Frictionless D Adoption for the Masses

or: How I Learned to Stop Worrying and Love the C Preprocessor

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If you remember just one thing...

- Programming is about people

Story time: John Montagu, the 4th Earl of Sandwich

Why tell a story?

- You're now unlikely to forget the story of the invention of the sandwich
- People are sensitive to storytelling
- More parts of the brain are activated

In contrast...

- Bullet points
- Can be pretty boring
- Nobody is going to remember this slide

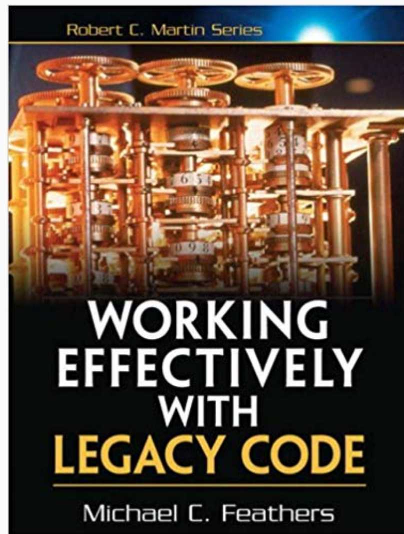
Stories are important . . .

- . . . Because they're important to people
- And programming is about people

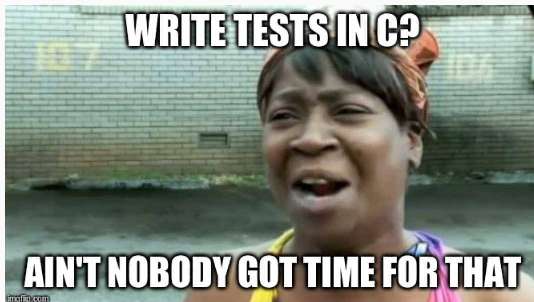
Why is Átila?

- D user since 2013
- DConf 2014 speaker
- 2014: In a new team put in charge of a legacy C codebase

Tests not included

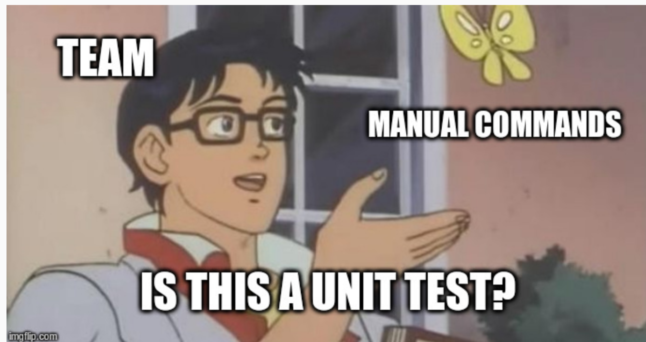


What language?



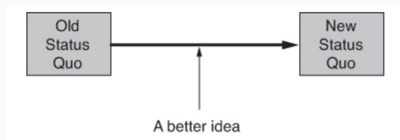
- The test language doesn't have to be C
- My choice was between C++ or D
- I chose C++. I didn't want to, but I did.

Convincing is hard, let's go shopping!

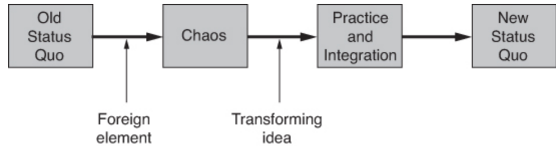


- Colleagues I'd never worked with
- 8 different meetings on the merits of automated testing
- If you're arguing you're losing (Dan Saks at CppCon 2016)

Change: what is good for? Absolutely Nothing



(a) Naïve model of change



(b) Satir change model

- From "Peopleware: Productive Software and Teams"
- Change doesn't happen until people feel safe
- Also from Peopleware: people dislike change
- Loss aversion: twice as powerful as similar gain
- Automated testing chaotic enough for them

