D Programming Language: The Sudden

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Introduction

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Sudden Sequels

- Pronouncing “Melbourne” and “Brisbane”

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- *Burn Identity*

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- The Dark Knight Rises

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  Batman vs. Bun


Mind = Blown
Thrones Memes at GameOfLaughs.com


PUBLIC
PHONE

Motivation

- Systems-level programming a necessity
- Several application categories
- Faster is better—no “good enough” limit
- Ever-growing modeling needs
- No room below, no escape: all in same language
    - Runtime support
    - Machine, device interface
    - Base library
- This is (literally) where the buck stops

D Design Principles

- Leave no room below
    - share memory model with C
    - statically typed
- Multi-paradigm; balanced
- Practical
- Principled
- Avoid arcana

Why?

- Party line
  - convenience
  - modeling power
  - efficiency
- Actual reasons
  - Produces fast binaries, fast
  - Easier to get into than alternatives
  - Fun

Why not?

- Party line
  -
- Actual reasons
  - Poor on formal specification
  - Little corporate pickup, support
  - Dearth of libraries
  - Large

The “Meh”

```
#!/usr/bin/rdmd
import std.stdio;
void main() {
  writeln("Hello, world!");
}
```

- Why the `std.std` stutter?
- Why import stuff for everything?
- Why no code at top level?
- However:
  - Simple
  - Correct
  - Scriptable

The Innocently Plausible

```
void main() {
  import std.stdio;
  writeln("Hello, world!");
}
```

- Doesn't work in Java, C#
- Career-limiting move in Python, C, C++
- In D, most everything can be scoped everywhere
  - Functions
  - Types (Voldermort types)
  - Even generics
  - Better modularity, reasoning

The Unexpected Emergent

```
void log(T)(T stuff) {
  import std.datetime, std.stdio;
  writeln(Clock.currTime(), ' ', stuff);
}
void main() {
  log("hello");
}
```

- If not instantiated, no `import`
- `import`s cached once realized
- Generics faster to build, import
- Less pressure on linker

Heck, add variadics too

```
void log(T...)(T stuff) {
  import std.datetime, std.stdio;
  writeln(Clock.currTime(), ' ', stuff);
}
void main() {
  log("Reached Nirvana level: ", 9);
}
```

Suddenly

Natural lexical scoping leads to faster builds

Approach to Purity

Thesis

- Writing entire programs in pure style challenging
- Writing fragments of programs in pure style easy, useful

- + Easier to verify useful properties, debug
- + Better code generation
- − Challenge: interfacing pure and impure code

Functional Factorial (yawn)

```
ulong factorial(uint n) {
   return n <= 1 ? 1 : n * factorial(n - 1);
}
```

- It's PSPACE!
- Somebody should do hard time for this

However, it's pure

```
pure ulong factorial(uint n) {
   return n <= 1 ? 1 : n * factorial(n - 1);
}
```

- Pure is good

Functional Factorial, Fixed

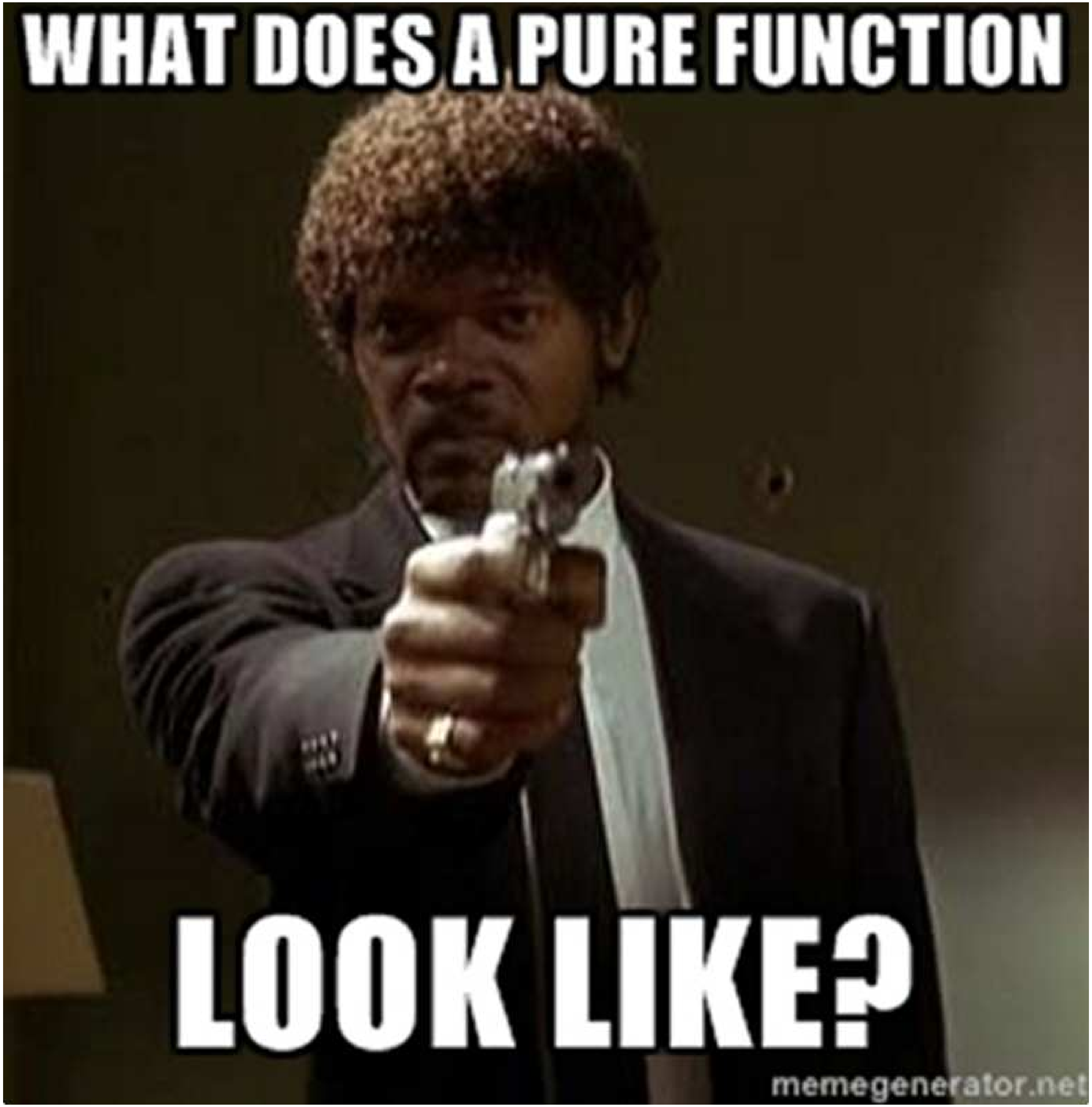
```
pure ulong factorial(uint n) {
   ulong crutch(uint n, ulong result) {
      return n <= 1
        ? result
        : crutch(n - 1, n * result);
   }
   return crutch(n, 1);
}
```

