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FOSDEM'24

The D Programming Language for Modern Open Source Development

-- Programming in DLang

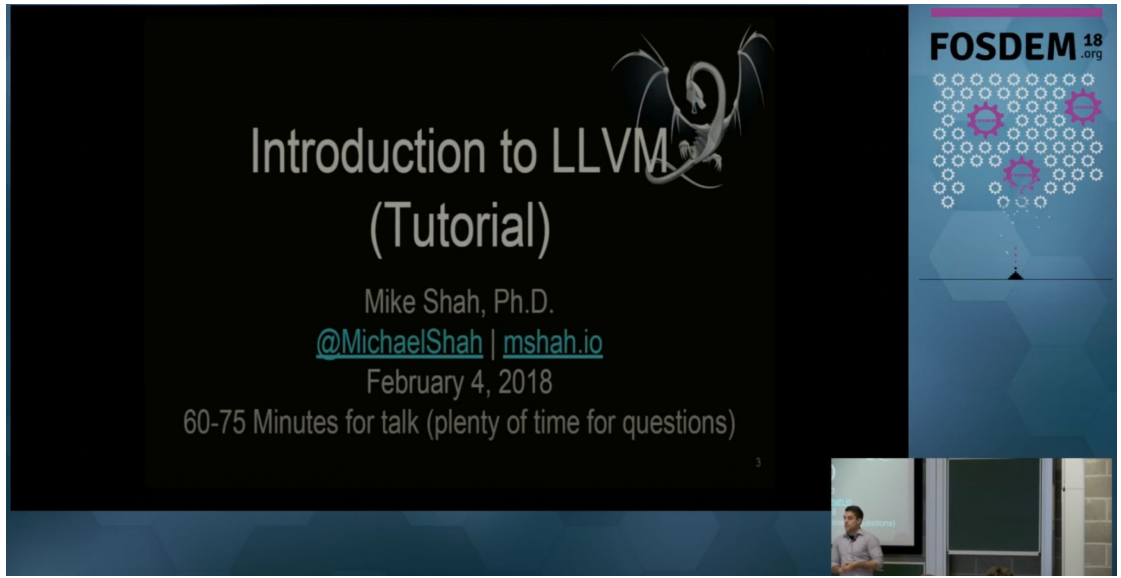
with Mike Shah

16:00 - 16:50 Sat, Feb 3, 2024
Location: k.1.105 (La Fontaine)
50 minutes | Introductory Audience

Social: @MichaelShah
Web: mshah.io
Courses: courses.mshah.io
YouTube
www.youtube.com/c/MikeShah
http://tinyurl.com/mike-talks

FOSDEM 2018

- It has been 6 years since my last FOSDEM talk!
  - My how time flies!
- Thank you very much again for having me -- we will have some fun today.
  - (And then I'll see you again in hopefully < 6 years)



Introduction to LLVM Building simple program analysis tools and instrumentation
https://www.youtube.com/watch?v=VKIv_Bkp4pk

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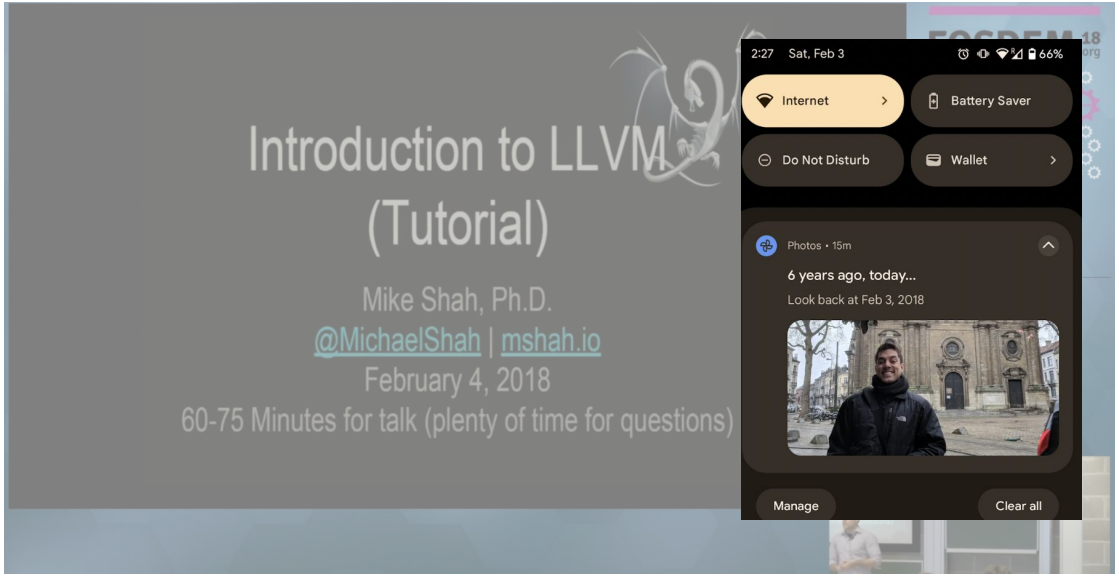


Introduction to LLVM Building simple program analysis tools and instrumentation
https://www.youtube.com/watch?v=VKIv_Bkp4pk

Your Tour Guide for Today

by Mike Shah

- Associate Teaching Professor at Northeastern University in Boston, Massachusetts.
  - I **love** teaching: courses in computer systems, computer graphics, geometry, and game engine development.
  - My research is divided into computer graphics (geometry) and software engineering (software analysis and visualization tools).
- I do consulting and technical training on modern C++, DLang, Concurrency, and Graphics Programming
  - Usually graphics or games related -- e.g. Building 3D application plugins
- Outside of work: guitar, running/weights, traveling and cooking are fun to talk about

Je parle une petit francais -- Bienvenue!
Je suis prefere le question en anglias pour le meillere result

Web
www.mshah.io
YouTube
https://www.youtube.com/c/MikeShah
Non-Academic Courses
courses.mshah.io

FOSDEM'24

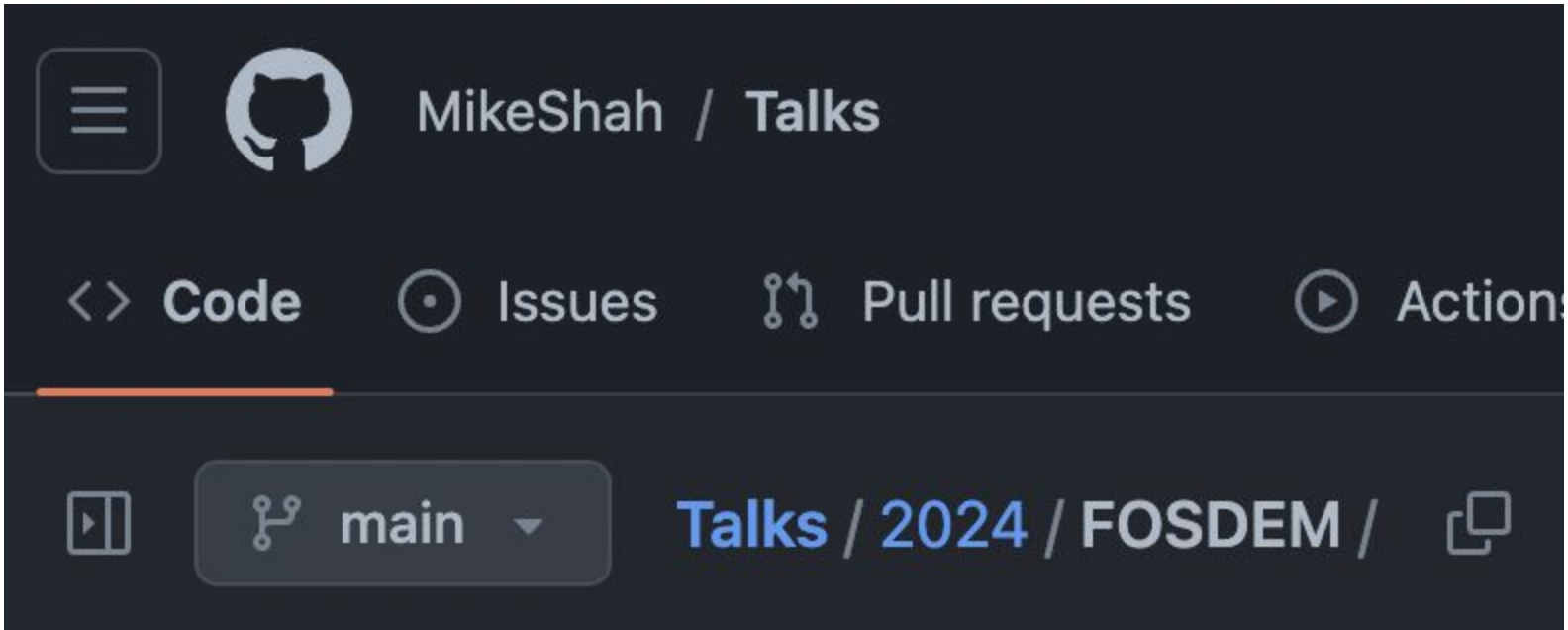
Abstract

The abstract that you read and enticed you to join me is here!

The D programming language has been quietly growing for well over two decades. This modern programming language supports multiple programming paradigms, a range of memory safety features, and an ecosystem with 3 open source compilers. So why should an open source developer consider learning or using the D programming language? In this talk I will show examples of how D has replaced all of my Python code for my projects, and why I think D truly is a language that allows you to "write fast, read fast, and run fast" code. I will introduce the language, several of my favorite productivity features, and tools in the D programming language ecosystem. Throughout the talk, the audience will also be pointed to several open source tools written in the D language to be inspired from. Audience members looking for a new language to learn, or otherwise the programming language enthusiast may also benefit from a tour of the D language and its features.

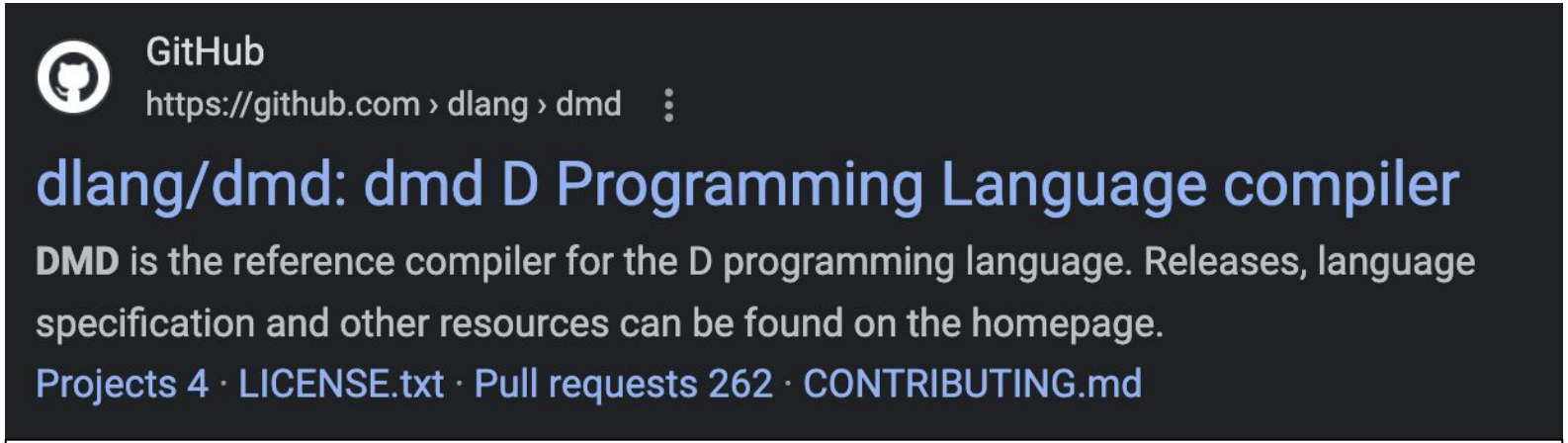
Code for the talk

- Located here: https://github.com/MikeShah/Talks/tree/main/2024/FOSDEM



What I want to do today...

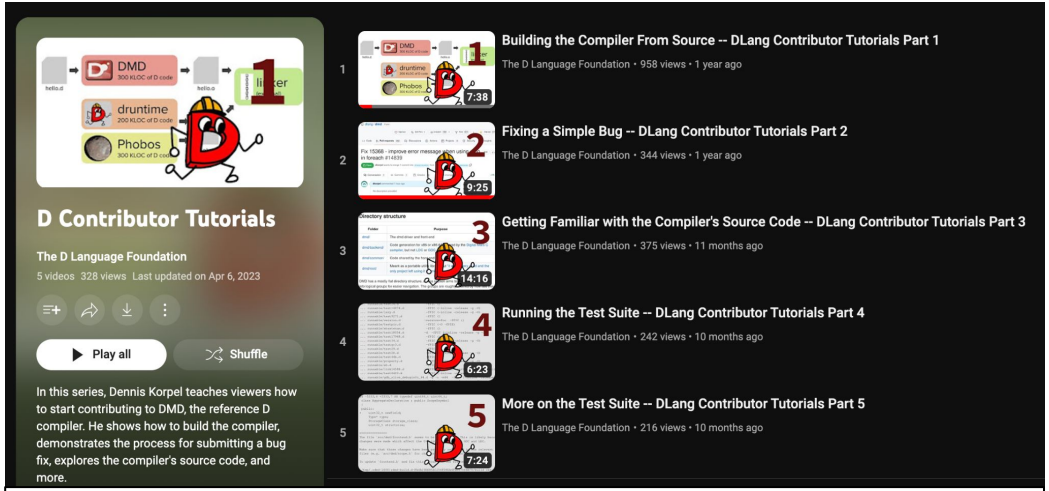
- I want you to get excited or curious about an **open source project** -- a programming language!
- That language is of course... the **D programming language**!
- And maybe one day -- you will contribute to the compiler or ecosystem!



https://github.com/dlang/dmd

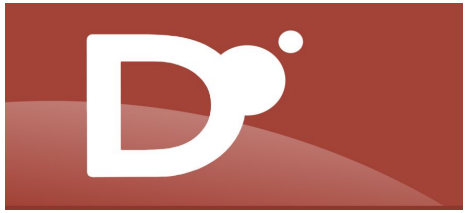
(Pssst...My dream for you is to get excited enough to contribute)

- There's a great playlist (linked below) where you can learn about hacking on the compiler and contributing to this project
  - I think there's also plenty to learn just looking at the source code of a **D's very fast reference compiler** (DMD)
  - And maybe you'll one day fix a bug or two!
- Okay -- now that you know what my dream is for you -- let's do the rest of the talk.



