

Program Structure

“to get a deeper understanding of the language”



Deep C - a 3 day course
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forward declaration

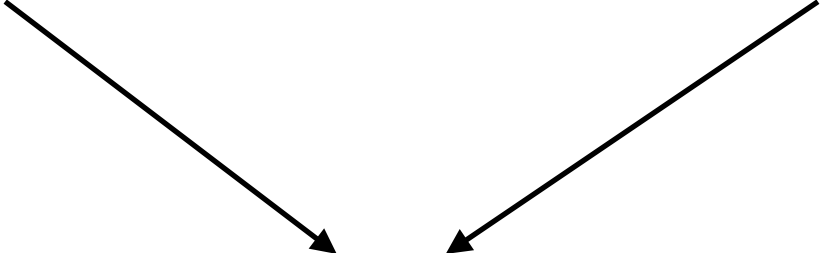
- `#include` is the most obvious code reflection of coupling

when is a `#include` required?

```
#include "wibble.h"
```

when is a `#include` not required?

```
struct wibble;
```



```
#ifndef WIBBLE_INCLUDED
#define WIBBLE_INCLUDED

...

struct wibble
{
    ...
};

#endif
```

forward declaration

- which of 1,2,3,4,5,6 won't compile?

```
struct wibble;  
  
struct data_member  
{  
    struct wibble    value;    // 1  
    struct wibble *  pointer;  // 2  
};  
  
struct wibble    global_value;    // 3  
struct wibble *  global_pointer;  // 4  
  
extern struct wibble    ext_global_value;    // 5  
extern struct wibble *  ext_global_pointer;  // 6
```

data declarations/definitions



forward declaration

- 1 and 3 won't compile

```
struct wibble;

struct data_member
{
    struct wibble    value;    // 1 ← x
    struct wibble * pointer;    // 2
};

struct wibble    global_value;    // 3 ← x
struct wibble * global_pointer;    // 4

extern struct wibble    ext_global_value;    // 5
extern struct wibble * ext_global_pointer;    // 6
```

data declarations/definitions

forward declaration

- which of 7,8,9,10 won't compile?

```
struct wibble;

struct wibble    return_value(void);           // 7
struct wibble * return_pointer(void);          // 8

void parameter_value(struct wibble w);         // 9
void parameter_pointer(struct wibble * p);     // 10
```



function declarations

forward declaration

- they all compile!

```
struct wibble;  
  
struct wibble    return_value(void);           // 7  
struct wibble *  return_pointer(void);         // 8  
  
void parameter_value(struct wibble w);         // 9  
void parameter_pointer(struct wibble * p);     // 10
```



function declarations

forward declaration

- which of 11,12,13,14 won't compile?

```
struct wibble;

struct wibble return_value(void)           // 11
{ ... }

void parameter_value(struct wibble w)      // 12
{ ... }

struct wibble * return_pointer(void)       // 13
{ ... }

void parameter_pointer(struct wibble * p)  // 14
{ ... }
```


function definition '*signatures*'





forward declaration

- 11,12 won't compile

```
struct wibble;
```

 → `struct wibble return_value(void) // 11`
`{ ... }`

 → `void parameter_value(struct wibble w) // 12`
`{ ... }`

 → `struct wibble * return_pointer(void) // 13`
`{ ... }`

 → `void parameter_pointer(struct wibble * p) // 14`
`{ ... }`

function definition '*signatures*'

forward declaration

- which of 15,16,17 won't compile*

```
struct wibble;  
  
void pass_pointer(struct wibble * p) // 15  
{  
    pass(p);  
}  
  
void arrow_pointer(struct wibble * p) // 16  
{  
    arrow(p->member);  
}  
  
void deref_pointer(struct wibble * p) // 17  
{  
    deref(*p);  
}
```



