Structured logging

Bartek ’BaSz’ Szurgot

https://www.baszerr.eu

November 12, 2017

Intro

Who am I?

- Dealing with:
  - **C++**
  - **Linux**
  - Embedded SW
  - Distributed SW
  - Algorithms and data structures
  - DevOps
  - Security
  - Electronics
  - 3D printing

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- **Ba**rtek **Sz**urgot $\Longrightarrow$ **BaSz**
- `#!/bin/`**bash**

A tale of a string search

A tale of a string search

```
1  template<unsigned N>
2  char* findX(char (&str)[N])
3  {
4    for(auto it=str; it!=str+N; ++it)
5      if(*it == 'x')
6        return it;
7    return nullptr;
8  }
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String search – *sentinel*

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8    str[N-1] = 0;
9    if(it == str+N-1)
10     return nullptr;
11   return it;
12 }
```

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"Just" logging?!

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Tale of an addressing scheme. . .

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  - Reasonabely easy to `grep`-through

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http://s.quickmeme.com/img/c9/c9d627a0808351c4389ee4a7ef591240b64c7cf8844f979e9d646e26a872dff4.jpg

What’s on the menu? (ELK-referenced)

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Generation Transforming Indexing Analyzing

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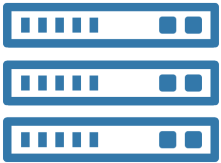

http://nephoscale.com/_img/dedicated-server.png
https://www.javacodegeeks.com/wp-content/uploads/2013/06/logo-icon.png
https://michael.bouvy.net/blog/wp-content/uploads/2013/11/logstash.png
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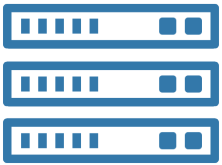
Analyzing



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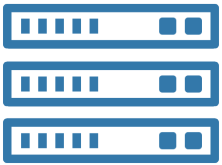

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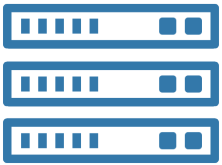

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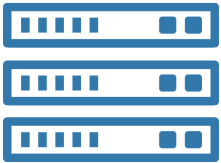

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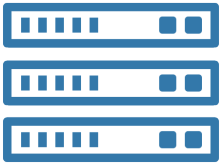

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Coding part. . .

- Highly simplified
- Ignored:
  - Corner cases
  - Thread-safety
  - Optimizations
  - Error handling
  - OOP wrappers
  - Encapsulation
  - Consts
  - . . .
  - . . .
- Readability++

https://i1.wp.com/dbakevlar.com/wp-content/uploads/2016/03/too-easy.png

What is log?

Any ideas?

Any ideas?

```
1  72.27.10.1 - - [10/Sep/2017:09:01:35] "GET␣/ThreadPool.ut.cpp␣HTTP/1.1" 200 4794 "http://localhost/" "MyBrowser-xx" "-"
2  72.27.10.1 - - [10/Sep/2017:09:01:34] "Error␣processing␣/ThreadPool.ut.cpp␣-␣404␣-␣no␣such␣file␣of␣directory"
3  72.27.10.1 - - [10/Sep/2017:09:01:34] "GET␣/CacheLine.ut.cpp␣HTTP/1.1" 200 2185 "http://localhost/" "MyBrowser-xx" "-"
4  72.7.0.1 - - [10/Sep/2017:09:01:35] "GET␣/ThreadPool.ut.cpp␣HTTP/1.1" 200 4794 "http://localhost/" "MyBrowser-xx" "-"
5  72.7.30.1 - - [10/Sep/2017:09:01:34] "Error␣processing␣/ThreadPool.ut.cpp␣-␣404␣-␣no␣such␣file␣of␣directory"
6  72.17.0.221 - - [10/Sep/2017:09:01:28] "GET␣/␣HTTP/1.1" 200 2721 "-" "MyBrowser-xx" "-"
7  72.7.0.1 - - [10/Sep/2017:09:01:31] "GET␣/ActiveObject.ut.cpp␣HTTP/1.1" 200 1107 "http://localhost/" "MyBrowser-xx" "-"
8  72.7.0.1 - - [10/Sep/2017:09:01:33] "GET␣/Fifo.hpp␣HTTP/1.1" 200 3754 "http://localhost/" "MyBrowser-xx" "-"
9  72.7.0.1 - - [10/Sep/2017:09:01:31] "GET␣/ActiveObject.ut.cpp␣HTTP/1.1" 200 1107 "http://localhost/" "MyBrowser-xx" "-"
10 72.7.0.1 - - [10/Sep/2017:09:01:33] "GET␣/Fifo.hpp␣HTTP/1.1" 200 3754 "http://localhost/" "MyBrowser-xx" "-"
11 1.32.0.1 - - [10/Sep/2017:09:01:34] "GET␣/Provider.hpp␣HTTP/1.1" 200 1201 "http://localhost/" "MyBrowser-xx" "-"
12 172.227.10.1 - - [10/Sep/2017:09:01:34] "GET␣/CacheLine.ut.cpp␣HTTP/1.1" 200 2185 "http://localhost/" "MyBrowser-xx" "-"
13 72.7.0.1 - - [10/Sep/2017:09:01:35] "GET␣/ThreadPool.ut.cpp␣HTTP/1.1" 200 4794 "http://localhost/" "MyBrowser-xx" "-"
14 72.7.0.1 - - [10/Sep/2017:09:01:34] "Error␣processing␣/ThreadPool.ut.cpp␣-␣404␣-␣no␣such␣file␣of␣directory"
15 42.1.2.4 - - [10/Sep/2017:09:01:34] "GET␣/CacheLine.ut.cpp␣HTTP/1.1" 200 2185 "http://localhost/" "MyBrowser-xx" "-"
16 72.7.0.1 - - [10/Sep/2017:09:01:35] "GET␣/ThreadPool.ut.cpp␣HTTP/1.1" 200 4794 "http://localhost/" "MyBrowser-xx" "-"
17 72.7.0.1 - - [10/Sep/2017:09:01:36] "GET␣/JoiningThread.ut.cpp␣HTTP/1.1" 200 2099 "http://localhost/" "MyBrowser-xx" "-"
18 72.7.0.1 - - [10/Sep/2017:09:01:37] "GET␣/ThreadsCount.hpp␣HTTP/1.1" 200 474 "http://localhost/" "MyBrowser-xx" "-"
19 72.7.0.1 - - [10/Sep/2017:09:01:40] "GET␣/ActiveObject.hpp␣HTTP/1.1" 500 - "internal␣server␣error!"
20 172.7.222.191 - - [10/Sep/2017:09:01:41] "GET␣/50x.html␣HTTP/1.1" 200 537 "http://localhost/" "MyBrowser-xx" "-"
21 72.7.0.1 - - [10/Sep/2017:09:01:43] "GET␣/CacheLine.ut.cpp␣HTTP/1.1" 200 2185 "http://localhost/" "MyBrowser-xx" "-"
22 55.3.1.3 - - [10/Sep/2017:09:01:45] "GET␣/Provider.ut.cpp␣HTTP/1.1" 200 2689 "http://localhost/" "MyBrowser-xx" "-"
23 72.7.0.1 - - [10/Sep/2017:09:01:31] "GET␣/ActiveObject.ut.cpp␣HTTP/1.1" 200 1107 "http://localhost/" "MyBrowser-xx" "-"
24 72.7.0.1 - - [10/Sep/2017:09:01:33] "GET␣/Fifo.hpp␣HTTP/1.1" 200 3754 "http://localhost/" "MyBrowser-xx" "-"
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http://www.pd4pic.com/images/admittance-entry-prohibited-forbidden-not-allowed.png

Any ideas?

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Data structure!


O'REILLY
Copyrighted Material
I ♥ Logs
EVENT DATA, STREAM PROCESSING, AND DATA INTEGRATION
Jay Kreps
Copyrighted Material

System activity log

System activity log

```
{
  "timestamp": "2017-03-14T11:12:13Z",
  "priority": "warning",
  "process": "foo-bar daemon",
  "thread": "42",
  "message": "CPU 3 is overheating!"
}
```

System activity log

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{
  "timestamp": "2017-03-14T11:12:13Z",
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  "process": "foo-bar daemon",
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}
```

1. Common fields
2. User-defined message

Typical logger

stream-like?

```
1 myLog << "hello!␣the␣answer␣is:"
2       << answer << ",␣i␣guess...";
```

stream-like?

