Creating a Custom Serialization Format

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What are we doing here?

1. Motivations
2. Queries
3. The Format
4. Performance
5. Future

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1. Motivations

"The field is too in love with horribly inefficient frameworks. Writing network code and protocols is now considered too low level for people."

- jnordwick (Hacker News)

Motivations

- Computers make meaning out of voltages
- Serialization is everywhere
  - Network protocols
  - Video encoding
  - Machine code
  - HTTP/2 headers
  - Hard drive communication
  - Video display
- Engineers should know what's inside the black box

Motivations

- JSON is the de facto serialization format
- Common pattern:
  1. Get entire document
  2. Inflate serialized data
  3. Walk data structure & extract
- New pattern:
  1. Query the document
  2. Get only the data you need
  3. Still need to inflate

Motivations

- Query capabilities over JSON documents
- Documents stored as a byte array

JSON Document (Augmented)

```
{
  "null"    : null,
  "boolean" : true,
  "integer" : 1,
  "float"   : 2.3,
  "string"  : "a string",
  "array"   : [4, 5, 6],
  "map"     : {"foo": 1}
}
```

2. Queries

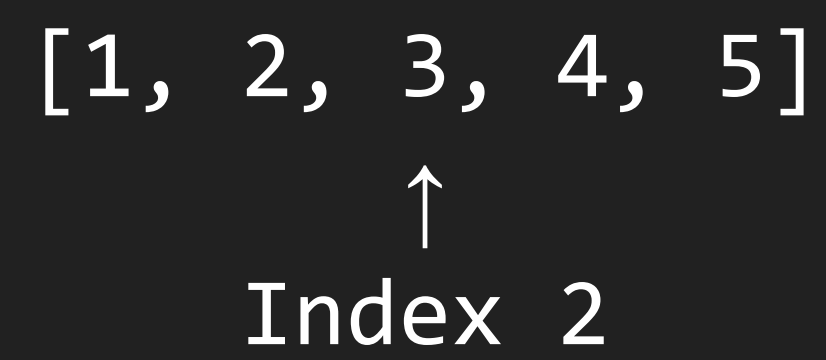
Query Types

- Array Index
- Array Slice
- Array Iteration

- Map Access
- Map Keys
- Map Iteration

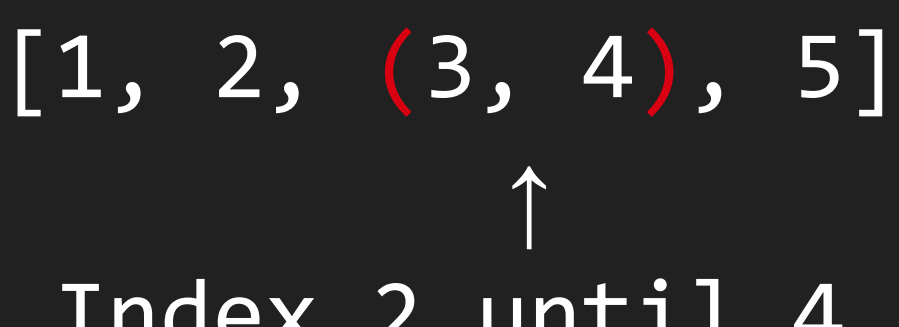
Array Index

```
Query:  [2]
Result: 3
```



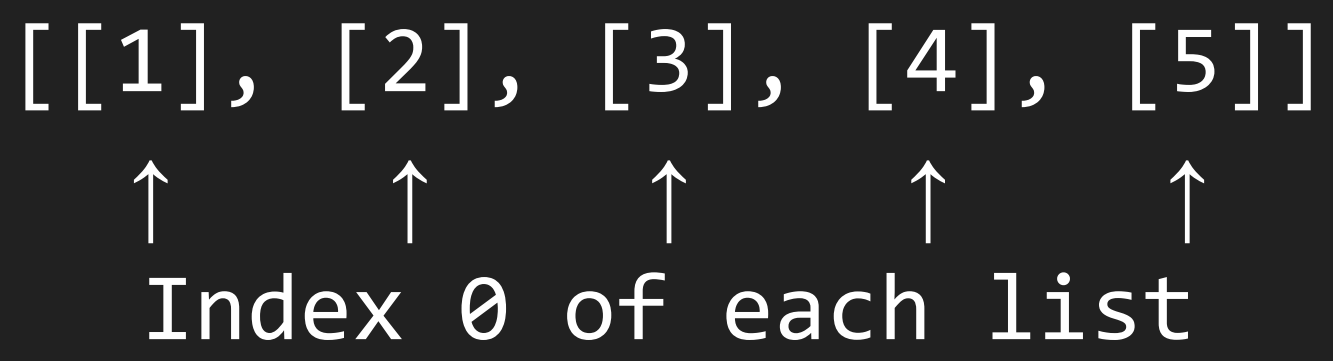
Array Slice

```
Query:  [2:-1]
Result: [3, 4]
```