function definition bodies

* ignore pass(),arrow(),deref() not being prototyped

forward declaration

- 16 and 17 won't compile

```
struct wibble;

void pass_pointer(struct wibble * p) // 15
{
    ✓ → pass(p);
}

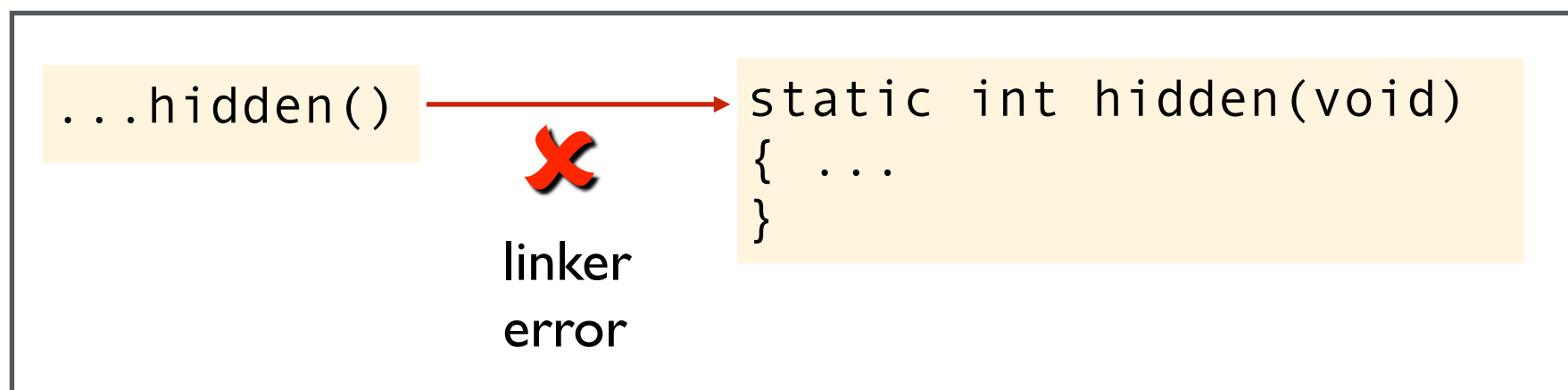
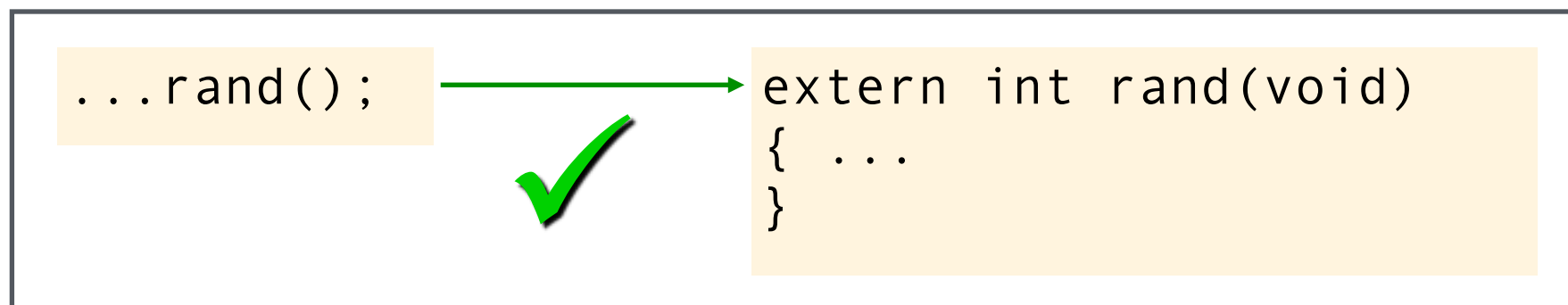
void arrow_pointer(struct wibble * p) // 16
{
    ✗ → arrow(p->member);
}

void deref_pointer(struct wibble * p) // 17
{
    ✗ → deref(*p);
}
```

function definition bodies

linking

- a linker links the use of an identifier in one file with its definition in another file
- an identifier is made available to the linker by giving it external linkage (the default) or using the `extern` keyword
- an identifier is hidden from the linker by giving it internal linkage using the `static` keyword



external linkage pattern

- if a function definition has external linkage it should have been previously prototyped (in a header file)

eg.h

```
...  
int eg(const char * s);  
...
```

← function prototype

eg.c

```
#include "eg.h"  
  
int eg(const char * s)  
{  
    ...  
}
```



Using -Wmissing-prototypes detects
function definitions with external linkage
but no prior function prototype




