

# Appendix D - Performance

The text talks about performance in § 1.3, 2B, 4D, 6.2.4, 6B.2, 10 intro, 11.1, 17.6.3, 18 intro, 19.5, 20.1.2, 22.1.1, 26.5.4, 26.5.6, 28 intro, 29.1, 30.4.6, 33.4, 34.3.4.

Goal: Excellent performance, on par with C++,  
similar to C, or sometimes even faster.

Benchmarks: see § 1.3  
2023 Jan – Chess game: Jai was some 4-8 % slower than C

This is partly achieved by having:

- NO garbage collection (GC)
- NO automatic memory management
- NO exceptions (they are too complex, weighs too heavy on performance)
- NO RAII (Resource Acquisition Is Initialization), like: a struct has to have a copy constructor, move constructor, iterator, and so on, which leads to high friction
- temporary storage, which is much faster than malloc
- the context resides in cache

Jai has these characteristics to increase performance:

- 1) LLVM optimizations
- 2) boolean operators && and || are short-circuited.
- 3) strings are immutable, not '0'-terminated
- 4) arrays are built into the compiler (very efficiently (contiguously) stored, *on the stack* for small arrays so they are very fast
- 5) developer has complete control over memory allocation: packing (alignment/padding)  
for example: struct memory layout: fields are contiguous, packed together or aligned

To increase performance you can make use of:

- 1) inlining procedures with `inline`
- 2) disable assertions: `#import "Basic"() (ENABLE_ASSERT=false);` (see § 6.1.3 and § 20.1.2)
- 3) use `---` to avoid default initialization of variables.
- 4) turn off cast bound checks at runtime: `cast, no_check(type) var;`
- 5) use SOA (struct of arrays) instead of AOS (array of structs) (see § 26.10)
- 6) if you only need to print simple strings or numbers, use `write_*` procs instead of `print`. (see § 5.7.2)
- 7) use a `String_Builder` to accumulate a lot of strings. (see § 19.5)
- 8) turn off array bounds checking with `#no_abc` (see § 18.3.2)
- 9) disable stack-trace on crash: setting **Compiler.Build\_Options.backtrace\_on\_crash.OFF** will turn off the crash handler (and cause less code to get imported when your program is built). (see § 30.4.5)  
modules/Default\_Metaprogram now handles the argument **-no\_backtrace\_on\_crash**, which will cause the crash handler not to be loaded.
- 10) set build option `runtime_storageless_type_info` to true (see § 30.4.7)
- 11) use relative pointers (see § 10.6)
- 12) cast the index of a for (normally type `s64`) to a smaller integer type
- 13) alignment of fields in structs (see § 12.11)
- 14) when defining large arrays, use 64-bit cache alignment: (see § 18.3.4), for example:  
`array := NewArray(500, int, alignment=64);``
- 15) use e.g. `enum u16` type instead of `enum` (which is 64bit)

- 16) for faster memory management: keep things on structs by value where possible.  
17) it is better to return things from a procedure by value; this avoid having extra stack copies like in C.

Jai compiler command-line options for performance:

**-release** Build a release build, i.e., tell the default metaprogram to disable stack traces and enable optimizations.

-no\_dce Turn off dead code elimination.  
-no\_check Do not import modules/Check and run it on the code.  
-no\_check\_bindings Disable checking of module bindings when running modules/Check.

Options in a build metaprogram for a release build (disabling checks and decrease output size):

(In a build program the full command will be like: `target_options.optimization_level = .RELEASE;` )

```
optimization_level = .RELEASE;  
set_optimization_level(*target_options, 2, 0);
```

```
stack_trace = false;  
backtrace_on_crash = .OFF;  
array_bounds_check = .OFF;  
cast_bounds_check = .OFF;  
math_bounds_check = .OFF;  
null_pointer_check = .OFF;  
runtime_storageless_type_info = true;  
emit_debug_info=.NONE; // (no .pdb files are created)  
write_added_strings = false;  
dead_code_elimination = .ALL;  
shorten_filenames_in_error_messages = true;  
lazy_foreign_function_lookups = true;  
enable_bytecode_inliner = true;  
enable_frame_pointers = false;
```

LLVM-options:

(In a build program the full command will be like:

```
target_options.llvm_options.gen_optimization_level = 3; )
```

```
.gen_optimization_level = 3;  
.enable_tail_calls = false;  
.enable_loop_unrolling = false;  
.enable_slp_vectorization = false;  
.enable_loop_vectorization = false;  
.reroll_loop = false;  
.verify_input = false;  
.verify_output = false;  
.merge_functions = false;  
.disable_inlining = true;  
.disable_mem2reg = false;  
.enable_split_modules = false;
```

(See also `Llvm_options / X64_Options`: § 30.4.8)

Choosing between a debug or release build:

See 30.4.9 / 30.10

How to measuring performance:

- using `get_time`: see § 6B.2, or with a macro: see § 26.5.6.