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1 myLog << "hello!␣the␣answer␣is:"
2       << answer << ",␣i␣guess...";
```

- Where is the end?

stream-like?

```
1 myLog << "hello!␣the␣answer␣is:"
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- Where is the end?
- See a typo?

stream-like?

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- What is the output? (`int answer=42`)

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```

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  1. `hello!  the answer is:2a, i guess...`

stream-like?

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  1. `hello!  the answer is:2a, i guess...`
  2. `hello!  the answer is:0x2a, i guess...`

stream-like?

```
1 myLog << "hello!␣the␣answer␣is:"
2       << answer << ",␣i␣guess...";
```

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- What is the output? (`int answer=42`)
  1. `hello!  the answer is:2a, i guess...`
  2. `hello!  the answer is:0x2a, i guess...`
  3. `hello!  the answer is:052, i guess...`

stream-like?

```
1 myLog << "hello! the answer is:"
2       << answer << ", i guess...";
```

- Where is the end?
- See a typo? Spaces, spaces...
- What is the output? (`int answer=42`)
  1. `hello!  the answer is:2a, i guess...`
  2. `hello!  the answer is:0x2a, i guess...`
  3. `hello!  the answer is:052, i guess...`
  4. etc...:/

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  1. `hello!  the answer is:2a, i guess...`
  2. `hello!  the answer is:0x2a, i guess...`
  3. `hello!  the answer is:052, i guess...`
  4. etc...:/
- Translations? :/

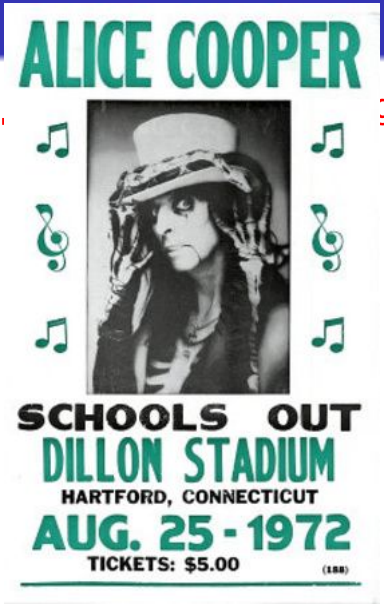
https://image.spreadshirtmedia.com/image-server/v1/compositions/1009027141/views/1,width=300,height=300,appearanceId=231,version=1461139005/where-s-your-god-now-women-s-t-shirts-women-s-t-shirt

printf-like?

```
1 log("hello!␣the␣answer␣is:␣%s,␣i␣guess...",
2     answer);
```

printf-like?

```
1 log("hello! the                    guess...",
2     answer);
```



printf-like?

```
1 log("hello!␣the␣answer␣is:␣%s,␣i␣guess...",
2     answer);
```

printf-like?

```
1 log("hello!␣the␣answer␣is:␣%s,␣i␣guess...",
2     answer);
```

- See a bug?

printf-like?

```
1 log("hello!␣the␣answer␣is:␣%s,␣i␣guess...",
2     answer);
```

- See a bug? Incompatible types!

printf-like?

```
1 log("hello!␣the␣answer␣is:␣%s,␣i␣guess...",
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- See a bug? Incompatible types!
- Runtime-parse of compile-time known format
- "Accidental" type erasure...

printf-like?

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```

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- Runtime-parse of compile-time known format
- "Accidental" type erasure...
- No support for non-standard types :/

printf-like?

```
1 log("hello!␣the␣answer␣is:␣%s,␣i␣guess...",
2     answer);
```

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- Runtime-parse of compile-time known format
- "Accidental" type erasure...
- No support for non-standard types :/
- Tried `printf` with templates? ;)

printf-like?

```
1 log("hello!␣the␣answer␣is:␣%s,␣i␣guess...",
2     answer);
```

- See a bug? Incompatible types!
- Runtime-parse of compile-time known format
- "Accidental" type erasure...
- No support for non-standard types :/
- Tried `printf` with templates? ;)
- Variadic templates? Close, but...

https://i.pinimg.com/736x/6d/dd/19/6ddd19ba7a71a85f6434251e3dd6e8f9.jpg

Output?

Output?

```
72.27.10.1 - - [10/Sep/2017:09:01:35] "GET /ThreadPool.ut.cpp HTTP/1.1" 200 4794 "http://localhost/" "MyBrowser-xx" "-"
72.27.10.1 - - [10/Sep/2017:09:01:34] "Error processing /ThreadPool.ut.cpp - 404 - no such file of directory"
72.27.10.1 - - [10/Sep/2017:09:01:34] "GET /CacheLine.ut.cpp HTTP/1.1" 200 2185 "http://localhost/" "MyBrowser-xx" "-"
72.7.0.1 - - [10/Sep/2017:09:01:35] "GET /ThreadPool.ut.cpp HTTP/1.1" 200 4794 "http://localhost/" "MyBrowser-xx" "-"
72.7.30.1 - - [10/Sep/2017:09:01:34] "Error processing /ThreadPool.ut.cpp - 404 - no such file of directory"
72.17.0.221 - - [10/Sep/2017:09:01:28] "GET / HTTP/1.1" 200 2721 "-" "MyBrowser-xx" "-"
72.7.0.1 - - [10/Sep/2017:09:01:31] "GET /ActiveObject.ut.cpp HTTP/1.1" 200 1107 "http://localhost/" "MyBrowser-xx" "-"
72.7.0.1 - - [10/Sep/2017:09:01:33] "GET /Fifo.hpp HTTP/1.1" 200 3754 "http://localhost/" "MyBrowser-xx" "-"
72.7.0.1 - - [10/Sep/2017:09:01:31] "GET /ActiveObject.ut.cpp HTTP/1.1" 200 1107 "http://localhost/" "MyBrowser-xx" "-"
72.7.0.1 - - [10/Sep/2017:09:01:33] "GET /Fifo.hpp HTTP/1.1" 200 3754 "http://localhost/" "MyBrowser-xx" "-"
1.32.0.1 - - [10/Sep/2017:09:01:34] "GET /Provider.hpp HTTP/1.1" 200 1201 "http://localhost/" "MyBrowser-xx" "-"
172.227.10.1 - - [10/Sep/2017:09:01:34] "GET /CacheLine.ut.cpp HTTP/1.1" 200 2185 "http://localhost/" "MyBrowser-xx" "-"
72.7.0.1 - - [10/Sep/2017:09:01:35] "GET /ThreadPool.ut.cpp HTTP/1.1" 200 4794 "http://localhost/" "MyBrowser-xx" "-"
72.7.0.1 - - [10/Sep/2017:09:01:34] "Error processing /ThreadPool.ut.cpp - 404 - no such file of directory"
42.1.2.4 - - [10/Sep/2017:09:01:34] "GET /CacheLine.ut.cpp HTTP/1.1" 200 2185 "http://localhost/" "MyBrowser-xx" "-"
72.7.0.1 - - [10/Sep/2017:09:01:35] "GET /ThreadPool.ut.cpp HTTP/1.1" 200 4794 "http://localhost/" "MyBrowser-xx" "-"
72.7.0.1 - - [10/Sep/2017:09:01:36] "GET /JoiningThread.ut.cpp HTTP/1.1" 200 2099 "http://localhost/" "MyBrowser-xx" "-"
72.7.0.1 - - [10/Sep/2017:09:01:37] "GET /ThreadsCount.hpp HTTP/1.1" 200 474 "http://localhost/" "MyBrowser-xx" "-"
72.7.0.1 - - [10/Sep/2017:09:01:40] "GET /ActiveObject.hpp HTTP/1.1" 500 - "internal server error!"
172.7.222.191 - - [10/Sep/2017:09:01:41] "GET /50x.html HTTP/1.1" 200 537 "http://localhost/" "MyBrowser-xx" "-"
72.7.0.1 - - [10/Sep/2017:09:01:43] "GET /CacheLine.ut.cpp HTTP/1.1" 200 2185 "http://localhost/" "MyBrowser-xx" "-"
55.3.1.3 - - [10/Sep/2017:09:01:45] "GET /Provider.ut.cpp HTTP/1.1" 200 2689 "http://localhost/" "MyBrowser-xx" "-"
72.7.0.1 - - [10/Sep/2017:09:01:31] "GET /ActiveObject.ut.cpp HTTP/1.1" 200 1107 "http://localhost/" "MyBrowser-xx" "-"
72.7.0.1 - - [10/Sep/2017:09:01:33] "GET /Fifo.hpp HTTP/1.1" 200 3754 "http://localhost/" "MyBrowser-xx" "-"
72.7.0.1 - - [10/Sep/2017:09:01:34] "GET /LockProxy.hpp HTTP/1.1" 200 1201 "http://localhost/" "MyBrowser-xx" "-"
72.7.0.1 - - [10/Sep/2017:09:01:34] "GET /CacheLine.ut.cpp HTTP/1.1" 200 2185 "http://localhost/" "MyBrowser-xx" "-"
```

Output?


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1  72.27.10.1 -
2  72.27.10.1 -
3  72.27.10.1 -
4  72.7.0.1 -
5  72.7.30.1 -
6  72.17.0.221
7  72.7.0.1 -
8  72.7.0.1 -
9  72.7.0.1 -
10 72.7.0.1 -
11 1.32.0.1 -
12 172.227.10.1
13 72.7.0.1 -
14 72.7.0.1 -
15 42.1.2.4 -
16 72.7.0.1 -
17 72.7.0.1 -
18 72.7.0.1 -
19 72.7.0.1 -
20 172.7.222.19
21 72.7.0.1 -
22 55.3.1.3 -
23 72.7.0.1 -
24 72.7.0.1 -
25 72.7.0.1 -
26 72.7.0.1 -
```

```
Browser-xx" "-"
tory"
rowser-xx" "-"
owser-xx" "-"
ory"

Browser-xx" "-"
 "-"
Browser-xx" "-"
 "-"
-xx" "-"
yBrowser-xx" "-"
owser-xx" "-"
ry"
wser-xx" "-"
owser-xx" "-"
yBrowser-xx" "-"
ser-xx" "-"

-xx" "-"
wser-xx" "-"
ser-xx" "-"
Browser-xx" "-"
 "-"
r-xx" "-"
wser-xx" "-"
```