Array Iteration

```
Query:   .a[] [0]
Result: [1,2,3,4,5]
```



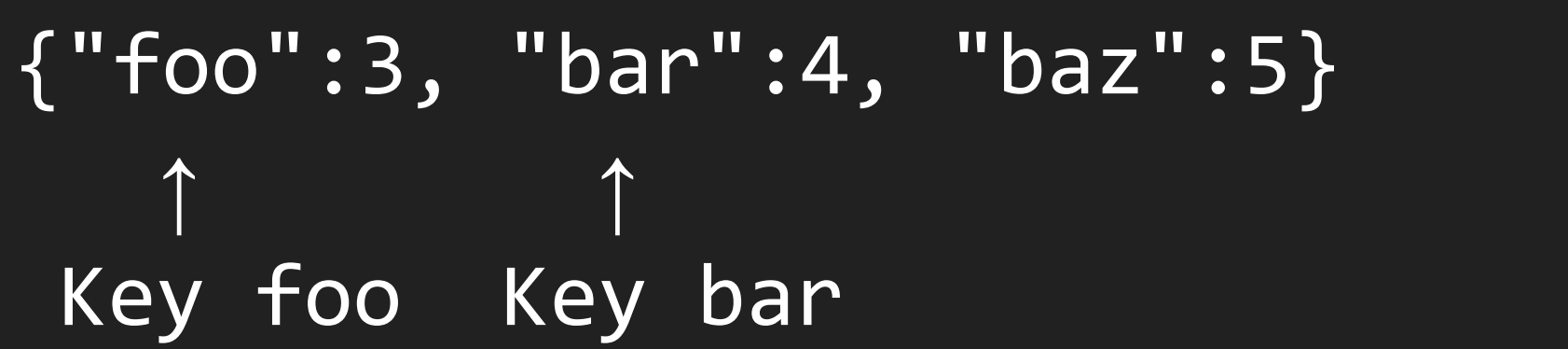
Map Access (Single)

```
Query:  .foo
Result: 3
```

```
{"foo": 3, "bar": 4}
   ↑
 Key foo
```

Map Access (Multiple)

```
Query:   .foo|bar
Result: {"foo":3, "bar":4}
```



Map Keys

```
Query:  keys
Result: ["foo", "bar"]
```

```
{"foo": 3, "bar": 4}
   ↑          ↑
   Map Keys
```

Map Iteration

```
Query:  .m[] [0]
Result: {"foo": 3, "bar": 4}

      {"foo": [3], "bar": [4]}
                ↑          ↑
        Index 0 of each array value
```

Example

```
{"foo": {"k1": [3,4]},
 "bar": {"k1": [5,6]}}

Query:   .m[] .k1 [0]
Result: {"foo": 3, "bar": 5}
```

Example

```
{"foo": {"1":1, "2":2, "3":3},
 "bar": {"4":4, "5":5, "6":6}}

Query:  .m[] keys
Result: {"foo": ["1","2","3"],
         "bar": ["4","5","6"] }
```

3. The Format

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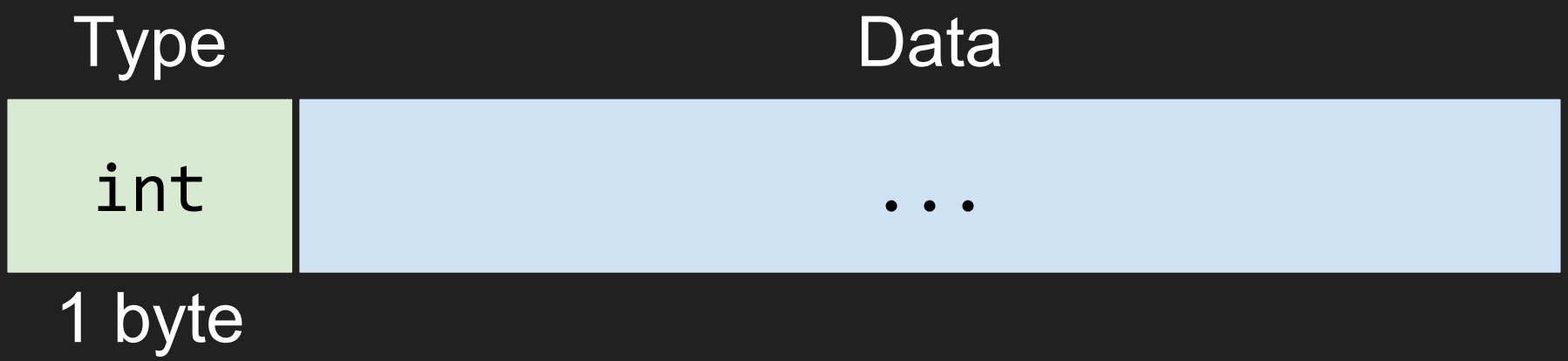
Types

Augmented JSON == JSON + integers

- Scalars
  - Null
  - Boolean
  - Integer (64 bit)
  - Float (64 bit)
  - String
- Composites
  - Array
  - Map

General Format

Every record starts with a single byte for the type:

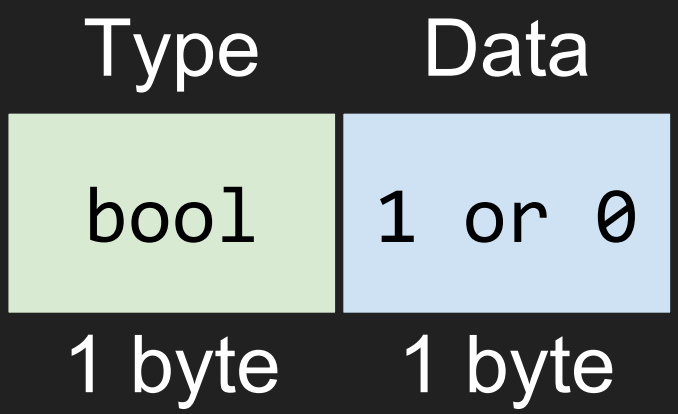


Scalars

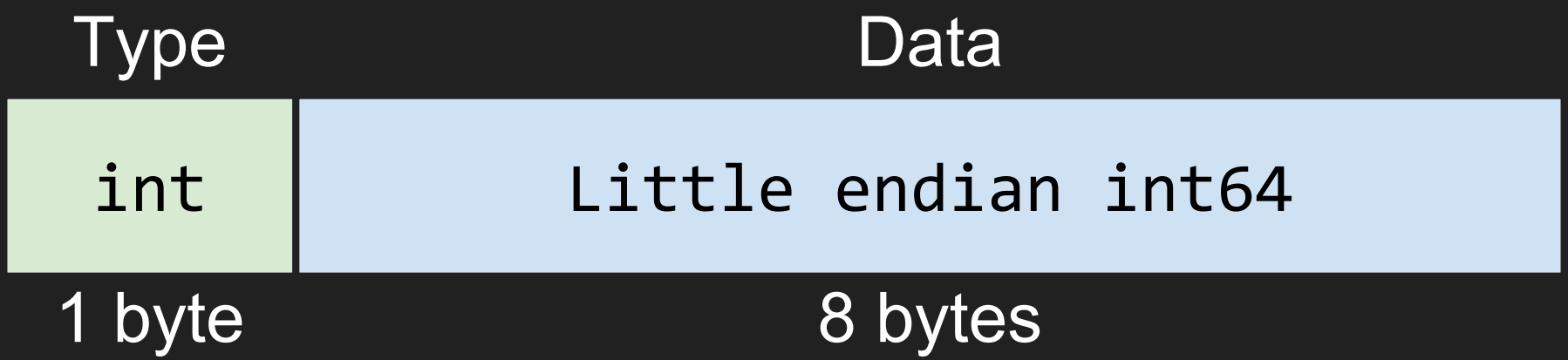
- Null
- Boolean
- Integer (64 bit)
- Float (64 bit)
- String

Scalar: Null

Scalar: Boolean

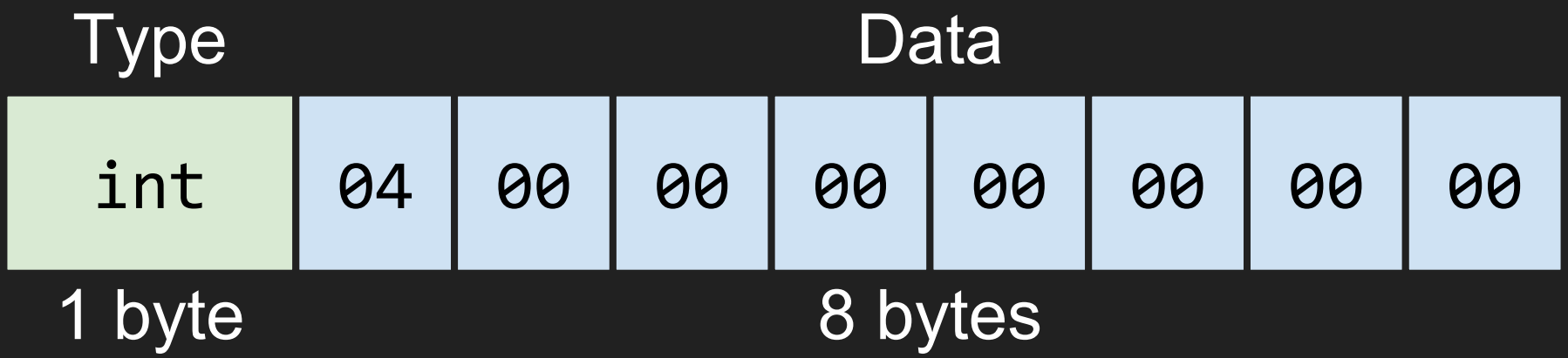


Scalar: Integer

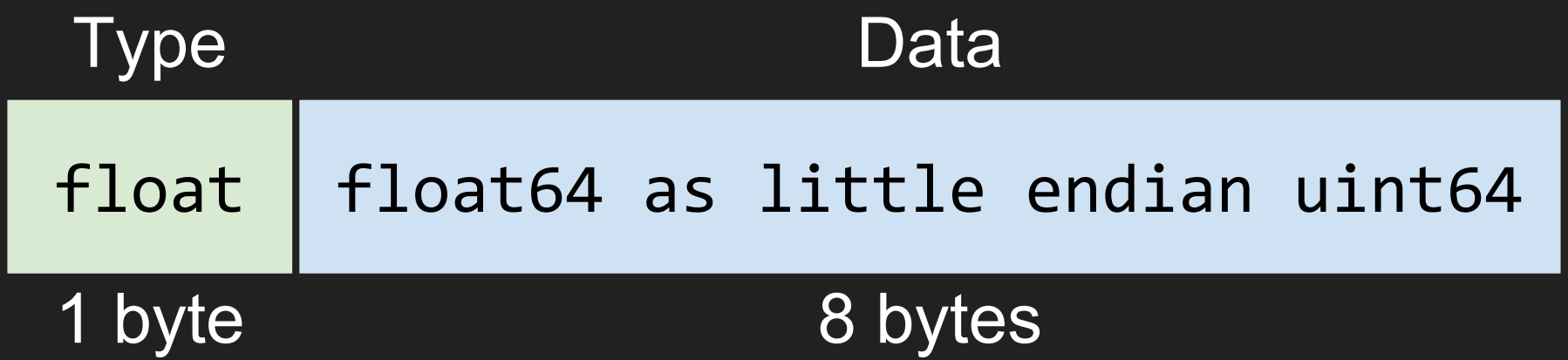


Scalar: Integer (example)