D Contributor Tutorials

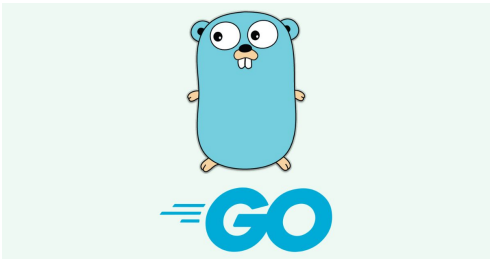
https://www.youtube.com/playlist?list=PLIldXzSkPUXXSkM5NjBAGNIdkd4Q2Zf0R






So I’m a bit of a programming language enthusiast



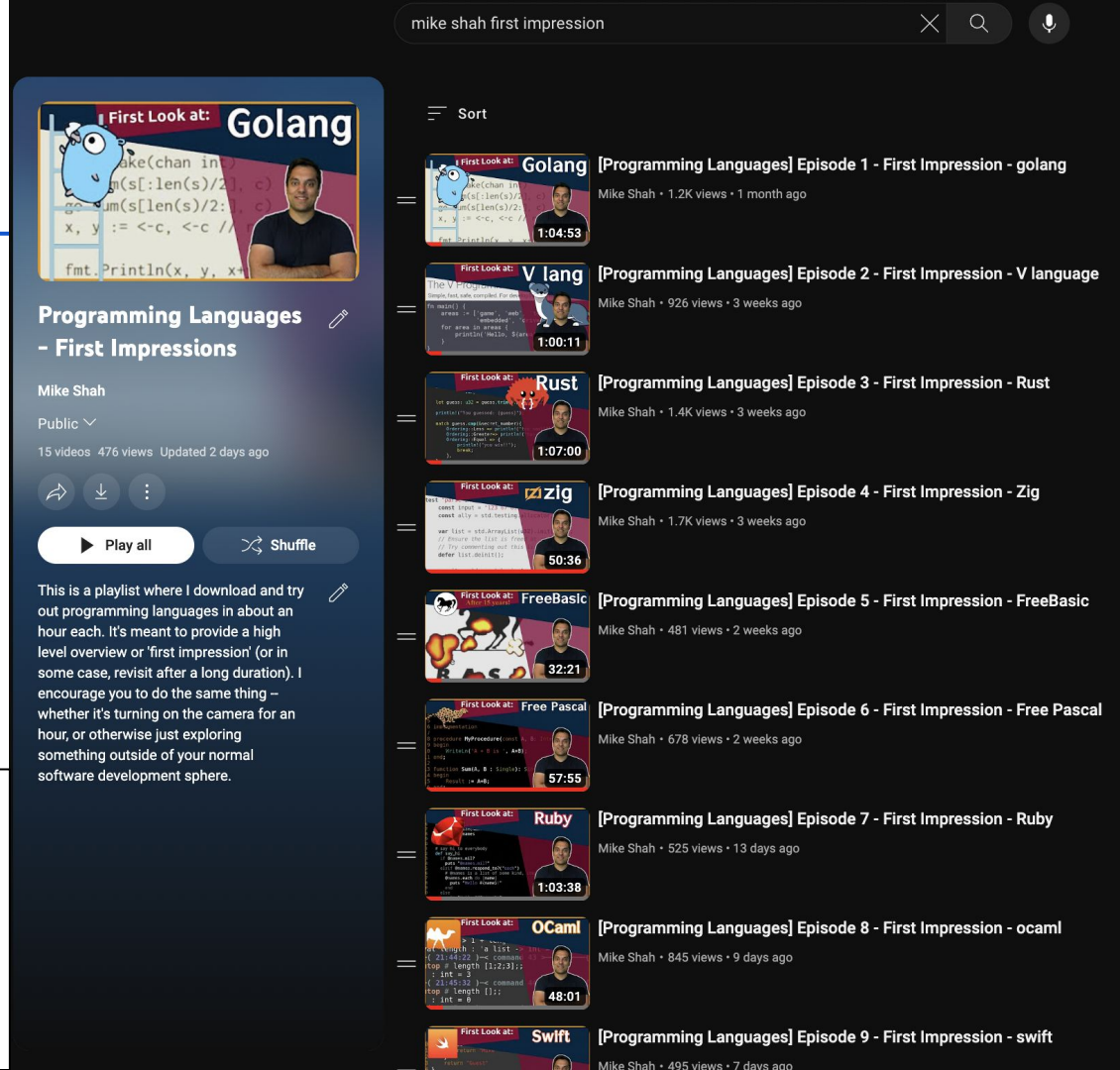
(Free Pascal)

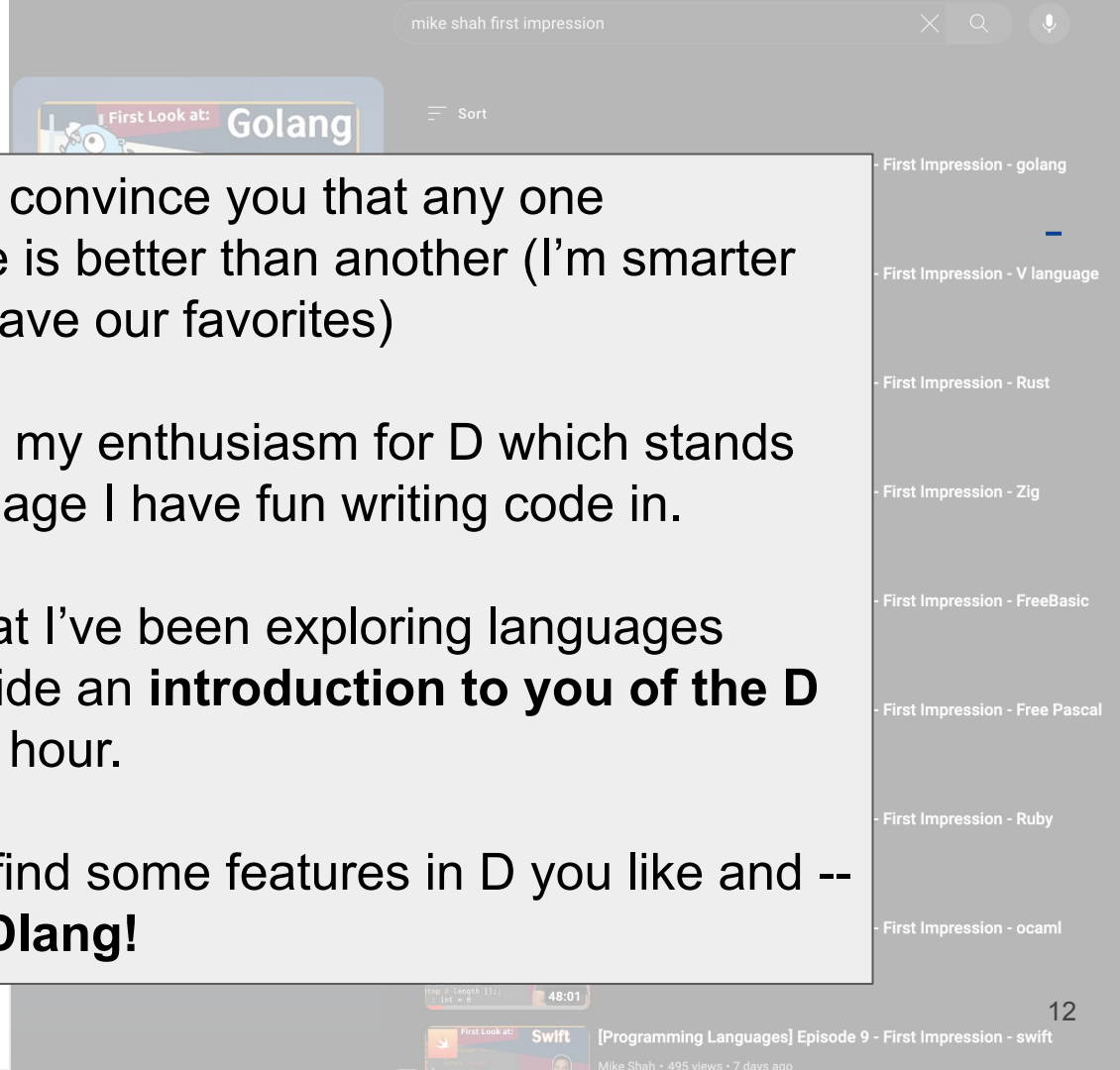
The past few months...

- I've been spending ~1-hour trying new programming languages
  - Most languages are new to me.
  - Some languages are very popular
  - Some languages are less mainstream

My recordings of 18 (and counting) programming languages can be found on the playlist below

Playlist: https://www.youtube.com/playlist?list=PLvv0ScY6vfd-5hJ47DNAOKKLLIHjz1Tzq





The past few months

- I've
  - tryi
  - lan
  - ○
  - ○
  - ○
- My
  - cou
  - lan
  - the

My goal today is not to convince you that any one programming language is better than another (I'm smarter than that...and we all have our favorites)

But--I do want to share my enthusiasm for D which stands out to me -- it's a language I have fun writing code in.

So in the same way that I've been exploring languages recently, I want to provide an **introduction to you of the D language** for about an hour.

...**and maybe** you will find some features in D you like and -- **maybe you'll try out Dlang!**

Playlist:
https://www.youtube.com/playlist?list=PLvv0S
cY6vfd-5hJ47DNAOKKLLIHjz1Tzq

The past few months...

- I've
  - tryi
  - lan
    -
    -
    -
- My
  - cou
  - lan
  - the

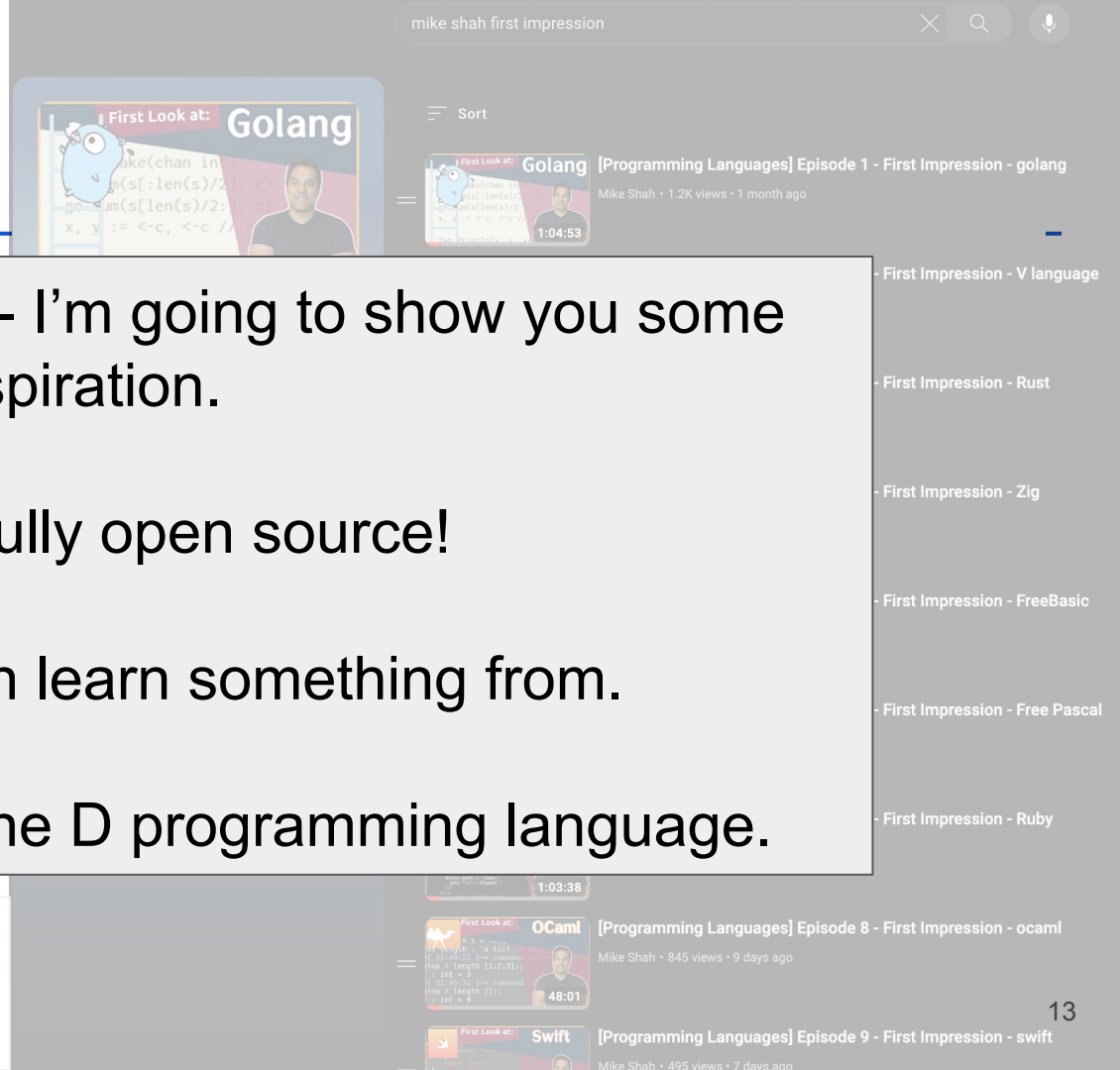
Along our journey -- I'm going to show you some cool projects for inspiration.

