Pointers vs Values: digging into the performance war

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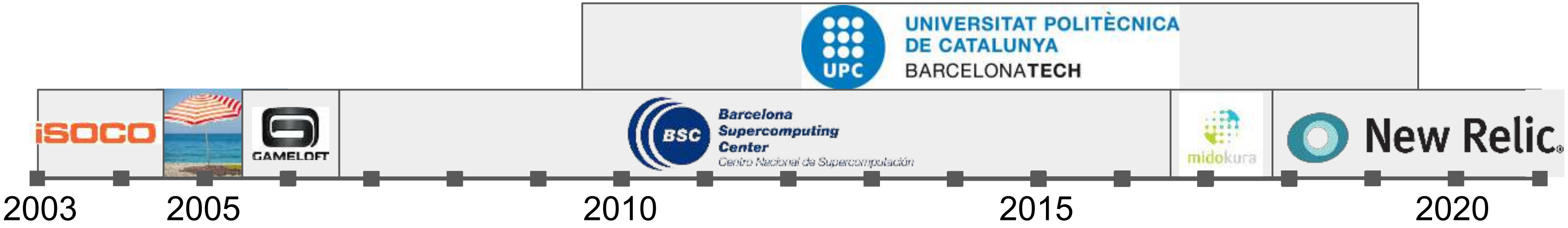
Who am I?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midokura
New Relic
2003
2005
2010
2015
2020

The Core Agents and Open Standards Team

JF

Mario

Juan

Antonio

Carlos

David

Cristian

Frank

Table of contents

Refreshing: values vs pointers

Digging more: µBenchmarks

A more realistic use case

Let New Relic measure it!

Conclusions

Using values vs using pointers

- Values
  - Safe against nil
  - Cleaner
    - no need to check for nil
    - no pointer operators *, &
- Pointers
  - Allow passing arguments by reference
  - Allow sharing a common state between different instances

The super-optimizer opinion

AWAYS USE POINTERS
IS FASTER THAN MOVING COMPLETE STRUCTS

“We should forget about small efficiencies, say about 97% of the time: premature optimization is the root of all evil"

-- Donald Knuth

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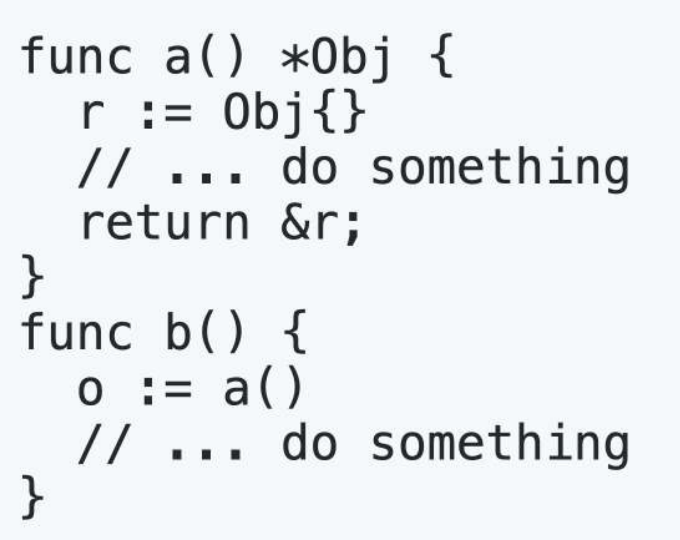
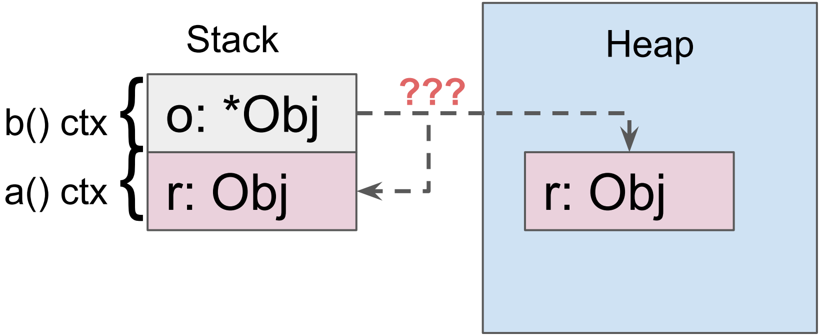
- T(Heap allocation) >> T(Stack Allocation)
- Golang applies “Escape Analysis” techniques to infer where an object is allocated
- Abuse of pointers escape values to the heap



```
func a() *Obj {
  r := Obj{}
  // ... do something
  return &r;
}
func b() {
  o := a()
  // ... do something
}
```



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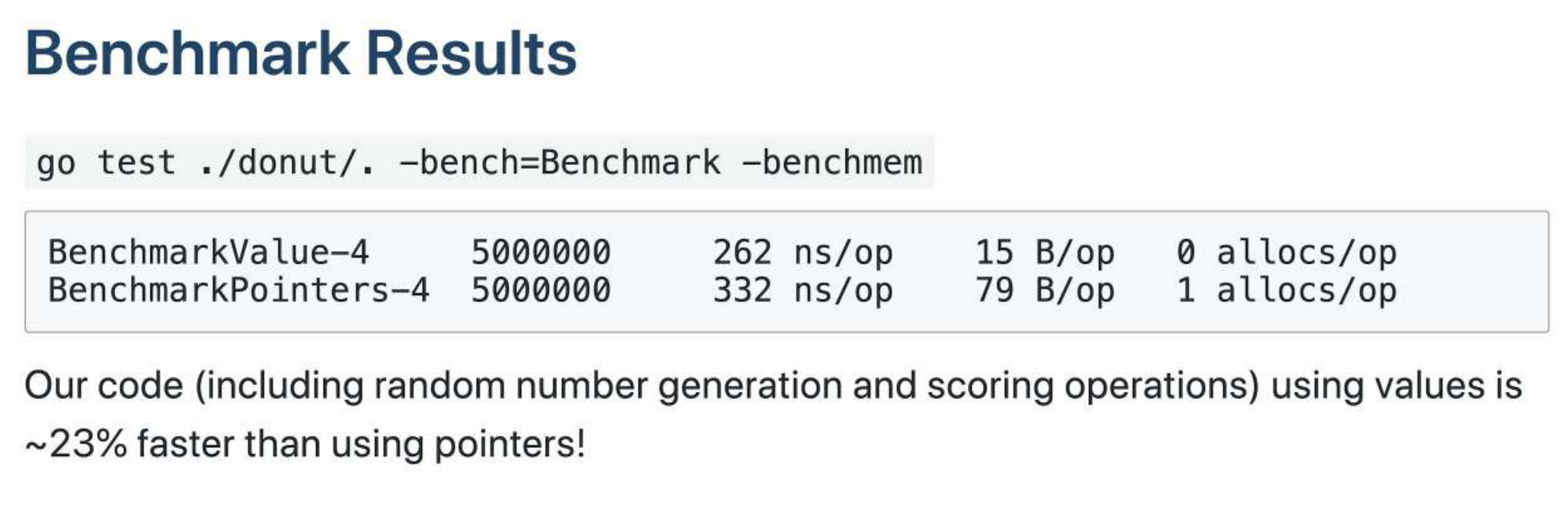
- T(Heap allocation) >> T(Stack Allocation)



Benchmark Results

```
go test ./donut/. -bench=Benchmark -benchmem
```

```
BenchmarkValue-4       5000000      262 ns/op     15 B/op    0 allocs/op
BenchmarkPointers-4    5000000      332 ns/op     79 B/op    1 allocs/op
```

Our code (including random number generation and scoring operations) using values is ~23% faster than using pointers!

```
f



}
func b() {
  o := a()
  // ... do something
}
```