http://windsorite.ca/wp-content/uploads/2016/09/20160930-153449-640x427.jpg
https://imgflip.com/i/1yf2il

Output?


```
1  72.27.10.1 -
2  72.27.10.1 -
3  72.27.10.1 -
4  72.7.0.1 -
5  72.7.30.1 -
6  72.17.0.221
7  72.7.0.1 -
8  72.7.0.1 -
9  72.7.0.1 -
10 72.7.0.1 -
11 1.32.0.1 -
12 172.227.10.1
13 72.7.0.1 -
14 72.7.0.1 -
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16 72.7.0.1 -
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18 72.7.0.1 -
19 72.7.0.1 -
20 172.7.222.19
21 72.7.0.1 -
22 55.3.1.3 -
23 72.7.0.1 -
24 72.7.0.1 -
25 72.7.0.1 -
26 72.7.0.1 -
```

```
Browser-xx" "-"
tory"
rowser-xx" "-"
owser-xx" "-"
ory"

Browser-xx" "-"
 "-"
Browser-xx" "-"
 "-"
-xx" "-"
yBrowser-xx" "-"
owser-xx" "-"
ry"
wser-xx" "-"
owser-xx" "-"
yBrowser-xx" "-"
ser-xx" "-"

-xx" "-"
wser-xx" "-"
ser-xx" "-"
Browser-xx" "-"
 "-"
r-xx" "-"
wser-xx" "-"
```

http://windsorite.ca/wp-content/uploads/2016/09/20160930-153449-640x427.jpg
https://imgflip.com/i/1yf2il

Idea

Problems to solve

Problems to solve

1. Uniform representation per type

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1. Uniform representation per type
2. **Machine-readable**

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3. User-types supported

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6. Compile-time checks

Problems to solve

1. Uniform representation per type
2. **Machine-readable**
3. User-types supported
4. Easy to use
5. No "internal states"
6. Compile-time checks
7. Possible translations

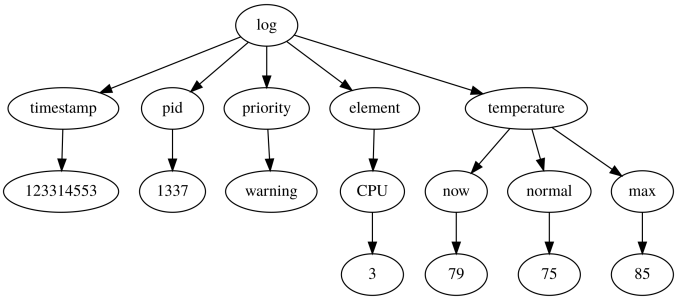
http://blogs.solidworks.com/tech/wp-content/uploads/sites/4/fish-upgrade.jpg

Expected output

- Structure-preserving

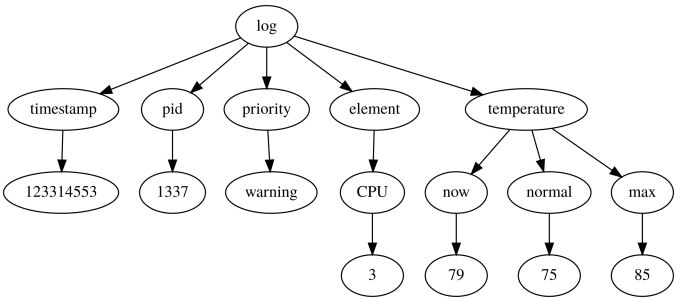
Expected output

- Structure-preserving



Expected output

- Structure-preserving
- Machine-readable
- Queryable!



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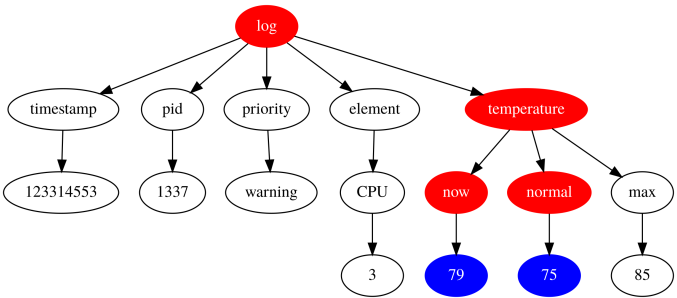

Expected output

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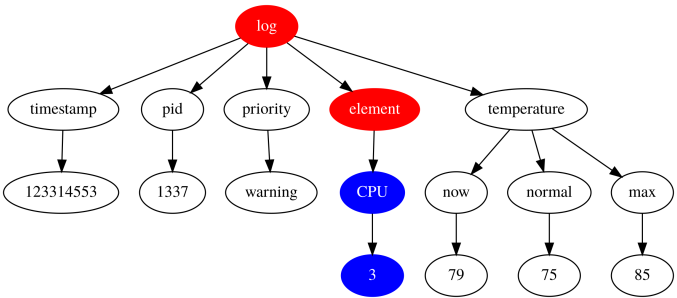

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- Structure-preserving
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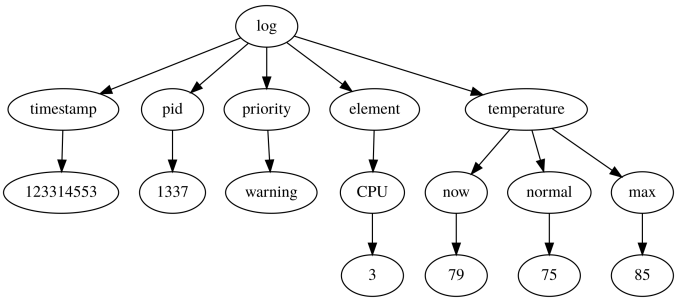
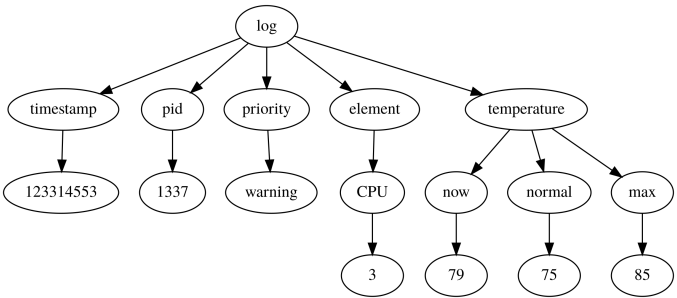