Most of which are fully open source!

All of which you can learn something from.

And all of them in the D programming language.

Playlist:
https://www.youtube.com/playlist?list=PLvv0ScY6vfd-5hJ47DNAOKKLLIHjz1Tzq



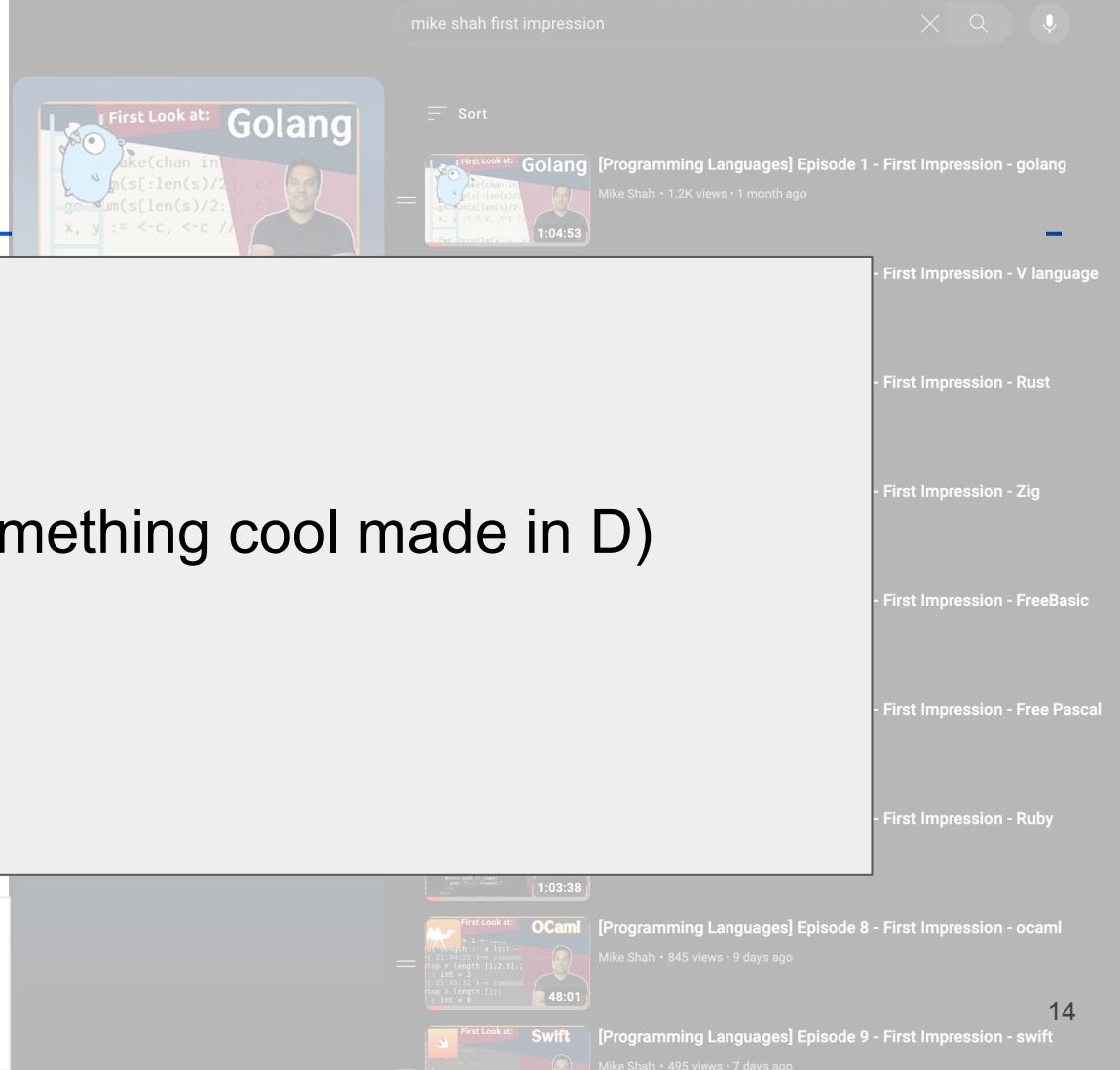
The past few months...

- I've
  - tryi
  - lan
  -
- My
  - cou
  - lan
  - the

So -- let's begin!

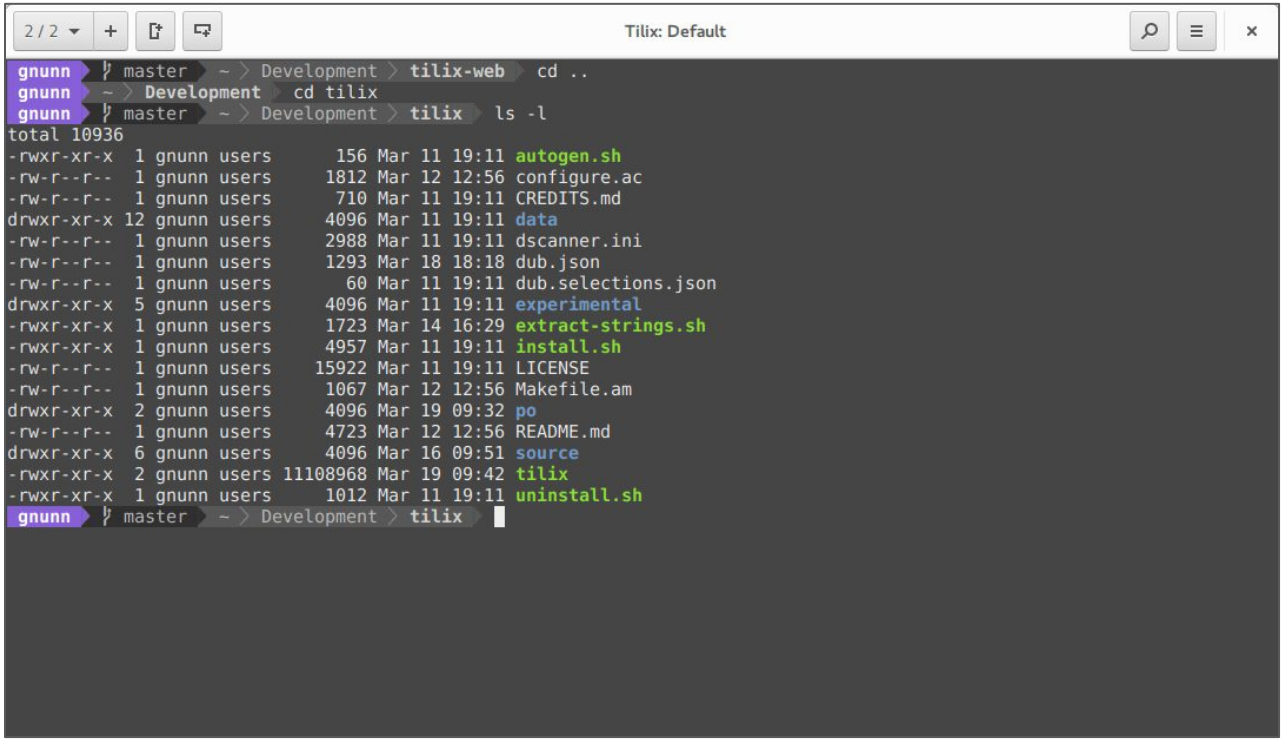
(...and start with something cool made in D)

Playlist: https://www.youtube.com/playlist?list=PLvv0ScY6vfd-5hJ47DNAOKKLLIHjz1Tzq



Built in the D Programming Language

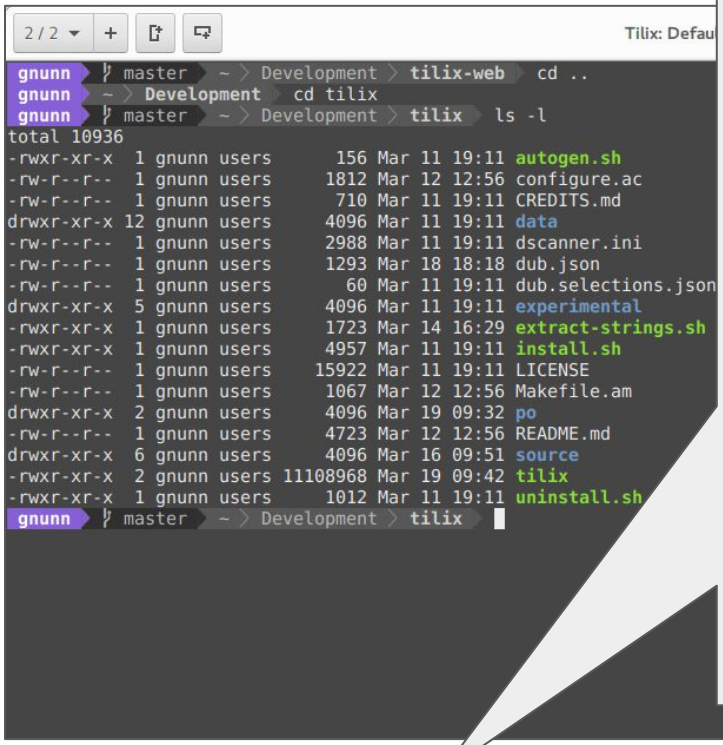
Tilix -- Terminal Emulator



- Blog on Development: https://dlang.org/blog/2017/08/11/on-tilix-and-d-an-interview-with-gerald-nunn/
- Github or Dub Repository: https://github.com/gnunn1/tilix/

Built in the D Programming Language

Tilix -- Terminal Emulator



Why you might care to look?

- Nice look at how to do GUI development with libraries like gtk.
- D can simply import C code with **ImportC**
  - **A full C compiler built into D**
- Many bindings to C libraries that you get for free with the D language.

https://github.com/gnunn1/tilix/blob/master/source/app.d

```d
import gtk.Main;
import gtk.Version;
import gtk.MessageDialog;

import gx.i18n.l10n;
import gx.gtk.util;
import gx.gtk.vte;

import gx.tilix.application;
import gx.tilix.cmdparams;
import gx.tilix.constants;

int main(string[] args) {
    static if (USE_FILE_LOGGING) {
        sharedLog = new FileLogger("/tmp/tilix.log");
    }

    bool newProcess = false;
    string group;

    string cwd = Util.getCurrentDir();
    string pwd;
    string de;
    trace("CWD = " ~ cwd);
```

- Blog on Development: https://dlang.org/blog/2017/08/11/on-tilix-and-d-an-interview-with-gerald-nunn/
- Github or Dub Repository: https://github.com/gnunn1/tilix/

DLang a First Impression

(La premiere impression)

Pop Quiz: (l'examen surprise!) (1/3)

- Let's take a look at an example of D code
  - I'll give everyone a minute to think about it
  - Try to think about what is being done
  - So... what does this program do?

```
1  void main()
2  {
3      import std.algorithm, std.stdio;
4
5      "Starting program".writeln;
6
7      enum a = [ 3, 1, 2, 4, 0 ];
8
9      static immutable b = sort(a);
10
11
12     pragma(msg, "Finished compilation: ", b);
13 }
14
15
```

Pop Quiz: (l'examen surprise!) (2/3)

- One of the first examples on the www.dlang.org webpage
  - An example of sorting an array!
  - Line 3:
    - There's a built-in standard library (named 'Phobos')
  - Line 5:
    - Function call using universal function call syntax (UFCS)
  - Line 7:
    - enum constant
  - Line 9:
    - immutable static data stored in b
  - Line 12:
    - pragma outputs value after compilation
- This program does most of its work (the working) at compile-time!

Sort an Array at Compile-Time

your code here

```
1  void main()
2  {
3      import std.algorithm, std.stdio;
4
5      "Starting program".writeln;
6
7      enum a = [ 3, 1, 2, 4, 0 ];
8      // Sort data at compile-time
9      static immutable b = sort(a);
10
11     // Print the result _during_ compilation
12     pragma(msg, "Finished compilation: ", b);
13 }
14
15
```

Why you might care to look?

- D tries to **execute as much as possible at compile-time**
  - And the code...just looks like regular code!
- Compile-time execution saves the user time at run-time -- big win!

- https://dlang.org/blog/2017/06/05/compile-time-sort-in-d/
- https://tour.dlang.org/tour/en/gems/compile-time-function-evaluation-ctfe

Compile-time code is runtime code

It's true. There are no hurdles to jump over to get things running at compile time in D. Any compile-time function is also a runtime function and can be executed in either context. However, not all runtime functions qualify for CTFE (Compile-Time Function Evaluation).

The fundamental requirements for CTFE eligibility are that a function must be portable, free of side effects, contain no inline assembly, and the source code must be available. Beyond that, the only thing deciding whether a function is evaluated during compilation vs. at run time is the context in which it's called.