- Threads state through as parameters
- You know what? I don't care for it

Honest Factorial

```
ulong factorial(uint n) {
   ulong result = 1;
   foreach (uint i = 2; i <= n; ++i) {
      result *= i;
   }
   return result;
}
```

- But no longer pure!
- Well allow me to retort


WHAT DOES A PURE FUNCTION
LOOK LIKE?
memegenerator.net

Pure is as pure does

- “Pure functions always return the same result for the same arguments”
- No reading and writing of global variables
  - (Global constants okay)
- No calling of im`pure` functions
- Who said anything about local, transient state inside the function?

Transitive State

```
pure void reverse(T)(T[] a) {
  foreach (i; 0 .. a.length / 2) {
    swap(a[i], a[$ - i - 1]);
  }
}
```

- Possibility: disallow
- More useful: relaxed rule
- Operate with transitive closure of state reachable through parameter
- Not functional pure, but an interesting superset
- No need for another annotation, it's all in the signature!

User-defined types

```
pure BigInt factorial(uint n) {
   BigInt result = 1;
   for (; n > 1; --n) {
      result *= n;
   }
   return result;
}
```

- Better yet: purity deduced for generics and lambdas

Aftermath

- If parameters reach mutable state:
    - Relaxed pure—no globals, no I/O, no im`pure` calls
- If parameters can't reach mutable state:
    - "Haskell-grade" observed purity
    - Yet imperative implementation possible
    - As long as it's local only

Suddenly

Combining purity with mutability improves both

The Generative Connection

Generative programming

- In brief: code that generates code
- Generic programming often requires algorithm specialization
- Specification often present in a DSL

Embedded DSLs

Force into host language's syntax?

Embedded DSLs

- Formatted printing?

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- Regular expressions?

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- . . . Pasta for everyone!

Embedded DSLs

Here: use with native grammar

Process during compilation

Generate D code accordingly

Compile-Time Evaluation

- A large subset of D available for compile-time evaluation

```
ulong factorial(uint n) {
    ulong result = 1;
    for (; n > 1; --n) result *= n;
    return result;
}
...
auto f1 = factorial(10); // run-time
static f2 = factorial(10); // compile-time
```

Code injection with `mixin`

```
mixin("writeln(\"hello, world\");");
mixin(generateSomeCode());
```

- Not as glamorous as AST manipulation but darn effective
- Easy to understand and debug

- Now we have compile-time evaluation AND `mixin`. . .

Wait a minute!