But D can call C

- From dlang.org:

```
extern (C) int strcmp(const(char)* string1, const(char)* string2);
```

- Unnecessary: already in core.stdc.string
- Simpler than “real” code
- In reality:

```
extern (C) int weird_api(Foo* foo, Bar* bar, int flags);
```

- Foo is in foo.h, Bar in bar.h, fields in other headers

Preprocessor required

```
extern (C) int weird_api(Foo* foo, Bar* bar, int flags);
```

- `flags` meant to be calculated from a macro:

```
#define FLAGS(x, y, z) (((x) * 1024) | ((y) * 64) | (z))
Foo foo;
Bar bar;
weird_api(&foo, &bar, FLAGS(1, 2, 3));
// checking error codes is for amateurs
```

Preprocessor required

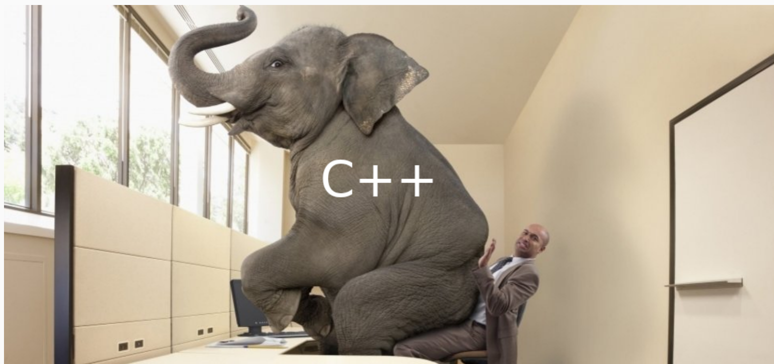
```c
struct Struct {
  struct Foo {
    struct Bar* bar;
  } foo;
};
// because typing is more important than reading
#define getvalue(x) (x).foo.bar->value
```

Issues

- Manual wrapping too laborious
- dstep didn't work
- Warped didn't work. . .
- Calypso was non-starter

The elephant in the room

```
extern "C" {
    #include "my_api.h"
}
```



C++'s rise to power: a historic perspective

- In practice, a superset of C
- Incremental adoption at no cost
- No loss $\implies$ no aversion
- Can't lose by arguing when there's no arguing
- C++'s killer feature: `#include`
- Conclusion: shamelessly copy C++'s approach

The goal

Emulate the C++ experience of interfacing to C:

```
#include "nanomsg/nn.h"
#include "nanomsg/pubsub.h"

void main() {
    const sock = nn_socket(AF_SP, NN_PUB);
    scope(exit) nn_close(sock);
}
```

dpp Approach

- Use libclang to parse the C headers
- Translate the C AST into D syntax
  - Deal with impedance mismatch such as multiple C declarations
- Expand the translations in place
  - Originally per header file
- Translations are not meant to be checked in
- Macros?

Enabling preprocessor macro usage

- libclang has an option to remember macros
- Redeclare all macros in the `#included` headers

```
// was: #include "header.h"
extern(C) int add(int, int);

#define MACRO 42
```

- Run the C preprocessor on the dpp file
  - If you can't beat them, join them
- Call a D compiler on the resulting valid D code
  - Replacing the compiler is scary, wrapping it is chocolate and bunnies

Calling libclang from D

- Fortunately already had bindings from dstep
- Add `@safe @nogc pure nothrow` to every function
  - Exception made for callbacks
- Add `in` to all parameters
- Wrote OOP-like wrapper for the C functions

Implementation

```
switch(cursor.kind) with(Cursor.Kind) {
  default: return [];
  case StructDecl:
      string[] ret;

      ret ~= `struct Foo {`;
      foreach(field; cursor) {
          ret ~= translateField(field);
      }
      ret ~= `}`;

      return ret;

  case FunctionDecl:
```