The CTFE Documentation includes the following statement:

In order to be executed at compile time, the function must appear in a context where it must be so executed...

- pragma outputs value after compilation

- This program does most of its work (the working) at compile-time!

The D Programming Language

(Le langage de programmation D)

D Language History - Created by Walter Bright [wiki]

- Walter Bright
  - Wrote a C Compiler (Datalight C compiler)
  - Famously created the Zortech C++ compiler
  - Designed the game Empire
    - (There is even a translation of Empire to D!)
  - Between 1999-2006 worked alone on D version 1 programming language.
    - (Originally it was the Digital Mars Compiler, but everyone colleagues and friends insisted on calling it the next evolution to C++, thus the name ‘D’)
- Around 2006 or 2007 -- D2 would start being developed with Andrei Alexandrescu and others.
  - Full history here - Origins of the D Programming Language
    - https://dl.acm.org/doi/pdf/10.1145/3386323

Dconf 2022 in London

D hosts an online and in-person conference every year: https://dconf.org/

So what is the D Programming Language? (1/2)

So what is the D Programming Language? (2/2)

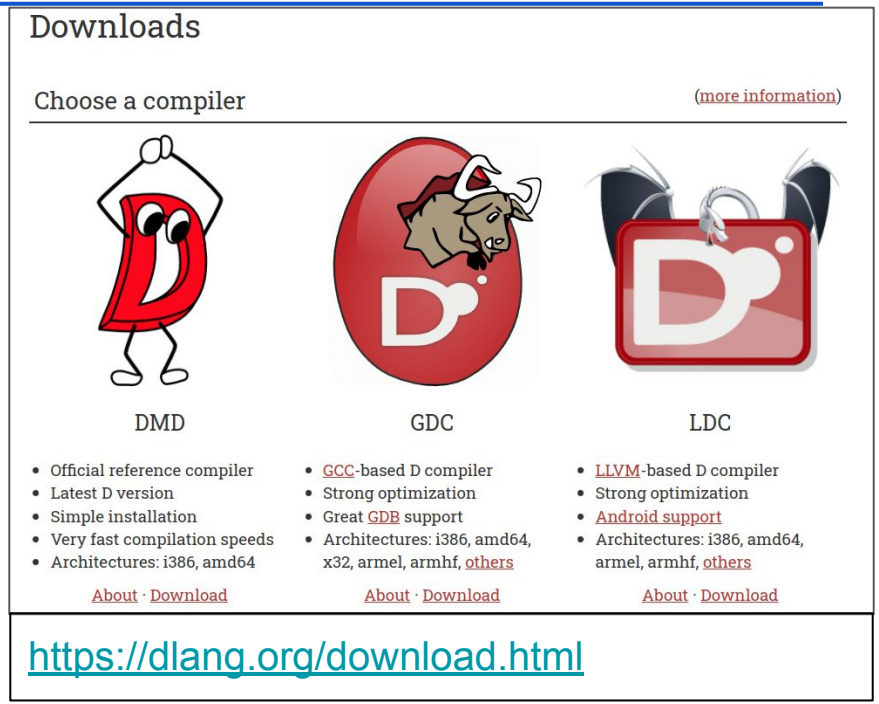
D is a general-purpose programming language with static typing, systems-level access, and C-like syntax. With the **D Programming Language**, write fast, read fast, and run fast.

https://dlang.org/

So, over the last 25 years -- now three D Compilers!

- DMD is the official reference compiler
  - The compiler **is open-source** and you can fork a copy of it today
  - DMD is a **very fast compiler** (in part because of D's module system)
- GDC
  - GCC-based D Compiler Frontend
  - Good GDB support
- LDC - LLVM based D Compiler
  - Allows you to get LLVM optimizations and target many architectures

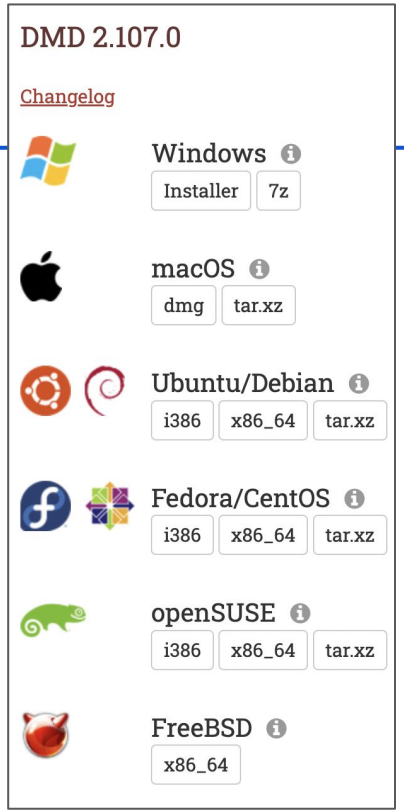
Note: Common for D programmers to develop in DMD for quick edit-compile-run cycles, and then deploy using GDC or LDC

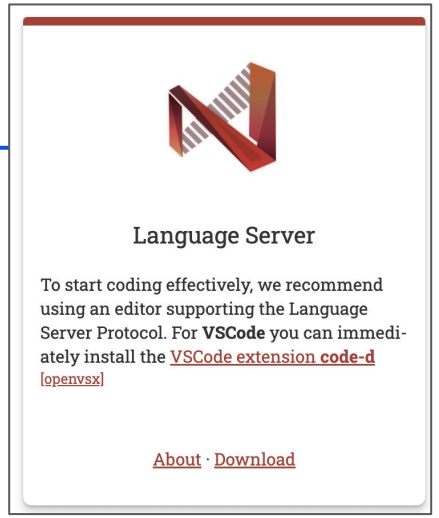


https://dlang.org/download.html

Downloading the Tools

- The download of any of the compilers is relatively simple and available for many architectures from the homepage
  - Along with the download, you also get:
    - **Dub** - the package manager for managing dependencies and as a lightweight build tool.
    - Other useful tools like **dfmt** (a code formatter) and **dscanner** (a linter) exist
    - A VSCode extension (**code-d)** is available, as well as some support in IntelliJ for D.



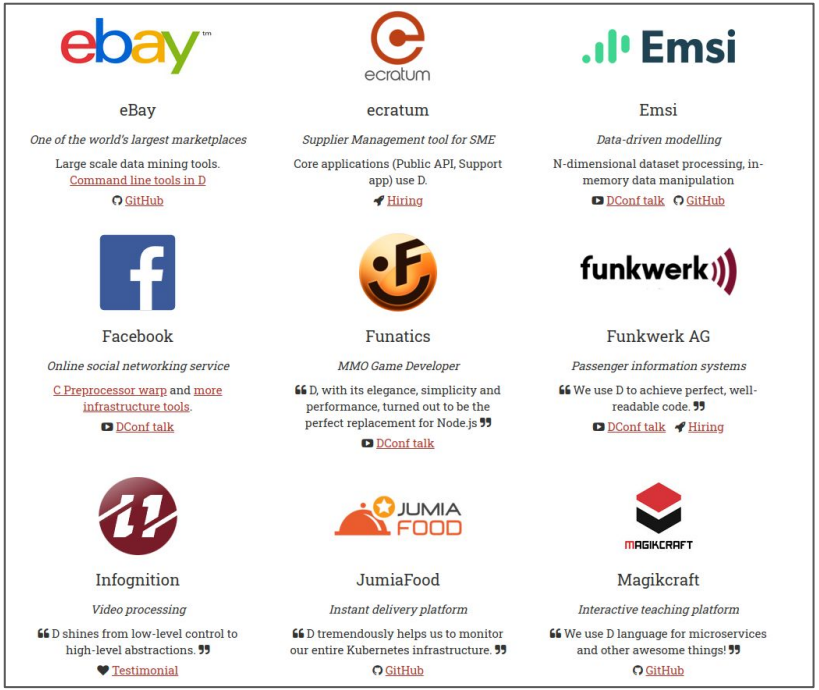


https://dlang.org/download.html

Note: Brian Callahan gets a lot of credit for bringing D to OpenBSD https://briancallahan.net/blog/20211013.html

DLang Domains

- It's a general purpose-language systems language, so D can be used in any domain.
- Dlang has found **some niches in performance-based** domains:
  - e.g. image processing, gaming, streaming, finance, and simulation



https://dlang.org/orgs-using-d.html

Built in the D Programming Language

Eilmer(/ɛlmə/) Compressible Flow Simulator

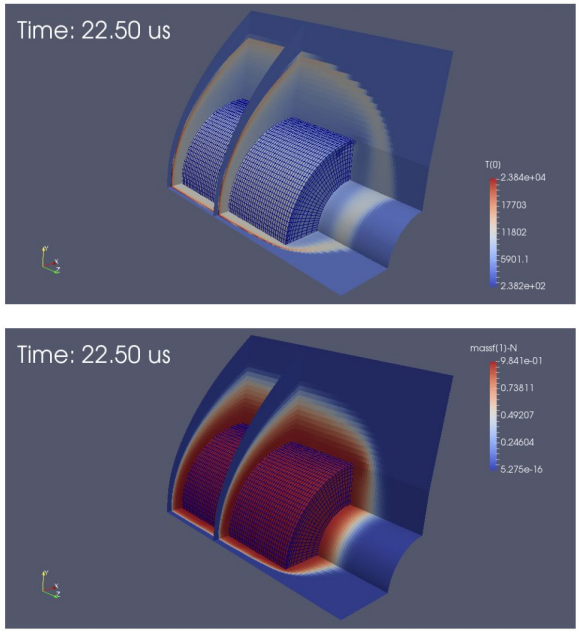
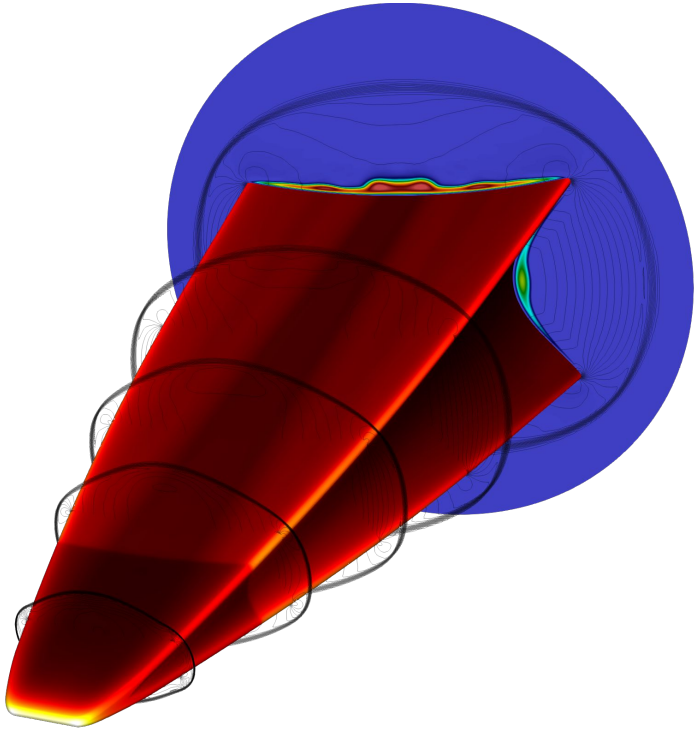


Figure 5.7: Static temperature and mass fraction of nitrogen atoms in the flow field from the chemical nonequilibrium simulation.



- Website: https://gdtk.uqcloud.net/ and https://gdtk.uqcloud.net/pdfs/eilmer-user-guide.pdf
- Github or Dub Repository: https://github.com/gdtk-uq/gdtk

Built in the D Programming Language

Eilmer(/ɛlmə/) Compressible Flow Simulator

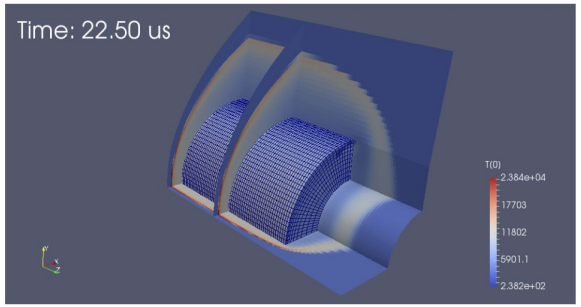


Figure 5.7: Static temperature and mass fraction of nitro ms in the flow fiel from the chemical nonequilibrium simulation.

Why you might care to look?

- Project with 10+ years in development
  - High performance!
- From the github page: *"Our focus is on open source development to give a simple access point for doing gas dynamics in research and teaching."*

https://gdtk.uqcloud.net/docs/eilmer/about/

Install prerequisites

The main requirement is a D language compiler. We recommend using the latest stable release of the LLVM D compiler.