Table of contents

Refreshing: values vs pointers

Digging more: µBenchmarks

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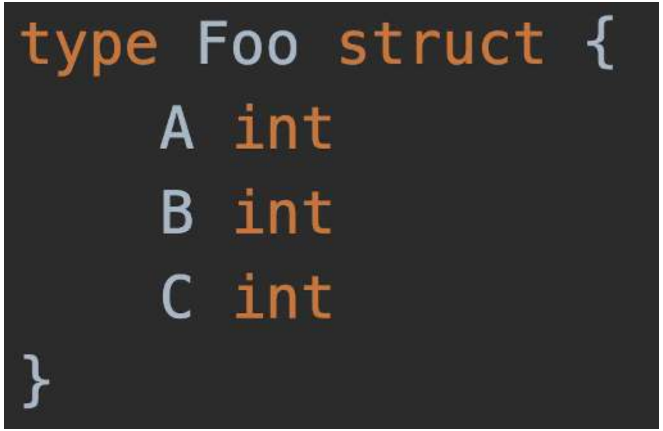
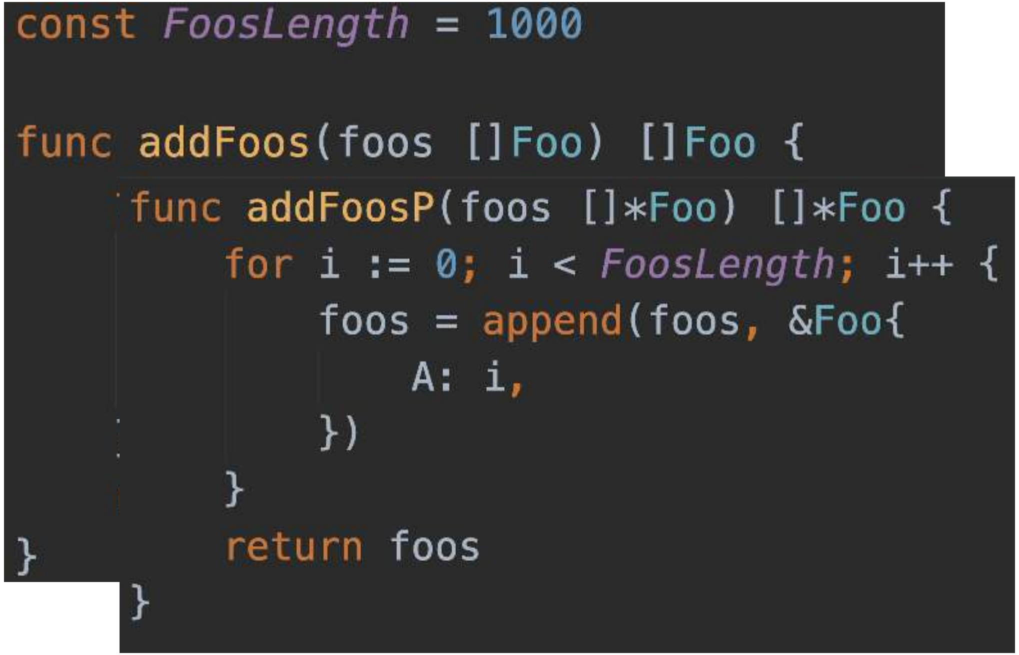
Conclusions

Digging more: µBenchmarks

- Small, localized benchmarks to test a single system functionality.
- Not really meaningful from a wider application point of view



```go
type Foo struct {
    A int
    B int
    C int
}
```



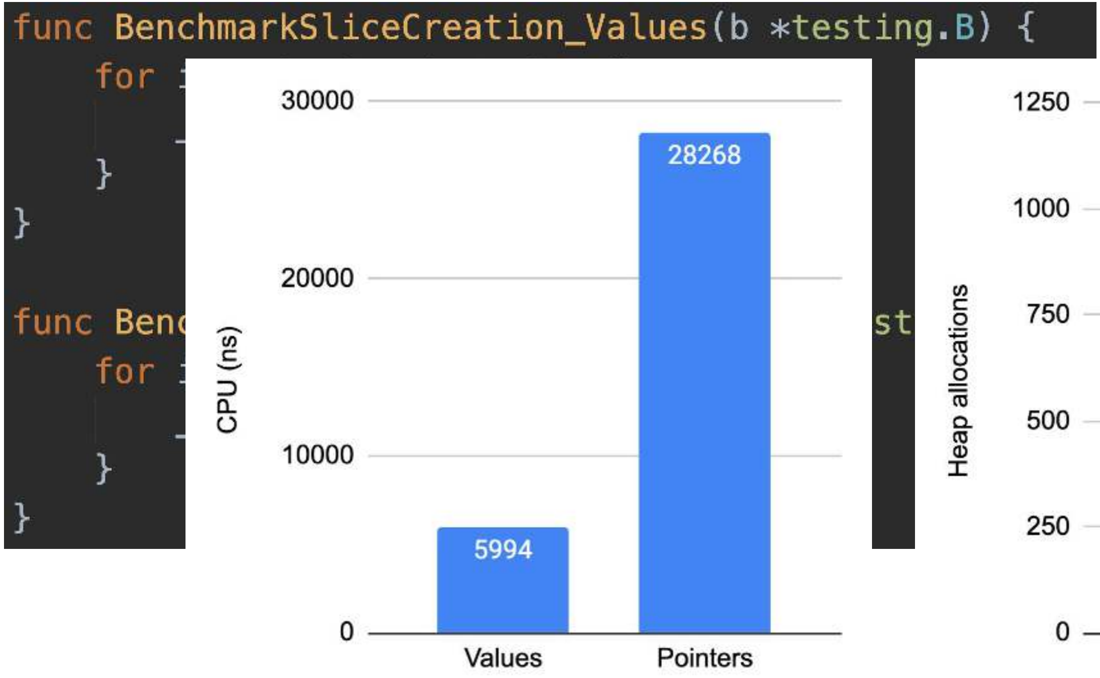
```go
const FoosLength = 1000

func addFoos(foos []Foo) []Foo {

}
```

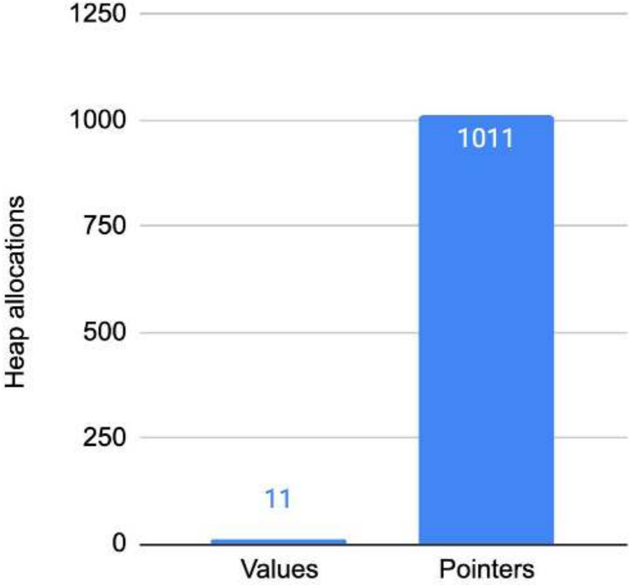
```go
func addFoosP(foos []*Foo) []*Foo {
    for i := 0; i < FoosLength; i++ {
        foos = append(foos, &Foo{
            A: i,
        })
    }
    return foos
}
```