Implementation

```
with(Cursor.Kind) {
    return [
        StructDecl:         &translateStruct,
        UnionDecl:          &translateUnion,
        EnumDecl:           &translateEnum,
        FunctionDecl:       &translateFunction,
        FieldDecl:          &translateField,
        TypedefDecl:        &translateTypedef,
        MacroDefinition:    &translateMacro,
        InclusionDirective: &ignore,
        EnumConstantDecl:   &translateEnumConstant,
        VarDecl:            &translateVariable,
    ];
}
```

Testing

```
shouldCompile(
    C(
        q{
            struct Foo { int ints[4]; };
        }
    ),
    D(
        q{
            auto f = Foo();
            static assert(f.sizeof == 16, "Wrong sizeof for Foo");
            static assert(is(typeof(Foo.ints) == int[4]));
        }
    ),
);
```

Testing

```
Could not execute `dmd -o- -c app.d`:
app.d(65): Error: static assert:  "Wrong sizeof for Foo"


app.d:
----------
   53:   extern(C)
   54:   {
   55:       struct Foo
   56:       {
   57:           int[4] ints;
   58:       }
   59:   }
   60:
   61:
   62:   void main() {
   63:
   64:                   auto f = Foo();
   65:                   static assert(f.sizeof == 15, "Wrong sizeof for Foo");
   66:                   static assert(is(typeof(Foo.ints) == int[4]));
   67:
   68:   }

  }
```

To understand recursion, you must first understand recursion

- Child cursors get “sent back” to the main translation function
- Cursor types get translated in a similar recursive manner
- Bonus: not having to write production code (TDD FTW)

C: still surprising me after 25 years

```c
// Apparently valid C code (who knew?)
struct BadlyNamed {
  void (*why)(void);
  struct why* (*func)(void);
};

// when inlining was new I guess
#define redOnesGoFaster() (42)
int (redOnesGoFaster)(void);
```

Macros: not so fast

```
#define OOPS1(x) (x)->foo
#define OOPS2(x) sizeof(x)
#define OOPS3(x) ((void*)(x))       // C cast (easy mode)
#define OOPS4(x) ((MyStruct*)(x))  // C cast (normal mode)
#define OOPS5(T, x) ((T*)(x))       // C cast (hard mode)
// Not valid D code
#define STRUCT_INIT(type) { STRUCT_EXTRA_INIT 1, type },
```

Does it work?

- The nanomsg slide works
- `curl` example just worked
  - With `std.string.toStringz`, `std.conv.text`, and `std.stdio.stderr`
- C standard library: `stdio.h` (`printf`), `stdlib.h` (`malloc`, `free`)
- `#include <Python.h>` just worked
  - Would get around 3.6 → 3.7 pyd crash
- Modulo bugs, yes!

#include Python!

```c
#include "Python.h"
#include "datetime.h"
#include "structmember.h"

enum isPython3 = is(PyModuleDef);
enum isPython2 = !isPython3;
```

The holy grail

```
#include <vector>

vector!int v;
v.push_back(42);
```

- Has to be as easy as that
- Never mind the standard library: Qt? Eigen?

Apparently C++ is complicated

- libclang is not all it's made out to be
  - No way to query for `constexpr`
  - No way to get a struct's template parameters
- Algorithm to output D struct or class
- `std::is_reference_v` can't be translated
  - Almost definitely going to be used in SFINAE
- D is the only language with any hope of translating C++
  - Template specialisations
  - Template constraints can emulate SFINAE, `std::void_t`, concepts?

Hacking around the C++ standard library

- Tell dpp to ignore everything in namespace `std`
- Define ignored cursors ourselves:

```
void takesVector(ref const(vector!int));

extern(C++, "std") {
  struct allocator(T);
  struct vector(T, A = allocator!T);
}
```

Conclusion

- Programming is about people
- If you're arguing, you're losing
- Out-C++ C++
- Go forth and `#include`

Questions?

Slide intentionally left blank