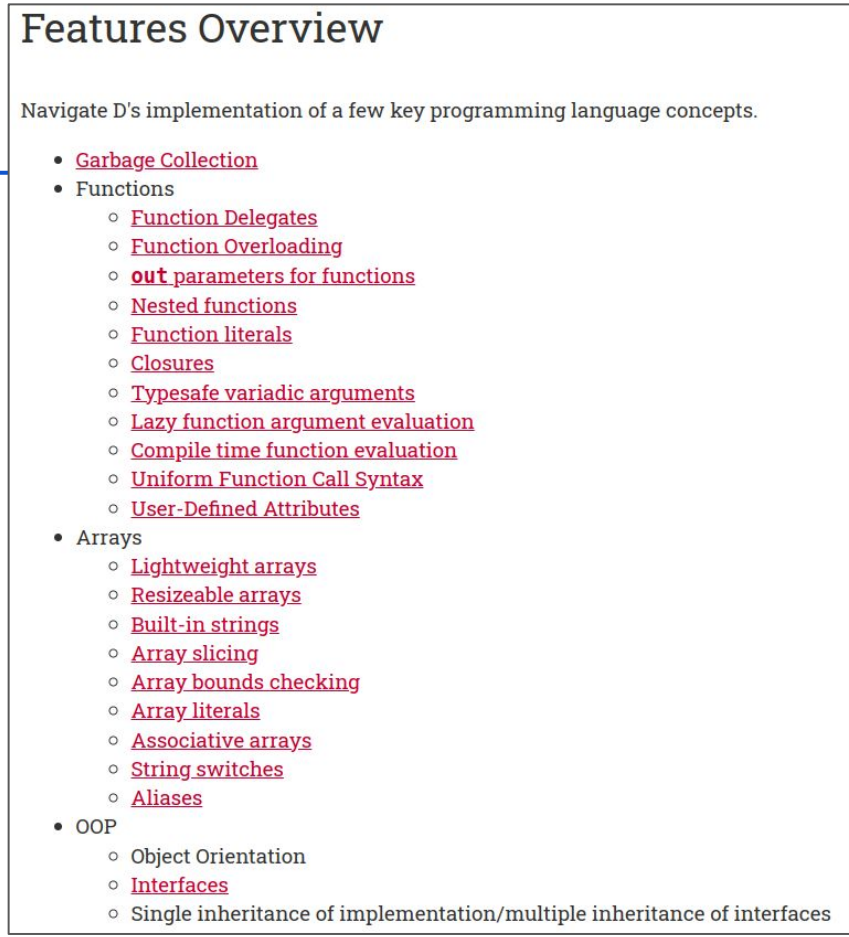
To build Eilmer and other programs in the toolkit, you will require:

- D compiler
  - Binary releases for the latest stable release of the LLVM D compiler (`ldc2` and `ldmd2`) may be found at: https://github.com/ldc-developers/ldc/releases .

- Website: https://gdtk.uqcloud.net/ and https://gdtk.uqcloud.net/pdfs/eilmer-user-guide.pdf
- Github or Dub Repository: https://github.com/gdtk-uq/gdtk

DLang Features

- We've seen **compile-time function execution** (ctfe) as one modern feature of the D language compiler
- The language itself supports many nice quality of life features for safety and productivity -- for example:
  - Built-in dynamic arrays
  - Built-in Associative arrays (i.e. map/hashtable/dictionary)
  - Bounds checked arrays
    - (With ability to disable if needed)
  - lambda's and delegates
  - Uniform Function Call Syntax (UFCS)
  - Object-Oriented Programming Paradigm
  - Functional paradigms (lazy evaluation, pure functions)
  - Concurrency
  - Garbage Collection or manual memory management options
    - i.e. You can just use malloc/free if you really want!
  - and more!



Features Overview

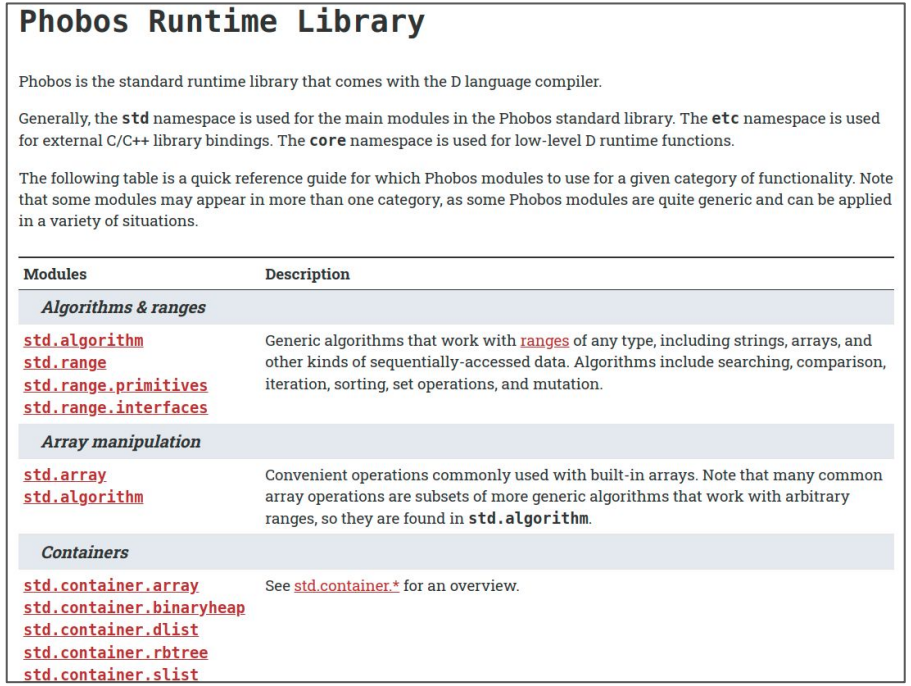
Navigate D's implementation of a few key programming language concepts.

- Garbage Collection
- Functions
  - Function Delegates
  - Function Overloading
  - `out` parameters for functions
  - Nested functions
  - Function literals
  - Closures
  - Typesafe variadic arguments
  - Lazy function argument evaluation
  - Compile time function evaluation
  - Uniform Function Call Syntax
  - User-Defined Attributes
- Arrays
  - Lightweight arrays
  - Resizeable arrays
  - Built-in strings
  - Array slicing
  - Array bounds checking
  - Array literals
  - Associative arrays
  - String switches
  - Aliases
- OOP
  - Object Orientation
  - Interfaces
  - Single inheritance of implementation/multiple inheritance of interfaces

https://dlang.org/comparison.html

Phobos The Standard Runtime Library

- Phobos is the **standard runtime library** that comes with D.
  - Thus, I like to think of D as a ‘batteries included’ language
  - You can get started immediately and be productive and writing software to solve problems.
    - Phobos comes ready with a rich set of algorithms, containers (data structures), and other common libraries for solving problems.
      - “Containers” are the standard libraries **data structures** (beyond the built-in types) that describe how we access and store data.
      - And the “**algorithms**” and “**ranges**” and are building blocks for computation
- The Standard Library (std) has common data structures and ability to work with data (json, csv, xml), compression (zip), networking (sockets, curl), etc.



Phobos Runtime Library

Phobos is the standard runtime library that comes with the D language compiler.

Generally, the `std` namespace is used for the main modules in the Phobos standard library. The `etc` namespace is used for external C/C++ library bindings. The `core` namespace is used for low-level D runtime functions.

The following table is a quick reference guide for which Phobos modules to use for a given category of functionality. Note that some modules may appear in more than one category, as some Phobos modules are quite generic and can be applied in a variety of situations.

Modules	Description
Algorithms & ranges	

`std.algorithm`
`std.range`
`std.range.primitives`
`std.range.interfaces`
	Generic algorithms that work with ranges of any type, including strings, arrays, and other kinds of sequentially-accessed data. Algorithms include searching, comparison, iteration, sorting, set operations, and mutation.

Array manipulation	
`std.array` `std.algorithm`	Convenient operations commonly used with built-in arrays. Note that many common array operations are subsets of more generic algorithms that work with arbitrary ranges, so they are found in `std.algorithm`.
Containers	

`std.container.array`
`std.container.binaryheap`
`std.container.dlist`
`std.container.rbtree`
`std.container.slist`
	See std.container.* for an overview.

https://dlang.org/phobos/index.html

Curl (YouTube API)

```
23 // Retrieves all of the playlists from the channel.
24 void GetPlaylists(){
25     // Query all the playlists for the channel
26     string query = "https://youtube.googleapis.com/youtube/v3/playlists?part=snippet%2CcontentDetail
   s&channelId="~gChannelID~"&maxResults=50&key="~gYouTubeAPIKey~"";
27
28     // Perform the query
29     auto content = get(query);
30     // Now we parse the content into json "j"
31     auto j = parseJSON(content);
32
33     foreach(key; j["items"].array){
34         writeln("   <tr>");
35         string id = strip(j["items"][counter]["id"].toString,"\"");
```

The following is a capture of one of my command-line scripts

- I take advantage of **std.net.curl** to make YouTube API calls
  - See line 29 (Note: Consider using a Builder to create a Query String)
- **std.json** is then used to retrieve data
  - ‘auto’ at line 29 infers the type, and then we parse the JSONObject
- Then I use a **range-based** loop (line 33) to iterate through the keys of my json object.

Curl (Github API)

```
41 /// Perform a Request on the github api
42 auto GetRequest(DefaultUser user, Course course, string request){
43     // Setup an HTTP Request
44     auto http = HTTP();
45     http.url = "https://api.github.com/orgs/"~course.coursename~"/"~request;
46     http.method = HTTP.Method.get;
47     http.setAuthentication(user.uname,user.OAUTH);
48 
49     // Store the result of the data that we retrieve
50     char[]    resultString;
51 
52     // Retrieve the header data
53     http.onReceiveHeader = (in char[] key, in char[] value) {
54         writeln("onRecieveHeader: ",key, ": ", value);
55     };
```

Yet another tool -- again -- same pattern but with calls to GitHub API

- Observe line 53 we set the event handler using a lambda function
  - Attributes '**in**' function effectively as 'transitive const' data.

Set the event handler that receives incoming headers.

```
{null} onReceiveHeader();
```

DLang for Scripts (1/2)

- As an interesting anecdote -- most of these scripts (and I have dozens of them...) use to be written in Python.
  - The translation was relatively simple -- and I've found D to be writeable like the Python language
- **But -- I still execute my source files like scripts in Python**
  - (I'll explain on the next slide)

Curl + YouTube API

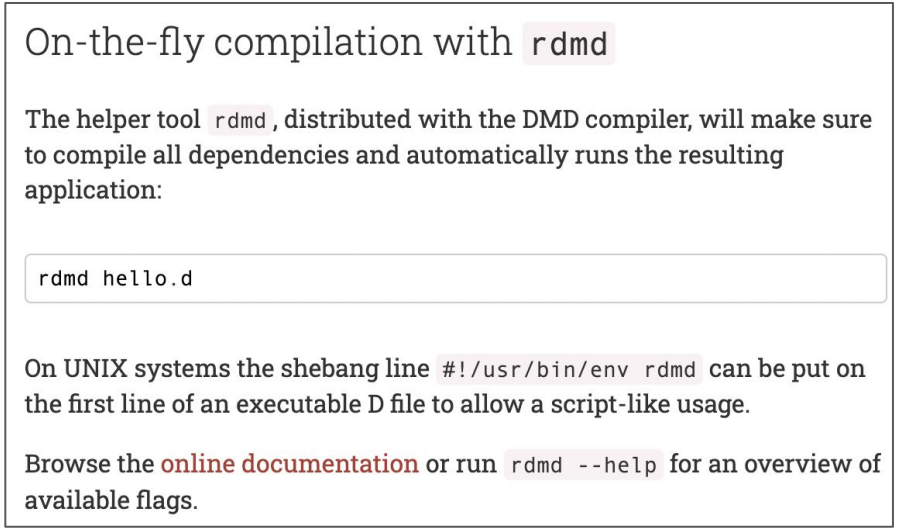
```
23 // Retrieves all of the playlists from the channel.
24 void GetPlaylists(){
25     // Query all the playlists for the channel
26     string query = "https://youtube.googleapis.com/youtube/v3/playlists?part=snippet%2CcontentDetail
   s&channelId="~gChannelID~"&maxResults=50&key="~gYouTubeAPIKey~"";
27
28     // Perform the query
29     auto content = get(query);
30     // Now we parse the content into json "j"
31     auto j = parseJSON(content);
32
33     foreach(key; j["items"].array){
34         writeln("   <tr>");
35         string id = strip(j["items"][counter]["id"].toString,"\"");
```

Curl + Github API

```
41 /// Perform a Request on the github api
42 auto GetRequest(DefaultUser user, Course course, string request){
43     // Setup an HTTP Request
44     auto http = HTTP();
45     http.url = "https://api.github.com/orgs/"~course.coursename~"/"~request;
46     http.method = HTTP.Method.get;
47     http.setAuthentication(user.uname,user.OAUTH);
48
49     // Store the result of the data that we retrieve
50     char[]    resultString;
51
52     // Retrieve the header data
53     http.onReceiveHeader = (in char[] key, in char[] value) {
54         writeln("onRecieveHeader: ",key, ": ", value);
55     };
```

DLang for Scripts (2/2)

- A little helper tool called **rdmd** will compile (and cache) on the fly.
  - Great -- now I get a **statically typed, systems language** that I can write my scripts in.
- (Note: ldmd2 is the equivalent for the LDC compiler of rdmd)



On-the-fly compilation with `rdmd`

The helper tool `rdmd`, distributed with the DMD compiler, will make sure to compile all dependencies and automatically runs the resulting application:

```
rdmd hello.d
```

On UNIX systems the shebang line `#!/usr/bin/env rdmd` can be put on the first line of an executable D file to allow a script-like usage.

Browse the online documentation or run `rdmd --help` for an overview of available flags.

