# Parsing zone files really fast

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## Or, going from *50MB/s to 700MB/s (and beyond!)

# Motivation

- Zone files can be huge and/or many
  - .com (160,691,699 domains, 23.9GB)
  - .nl (6.288.572 domains)
  - .se (1.464.131 domains, 1.2GB)
- Load times are an issue
  - Database performance plays a role too

# Bit on parsing

- Tokenize (Lex) then parse according to grammar (Yacc)
- Useful for context-free languages
- Preprocessor output is compiled

```c
#include <stdio.h>
// directives and comments are
// handled by preprocessor

// keywords, identifiers, string
// literals and integers are always
// parsed as such, regardless of
// scope or position
int main(int argc, char *argv[])
{
     printf("Hello world!\n");
     return 0;
}
```

# Bit on zone parsing

- Not context-free
  - Location defines type
  - Only tokens are strings, newlines and parentheses

```
$ORIGIN example.com.
$TTL 3660

example.com. IN 3600 SOA ns.example.com. hostmaster.example.com. (
                         2023020401 7200 3600 1209600 3600 )

; reuse owner (start with blank), class and ttl
 A 192.0.2.1

; append origin (no trailing .) and reuse class
www 3600 A 192.0.2.1

; syntax error (start with blank), but no class or ttl
 mail A 192.0.2.1

; syntax error (did not start with blank), type is owner
A 192.0.2.1
```

# Bit more on zone parsing

- Lex and Yacc make it harder
- Only more-or-less “standardized”

# But, why is it slow?

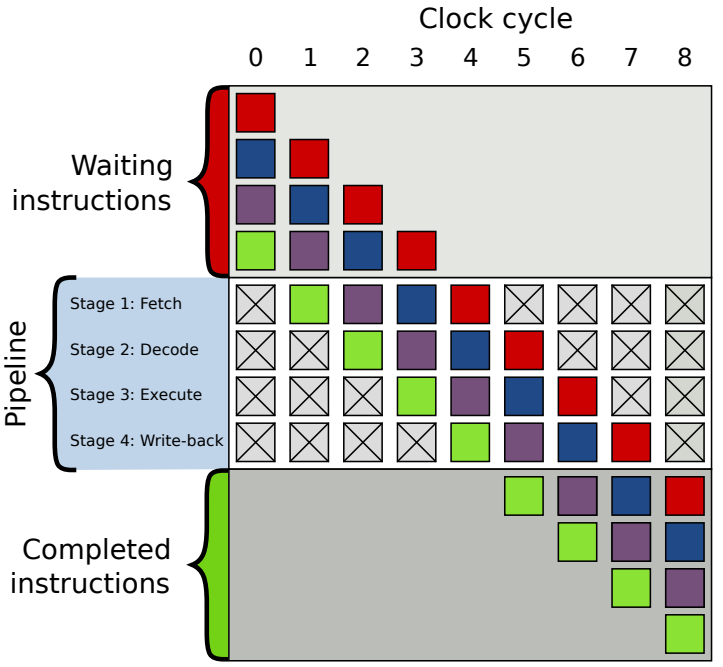
- Lex prefers longest prefix
  - Match multiple expressions (optimized?)
- Copies and unescapes each token
- Splits and rejoins labels
  - (re)allocate, cat, repeat
- Joins encoded data first

# But, why is it still slow?

- Dropped Lex and Yacc
  - Fields and order are (sort-of) fixed
- Cut (re)allocations
  - Maximum size 65535 bytes
- Yields around ~180 MB/s (with mmap)

# Pipelining

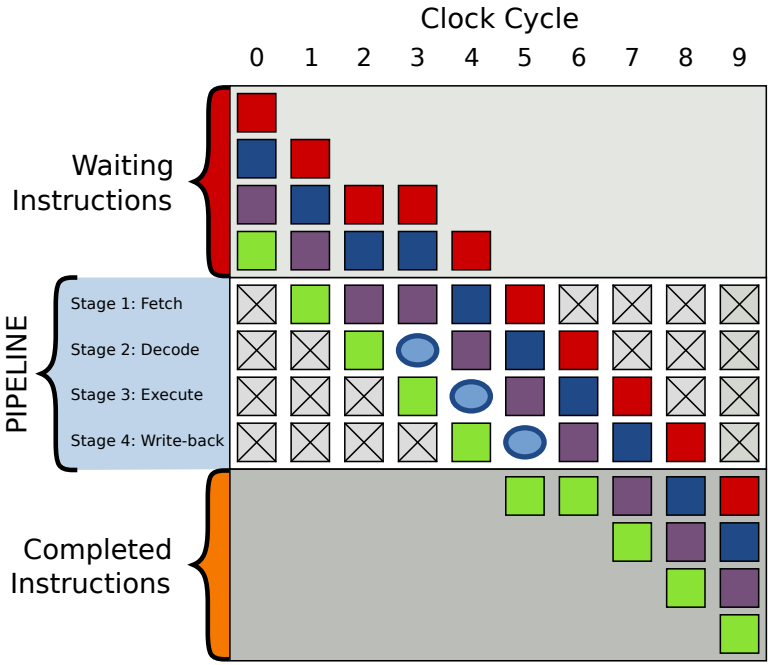
- Fetch, decode, execute and write-back happen simultaneously in various stages