µBenchmarks: initial results

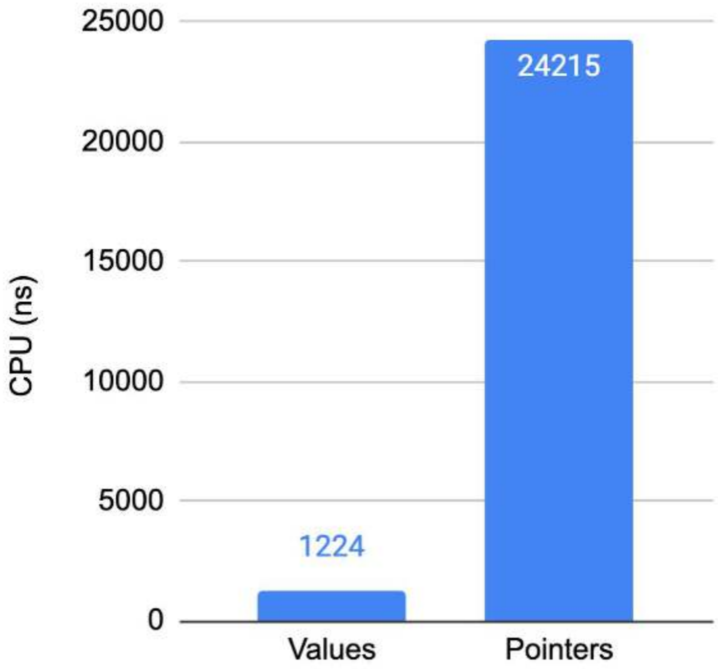


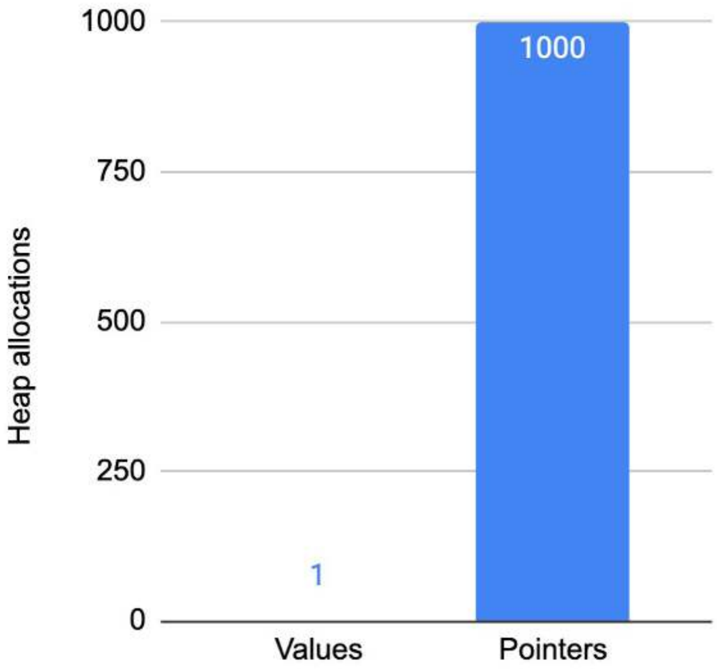
```
func BenchmarkSliceCreation_Values(b *testing.B) {
    for i
        _
    }
}

func Benc                                                  st
    for i
        _
    }
}
```



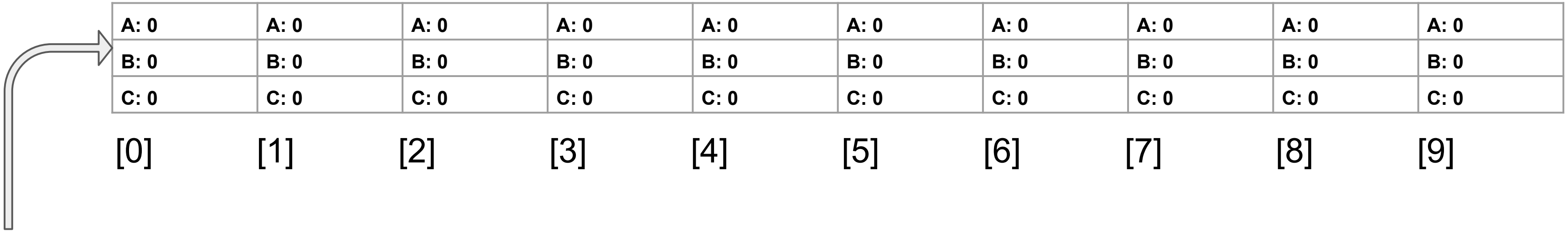
µBenchmarks: pre-allocated arrays





Adding a value to an array

```
arr := make([]Foo, 0, 10)
```

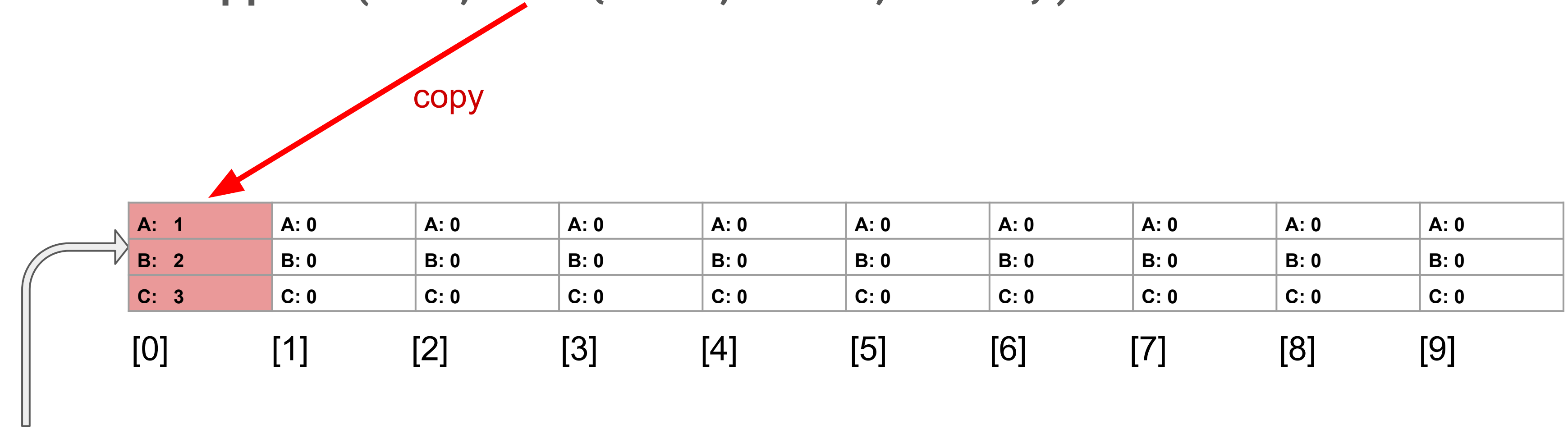


A: 0	A: 0	A: 0	A: 0	A: 0	A: 0	A: 0	A: 0	A: 0	A: 0
B: 0	B: 0	B: 0	B: 0	B: 0	B: 0	B: 0	B: 0	B: 0	B: 0
C: 0	C: 0	C: 0	C: 0	C: 0	C: 0	C: 0	C: 0	C: 0	C: 0
[0]	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]

```
arr
  - length: 0
  - capacity: 10
```

Adding a value to an array

```
arr := make([]Foo, 0, 10)
arr = append(arr, Foo{A: 1, B: 2, C: 3})
```

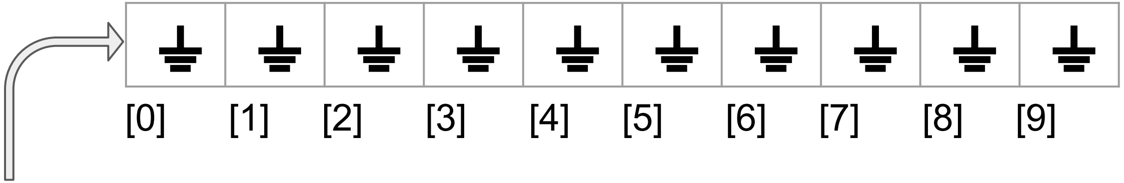


[0]	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
A: 1	A: 0	A: 0	A: 0	A: 0	A: 0	A: 0	A: 0	A: 0	A: 0
B: 2	B: 0	B: 0	B: 0	B: 0	B: 0	B: 0	B: 0	B: 0	B: 0
C: 3	C: 0	C: 0	C: 0	C: 0	C: 0	C: 0	C: 0	C: 0	C: 0

```
arr
  - length: 1
  - capacity: 10
```

Adding a reference to an array

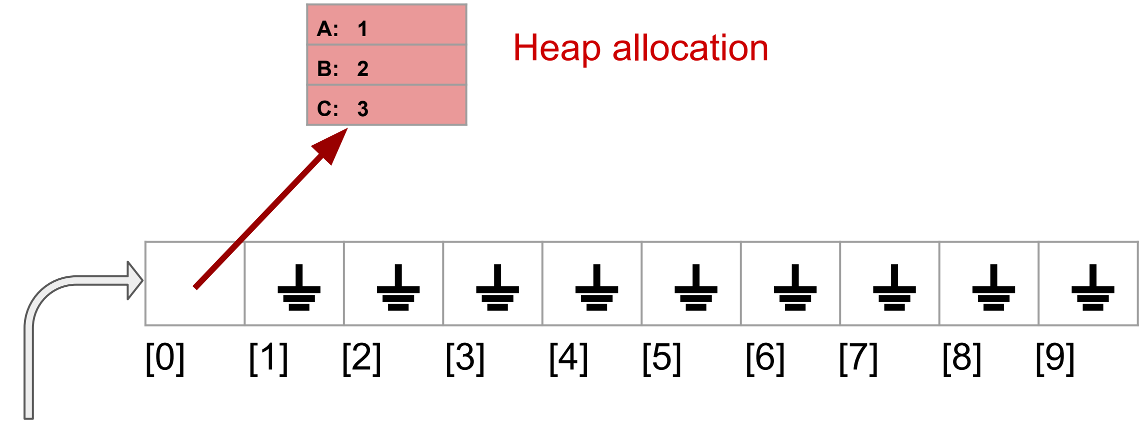
```
arr := make([]*Foo, 0, 10)
```



```
arr
  - length: 0
  - capacity: 10
```