(Aside) DLang for Scripts Performance

- *Generally speaking*, compiled languages (as you may know) often achieve more performance versus interpreted languages
  - That is the case with my ‘D’ versus ‘Python’ performance case
    - (Yes, Python numpy, or calling into pyCuda speeds things up)
  - But the point is, I get a language that’s easy to write in, but boosts great performance.
  - **DMD is a fast compiler -- rdmd allows me to use dmd almost like a scripting language**
- **Yet -- there’s more to the performance story!**

[Dlang Series Teaser] Dlang versus Python speed comparison (Matrix Multiply)

https://www.youtube.com/watch?v=HS7X9ERdjM4&list=PLvv0ScY6vfd9Fso-3cB4CGnSlW0E4btJV

Curl (Github API)

```
134     foreach(student ; students.parallel){
135         if(student.reponame.indexOf(reponame_prefix)>=0){
136             auto pid = spawnShell("git clone https://"~us
    se.coursename~"/"~student.reponame~"");
137         }
138     }
```

I can get thread-based parallelism relatively cheaply!

- Observe line 134, I can simply call `.parallel` on an array, and within a range-based loop this create multiple threads.

RayTracer

- So here was a Raytracer that I built-in the D programming language
  - An obvious candidate for parallelism from the std.parallelism module

- Talk/Website: https://www.youtube.com/watch?v=nCIB8df7q2g
- Github or Dub Repository: https://github.com/MikeShah/Talks/tree/main/2022/2022_dconf_London

```
74      foreach(y ; cam.GetScreenHeight.iota.parallel){
75          foreach(x; cam.GetScreenHeight().iota.parallel){
76  //      for(int y=cam.GetScreenHeight()-1; y >=0; --y){
77  //          for(int x= 0; x < cam.GetScreenWidth(); ++x){
78
79                  // Cast ray into scene
80                  // Accumulate the pixel color from multiple samples
81                  Vec3 pixelColor = Vec3(0.0,0.0,0.0);
```

- Again observe that I'm able to parallelize this loop
- There's also something interesting going on here syntactically to talk about with D
- The function calls take advantage of **Universal Function Call Syntax** (UFCS) -- a great feature for readability
    - `cam.GetScreenHeight.iota.parallel`
        - **as opposed to**
    - `parallel(iota(cam.GetScreenHeight()));`

(Aside)

- The D Compiler has a **built-in profiler** and **gc (memory) profiler**
- You can watch my previous talk below to learn more about how .parallel improved performance
  - **DConf Online '22 - Engineering a Ray Tracer on the Next Weekend with DLang**
  - https://www.youtube.com/watch?v=MFhTRiobWfU

-profile [switches see -profile]

```
dmd -profile -g ./src/*.d -of=prog && ./prog && display ./output/image.ppm
```

- So highlighted above is the '-profile' flag being used.
- Below is the summary of the profile (trace.log)
  - Note the summary is found at the bottom of trace.log

```
614 ======== Timer frequency unknown, Times are in Megaticks ========
615
616   Num          Tree        Func        Per
617   Calls        Time        Time        Call
618
619 4888100       51585       51369           0     double utility.GenerateRandomDouble()
620 13419031      12011       10287           0      vec3.Vec3 vec3.Vec3.opBinary!("-").opB
621 12866509       9584        6947           0      double vec3.DotProduct(const(vec3.Vec3
622 10279720      34363        6823           0      bool sphere.Sphere.Hit(ray.Ray, double
623 6814276        5462        4708           0     vec3.Vec3 vec3.Vec3.opBinary!("+").opBi
624 35995879       4336        3747           0      const bool vec3.Vec3.IsZero()
625 6498806        3946        3466           0     vec3.Vec3 vec3.Vec3.opBinaryRight!("*")
626 2570181       73278        2032           0     vec3.Vec3 main.CastRay(ray.Ray, sphere.H
627 20559440       4289        1867           0      const double vec3.Vec3.LengthSquared()
628 84971600       1543        1543           0      pure nothrow @nogc @trusted bool core.
```


-profile=gc (After making a Vec3 a struct)

```
dmd -g -profile=gc ./src/*.d  -of=prog
```

- Now notice there are no allocations for Vec3!
  - They're all done on the stack -- so let's do another speed test!

```
1 bytes allocated, allocations, type, function, file:line
2       993941664        10353559 sphere.HitRecord main.CastRay ./src/main.d:23
3       993839232        10352492 sphere.HitRecord sphere.HittableList.Hit ./src/sphere.d:44
4       288000000         4500000 ray.Ray camera.Camera.GetCameraRay ./src/camera.d:33
5       227915392         3561178 ray.Ray material.Lambertian.Scatter ./src/material.d:27
6       146712384         2292381 ray.Ray material.Metal.Scatter ./src/material.d:46
```

And more graphics open-source projects...

Dagon -- Game Engine

- Website with games and tutorials: https://gecko0307.github.io/dagon/
- Github or Dub Repository: https://github.com/gecko0307/dagon | https://code.dlang.org/packages/dagon

Dagon -- Game Engine

Why you might care to look?

- It's a substantial project that would be of interest to graphics developers
- You can take a look at the project hierarchy to see how a D project is organized.
- Fun comparison of C++ and D renderers [here]

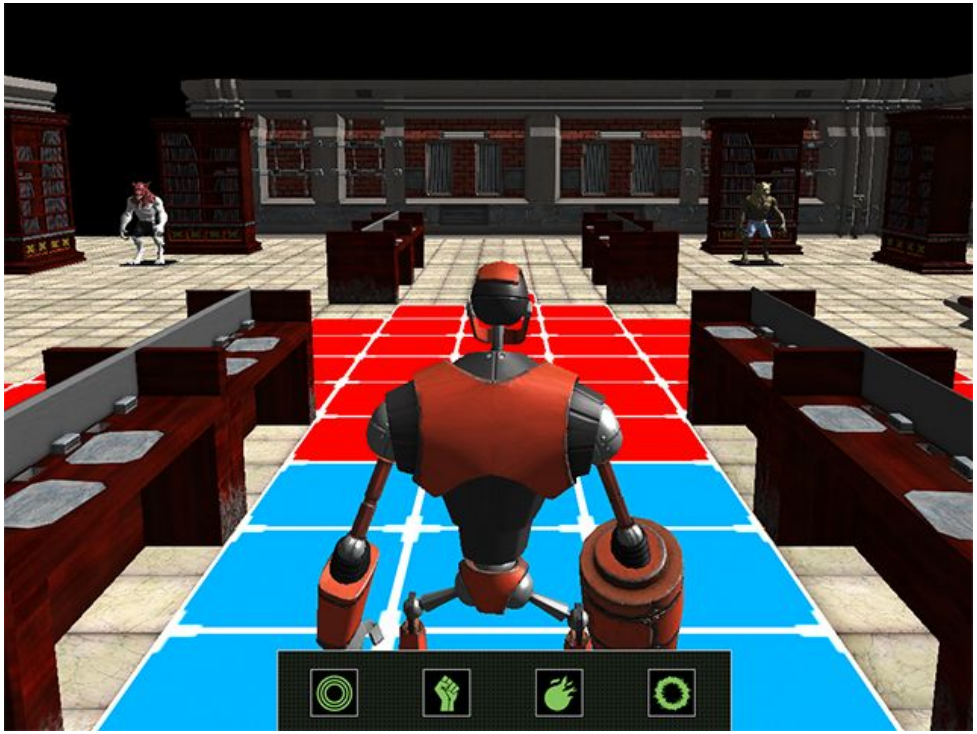
https://github.com/gecko0307/dagon/blob/master/src/dagon/graphics/mesh.d

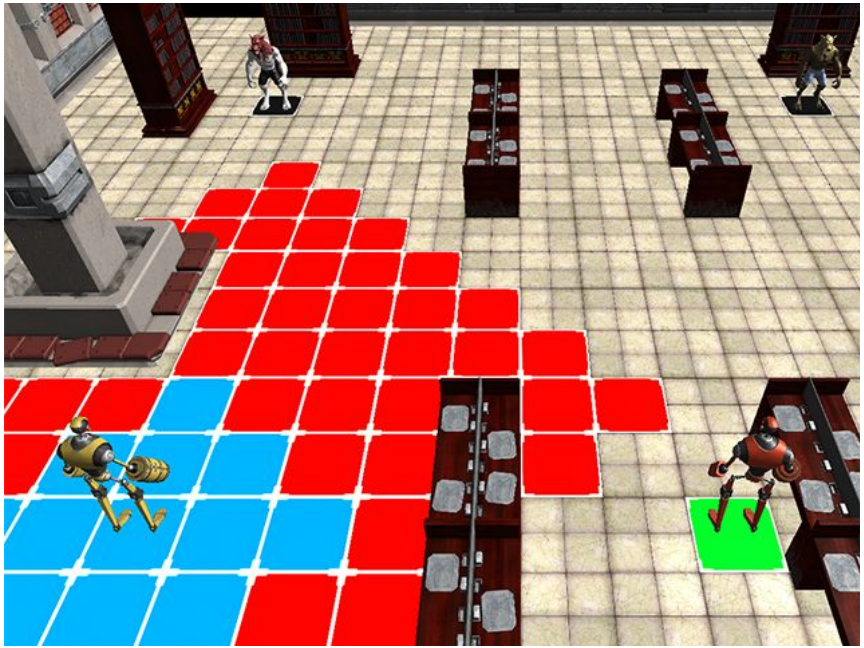
```
28    module dagon.graphics.mesh;
29
30    import std.math;
31    import std.algorithm;
32
33    import dlib.core.memory;
34    import dlib.core.ownership;
35    import dlib.geometry.triangle;
36    import dlib.math.vector;
37    import dlib.geometry.aabb;
38
39    import dagon.core.bindings;
40    import dagon.graphics.drawable;
41
42    enum VertexAttrib
43    {
44        Vertices = 0,
45        Normals = 1,
46        Texcoords = 2
47    }
```

- Website with games and tutorials: https://gecko0307.github.io/dagon/
- Github or Dub Repository: https://github.com/gecko0307/dagon | https://code.dlang.org/packages/dagon

Built in the D Programming Language

Dash -- Game Engine

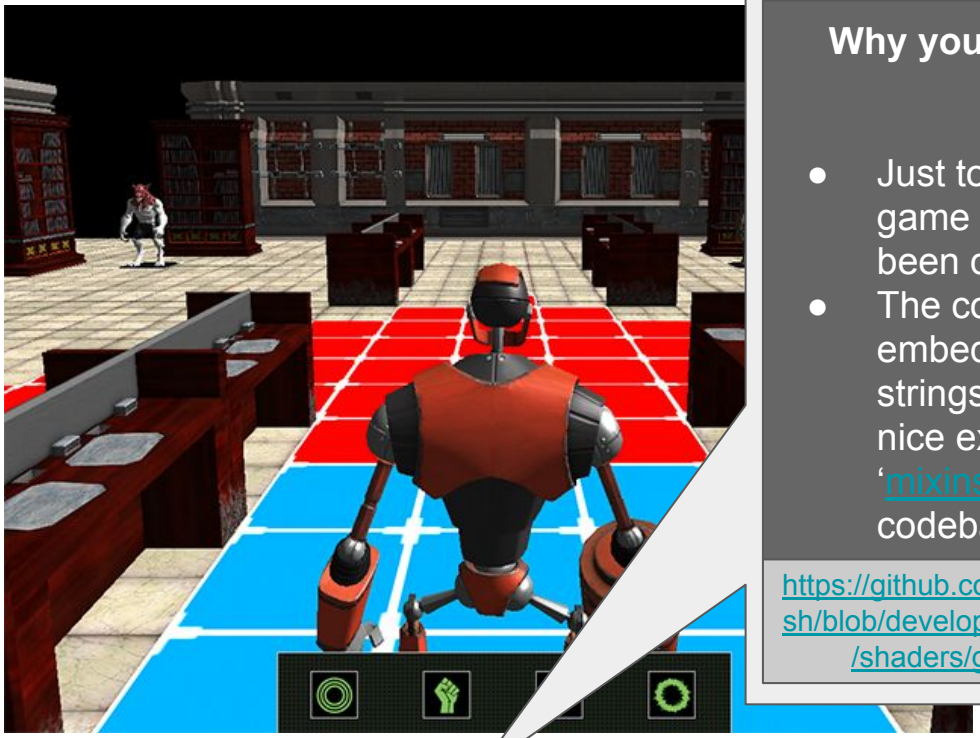




- Website with games: https://circularstudios.com/
- Github or Dub Repository: https://github.com/Circular-Studios/Dash
- Forum Post: https://forum.dlang.org/thread/qnaqymkehjvopwxwvwig@forum.dlang.org

Built in the D Programming Language

Dash -- Game Engine



Why you might care to look?