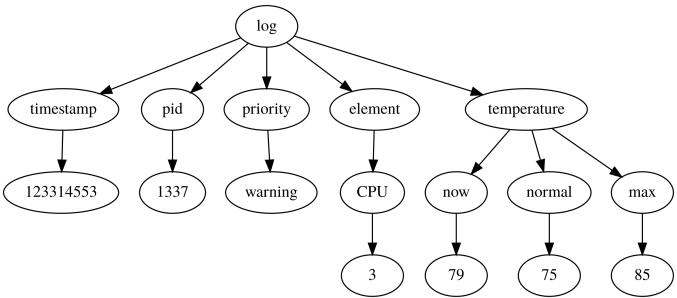
Expected output

- Structure-preserving
- Machine-readable
- Queryable!
- Examples:
  - JSON
  - XML
  - BSON
  - YML
  - ...

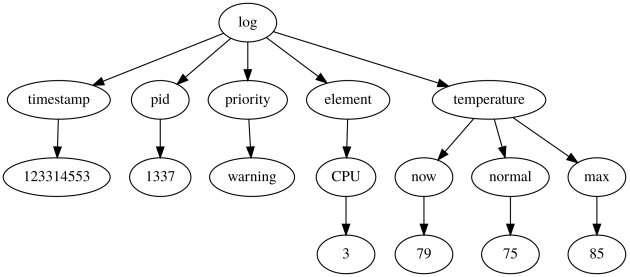


Expected output

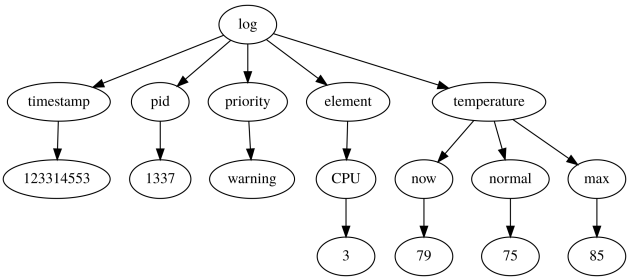
- Structure-preserving
- Machine-readable
- Queryable!
- Examples:
  - JSON
  - XML
  - BSON
  - YML
  - ...
- Text output? Bells and whistles...



JSON output example



JSON output example




```
1  {
2    "timestamp": 123314553,
3    "pid": 1337,
4    "priority": "warning",
5    "element": {
6      "CPU": 3
7    },
8    "temperature": {
9      "now": 79,
10     "normal": 75,
11     "max": 85
12   }
13 }
```

The Difference

The Difference

```
{
  "timestamp": 123314553,
  "pid": 1337,
  "priority": "warning",
  "message": "CPU␣3␣is␣
    ↪ overheating!␣current
    ↪ ␣temperature␣is␣79,␣
    ↪ normal␣is␣up␣to␣75;␣
    ↪ maximum␣temperature␣
    ↪ is␣85"
}
```

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      ↪  temperature is 79,
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```

http://www.fitnessmash.com/wp-content/uploads/2015/01/What-does-that-even-mean-meme.jpg

The Difference

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http://media02.hongkiat.com/geek-products/IP-Address-Door-Mat-geek.jpg

Possibilities

1. Filtering
2. Statistics
3. Reacting (!)

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```
{
  "timestamp": 1231234,
  "priority": "info",
  "pid": 4242,
  "path": "/images/924",
  "method": "GET",
  "response": {
    "status": 200,
    "processing_time_ms": 11
  }
}
```

Possibilities

1. Filtering
2. Statistics
3. Reacting (!)

```
{
  "timestamp": 1231234,
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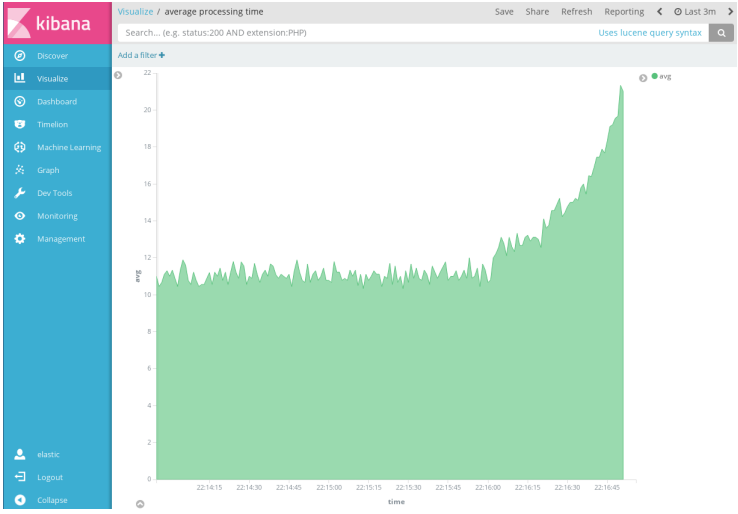
```



Possibilities

1. Filtering
2. Statistics
3. Reacting (!)

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  "timestamp": 1231234,
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  "method": "GET",
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```

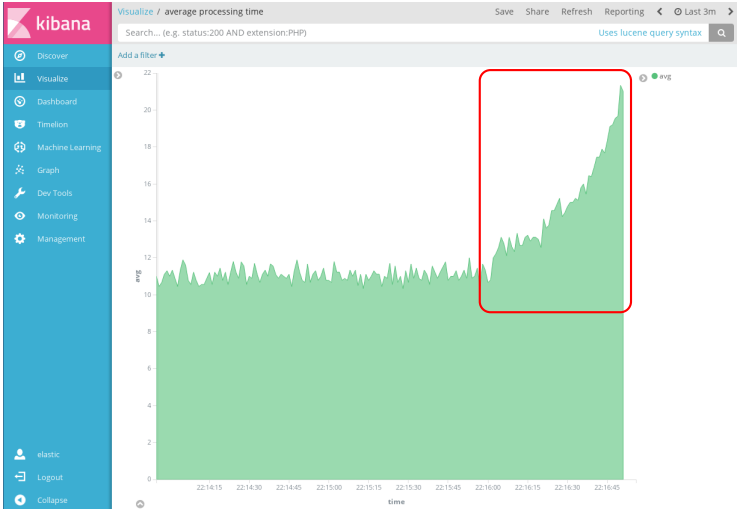

API

Simple log API

- Raw arguments
- **NO** explicit formatting

Simple log API

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- **NO** explicit formatting

```
1 log( Timestamp{}, Pid{}, Pri::warning,
2      // NOTE: optional text description
3      HwElement::CPU_3,
4      Temperature{getTemp(), 75, 85} );
```

Simple log API

- Raw arguments
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```
1 log( Timestamp{}, Pid{}, Pri::warning,
2      // NOTE: optional text description
3      HwElement::CPU_3,
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```
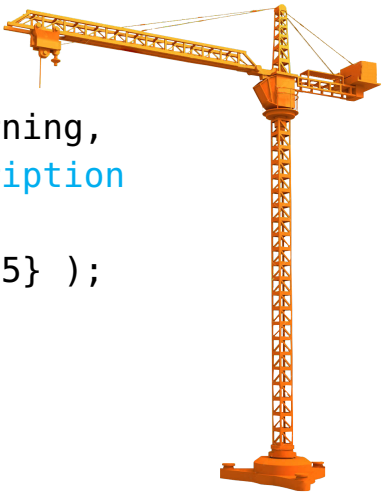

- Easy! :)
- Unified reprensetation

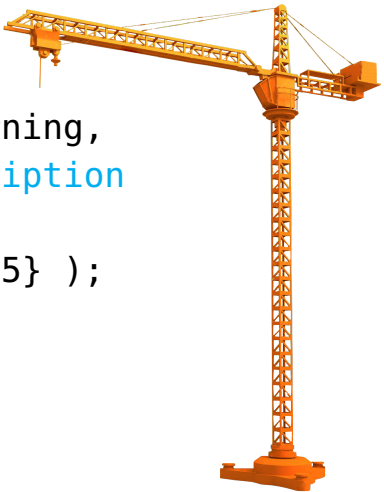


Simple log API

- Raw arguments
- **NO** explicit formatting