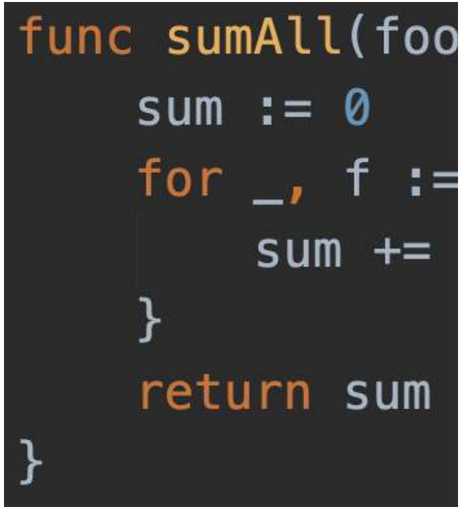
Adding a reference to an array

```
arr := make([]*Foo, 0, 10)
arr = append(arr, &Foo{A: 1, B: 2, C: 3})
```

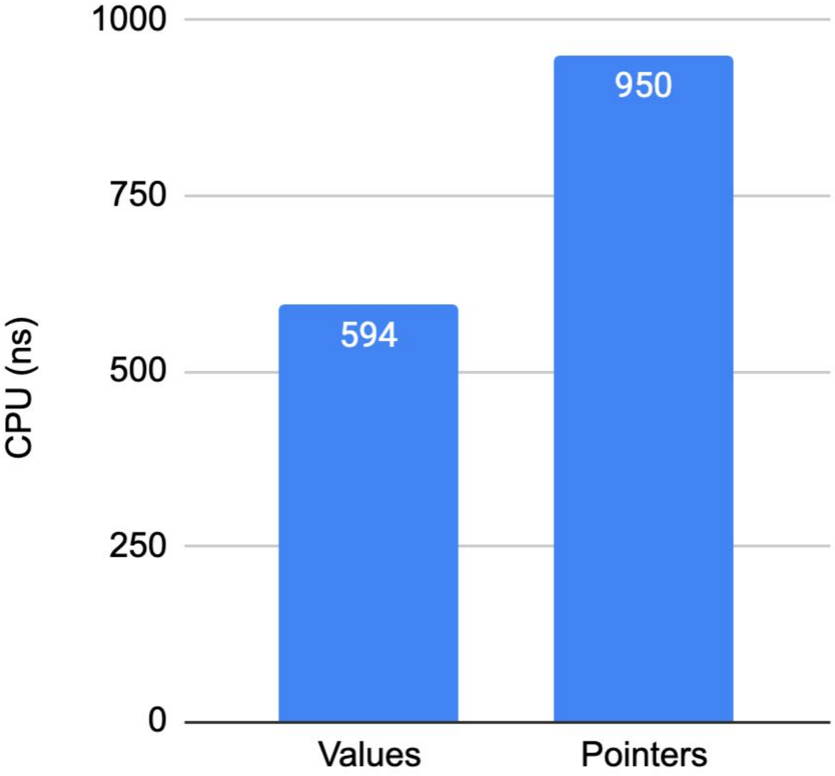


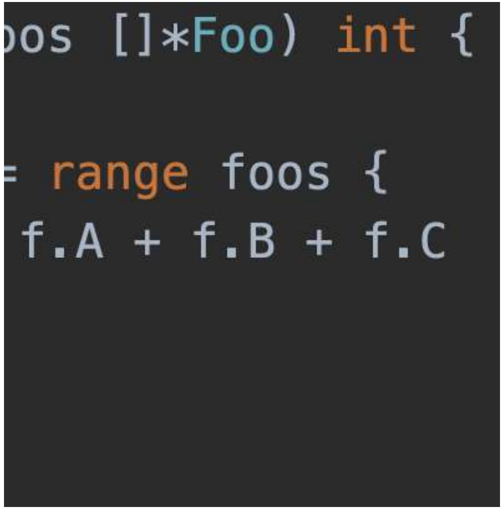
```
arr
  - length: 1
  - capacity: 10
```

µBenchmark: array iteration (no allocations)



```
func sumAll(foo
    sum := 0
    for _, f :=
        sum +=
    }
    return sum
}
```

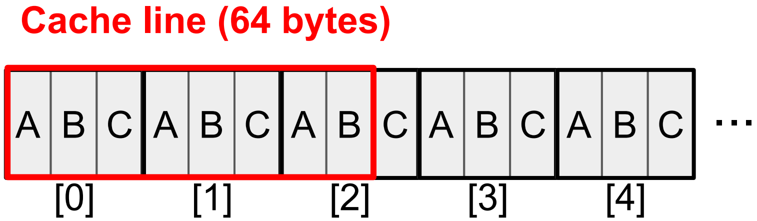




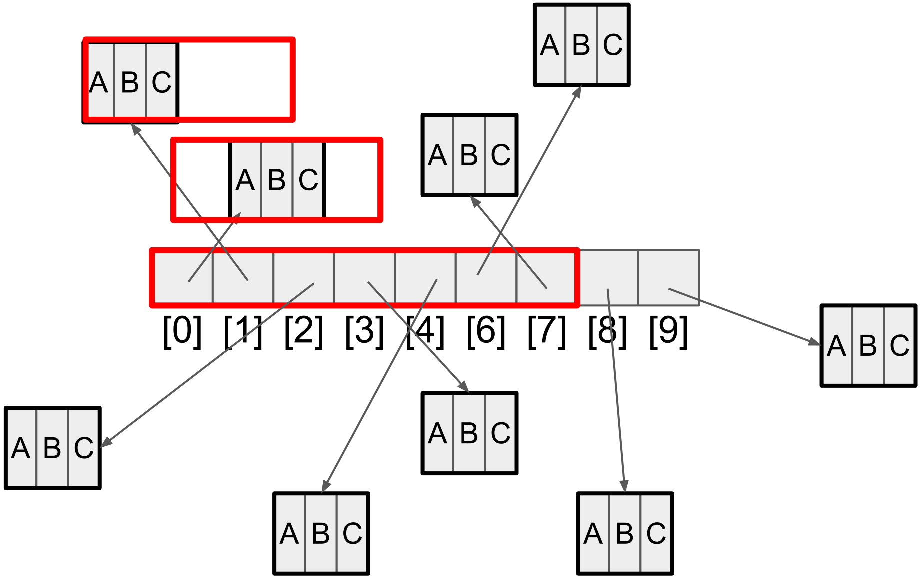
```
oos []*Foo) int {

= range foos {
f.A + f.B + f.C
```