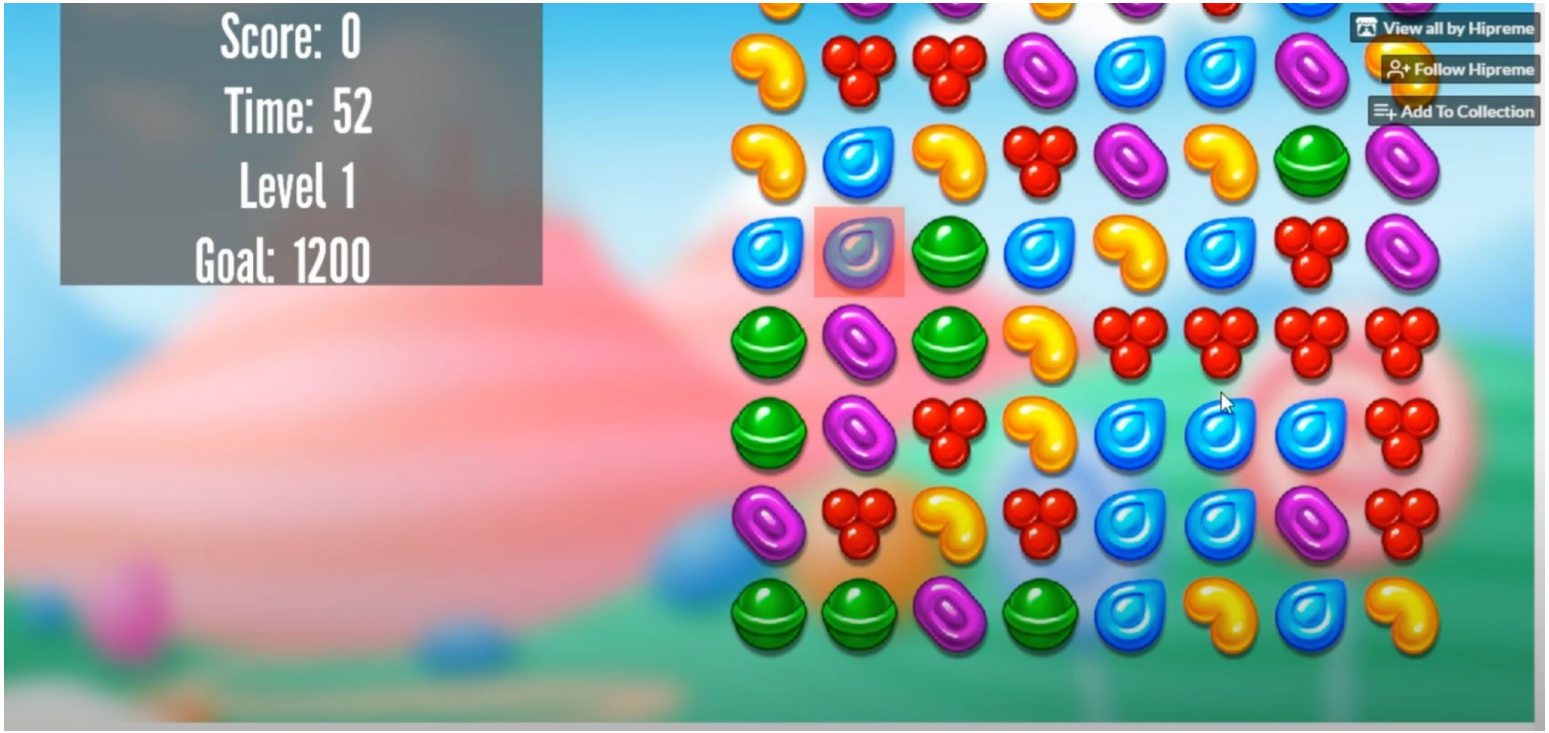
- Just to show another game engine that had been done in D!
- The code shows embedding shaders as strings -- there's also nice examples of 'mixins' in the codebase.

https://github.com/Circular-Studios/Dash/blob/develop/source/dash/graphics/shaders/glsl/ambientlight.d

```
module dash.graphics.shaders.glsl.ambientlight;
import dash.graphics.shaders.glsl;

package:

/// Takes in a clip-space quad and interpolates the UVs
immutable string ambientlightVS = glslVersion ~ q{
    layout(location = 0) in vec3 vPosition_s;
    layout(location = 1) in vec2 vUV;

    out vec4 fPosition_s;
    out vec2 fUV;

    void main( void )
    {
        fPosition_s = vec4( vPosition_s, 1.0f );
        gl_Position = fPosition_s;
        fUV = vUV;
    }
};
```

- Website with games: https://circularstudios.com/
- Github or Dub Repository: https://github.com/Circular-Studios/Dash
- Forum Post: https://forum.dlang.org/thread/qnaqymkehjvopwxwvwig@forum.dlang.org

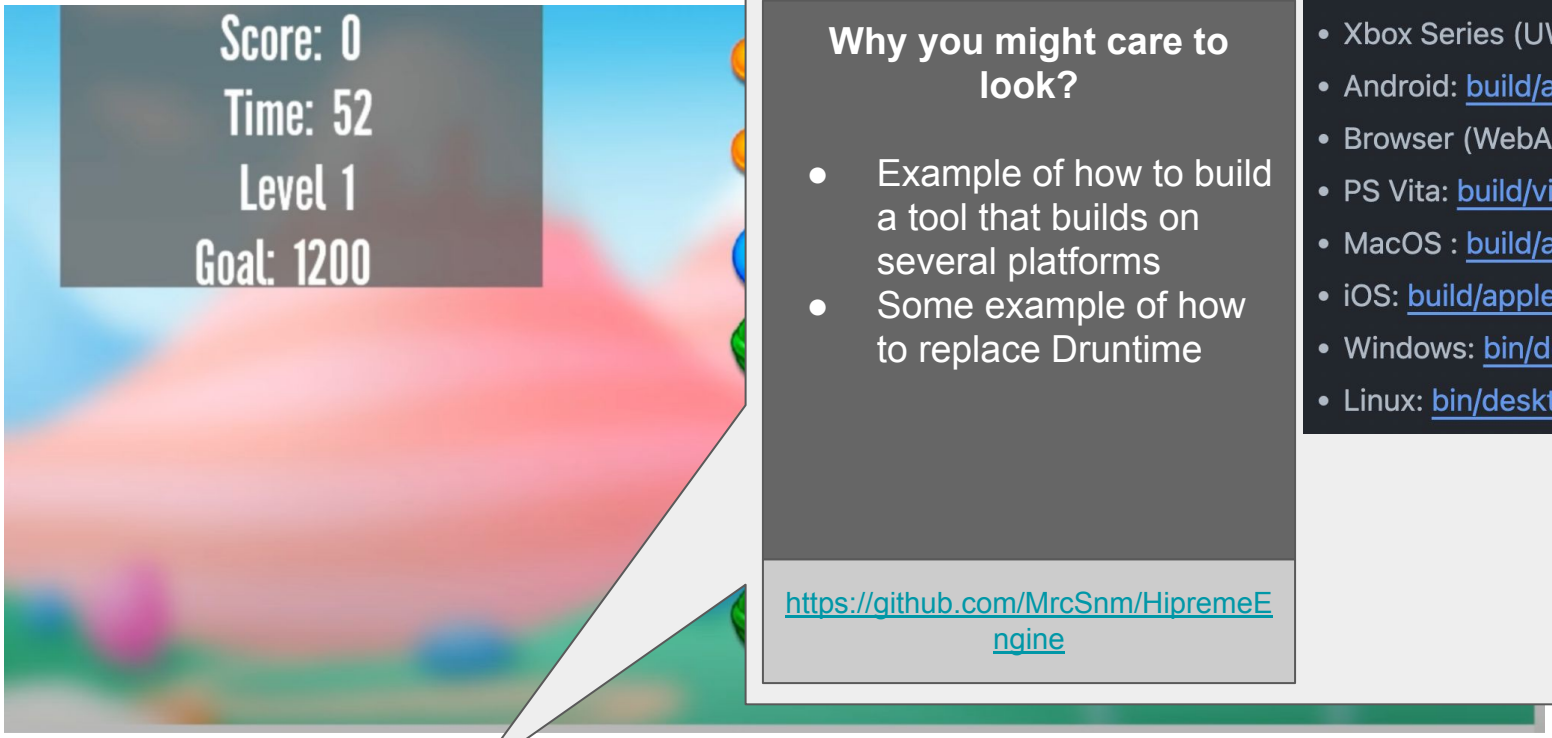
Hipreme Engine -- Game Engine



- Github or Dub Repository: https://github.com/MrcSnm/HipremeEngine
- DConf 2023 Talk: DConf '23 -- Hipreme Engine: Bringing D Everywhere -- Marcelo Mancini

Built in the D Programming Language

Hipreme Engine -- Game Engine



Why you might care to look?

- Example of how to build a tool that builds on several platforms
- Some example of how to replace Druntime

https://github.com/MrcSnm/HipremeEngine

- Xbox Series (UWP): build/uwp
- Android: build/android/
- Browser (WebAssembly): build/wasm
- PS Vita: build/vita
- MacOS : build/appleos
- iOS: build/appleos
- Windows: bin/desktop
- Linux: bin/desktop

- Github or Dub Repository: https://github.com/MrcSnm/HipremeEngine
- DConf 2023 Talk: DConf '23 -- Hipreme Engine: Bringing D Everywhere -- Marcelo Mancini

(Aside) Other Graphics Resources

- The bind-bc libraries by Michael (Mike) Parker provide access to libraries like Simple Directmedia layer (SDL) and other graphical libraries to enable much of this game work.

https://code.dlang.org/packages/bindbc-sdl

(Aside) Commercial Games with D Language

- D has also been used in AAA commercial games
  - Full presentations here:
    - Using D Alongside a Game Engine
      - https://dconf.org/2013/talks/evans_1.html
    - Quantum Break: AAA Gaming With Some D Code
      - https://dconf.org/2016/talks/watson.html
    - D: Using an Emerging Language in Quantum Break
      - https://www.gdcvault.com/play/1023843/D-Using-an-Emerging-Language

DLang Paradigms

- Expressiveness
  - You can write in a procedural style, oop style, functional style, generic code, parallel code using threads, fibers, simd, etc.

Functional Style -- no raw loops

```d
// @ file functional_filter.d
import std.stdio;
import std.algorithm;   // map
import std.string;

void main(){

    // Loop style
    // A little better with foreach loop
    auto words = ["hello", "world", "dlang", "c++", "java"];
    int coolLangauges = 0;
    foreach(element ; words){
        if(element=="dlang"){
            coolLangauges++;
        }
    }
    writeln("Cool langauges found: ",coolLangauges);

    // Functional-style

    auto words2 = ["hello", "world", "dlang", "c++", "java"];
    import std.array;
    auto result = words.filter!(a=> a.indexOf("dlang") >=0).array;
    writeln("Cool langauges found: ",result);

}
```

Object-Oriented Style

```d
// @ inheritance.d
import std.stdio;

interface Dog{
    void Bark();
    void Walk();
}

class Husky : Dog{
    void Bark(){ writeln("Husky Bark!"); }
    void Walk(){ writeln("Husky Walk!"); }
}

class GoldenRetriever : Dog{
    void Bark(){ writeln("GoldenRetriever Bark!"); }
    void Walk(){ writeln("GoldenRetriever Walk!"); }
}

void main(){

    Dog dog1 = new Husky;
    Dog dog2 = new GoldenRetriever;

    Dog[] collection;
    collection ~= dog1;
    collection ~= dog2;
    foreach(doggy ; collection){
        doggy.Bark();
    }

}
```

“Hello world” of meta programming/introspection

Template Constraints and introspection

```
36 // NEW: Introspection capabilities at compile-time
37 //      to ensure class has memory and elements fields.
38 void printData(T)(T theStruct)
39     if(hasMember!(T,"memory") &&
40        hasMember!(T,"elements"))
41 {
42     foreach(i ; 0 .. theStruct.elements){
43         write(theStruct.memory[i],",");
44     }
45     writeln();
46 }
```

Not ready to try D?

- Use it as a ‘betterC’
  - Useful for bare-metal programming or enhancing a C-codebase.
    - disables D language run-time, so reduces dependencies
  - Get other features of the D language I have not talked about
    - e.g. unittest support
    - e.g. RAII support
    - e.g. Excellent metaprogramming support
    - compile-time functionality remains
- Nice talk on bare metal programming on kernels here:
  - DConf '23--Multiplix: Using D for Kernel Development--Zachary Yedidia

```
> dmd -betterC -unittest -run test.d
```

40.3 Retained Features

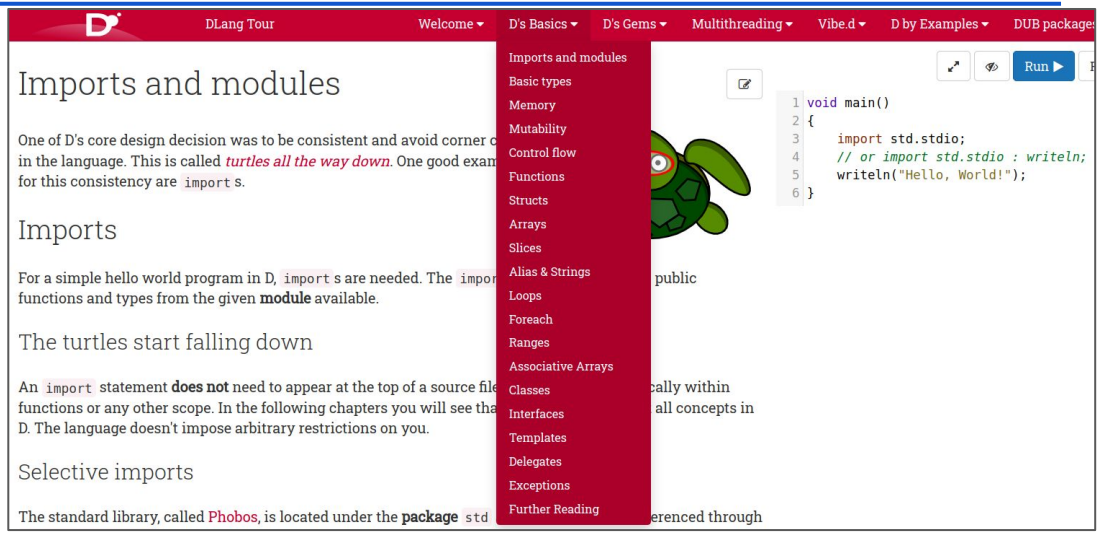
1. Nearly the full language remains available. Highlights include:
   1. Unrestricted use of compile-time features
   2. Full metaprogramming facilities
   3. Nested functions, nested structs, delegates and lambdas
   4. Member functions, constructors, destructors, operating overloading, etc.
   5. The full module system
   6. Array slicing, and array bounds checking
   7. RAII (yes, it can work without exceptions)
   8. `scope(exit)`
   9. Memory safety protections
   10. Interfacing to C++
   11. COM classes and C++ classes
   12. `assert` failures are directed to the C runtime library
   13. `switch` with strings
   14. `final switch`
   15. `unittest`
   16. `printf` format validation