```
1 log( Timestamp{}, Pid{}, Pri::warning,
2      // NOTE: optional text description
3      HwElement::CPU_3,
4      Temperature{getTemp(), 75, 85} );
```

- Easy! :)
- Unified reprensetation
- All tagged
- ADL-based customization



http://f9india.com/images/Tower-Crane.png

"Formatted" log API

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- Optional
- Positions only
- Allow translations

"Formatted" log API

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```
1 log( "$0!␣($2+$1)/0␣does␣not␣count␣as␣math!",
2      Username{"Bob"}, 2, 40 );
```

"Formatted" log API

- Optional
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```
log( "$0!␣($2+$1)/0␣does␣not␣count␣as␣math!",
     Username{"Bob"}, 2, 40 );
```

- Order – yes!
- Style – no!

"Formatted" log API

- Optional
- Positions only
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1 log( "$0!␣($2+$1)/0␣does␣not␣count␣as␣math!",
2      Username{"Bob"}, 2, 40 );
```

- Order – yes!
- Style – no!
- **Checked at compile-time**

http://www.marcodesalvo.it/wp-content/uploads/2014/07/merge-ahead.gif

What about common fields?

What about common fields?

http://www.the-arcade.ie/wp-content/uploads/2015/01/good_news_everyone.jpg

Your fields – your wrapper!

```
1  template<typename... Args>
2  void info(Args& ...args)
3  {
4    log(Time{}, Pid{}, Pri::info, args...);
5  }
6  template<typename... Args>
7  void warning(Args& ...args)
8  {
9    log(Time{}, Pid{}, Pri::warning, args...);
10 }
11 // ...
```

Your fields – your wrapper!

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1  template<typename... Args>
2  void info(Args& ...args)
3  {
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7  void warning(Args& ...args)
8  {
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Your fields – your wrapper!

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1  template<typename... Args>
2  void info(Args& ...args)
3  {
4    log(Time{}, Pid{}, Pri::info, args...);
5  }
6  template<typename... Args>
7  void warning(Args& ...args)
8  {
9    log(Time{}, Pid{}, Pri::warning, args...);
10 }
11 // ...
```
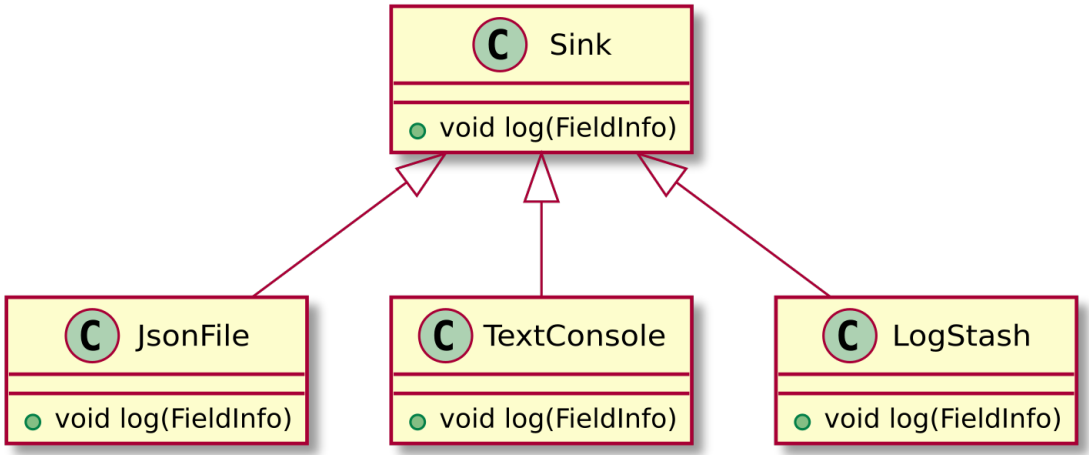
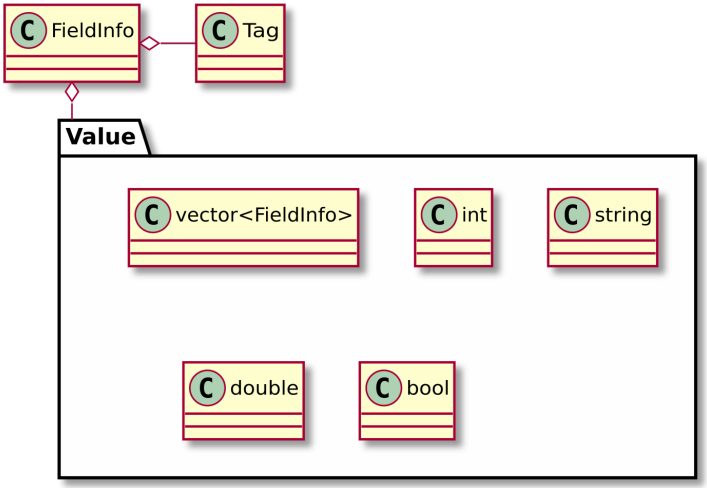

Logs' destination



Log represenation

Logical view



Implementation

```
1  struct FieldInfo
2  {
3    string tag_;
4    variant<
5            int, double, bool,
6            string,
7            vector<FieldInfo>
8          > value_;
9
10   FieldInfo& retag(string tag);
11 };
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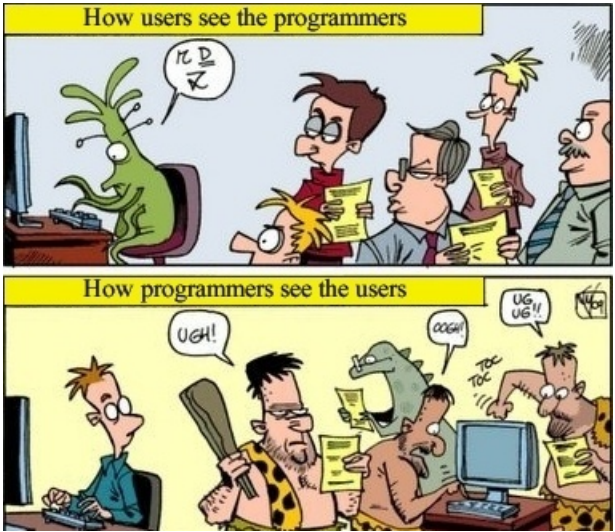
Recursive, variadic template?!

Recursive, variadic template?!

http://lifestyle.iloveindia.com/lounge/images/how-to-fix-computer-errors.jpg

User’s perspective



https://baszerr.eu/lib/exe/fetch.php/humour/programmers_and_users.jpg

Basic types

```
1 FieldInfo toFieldInfo(int);
2 FieldInfo toFieldInfo(bool);
3 FieldInfo toFieldInfo(double);
4 FieldInfo toFieldInfo(string);
```

http://thrivebybecky.com/wp-content/uploads/2013/06/Puzzle-Piece-Hand.jpg

User API – simple types

```
1  #include "FieldInfo.hpp"
2
3  struct Name
4  {
5    string value_;
6  };
7
8  inline FieldInfo toFieldInfo(Name name)
9  {
10   return toFieldInfo(name.value_).retag("name");
11 }
```

User API – simple types

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1  #include "FieldInfo.hpp"
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3  struct Name
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6  };
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11 }
```

User API – multi-field types