Enforcing cache memory contiguity

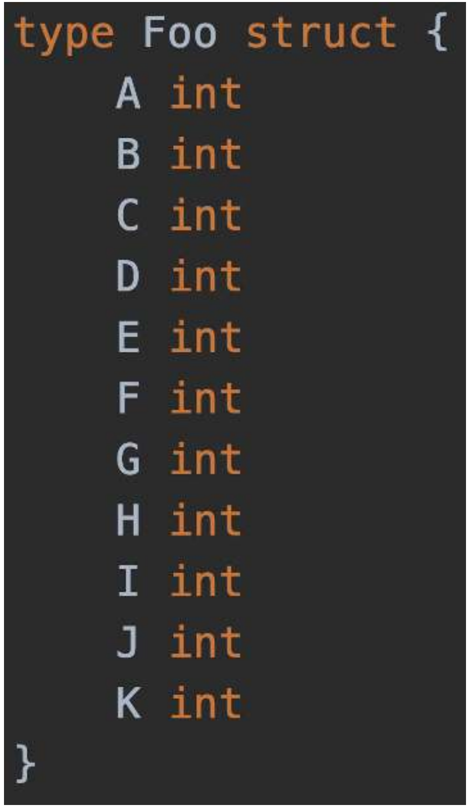


[ ]Foo{ … }

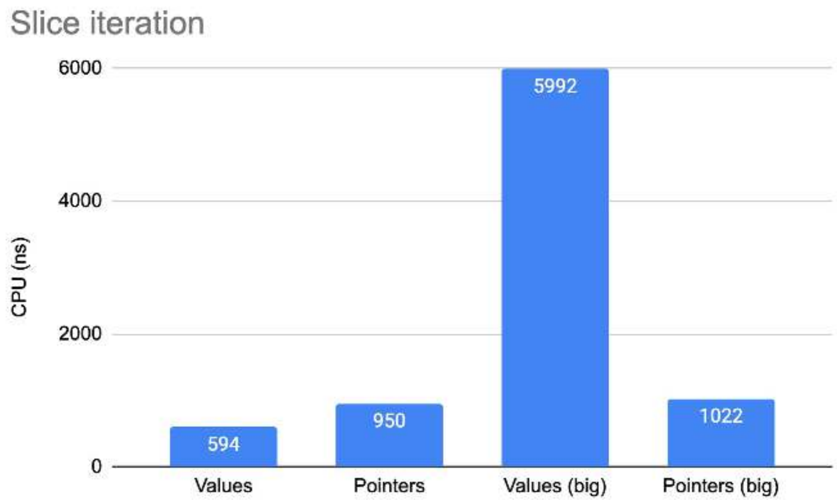


Increased cache misses

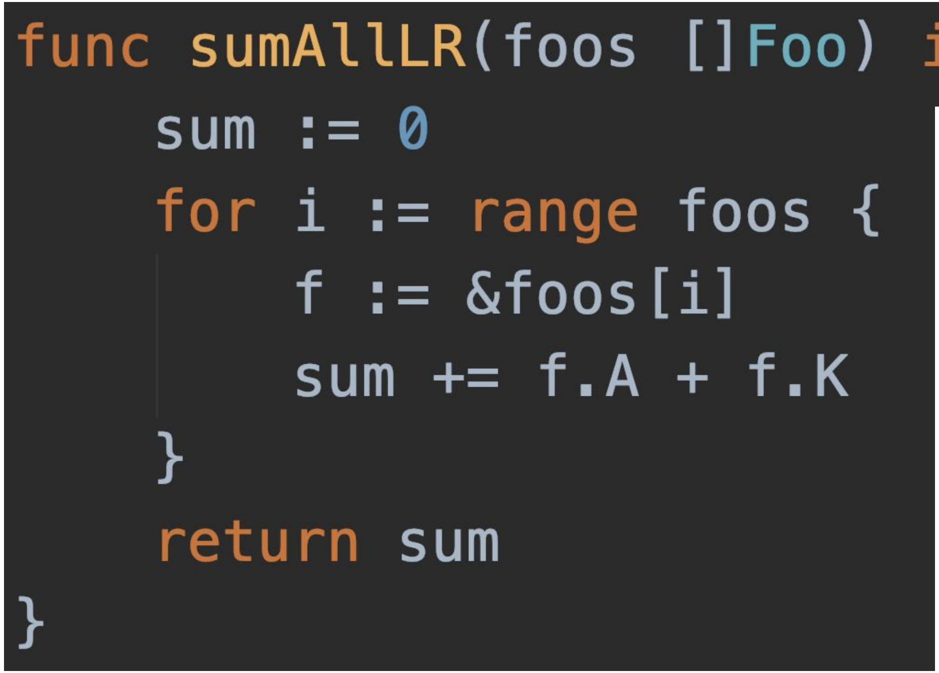
µBenchmark: structs >64 bytes



```go
type Foo struct {
    A int
    B int
    C int
    D int
    E int
    F int
    G int
    H int
    I int
    J int
    K int
}
```



Local µoptimization: minimize local var copy



```go
func sumAllLR(foos []Foo) int {
	sum := 0
	for i := range foos {
		f := &foos[i]
		sum += f.A + f.K
	}
	return sum
}
```

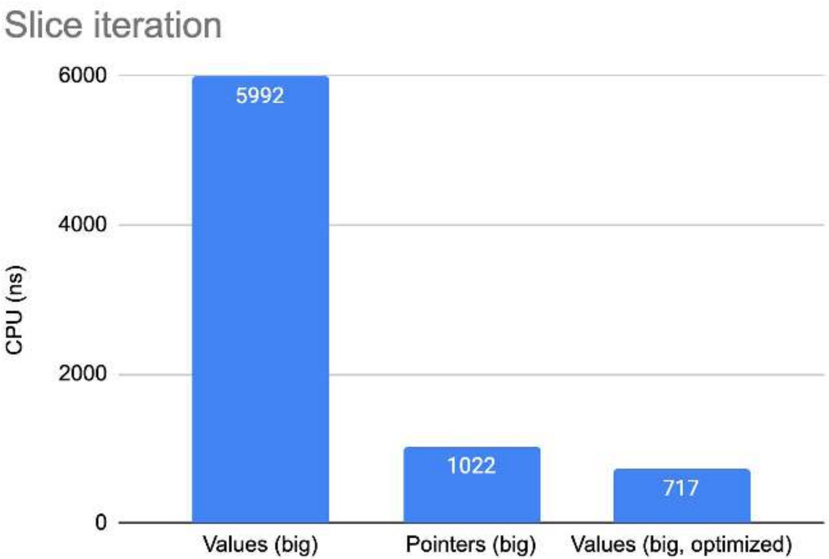


Table of contents

Refreshing: values vs pointers

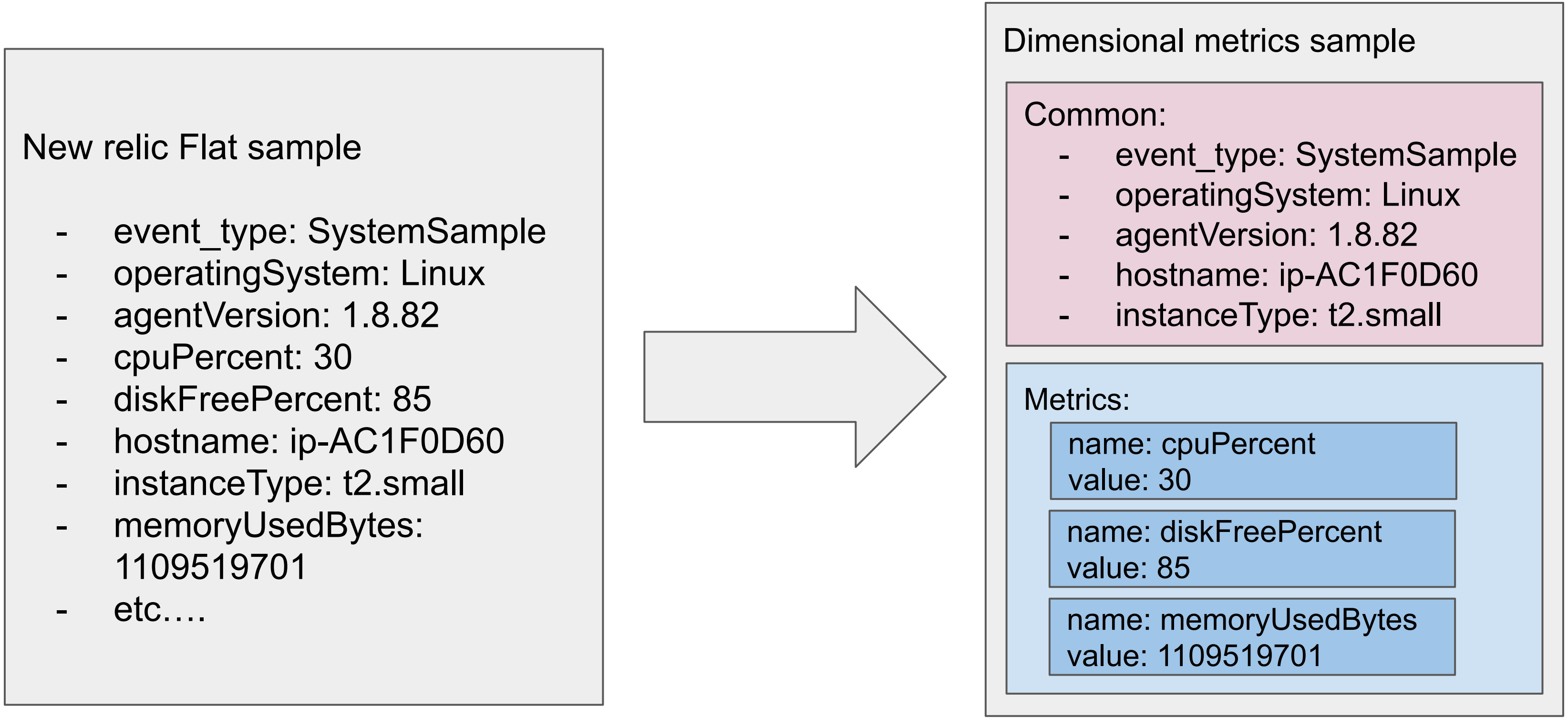
Digging more: µBenchmarks

A more realistic use case

Let New Relic measure it!

