o
```

- Now have an *object file* called *silly.o* which contains a function that can be used by other programs.

Using that object file

- Can use *silly.o* from program *prog.c* as follows:

```
int myVeryUsefulFunction (int arg); // So compiler knows its type

int main(void)
{
    int n = 10;
    printf("%d\n", myVeryUsefulFunction(n));  // Prints 10!
}
```

- Compile *prog.c* with:
  - `gcc $CFLAGS prog.c silly.o –o prog`

Gets passed straight through to the linker

Header files

- Don't want to have to declare the signature of all external functions
- So instead, put all signatures of an external .o file in a separate C file with the extension *.h*
  - Called a *header file*
- For example, *silly.h* would contain just the line

```
int myVeryUsefulFunction(int arg);
```

- *prog.c* would then be

```
#include "silly.h"
int main(void) {
    int n = 10;
    printf("%d\n", myVeryUsefulFunction(n));  // Prints 10!
}
```

Lab 5 example

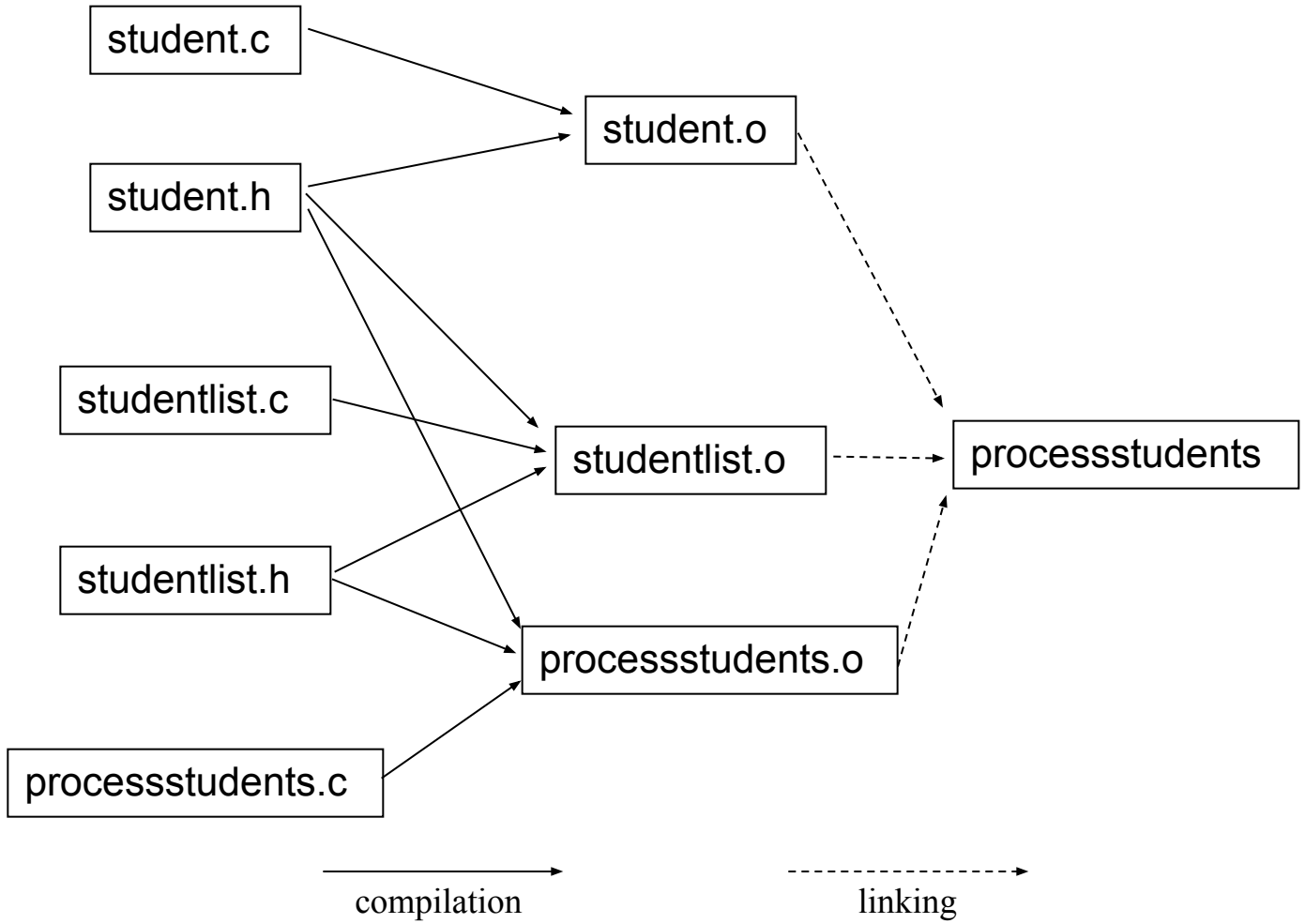
Breaks the code of *structexample3.c* into 3 modules:

1. The *Student* module: *student.c*, *student.h*
   - Typedef for *Student*; function *newStudent*, *readOneStudent*; student pool
2. The *StudentList* module: *studentlist.c*, *studentlist.h*
   - Typedef for *StudentList*; functions *readStudents, addStudent*
   - Abstracts out the idea of a *student list* (which *structexample3.c* didn't do)
3. The main program, *processStudents.c*
   - Begins:

```
#include "student.h"
#include "studentlist.h"
```

   - Reads students from file, prints the list

Dependency graph



Makefiles

- To reap full benefit of separate compilation, want to recompile only the changed modules, then relink.
- Done by *make*
  - Takes a *make file* as a parameter
    - Default name is *Makefile* or *makefile*
  - A make file is a textual description of the dependency graph plus the commands that make each target
  - Consists of a set of node descriptions of form

```
targetNodeName: sourceNode1 sourceNode2 ...
<tab>Rule to make target node if source nodes all made
```

  - Most rules can be omitted, as default rule to make a .o file is to compile the corresponding .c file

Example makefile (full)

Warning: all indents are with a single TAB char

```
# Definitions.
CFLAGS = -g -std=c99 -Wall -Werror

# Main target: create executable by linking the object files
processstudents: processstudents.o student.o studentlist.o
        gcc processstudents.o student.o studentlist.o -o processstudents

# Intermediate targets: create object files from C source codes.
processstudents.o: processstudents.c student.h studentlist.h
        gcc $(CFLAGS) -c processstudents.c

student.o: student.c student.h
        gcc $(CFLAGS) -c student.c

studentlist.o: studentlist.c student.h studentlist.h
        gcc $(CFLAGS) -c studentlist.c

# "Clean up" pseudo-target (used with the command "make clean")
Clean:
        rm *.o processstudents
```

Example makefile (minimised)

Warning: all indents are with a single TAB char

```
# Definitions.
CFLAGS = -g -std=c99 -Wall -Werror
OBJECTS = processstudents.o studentlist.o student.o

# Targets
processstudents: $(OBJECTS)
        $(CC) -o processstudents $(OBJECTS)

processstudents.o studentlist.o: studentlist.h

processstudents.o studentlist.o student.o: student.h

Clean:
        rm *.o processstudents
```