```
1  struct Point2D
2  {
3    int x_;
4    int y_;
5  };
6  inline auto toFieldInfo(Point2D p)
7  {
8    return FieldInfo{"point_2D",
9        { toFieldInfo(p.x_).retag("OX"),
10         toFieldInfo(p.y_).retag("OY") } };
11 }
```

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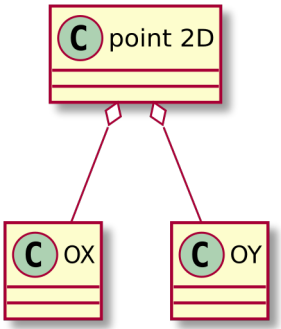

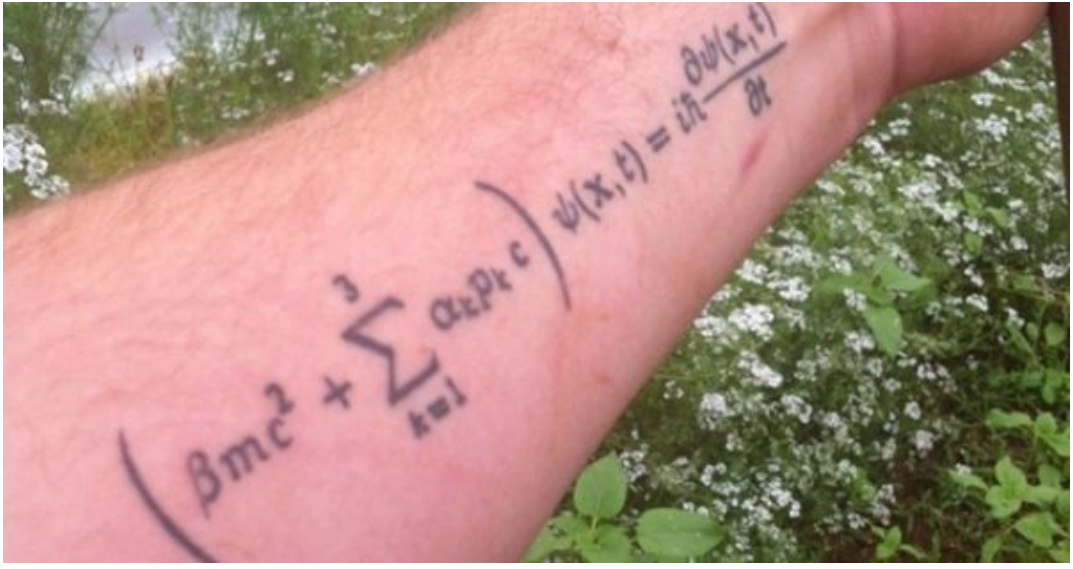

https://i.pinimg.com/600x315/a3/1a/e4/a31ae464ba243ba555b39f3b41444cfc.jpg

User API – nested types

```
1  struct Vector2D
2  {
3    Point2D from_;
4    Point2D to_;
5  };
6  inline auto toFieldInfo(Vector2D v)
7  {
8    return FieldInfo{"vector_2D",
9        { toFieldInfo(v.from_).retag("from"),
10         toFieldInfo(v.to_).retag("to") } };
11 }
```

User API – nested types

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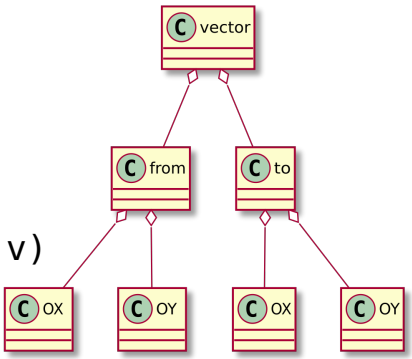
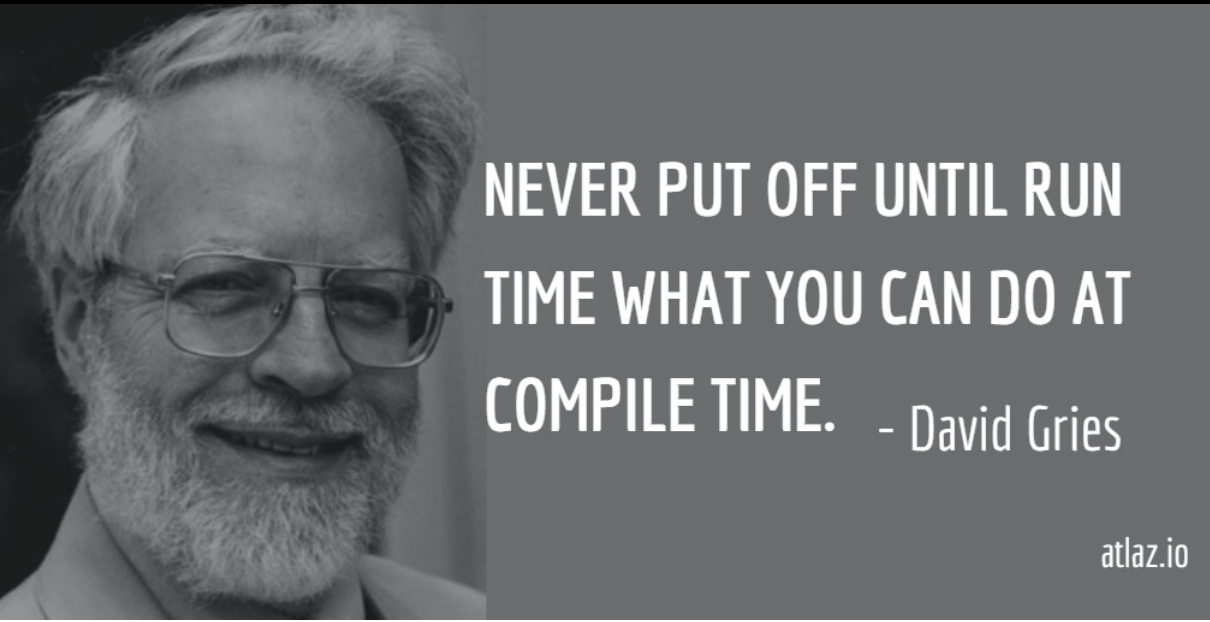


https://imgflip.com/i/1yme2m

Formatting



https://atlaz.io/blog/wp-content/uploads/2017/04/pablo-25.png

Logger with format

```
1 template<int N, typename... Args>
2 void log(Format<N> fmt, Args const&... args)
3 {
4   static_assert( N == sizeof...(args),
5                  "arity␣does␣not␣match");
6   format(fmt, args...);
7   // ...
8 }
```

Logger with format

```
1 template<int N, typename... Args>
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5                  "arity does not match");
6   format(fmt, args...);
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8 }
```

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7   // ...
8 }
```

String parsing

```
1  constexpr int formatCheckArity(char const* fmt)
2  {
3    const auto count = uniqueArgs(fmt);
4    if( count == 0 )
5      return 0;
6    const auto pos = lastArgPos(fmt);
7    if( count != pos + 1 )
8      throw std::runtime_error{"not all used"};
9    return count;
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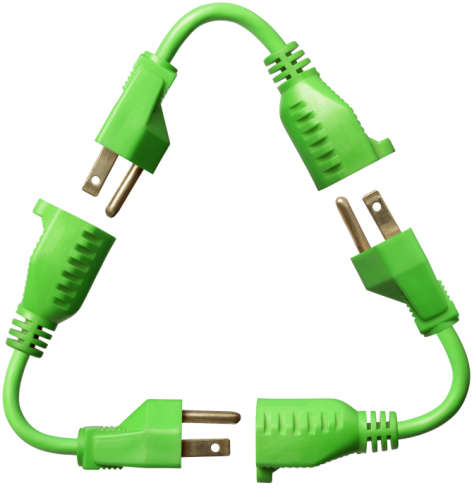
```

Glue it up!



http://powerplug-in.com/wp-content/uploads/2011/02/iStock_000007427834Small.jpg

Formatting

```
1 template<int N>
2 struct Format
3 {
4   char const* value_;
5 };
6
7 #define FORMAT(fmt) \
8   Format< formatCheckArity(fmt) >{fmt}
```