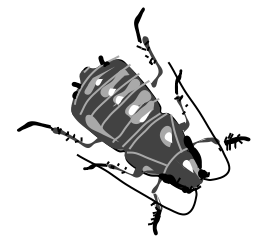
```
...
```

eg.h

```
#include "eg.h"
```

eg.c

```
int eg(const char * s)   
{  
    ...  
}
```



```
$ gcc ... -Werror -Wmissing-prototypes eg.c  
error: no previous prototype for 'eg'  
$
```

If the function should have external linkage then
add a function prototype to the header...



```
...  
int eg(const char * s);  
...
```



eg.h

```
#include "eg.h"
```

eg.c

```
int eg(const char * s)  
{  
    ...  
}
```

```
$ gcc ... -Werror -Wmissing-prototypes eg.c  
$
```

If the function should have internal linkage then make it so!



```
...
```

eg.h

```
#include "eg.h"
```

```
static int eg(const char * s)
{
    ...
}
```

eg.c



```
$ gcc ... -Werror -Wmissing-prototypes eg.c
$
```

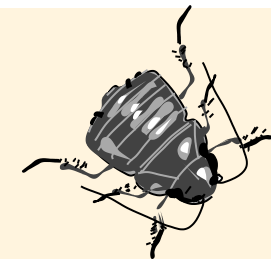
data linkage

- without a storage class or an initializer a data definition is tentative (external) – and can be repeated!
- this is confusing and not compatible with C++

ok in C, duplicate definition errors in C++



```
int v; // external, tentative definition
...
int v; // external, tentative definition
```



recommendation: extern data *declarations*

- use explicit extern keyword, do not initialize

recommendation: extern data *definitions*

- do not use extern keyword, do initialize

multiple declarations ok

```
extern int v;
extern int v;
```



single definition with initializer

```
int v = 42;
```



spot the problem

snafu.h

```
#ifndef SNAFU_INCLUDED
#define SNAFU_INCLUDED

#include <stddef.h>

int snafu(size_t);

#endif
```

wibble.h

```
#ifndef WIBBLE_INCLUDED
#define WIBBLE_INCLUDED

int wibble(const char *);
void wobble(size_t);

#endif
```



snafu.c

```
#include "snafu.h"
...
```

wibble.c

```
#include "snafu.h"
#include "wibble.h"
...
```

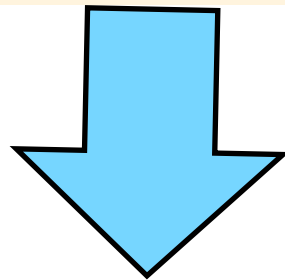
<stddef.h> contains a typedef for size_t

spot the problem

- wibble.c depends on the order of its #includes

wibble.c

```
#include "snafu.h"  
#include "wibble.h"  
...
```

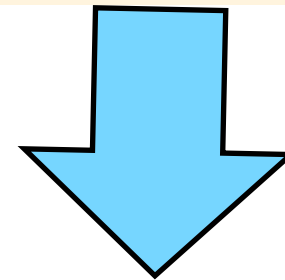


```
typedef ... size_t;  
  
int snafu(size_t);  
  
int wibble(const char *);  
void wobble(size_t);  
...
```



wibble.c

```
#include "wibble.h"  
#include "snafu.h"  
...
```



```
int wibble(const char *);  
void wobble(size_t);  
  
typedef ... size_t;  
  
int snafu(size_t);  
...
```



recommendation

- each source file should could `#include` it's own header first
- also possible to check each individual header file compiles!

wibble.h

```
#ifndef WIBBLE_INCLUDED
#define WIBBLE_INCLUDED

#include <stddef.h> // size_t

int wibble(const char *);
void wobble(size_t);

#endif
```

wibble.c

```
#include "wibble.h"
#include "snafu.h"
...
```

static linking
dynamic linking

position independent code

optimization

seams

- compile time

- link time

- runtime

summary