`4 = 0x0000_0000_0000_0004`

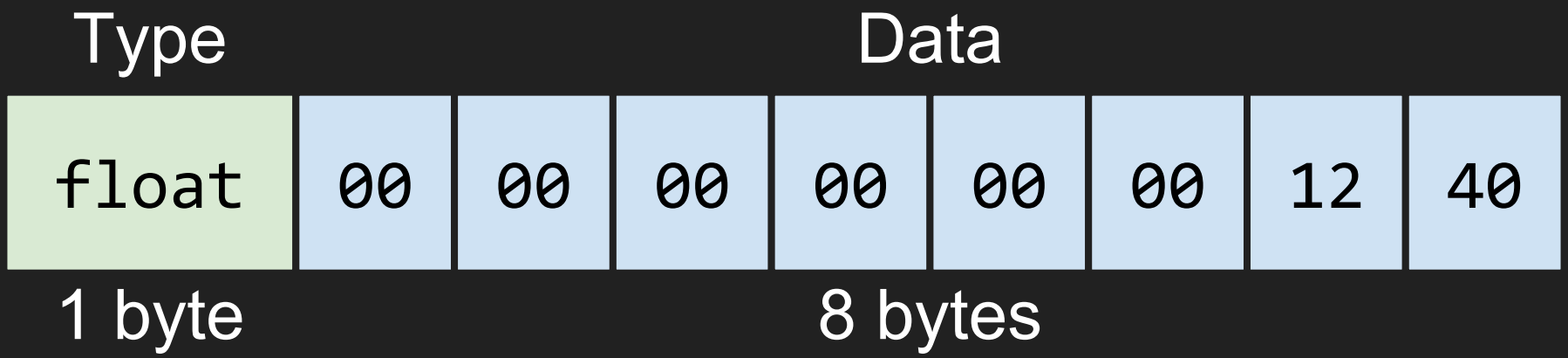


Scalar: Float

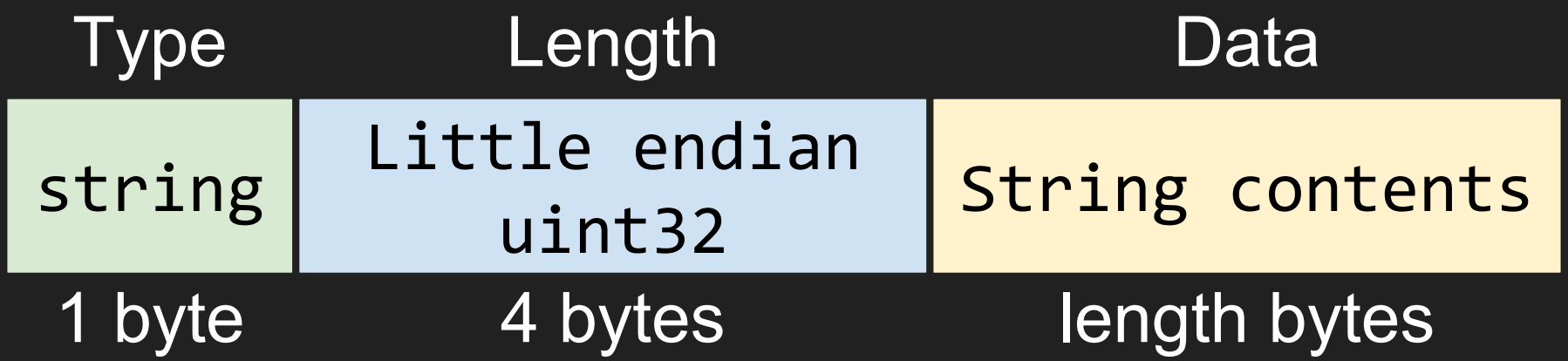


Scalar: Float (example)

4.5 = `0x4012_0000_0000_0000`

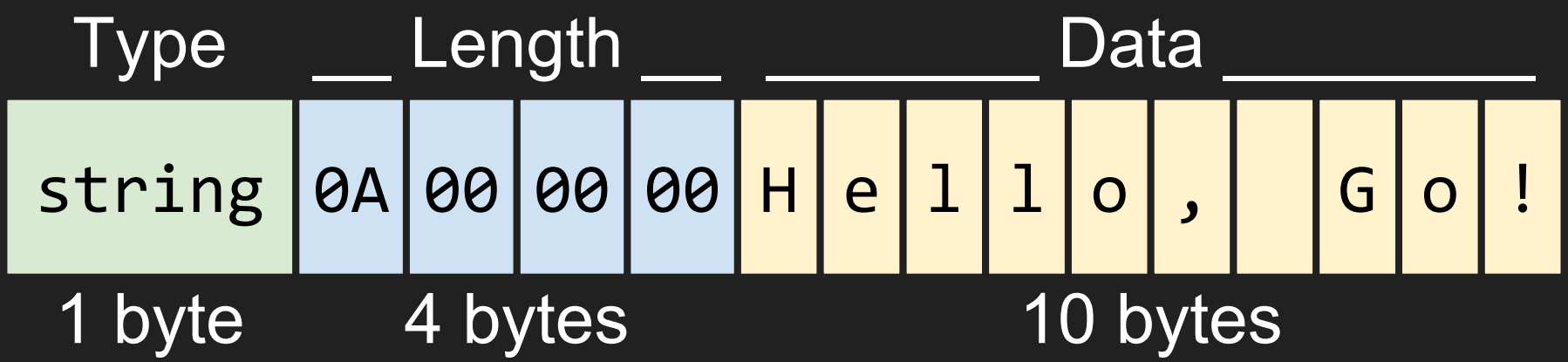


Scalar: String



Scalar: String (example)