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Usage

```
1 log( FORMAT("$1 is $0"), 42, "answer" );
2 log( FORMAT("$0/$0 == 1"), 42 );
3 //log( FORMAT("$2 is $0"), 42, "answer" );
4 //log( FORMAT("answer is $0"), 42, "answer" );
5
6 #define LOGF(fmt, ...) \
7   log( FORMAT(fmt), __VA_ARGS__ )
8 LOGF("$0 != $1", 4, 2);
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  - Input: `"pass the salt, $0"`
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  - Input: `"pass the salt, $0"`
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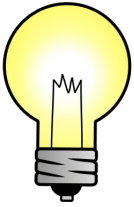
  - `FORMAT("use english only here")`
  - Text-based index!
  - `std::map<std::string, std::string>`



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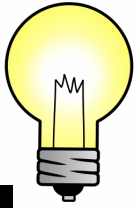
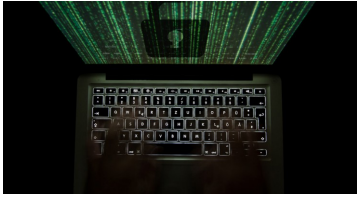
  - `grep 'FORMAT('`
  - `#define` custom `FORMAT`
  - Clang's AST tool





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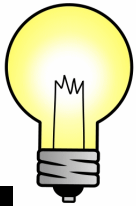
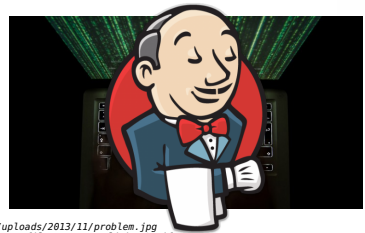




http://extra.shu.ac.uk/sbsblog/wp-content/uploads/2013/11/problem.jpg
http://www.how-to-draw-funny-cartoons.com/image-files/cartoon-light-8.gif
https://www.gohacking.com/wp-content/uploads/2015/01/how-to-hack-a-computer-735x400.jpg
https://www.rosehosting.com/blog/wp-content/uploads/2014/11/jenkins.png

Summary

Logging

```
1  72.27.10.1 - - [10/Sep/2017:09:01:35] "GET /ThreadPool.ut.cpp HTTP/1.1" 200 4794 "http://localhost/" "MyBrowser-xx" "-"
2  72.27.10.1 - - [10/Sep/2017:09:01:34] "Error processing /ThreadPool.ut.cpp - 404 - no such file of directory"
3  72.27.10.1 - - [10/Sep/2017:09:01:34] "GET /CacheLine.ut.cpp HTTP/1.1" 200 2185 "http://localhost/" "MyBrowser-xx" "-"
4  72.7.0.1 - - [10/Sep/2017:09:01:35] "GET /ThreadPool.ut.cpp HTTP/1.1" 200 4794 "http://localhost/" "MyBrowser-xx" "-"
5  72.7.30.1 - - [10/Sep/2017:09:01:34] "Error processing /ThreadPool.ut.cpp - 404 - no such file of directory"
6  72.17.0.221 - - [10/Sep/2017:09:01:28] "GET / HTTP/1.1" 200 2721 "-" "MyBrowser-xx" "-"
7  72.7.0.1 - - [10/Sep/2017:09:01:31] "GET /ActiveObject.ut.cpp HTTP/1.1" 200 1107 "http://localhost/" "MyBrowser-xx" "-"
8  72.7.0.1 - - [10/Sep/2017:09:01:33] "GET /Fifo.hpp HTTP/1.1" 200 3754 "http://localhost/" "MyBrowser-xx" "-"
9  72.7.0.1 - - [10/Sep/2017:09:01:31] "GET /ActiveObject.ut.cpp HTTP/1.1" 200 1107 "http://localhost/" "MyBrowser-xx" "-"
10 72.7.0.1 - - [10/Sep/2017:09:01:33] "GET /Fifo.hpp HTTP/1.1" 200 3754 "http://localhost/" "MyBrowser-xx" "-"
11 1.32.0.1 - - [10/Sep/2017:09:01:34] "GET /Provider.hpp HTTP/1.1" 200 1201 "http://localhost/" "MyBrowser-xx" "-"
12 172.227.10.1 - - [10/Sep/2017:09:01:34] "GET /CacheLine.ut.cpp HTTP/1.1" 200 2185 "http://localhost/" "MyBrowser-xx" "-"
13 72.7.0.1 - - [10/Sep/2017:09:01:35] "GET /ThreadPool.ut.cpp HTTP/1.1" 200 4794 "http://localhost/" "MyBrowser-xx" "-"
14 72.7.0.1 - - [10/Sep/2017:09:01:34] "Error processing /ThreadPool.ut.cpp - 404 - no such file of directory"
15 42.1.2.4 - - [10/Sep/2017:09:01:34] "GET /CacheLine.ut.cpp HTTP/1.1" 200 2185 "http://localhost/" "MyBrowser-xx" "-"
16 72.7.0.1 - - [10/Sep/2017:09:01:35] "GET /ThreadPool.ut.cpp HTTP/1.1" 200 4794 "http://localhost/" "MyBrowser-xx" "-"
17 72.7.0.1 - - [10/Sep/2017:09:01:36] "GET /JoiningThread.ut.cpp HTTP/1.1" 200 2099 "http://localhost/" "MyBrowser-xx" "-"
18 72.7.0.1 - - [10/Sep/2017:09:01:37] "GET /ThreadsCount.hpp HTTP/1.1" 200 474 "http://localhost/" "MyBrowser-xx" "-"
19 72.7.0.1 - - [10/Sep/2017:09:01:40] "GET /ActiveObject.hpp HTTP/1.1" 500 - "internal server error!"
20 172.7.222.191 - - [10/Sep/2017:09:01:41] "GET /50x.html HTTP/1.1" 200 537 "http://localhost/" "MyBrowser-xx" "-"
21 72.7.0.1 - - [10/Sep/2017:09:01:43] "GET /CacheLine.ut.cpp HTTP/1.1" 200 2185 "http://localhost/" "MyBrowser-xx" "-"
22 55.3.1.3 - - [10/Sep/2017:09:01:45] "GET /Provider.ut.cpp HTTP/1.1" 200 2689 "http://localhost/" "MyBrowser-xx" "-"
23 72.7.0.1 - - [10/Sep/2017:09:01:31] "GET /ActiveObject.ut.cpp HTTP/1.1" 200 1107 "http://localhost/" "MyBrowser-xx" "-"
24 72.7.0.1 - - [10/Sep/2017:09:01:33] "GET /Fifo.hpp HTTP/1.1" 200 3754 "http://localhost/" "MyBrowser-xx" "-"
25 72.7.0.1 - - [10/Sep/2017:09:01:34] "GET /LockProxy.hpp HTTP/1.1" 200 1201 "http://localhost/" "MyBrowser-xx" "-"
26 72.7.0.1 - - [10/Sep/2017:09:01:34] "GET /CacheLine.ut.cpp HTTP/1.1" 200 2185 "http://localhost/" "MyBrowser-xx" "-"
```

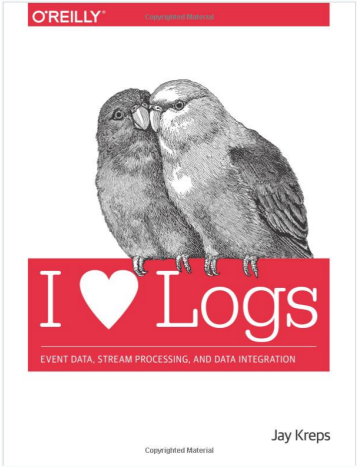
http://www.pd4pic.com/images/admittance-entry-prohibited-forbidden-not-allowed.png

Logging

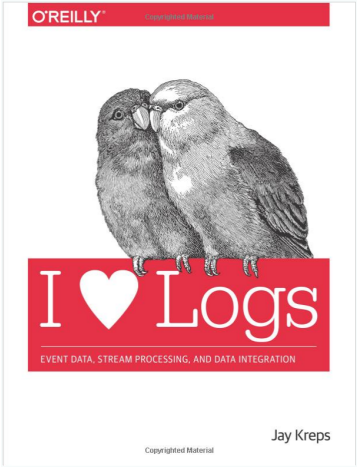
```
72.27.10.1 - - [10/Sep/2017:09:01:35] "GET␣/Th [illegible] HTTP/1.1" 200 4794 "http://localhost/" "MyBrowser-xx" "-"
72.27.10.1 - - [10/Sep/2017:09:01:34] "E [illegible] ut.cpp␣-␣404␣-␣no␣such␣file␣of␣directory"
72.27.10.1 - - [10/Sep/2017:09:01:34] [illegible] 200 2185 "http://localhost/" "MyBrowser-xx" "-"
72.7.0.1 - - [10/Sep/2017:09:01:35] [illegible]readPool.ut.cpp␣HT [illegible] 4794 "http://localhost/" "MyBrowser-xx" "-"
72.7.30.1 - - [10/Sep/2017:09:01 [illegible]or␣processing␣/ThreadPool. [illegible] 404␣-␣no␣such␣file␣of␣directory"
72.17.0.221 - - [10/Sep/2017:09 [illegible]ET␣/␣HTTP/1.1" 200 [illegible]1 "-" [illegible]er-xx" "-"
72.7.0.1 - - [10/Sep/2017:09: [illegible]ctiveObject [illegible]1.1" [illegible]07 "http://localhost/" "MyBrowser-xx" "-"
72.7.0.1 - - [10/Sep/2017:09 [illegible]] "GE [illegible].hpp␣HTTP [illegible]54 "ht [illegible]ocalhost/" "MyBrowser-xx" "-"
72.7.0.1 - - [10/Sep/2017:0 [illegible]1] "GET␣/ [illegible]Object [illegible]1.1" 20 [illegible] "http://localhost/" "MyBrowser-xx" "-"
72.7.0.1 - - [10/Sep/2017:0 [illegible]33] "GET␣/Fi [illegible] HTT [illegible]54 [illegible]alhost/" "MyBrowser-xx" "-"
1.32.0.1 - - [10/Sep/2017: [illegible]34] [illegible]01 "h [illegible]/localhost/" "MyBrowser-xx" "-"
172.227.10.1 - - [10/Sep/2 [illegible]9:01 [illegible]/Ca [illegible]1" 200 [illegible] "http://localhost/" "MyBrowser-xx" "-"
72.7.0.1 - - [10/Sep/2017: [illegible]:35 [illegible] 200 47 [illegible]tp://localhost/" "MyBrowser-xx" "-"
72.7.0.1 - - [10/Sep/2017: [illegible]34 [illegible]roc [illegible]cpp␣-␣4 [illegible]o␣such␣file␣of␣directory"
42.1.2.4 - - [10/Sep/2017: [illegible]34] [illegible]cheL [illegible] 200 218 [illegible]tp://localhost/" "MyBrowser-xx" "-"
72.7.0.1 - - [10/Sep/2017:0 [illegible]1" 200 4 [illegible]ttp://localhost/" "MyBrowser-xx" "-"
72.7.0.1 - - [10/Sep/2017:0 [illegible]/1.1" 2 [illegible]9 "http://localhost/" "MyBrowser-xx" "-"
72.7.0.1 - - [10/Sep/2017:09 [illegible] 200 [illegible]ttp://localhost/" "MyBrowser-xx" "-"
72.7.0.1 - - [10/Sep/2017:09: [illegible]ctiveObject [illegible]ternal␣server␣error!"
172.7.222.191 - - [10/Sep/2017. [illegible]"GET␣/50x.html␣HTTP/1.1" 2 [illegible]tp://localhost/" "MyBrowser-xx" "-"
72.7.0.1 - - [10/Sep/2017:09:01:4 [illegible]/CacheLine.ut.cpp␣HTTP/1.1 [illegible]85 "http://localhost/" "MyBrowser-xx" "-"
55.3.1.3 - - [10/Sep/2017:09:01:45] [illegible]vider.ut.cpp␣HTTP [illegible]689 "http://localhost/" "MyBrowser-xx" "-"
72.7.0.1 - - [10/Sep/2017:09:01:31] [illegible] 200 1107 "http://localhost/" "MyBrowser-xx" "-"
72.7.0.1 - - [10/Sep/2017:09:01:33] "GET␣/ [illegible]754 "http://localhost/" "MyBrowser-xx" "-"
72.7.0.1 - - [10/Sep/2017:09:01:34] "GET␣/LockF [illegible]/1.1" 200 1201 "http://localhost/" "MyBrowser-xx" "-"
72.7.0.1 - - [10/Sep/2017:09:01:34] "GET␣/CacheLine.ut.cpp␣HTTP/1.1" 200 2185 "http://localhost/" "MyBrowser-xx" "-"
```

http://www.pd4pic.com/images/admittance-entry-prohibited-forbidden-not-allowed.png

Data structure

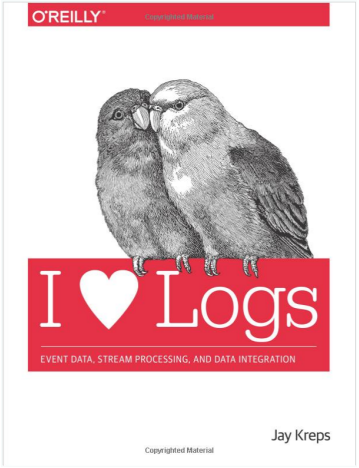


Data structure



- Log as data structure!
- ~50 pages! :)

Data structure



- Log as data structure!
- ~50 pages! :)

Jay Kreps

Logs meant for humans to read are a sort of anachronism.

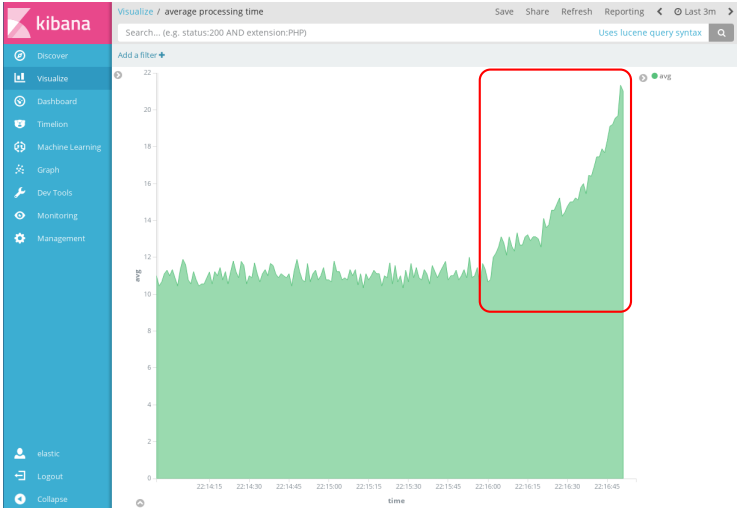
Logs are coming!

http://walldiskpaper.com/wp-content/uploads/2015/01/All-Elephant-Running-Wallpapers.jpg

Keep’em structured!

