

GSOC 2019 Proposal

Replace Runtime Hooks with Templates

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1. Introduction

Runtime hooks are an important part of the D ecosystem as they allow the compiler to express complicated operations with the help of a function call. Sadly, some of the current runtime hooks present safety concerns, as Mike Franklin explains in the *[gsoc] DMD - Ideas* thread¹ that when writing “array.length = 8;” - which is lowered to `_d_arraysetlengthT` - it is allowed in a `@safe pure nothrow` scope, even if this expression is lowered to a function that is not `@safe pure nothrow`. Lucia Cojocarus² brought forward another problem, explaining that some of these runtime hooks add a lot of indirection, which in turn adds to execution time overhead.

The solution to fix these issues is to change the runtime hooks to use templates instead of the `TypeInfo` class hierarchy. This solution was presented by both Cojocarus and Franklin, and it solves the safety issue as the implementation can be resolved at compile time rather than trust that the runtime developer will correctly implement the hooks. Additionally, the indirection is also solved as the hook can access the real type directly and use *Design by Introspection* techniques to further optimize the code for the specified type. Furthermore, by changing the hooks to use templates it will make it easier to get contributions as the code is now located only in the runtime instead of both the runtime and the compiler³. The conversion will also help with goal of turning the runtime into a “pay for what you use” library.

The expected outcome of this proposal is that all of the array hooks listed in Appendix A will be successfully converted into templates.

2. Why me

I have been programming for over 10 years now, and I am currently studying for a master’s degree in computer science at BTH in Sweden. I found D in early 2014 and have been using it since in a variety of hobby projects; as well as a few school assignments. Additionally, I’m one of the volunteers that maintains the D

¹ <https://forum.dlang.org/post/hequvmostuhwnvcgrcge@forum.dlang.org>

² Generic Lightweight DRuntime - Lucia Cojocaru | DConf2017 - <https://www.youtube.com/watch?v=endKC3fDxqs>

³ Generic Lightweight DRuntime - Lucia Cojocaru | DConf2017 - <https://www.youtube.com/watch?v=endKC3fDxqs>

packages on ArchLinux⁴ and I operate a Discord server⁵ around the D language with other like-minded fanatics.

The biggest D project I'm working on is PowerNex⁶, a from-scratch operating system I have been the sole developer of for more than three and a half years. It is this project that has taught me the most about runtime hooks, as before the existence of betterC PowerNex used a bare-metal runtime written by Adam D. Ruppe⁷. I was lucky to get this base code from Ruppe as it helped start the PowerNex project. As the D language evolved it required more and more new hooks to accommodate the growing set of runtime features, thus requiring me to learn and implement them to use the newer versions of D.

PowerNex has taught me how to traverse DMD's source code I needed to write patches⁸ to compile code for the PowerNex target instead on any of the other backend targets. These patches had to touch the frontend, to define `version=PowerNex` instead of `version=linux`, and the backend, to output a correct PowerNex executables.

The reasons for applying to GSoC and for wanting to work on this task is because I have felt for a long time that I want to help with the development of the language, but because I am a full time student I have not had the time to do any contributions. With the help of GSoC I can make this dream come true as I can make sure that my bills will be paid whilst helping the D language evolve.

3. Method

The steps for doing the conversion are based on the suggestions made by Mike Franklin in the *[GSoC] Trying to find a good topic* newsgroup thread⁹ and from Lucia Cojocarus talk.

Convert hook. There is many tasks that need to be done to complete the conversion to a template. These include changing all the references to TypeInfo to use the type directly, changing allocation methods to use match the safety requirements, replacing input data checks with their template counterparts, and fixing all the problems that shows up during the conversion. The next step is to add unittest to test that this template works like its non-template counterpart.

Compiler support. The task here is to make the compiler instantiate the new template instead of calling the old hook. It is important to add unittests here as well to ensure it will not break any code.

The druntime and the compiler PRs will be worked on the same time to be able to catch both compiler and runtime problems. One problem that could happen is that the CTFE get triggers and throws a error. This needs to be fixed before any of the PR have been submitted. After verifying that everything works as expected, and it will not break any code, the changes can be submitted as a PR to druntime and a PR to dmd. The dmd PR requires that the druntime PR has already been merged to not break any of the automated testers or anyone compiling a nightly build of the compiler. Along with the PR benchmark results will be submitted. These results give a quick overview of how important the change is for the language and incase of a performance degradation, if the hook needs to be changed in the near future.

⁴ <https://www.archlinux.org/people/trusted-users/#wild>

⁵ D Language Code Club - <https://discord.gg/bMZk9Q4>

⁶ <https://github.com/PowerNex/PowerNex>

⁷ <http://arsdnet.net/dcode/minimal.zip>

⁸ <https://github.com/PowerNex/powernex-dmd>

⁹ <https://forum.dlang.org/post/zxyoayqernoxosadppsr@forum.dlang.org>

Clean up. The last task after all PRs have been merged, is to submit a cleanup PR to druntime that removes the old, and now unused, hook.