"Hello, Go!" Length: `10 = 0x0000_000A`

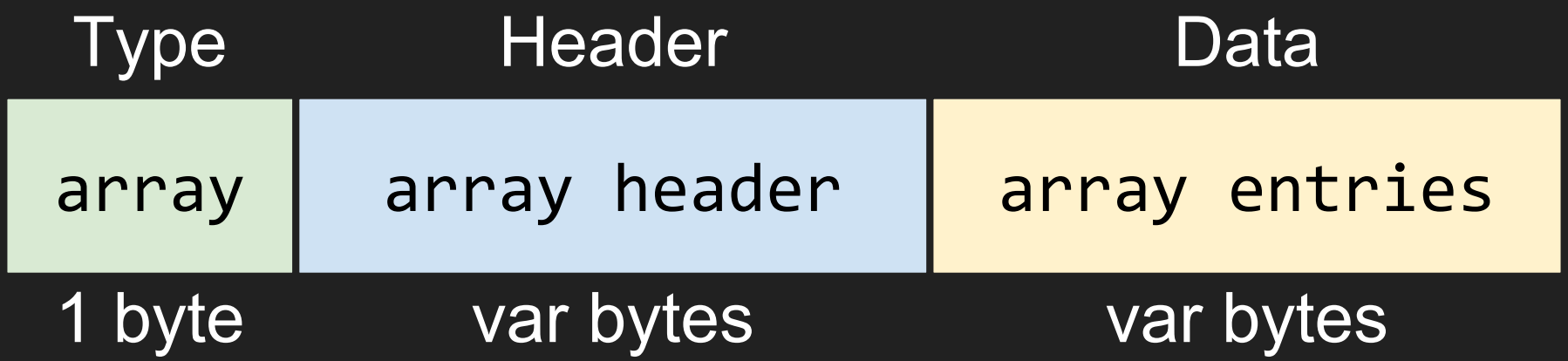


Composites

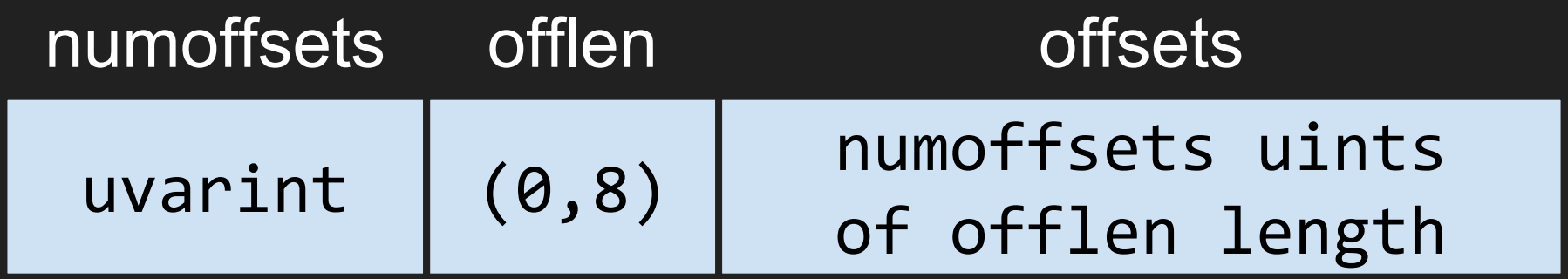
Recursive - contained data are defined by this same format