```
{
  "timestamp": 1231234,
  "priority": "info",
  "pid": 4242,
  "path": "/images/924",
  "method": "GET",
  "response": {
    "status": 200,
    "processing_time_ms": 11
  }
}
```

- **Machine**-readable!
- Automate



Example implementation

https://github.com/el-bart/but

- BUT::Log
  - C++14
  - Open-source
  - BSD-revised

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- BUT::Log
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- Presented concept
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Example implementation

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- BUT::Log
  - C++14
  - Open-source
  - BSD-revised
- Presented concept
- Extra Sinks, etc...
- Docker-based SDK

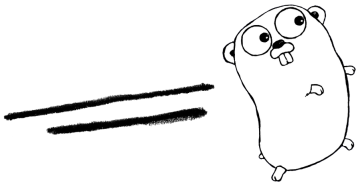
SDK with Docker talk

https://upload.wikimedia.org/wikipedia/commons/4/4e/Docker_container_engine_logo.svg

Universal idea

https://upload.wikimedia.org/wikipedia/commons/2/23/Golang.png
https://upload.wikimedia.org/wikipedia/en/3/30/Java_programming_language_logo.svg
https://upload.wikimedia.org/wikipedia/commons/f/f8/Python_logo_and_wordmark.svg
https://upload.wikimedia.org/wikipedia/commons/0/0d/C_Sharp_wordmark.svg
https://upload.wikimedia.org/wikipedia/commons/7/73/Ruby_logo.svg

Universal idea



C#

https://upload.wikimedia.org/wikipedia/commons/2/23/Golang.png
https://upload.wikimedia.org/wikipedia/en/3/30/Java_programming_language_logo.svg
https://upload.wikimedia.org/wikipedia/commons/f/f8/Python_logo_and_wordmark.svg
https://upload.wikimedia.org/wikipedia/commons/0/0d/C_Sharp_wordmark.svg
https://upload.wikimedia.org/wikipedia/commons/7/73/Ruby_logo.svg

Q&A

```
log("?");
```

https://www.baszerr.eu