Conclusions

Real world bench: dimensional metrics translator



New relic Flat sample

- event_type: SystemSample
- operatingSystem: Linux
- agentVersion: 1.8.82
- cpuPercent: 30
- diskFreePercent: 85
- hostname: ip-AC1F0D60
- instanceType: t2.small
- memoryUsedBytes: 1109519701
- etc.…

Dimensional metrics sample

Common:

- event_type: SystemSample
- operatingSystem: Linux
- agentVersion: 1.8.82
- hostname: ip-AC1F0D60
- instanceType: t2.small

Metrics:

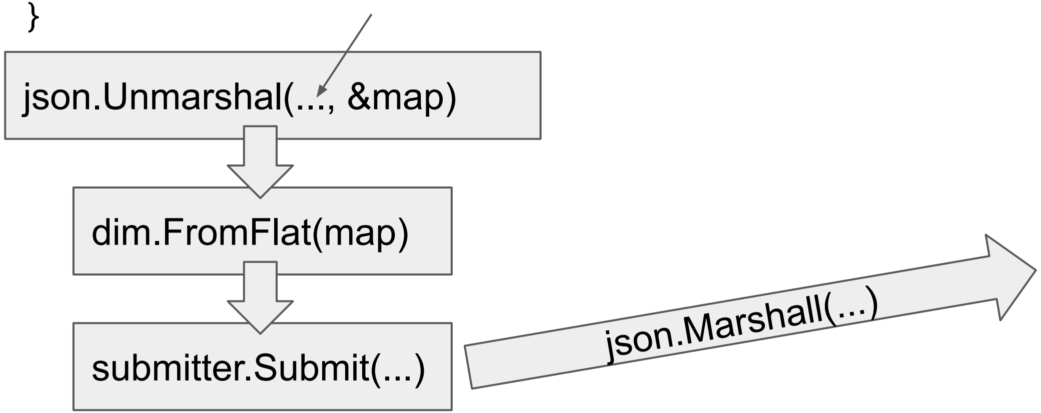
name: cpuPercent
value: 30

name: diskFreePercent
value: 85

name: memoryUsedBytes
value: 1109519701

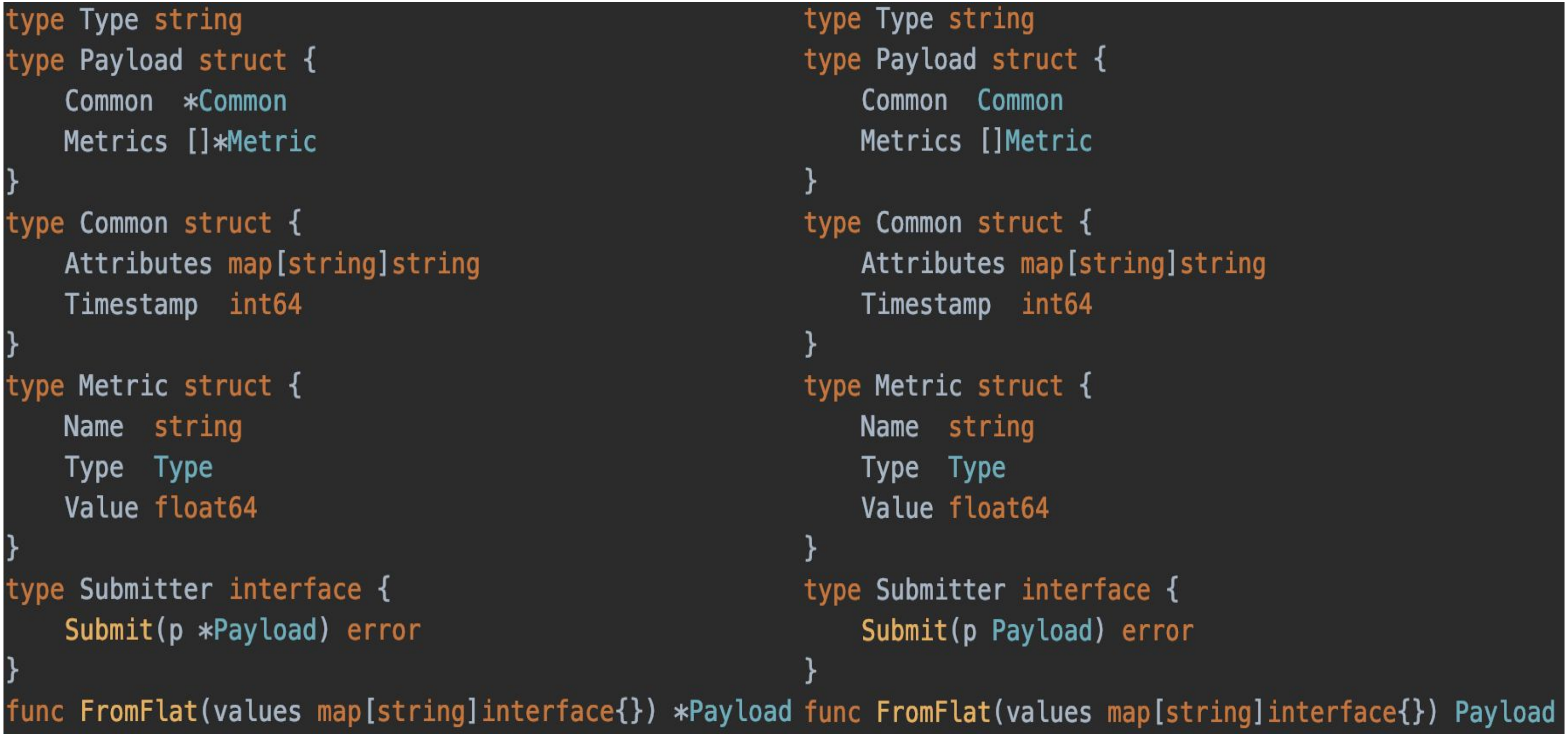
Dimensional metrics translator

```
{
  "event_type": "SystemSample",
  "operatingSystem": "Linux",
  "agentVersion": "1.8.82",
  "cpuPercent": 30,
  "diskFreePercent": 85,
  "hostname": "ip-AC1F0D60",
  "instanceType": "t2.small",
  "memoryUsedBytes": 1109519701
}
```



```
{
  "Common": {
    "event_type": "SystemSample",
    "operatingSystem": "Linux",
    "agentVersion": "1.8.82",
    "hostname": "ip-AC1F0D60",
    "instanceType": "t2.small"
  },
  Metrics: [{
    "name": "cpuPercent",
    "type": "Gauge", "value": 30
  }, {
    "name": "diskFreePercent",
    "type": "Gauge", "value": 85
  }, {
    "name": "memoryUsedBytes",
    "type": "Gauge",
    "value": 1109519701
  }]
}
```