- Array
- Map

Composite: Array



Composite: Array - Header



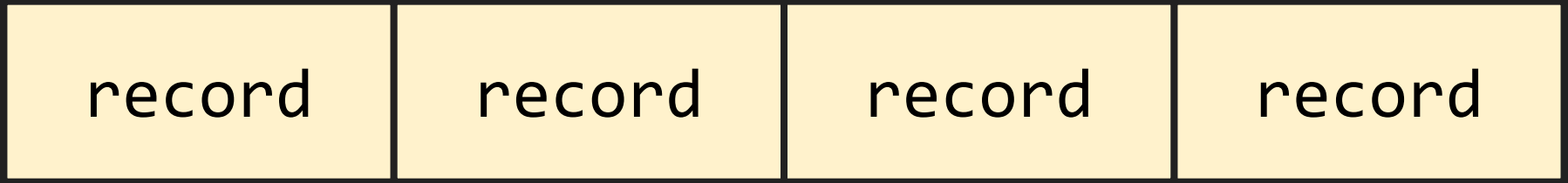
Composite: Array - Header offsets

2 or more offsets

Each offlen bytes

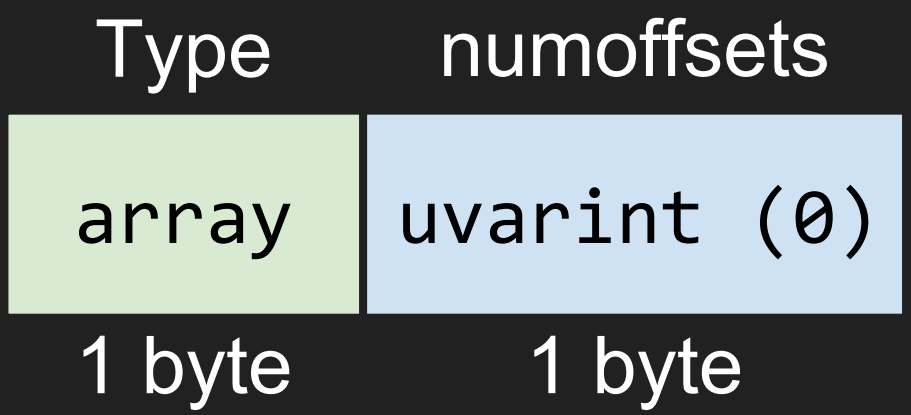
Composite: Array - Data

1 or more records



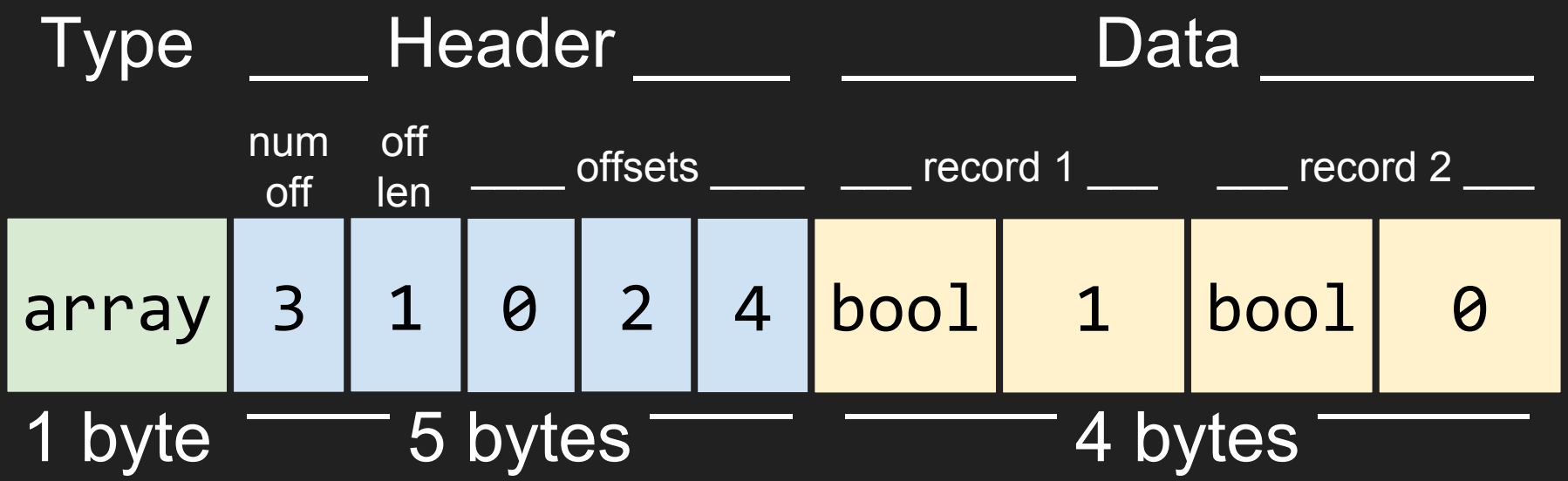
Each var bytes

Composite: Empty Array



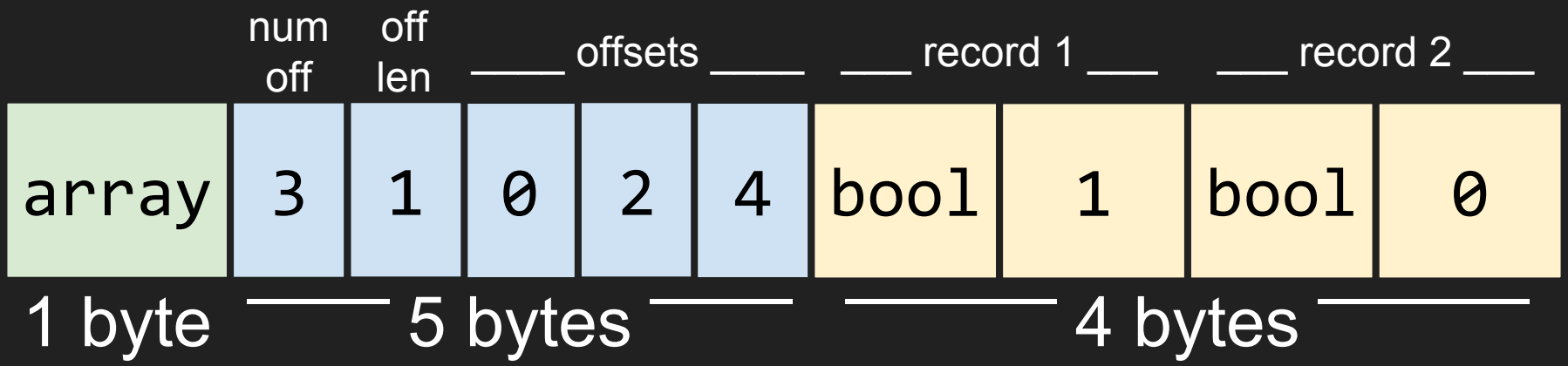
Composite: Array (example)

`[true, false]`

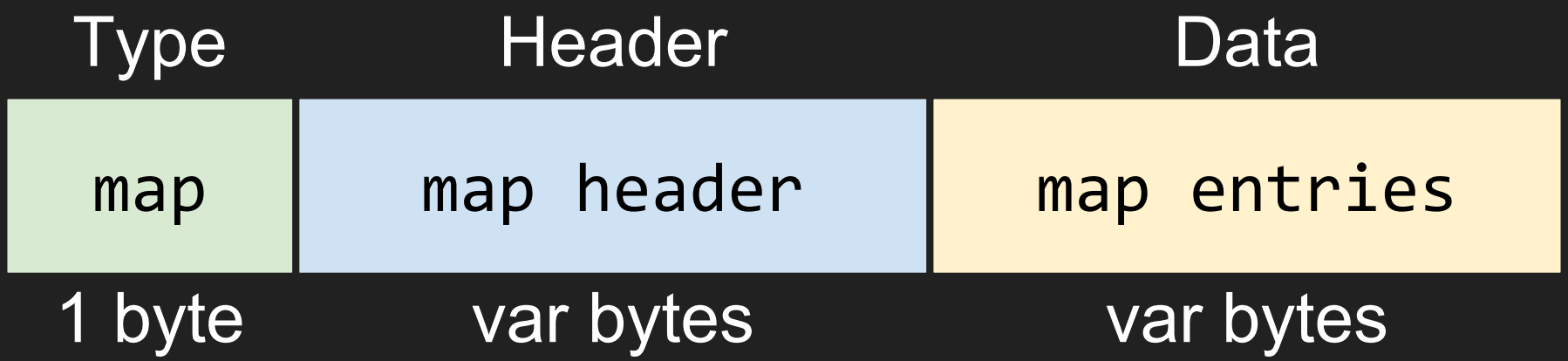


Composite: Array (example, slicing)

`[true, false]`



Composite: Map

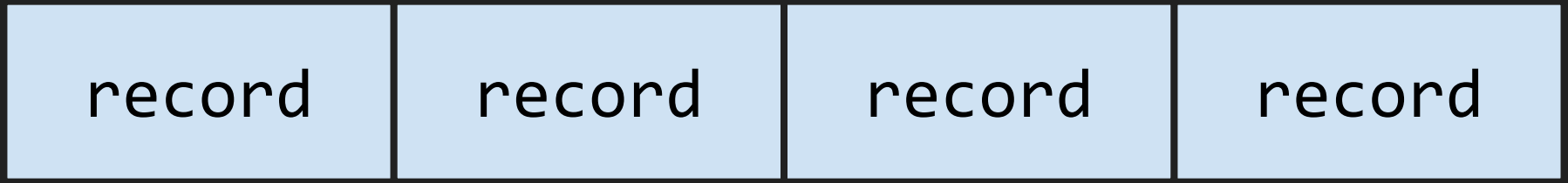


Composite: Map - Header

num recs	offlen	lenlen	header records
`uvarint`	`(0,8)`	`(0,8)`	`num recs` `header records`
var bytes	1 byte	1 byte	∝num recs