Example: bitfields in library

```
struct A {
  int a;
  mixin(bitfields!(
    uint, "x",    2,
    int,  "y",    3,
    uint, "z",    2,
    bool, "flag", 1));
}
A obj;
obj.x = 2;
obj.z = obj.x;
```

Parser

```
import pegged.grammar; // by Philippe Sigaud
mixin(grammar("
  Expr     <   Factor AddExpr*
  AddExpr  <   (’+’/’-’) Factor
  Factor   <   Primary MulExpr*
  MulExpr  <   (’*’/’/’) Primary
  Primary  <   Parens / Number / Variable
               / ’-’ Primary
  Parens   <   ’(’ Expr ’)’
  Number   <~ [0-9]+
  Variable <- Identifier
"));
```

Usage

```
// Parsing at compile-time:
static parseTree1 = Expr.parse(
  "1 + 2 - (3*x-5)*6");
pragma(msg, parseTree1.capture);
// Parsing at run-time:
auto parseTree2 = Expr.parse(readln());
writeln(parseTree2.capture);
```

Scaling up

1000 lines of D grammar →
3000 lines D parser

Highly integrated lex+yacc

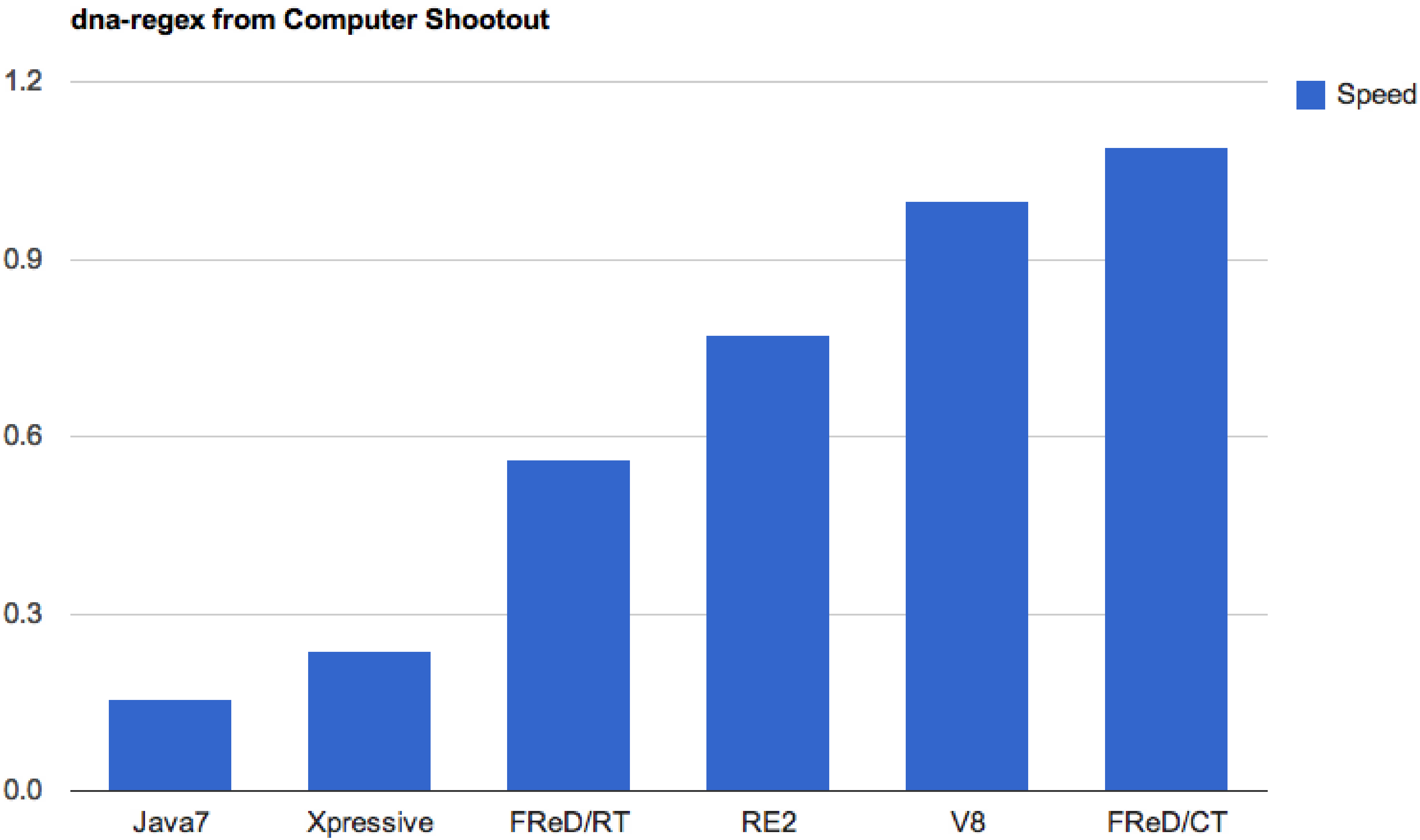
What about regexen?

Compile-time regular expressions

- GSoC project by Dmitry Olshansky, merged into `std`
- Fully UTF capable, no special casing for ASCII
- Two modes sharing the same backend:

```
auto r1 = regex("^.*/([^/]+)/?$");
static r2 = ctRegex!("^.*/([^/]+)/?$");
```

- Run-time version uses intrinsics in a few places
- Static version generates specialized automaton, then compiles it


dna-regex from Computer Shootout
1.2
0.9
0.6
0.3
0.0
Speed
Java7
Xpressive
FReD/RT
RE2
V8
FReD/CT

Summary

- Modularity + scoping
- Purity + sinning
- Compile-time evaluation + mixing code in