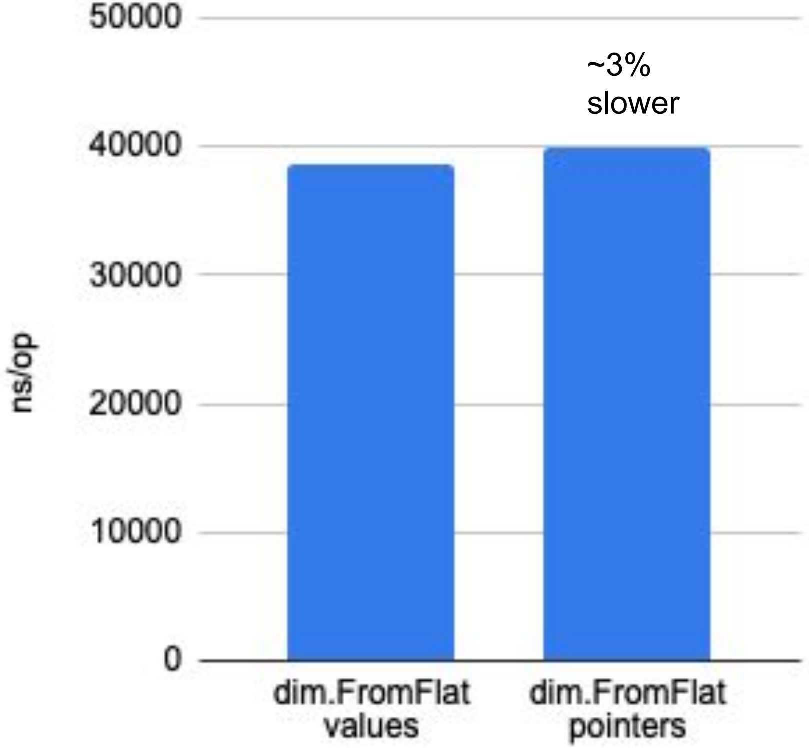
Benchmark: same code, 2 versions



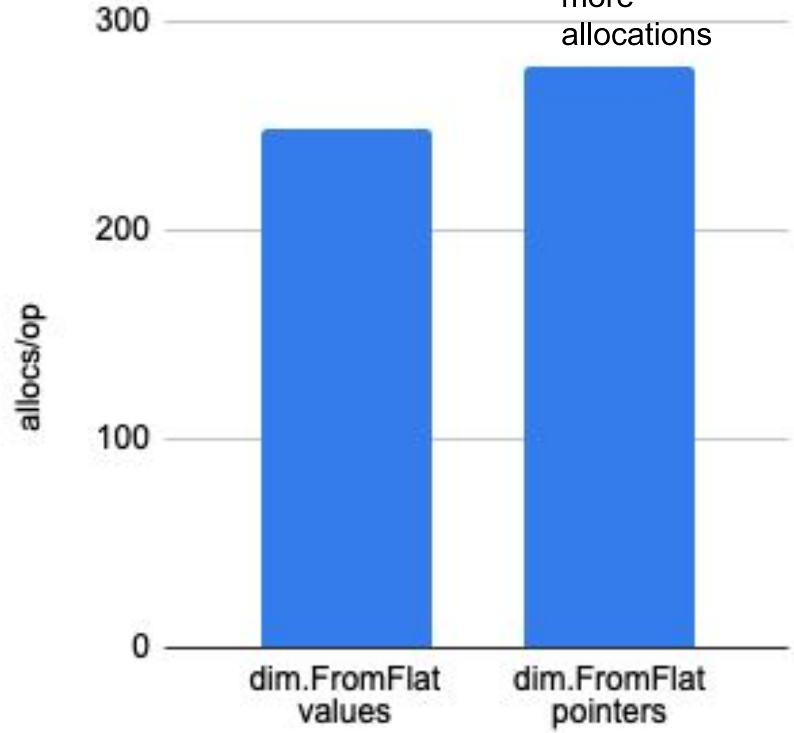
```go
type Type string
type Payload struct {
    Common  *Common
    Metrics []*Metric
}
type Common struct {
    Attributes map[string]string
    Timestamp  int64
}
type Metric struct {
    Name  string
    Type  Type
    Value float64
}
type Submitter interface {
    Submit(p *Payload) error
}
func FromFlat(values map[string]interface{}) *Payload
```

```go
type Type string
type Payload struct {
    Common  Common
    Metrics []Metric
}
type Common struct {
    Attributes map[string]string
    Timestamp  int64
}
type Metric struct {
    Name  string
    Type  Type
    Value float64
}
type Submitter interface {
    Submit(p Payload) error
}
func FromFlat(values map[string]interface{}) Payload
```

Benchmark Results

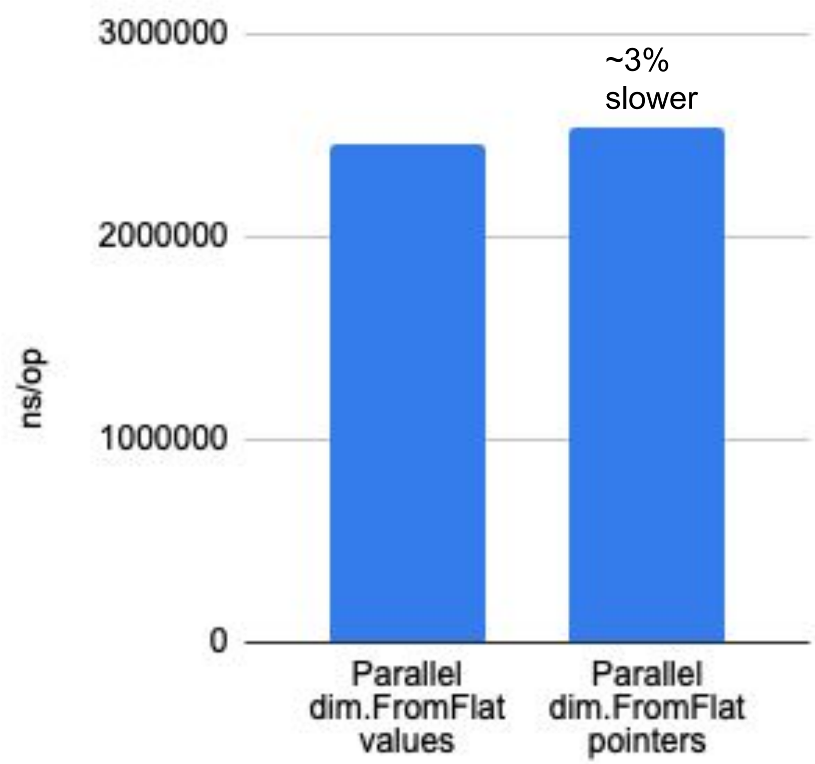


~3% slower

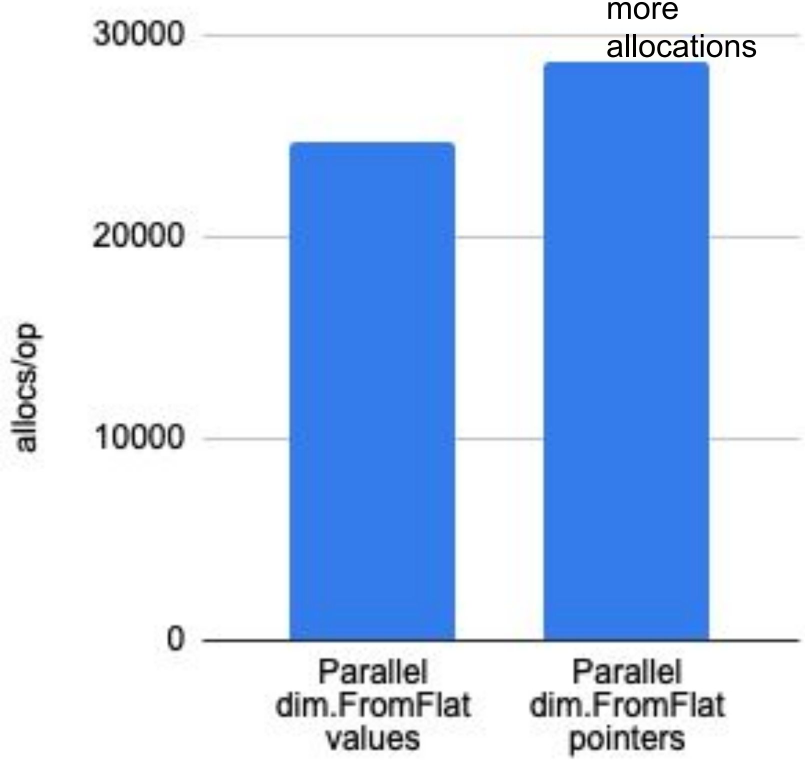


~12% more allocations

Benchmark Results (100 parallel goroutines)