Composite: Map - Header

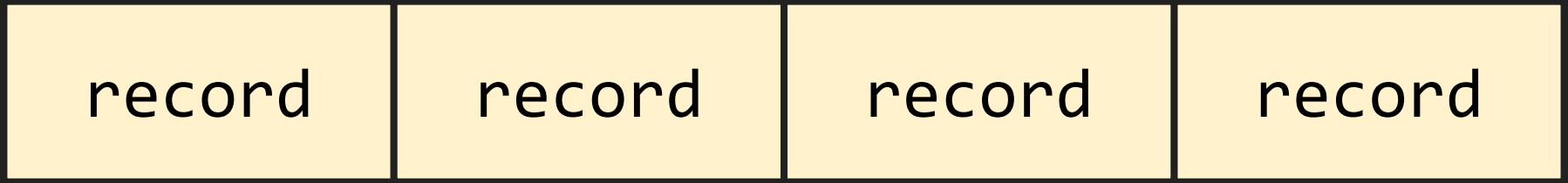
1 or more header records



Each 4 + offlen + lenlen bytes

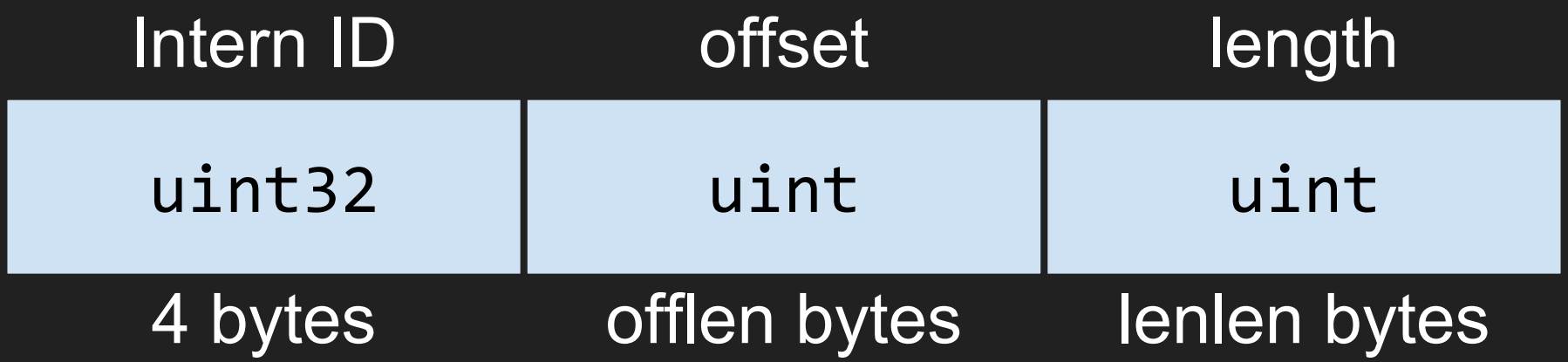
Composite: Map - Data

1 or more records



Each var bytes

Composite: Map - Header Record



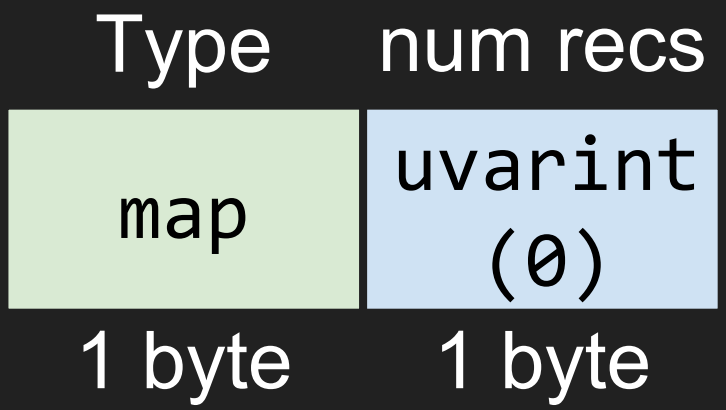
Composite: Map - Interned Keys

- Map keys are assigned a unique uint32 ID
- IDs are shared by identical strings
- Forward and reverse mappings stored next to the data
- Example:
  - `"true"  → 1`
  - `"false" → 2`