https://dlang.org/spec/betterc.html

Learning More About the D Language

The D language tour

- Nice set of online tutorials that you can work through in 1 day
  - Found directly on the D language website under ‘Learn’



https://tour.dlang.org/

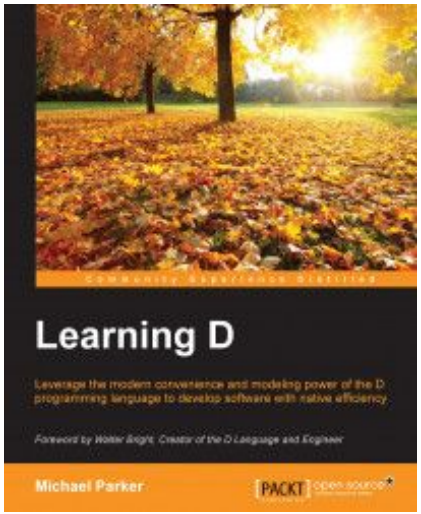
More Resources for Learning D

I would start with these two books

1. Programming in D by Ali Çehreli
    a. Freely available http://ddili.org/
2. Learning D by Michael Parker

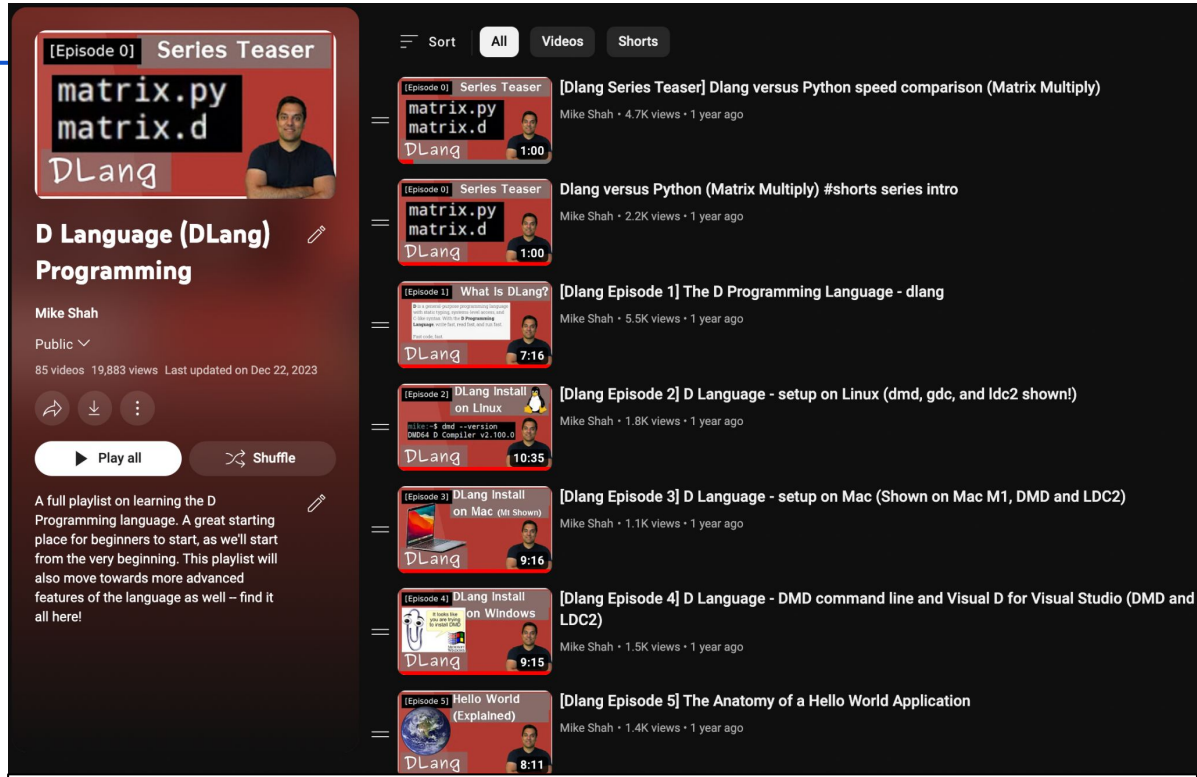
Any other books you find on D are also very good -- folks in the D community write books out of passion!

The online forums and discord are otherwise very active



YouTube

- I am actively adding more lessons about the D programming language
  - https://www.youtube.com/c/MikeShah



https://www.youtube.com/playlist?list=PLvv0ScY6vfd9Fso-3cB4CGnSlW0E4btJV

Teaching D Language

- You can hear my perspective
- **Even better** -- you can hear the students perspective
  - They built a networked collaborative paint program that is also available.
- D Conf 2023:
  - YouTube: https://www.youtube.com/live/wXTIafzlJVY?si=Xpy6g5h4wtIUrt2E&t=7711
  - Link to Conference Talk Description: https://dconf.org/2023/index.html

The Case for D [link] [archived link] (1/2)

- Andrei Alexandrescu [wiki] one of the main contributors to has a wonderful article on “The Case for D” written in 2009.
  - In short, D is a ‘high-level systems language’ where you can be productive, and enjoy coding....*Of course, I'm not deluding myself that it's an easy task to convince you.*

D Fundamentals

D could be best described as a high-level systems programming language. It encompasses features that are normally found in higher-level and even scripting languages -- such as a rapid edit-run cycle, garbage collection, built-in hashtables, or a permission to omit many type declarations -- but also low-level features such as pointers, storage management in a manual (' la C's **malloc**/**free**) or semi-automatic (using constructors, destructors, and a unique scope statement) manner, and generally the same direct relationship with memory that C and C++ programmers know and love. In fact, D can link and call C functions directly with no intervening translation layer. The entire C standard library is directly available to D programs. However, you'd very rarely feel compelled to go that low because D's own facilities are often more powerful, safer, and just as efficient. By and large, D makes a strong statement that convenience and efficiency are not necessarily at odds. Aside from the higher-level topics that we'll discuss soon, no description of D would be complete without mentioning its attention to detail: all variables are initialized, unless you initialize them with **void**; arrays and associative arrays are intuitive and easy on the eyes; iteration is clean; NaN is actually used; overloading rules can be understood; support for documentation and unit testing is built-in. D is multi-paradigm, meaning that it fosters writing code in object-oriented, generic, functional, and procedural

The Case for D [link] [archived link] (2/2)

- Andrei Alexandrescu [wiki] one of the main contributors to has a wonderful article on “The Case for D” written in 2009.
  - In short, D is a ‘high-level systems language’ where you can be productive, and enjoy coding.

- Again, you’ll decide yourself after trying if D is your new language of choice.
- My hope -- In this talk, I can at the least show you some great features of D, and where to look for inspiration for D in the open source world.

D Fundamentals

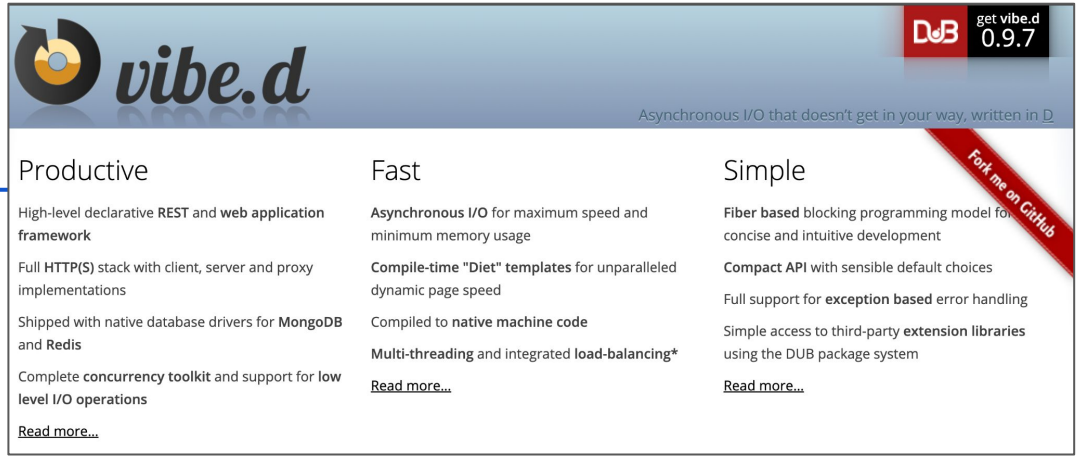
D could be best described as a high-level systems programming language. It encompasses features that are normally found in higher-level and even scripting languages -- such as a rapid edit-run cycle, garbage collection, built-in hashtables, or a permission to omit many type declarations -- but also low-level features such as pointers, storage management in a manual (' la C's **malloc**/**free**) or semi-automatic (using constructors, destructors, and a unique scope statement) manner, and generally the same direct relationship with memory that C and C++ programmers know and love. In fact, D can link and call C functions directly with no intervening translation layer. The entire C standard library is directly available to D programs. However, you'd very rarely feel compelled to go that low because D's own facilities are often more powerful, safer, and just as efficient. By and large, D makes a strong statement that convenience and efficiency are not necessarily at odds. Aside from the higher-level topics that we'll discuss soon, no description of D would be complete without mentioning its attention to detail: all variables are initialized, unless you initialize them with **void**; arrays and associative arrays are intuitive and easy on the eyes; iteration is clean; NaN is actually used; overloading rules can be understood; support for documentation and unit testing is built-in. D is multi-paradigm, meaning that it fosters writing code in object-oriented, generic, functional, and procedural

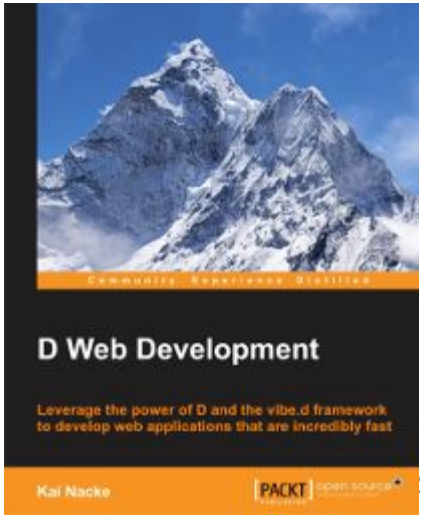
So why care as an open source developer?

- I’ve found D to be:
  - Readable
  - Writeable
  - Performant
  - Allow fast iteration times
  - This combination of attributes provides a competitive advantage
    - I *believe* based on working with students, that D-based projects are very easy to have contributors at different skill levels participate at scale.
- The ecosystem of D Compilers is very open, so no worry about D disappearing
- Overall:
  - A friendly language, allowing you to work at many different levels and paradigms, could be a wonderful way to build software and collaborate with others

What's next for me?

- Converting my website to use the vibe framework
  - See: https://vibed.org/
- Yet another open-source tool in the ecosystem for building scalable websites and web applications.





Some Summary of D Topics Today

- It is a compiled language
  - (i.e. machine code is executed as opposed to interpreting code)
- The compilers (DMD, LDC2, GDC) have years of optimization built into them
- D does lots of compile-time function evaluation (CTFE)
  - Run code at compile-time, so you don’t need to evaluate at run-time
- The language allows you to control system resources
  - i.e. You can turn on and off garbage collection for example.
- Parallelization can often be trivially enabled (e.g. std.parallel)
- Universal Function Call Syntax (UFCS) for writing readable code
- rdmd gives you a ‘script like’ feel to the language when you need
  - Keep all of your code and cognitive load in one programming language

Thank you Fosdem 2024!

The D Programming Language for Modern Open Source Development

-- Programming in DLang

with Mike Shah

Social: @MichaelShah
Web: mshah.io
Courses: courses.mshah.io
YouTube
www.youtube.com/c/MikeShah
http://tinyurl.com/mike-talks

16:00 - 16:50 Sat, Feb 3, 2024
Location: k.1.105 (La Fontaine)
50 minutes | Introductory Audience

Thank you!

Errata/Questions

Questions and notes after the talk

- **Questions during the talk**
  - Rust vs D
    - I have not used Rust professionally to comment on a large code base, but here are some thoughts.
    - Probably each have their own domains
      - I've found D code very 'malleable' (i.e. high plasticity) which may be an advantage
    - Anyone with a C, C++, Java background I suspect will have an easy transition to D
    - For game/graphics (my domain) or other highly stateful applications I've found D great!
    - For systems programming both are good languages with memory safety features
    - For experts in either 'Rust' or 'D', the old advice probably applies where you pick the language you are most comfortable in, and that's the language you'll like best.
- **Questions after the talk**
  - **pure** is available in D, so you can define pure functions
    - Useful for concurrency, minimizing state, improving chance of compile-time function
  - Regarding the 'template constraints' here's the page
    - https://dlang.org/articles/constraints.html
    - I *believe* no need to write 'static if' because constraint is evaluated at compile-time, but you could put in a static if
    - I also did not discuss 'pre' and 'post' contracts used when developing software -- which is another nice feature
  -

Extras and Notes

More Useful Links

- https://github.com/dlang-community/awesome-d
- Another list of projects and companies (here: https://github.com/dlang-community/awesome-d?tab=readme-ov-file#organizations) using D now or in the past.
- D repositories
  - https://github.com/topics/dlang and/or https://github.com/topics/d