~3% slower



~16% more allocations

Table of contents

Refreshing: values vs pointers

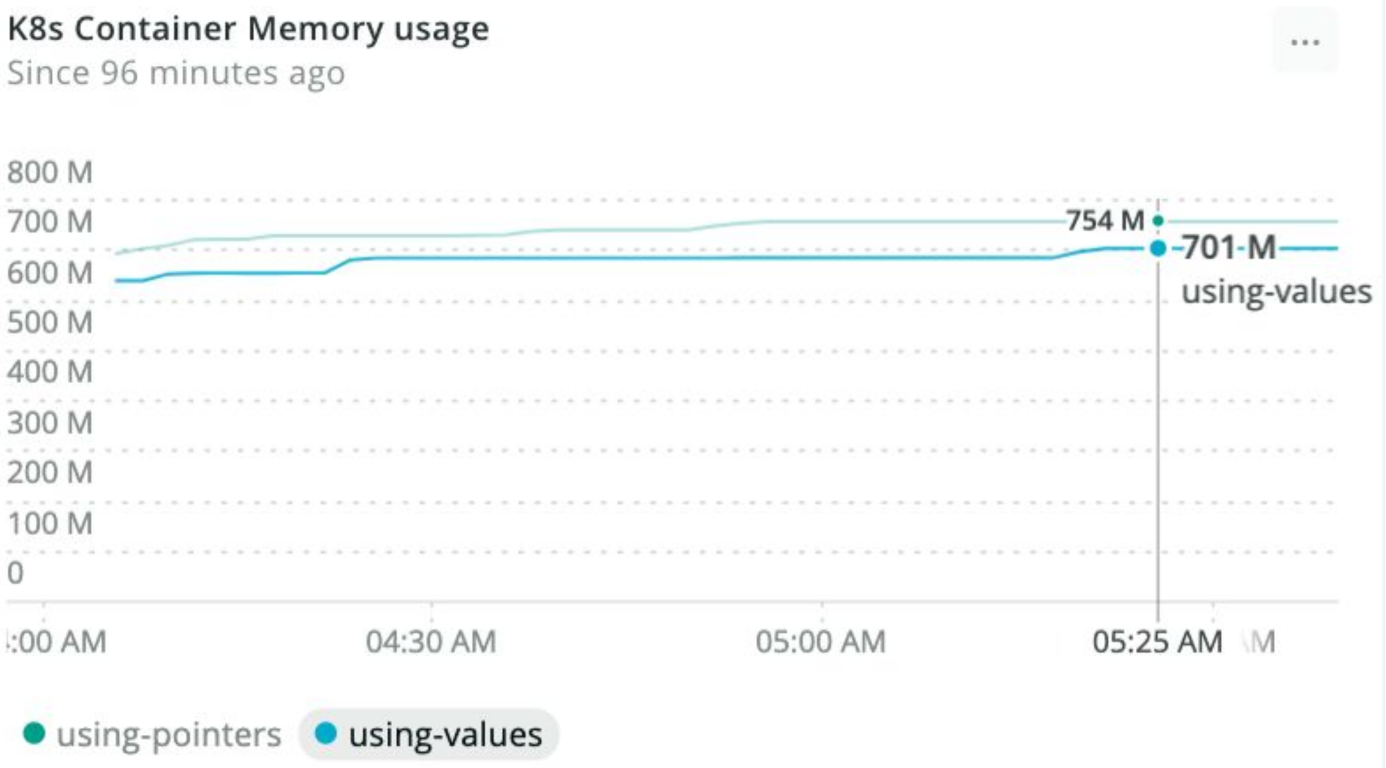
Digging more: µBenchmarks

A more realistic use case

Let New Relic measure it!

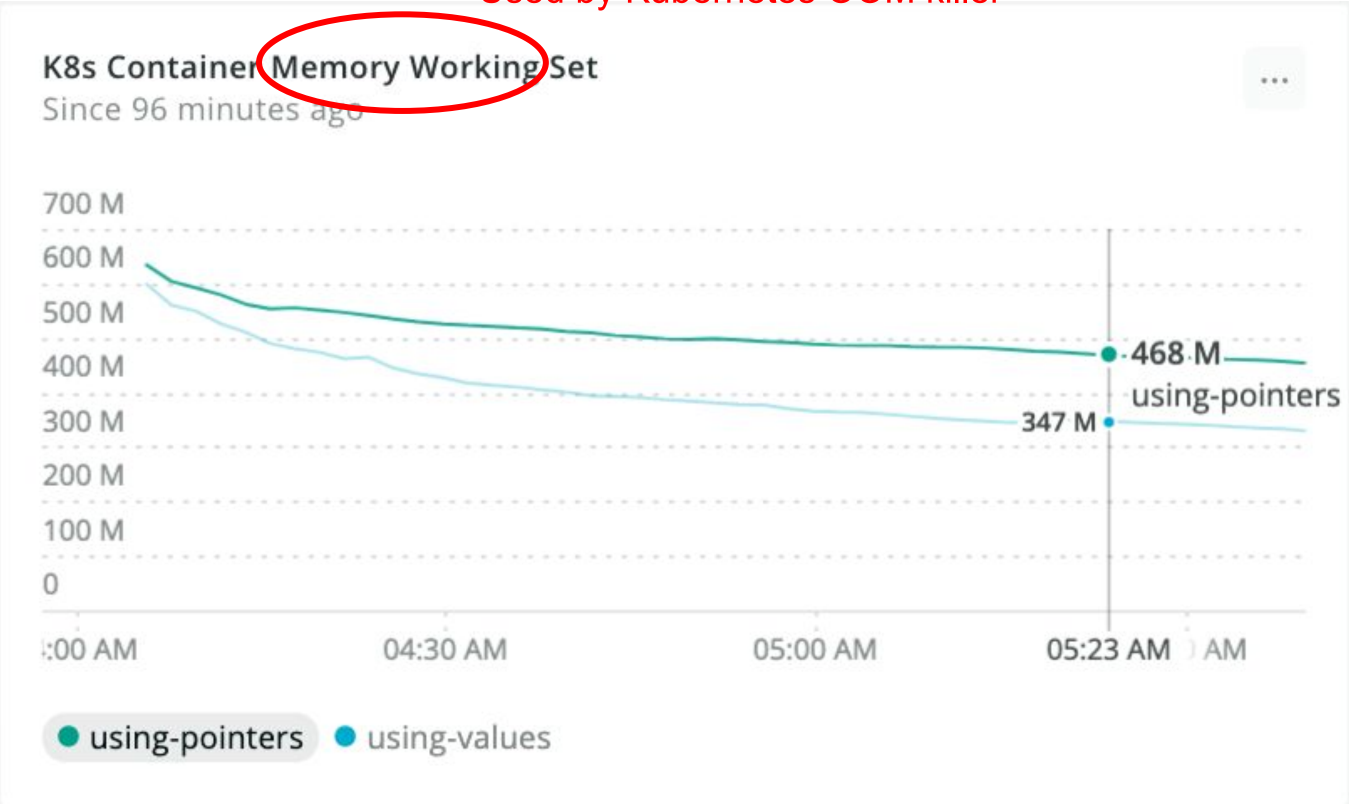
Conclusions

Running the example in Kubernetes. New Relic Metrics



Running the example in Kubernetes. New Relic Metrics

Used by Kubernetes OOM killer



With thousands of containers, this +35% might do the difference

Table of contents

Refreshing: values vs pointers

Digging more: µBenchmarks

A more realistic use case

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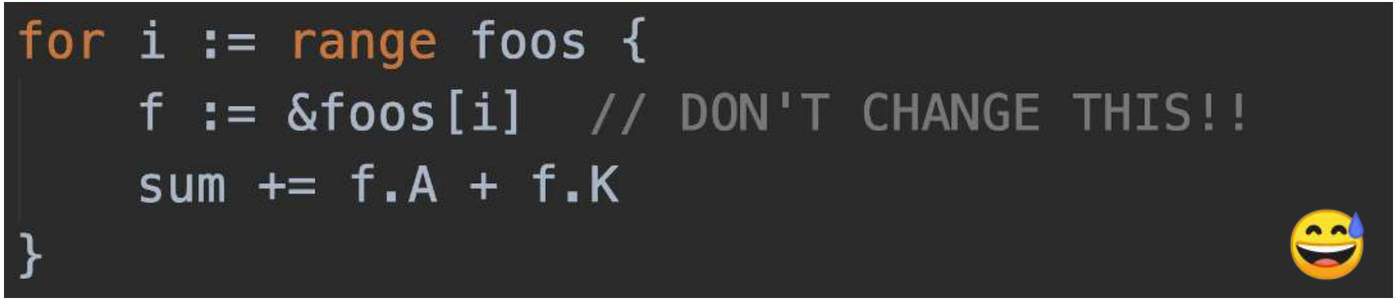
Conclusions

- First, aim for clean and robust code
- If, in a hot spot, performance is so critical that you must start micro-optimizing:
  - Consider reducing your memory generation (Heap allocations) rather than the memory copy
  - Consider the memory contiguity
  - Consider adding a comment:



```go
for i := range foos {
    f := &foos[i]  // DON'T CHANGE THIS!!
    sum += f.A + f.K
}
```

😅

Thank you for your attention!

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Barcelona Golang Meetup

January 2020

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