https://en.wikipedia.org/wiki/Pipeline_stall

# Pipeline stalls

- Data dependencies introduce a delay in execution, aka stall
- Basically, given **a + b = c** and **c + d = e**, the latter cannot be decoded before result of the former is written back
- NOP (no operation) cycles are called “bubbles”




https://en.wikipedia.org/wiki/Pipeline_stall

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# Pipeline flushes

- Jump instructions, e.g. **if** statements, may require fetched instructions to be discarded
- Branch prediction is used to improve flow
  - Mispredicted branches require a flush

# So, why is it not fast yet?

- State machine is sequential
- Hard to predict branches on user input

# Single instruction, multiple data

- Instruction set(s)
  - Vector registers and instructions
- Interest sparked by simdjson
  - Expresses throughput in GB/s
  - Talk by Daniel Lemire https://www.youtube.com/watch?v=wlvKAT7SZIQ
  - Paper by Geoff Langdale and Daniel Lemire https://arxiv.org/abs/1902.08318

# Classify blocks, not bytes

- Quickly identify 16, 32 or 64 bytes (in a set)


- Repeat multiple times
  - backslash, quote, semicolon, newline, special and space
- Cut branches and dependencies

Checkout Wojciech Muła's article (http://0x80.pl/articles/simd-byte-lookup.html)

# Vertical, not horizontal

- Single operation, no logic
- Create mask for logic operations

| @ | | S | O | A | tab | ( | ... | | 3 | 6 | 0 | 0 | ) | cr | lf |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | FF | | | | FF | | | FF | | | | | | FF | |
| 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |

# Classify escaped bits

- Find escaped characters
  - Follows odd sequence of backslashes

(“ \\ \ \\\ ”) `0110101110` > `0000010001`

# Classify quoted bits

- Mask quoted and comment
  - Semicolons in quoted, both in comments
  - Newlines only for comments
  - Hard to solve, branch for comments

(“”;” ; “;”\n”) `1110101111` > `1010100001` > `1100111110`

# Classify contiguous bits

- Bits that remain are contiguous

  (“”x”yyy;z\n”) `110000110` … `101000000` > `000111000`

- Identify transitions
  - Required for zone data, depends on format

  (“”x”yyy;z\n”) `101100101`

# Transitioning from bits

- Write out transitions
  - Uses fast bit counts
  - Complete tokens only, avoid branches
  - Sliding window, not continuous
- Unlikely branch to defer line count

# . . .

- Speedup text to wire conversion for names
  - Scan for non-escaped dots
  - Iterate over indexes
  - Fill in label lengths ((i + 1) - i)

# Sort-of perfect hash

- First char is primary key
  - Alphabetic, select 16 byte table
- Last char + length is secondary key
  - Alphanumeric (so far)
  - Multiply for good distribution (x + 1 = y)
  - Add length (no clashes so far)
  - Use SIMD compare-equal
- Simply alter “hash” if collisions occur

# But wait, there’s more

- Numbers and strings
  - Algorithms used in simdjson can likely be adopted
- Base64
  - Wojciech Muła and Daniel Lemire wrote a paper:
    “Faster Base64 Encoding and Decoding Using AVX2 Instructions”
- Hexadecimal
  - Geoff Langdale and Wojciech Muła wrote an article:
    ”Parsing hex numbers with validation”
- IP address conversion
  - “Fastest way to get IPv4 address from string”

# So nice, they compile it twice!

- More-or-less. Depends on architecture
  - SSE4.2, AVX2, AVX-512 for x86_64
- Use CPUID to select implementation
  - Do once at start, defeats purpose otherwise

# Are we there yet?

- In progress, definitely on right track!
  - Needs polish, working towards a release
- 700MB/s, aiming for 1GB/s
  - Depends on input too
- https://github.com/NLnetLabs/simdzone
  - Standalone, modern C library (BSD-3-Clause)
  - Easy to integrate and contribute

# Acknowledgments

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# Questions?

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If you find this interesting, extra pair(s) of eyes and/or hands are always welcome!

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