There are a few places where problem could halt or slow down the developments. There are of course bugs that need to be fixed, but these bugs will only be fixed if they are caused by the translation phase, if the bugs are from the old hook they should be fixed in a separate PR. This is to ensure that the code review on the PR should be as smooth and fast as possible and throwing in more changes than needed could be detrimental to the review process.

Another problem could happy would be that during the code review improvements could be suggested on how the translation could be done. This problem should be expected and planned for so it does not negatively influence the schedule.

4. Expected outcome

The expected outcome of this problem would be that all of the array hooks will be have been translate to templates. There will not be any expectation that these hooks will work in betterC mode. It would be a plus but it is not an expected outcome. There is a possibility that bugs will be found during the conversion and these will be reported to the bugtracker. Fixing these inside the PR will make the PR harder to review and fixing the bugs may break code.

5. Time plan

This is a rough estimate of how the time plan will look like. If a hook is easier than expected and I finish early I will continue with the hooks for the week after. If I run out of array hooks to convert I will contact my supervisor to try and find more hooks that I could convert.

My goal is to work at least 30 hours a week, which breaks down to six hour per day, five days per week. The only time where I might not be able to work fulltime is week 22-23 as these are the last weeks of school and I will have two exams. To make sure that this does not hurt the GSoC I have put a bit less work these weeks compared to the rest.

The metric used to plan which symbols to do each week is the lines of code inside each hook. This values should show a *in-a-ballpark* how hard it will be to translate the hook. Hooks that have a lot in common like all the different versions of `_d_arrayappend` will be translated at the same time. A visualization of the lines of code to be converted each week block can be seen in appendix 2.

Date	Goal	Lines of code
May 27	Start of GSoC	
W.22 - W.23	<code>_d_arrayappend*</code>	144
W.24 - W.25	<code>_d_arraysetctor</code> , <code>_d_arrayctor</code> , <code>_d_arraycat*</code>	190
June 24 - 28	First evaluation	
W.26 - W.27	<code>_d_arraysetlength*</code>	432
W.28 - W.29	<code>_d_arrayliteral*</code> , <code>_d_arraysetcapacity</code>	202
July 22 - 26	Second evaluation	

W.30 - W.31	<code>_d_delarray_t*</code> , <code>_d_arrayassign*</code> , <code>_d_arrayshrinkfit</code> , <code>_d_arraysetassign</code>	174
W.32 - W.33	<code>_d_newarray*</code>	183
August 19 - 26	Last evaluation	

Appendix 1 - Hooks to be translated

These hooks were found by running:

```
egrep -o -R "_d_.*array.*\([^.*[^\;]\$)" | grep -v "assocarray" | grep "TypeInfo"
```

Module: `rt.arrayassign`

- `_d_arrayassign`, Lines: 16
- `_d_arrayassign_l`, Lines: 36
- `_d_arrayassign_r`, Lines: 20
- `_d_arrayctor`, Lines: 32
- `_d_arraysetassign`, Lines: 22
- `_d_arraysetctor`, Lines: 28

Module: `rt.lifetime`

- `_d_arrayshrinkfit`, Lines: 41
- `_d_arraysetcapacity`, Lines: 168
- `_d_newarrayU`, Lines: 55
- `_d_newarrayT`, Lines: 11
- `_d_newarrayiT`, Lines: 29
- `_d_newarraymTX`, Lines: 11
- `_d_newarraymiTX`, Lines: 11
- `_d_delarray_t`, Lines: 25
- `_d_arraysetlengthT`, Lines: 192
- `_d_arraysetlengthiT`, Lines: 208
- `_d_arrayappendT`, Lines: 13
- `_d_arrayappendcTX`, Lines: 99
- `_d_arraycatT`, Lines: 61
- `_d_arraycatnTX`, Lines: 35
- `_d_arrayliteralTX`, Lines: 19

Module: `rt.tracegc`

- `_d_newarrayTTrace`, Lines: 15
- `_d_newarrayiTTrace`, Lines: 15
- `_d_newarraymTXTrace`, Lines: 18
- `_d_newarraymiTXTrace`, Lines: 18
- `_d_delarray_tTrace`, Lines: 14
- `_d_arrayliteralTXTrace`, Lines: 15
- `_d_arraycatTTrace`, Lines: 16
- `_d_arraycatnTXTrace`, Lines: 18
- `_d_arrayappendTTrace`, Lines: 16
- `_d_arrayappendcTXTrace`, Lines: 16
- `_d_arraysetlengthTTrace`, Lines: 16
- `_d_arraysetlengthiTTrace`, Lines: 16

Appendix 2 - Timeplan graph