Composite: Map - Header

header records

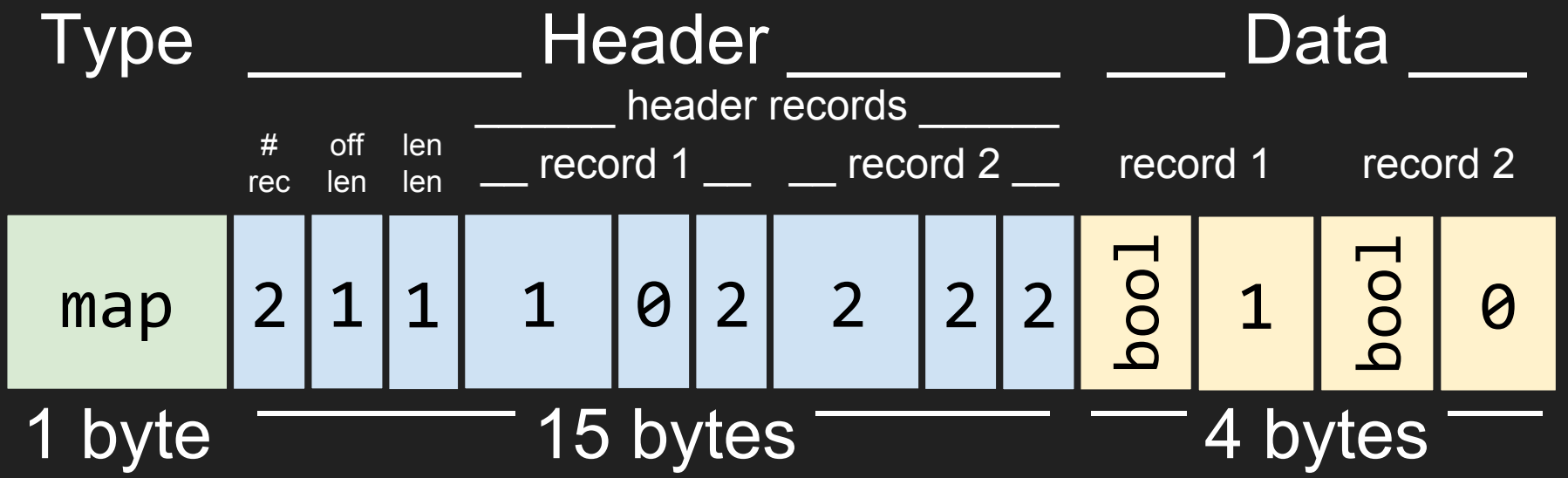
Composite: Empty Map



```
"true"  → 1
"false" → 2
```

Composite: Map (example)

```
{"false":false, "true":true}
```



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4. Performance

How fast is it?

It depends

… on:

- How much data you ask for
- How complex the query is
- How many CPU's
- Speed of the underlying data storage

Scalars

Serialize

Type	time/op	
Null	64.3 ns ± 2%	
Boolean	71.6 ns ± 1%	
Int	75.7 ns ± 0%	
Float	75.4 ns ± 1%	
String	88.6 ns ± 1%	"foobar"

Deserialize

Type	time/op
Null	16.0 ns ± 1%
Boolean	23.9 ns ± 1%
Int	26.6 ns ± 1%
Float	27.1 ns ± 1%
String	70.1 ns ± 1%

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Composites: Serialize

Type	# elems	time/op	time/op (ns)
Array	0	115 ns ± 0%	115 ns
Array	1	273 ns ± 1%	273 ns
Array	10	900 ns ± 1%	900 ns
Array	100	5.42 µs ± 1%	5420 ns
Array	1000	43.7 µs ± 1%	43700 ns
Array	10000	453 µs ± 1%	453000 ns
Array	100000	5.35 ms ± 1%	5350000 ns
Array	1000000	54.0 ms ± 3%	54000000 ns
Map	0	87.2 ns ± 1%	87 ns
Map	1	608 ns ± 1%	608 ns
Map	10	3.39 µs ± 1%	3390 ns
Map	100	34.1 µs ± 1%	34100 ns
Map	1000	374 µs ± 0%	374000 ns
Map	10000	4.37 ms ± 1%	4370000 ns
Map	100000	58.7 ms ± 2%	58700000 ns
Map	1000000	866 ms ± 4%	866000000 ns

Composites: Deserialize

Type	# elems	time/op	time/op (ns)
Array	0	136 ns ± 1%	136 ns
Array	1	201 ns ± 0%	201 ns
Array	10	588 ns ± 2%	588 ns
Array	100	4.05 µs ± 3%	4050 ns
Array	1000	38.1 µs ± 1%	38100 ns
Array	10000	380 µs ± 2%	380000 ns
Array	100000	3.81 ms ± 1%	3810000 ns
Array	1000000	39.9 ms ± 2%	39900000 ns
Map	0	158 ns ± 0%	158 ns
Map	1	361 ns ± 0%	361 ns
Map	10	1.97 µs ± 0%	1970 ns
Map	100	21.3 µs ± 0%	21300 ns
Map	1000	261 µs ± 1%	261000 ns
Map	10000	2.67 ms ± 1%	2670000 ns
Map	100000	38.3 ms ± 2%	38300000 ns
Map	1000000	757 ms ± 3%	757000000 ns

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Composites: Queries

Type	# elems	time/op
Array Get	1	25.9 ns ± 7%
Array Get	10	26.4 ns ± 6%
Array Get	100	26.6 ns ± 6%
Array Get	1000	26.3 ns ± 6%
Array Get	10000	26.3 ns ± 8%
Array Get	100000	26.0 ns ± 4%
Array Get	1000000	26.2 ns ± 7%
Map Get	1	35.3 ns ± 1%
Map Get	10	64.7 ns ± 0%
Map Get	100	74.6 ns ± 1%
Map Get	1000	121 ns ± 1%
Map Get	10000	157 ns ± 0%
Map Get	100000	221 ns ± 2%
Map Get	1000000	375 ns ± 1%

Type	# elems	time/op
Array Slice	1	70.1 ns ± 1%
Array Slice	10	73.9 ns ± 4%
Array Slice	100	73.7 ns ± 3%
Array Slice	1000	73.0 ns ± 2%
Array Slice	10000	73.4 ns ± 3%
Array Slice	100000	75.6 ns ± 3%
Array Slice	1000000	73.4 ns ± 2%
Map Keys	1	662 ns ± 9%
Map Keys	10	2.11 µs ± 8%
Map Keys	100	17.4 µs ± 8%
Map Keys	1000	173 µs ± 8%
Map Keys	10000	2.28 ms ± 4%
Map Keys	100000	35.6 ms ± 5%
Map Keys	1000000	348 ms ± 7%

5. Future

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In Progress & Future Work

- Replace simple scalar values
- Append to arrays
- Add new keys to a map
- Other ops (inc, dec, etc)
- Compression

Thank You

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