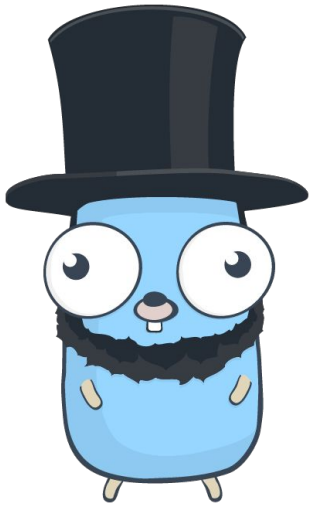
Profile all the things!

Using pprof in Go

John Potocny

Capital Go 2017



About Me

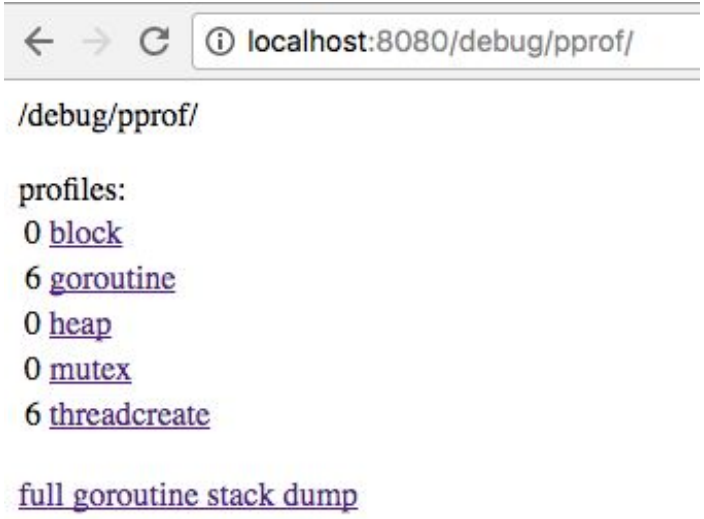
- @johnpotocny1
- Backend Developer @ VividCortex
- We’re hiring!

So, let’s talk about pprof

- Been around since before Go1 was released
- Initial support for CPU and heap profiling
- Full list of default profiles as of Go1.8:
  - CPU
  - Goroutine
  - Heap
  - ThreadCreate
  - Block
  - Mutex (New in Go1.8!)
- Godoc here: https://golang.org/pkg/runtime/pprof/

How do I use pprof?

- https://play.golang.org/p/FvEMZw0GhD
- Alternative: import “net/http/pprof”
  - **Demo1**




```go
package main

import (
    "fmt"
    "io"
    "log"
    "net/http"
    _ "net/http/pprof"
)

func main() {
    http.HandleFunc("/", handler)
    http.ListenAndServe("localhost:8080", nil)
}
```

How do I use pprof? (cont.)

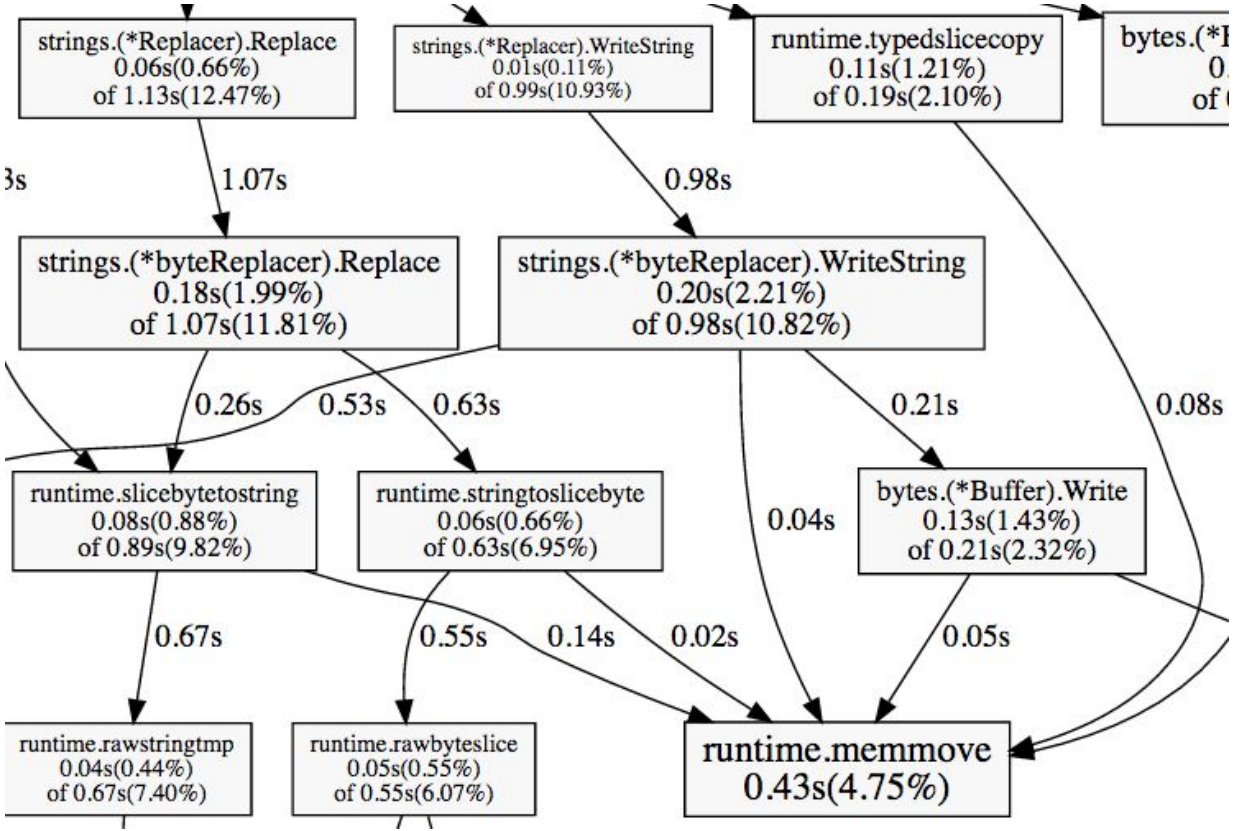
- Use ‘go tool pprof’ to fetch profiles from a program with a pprof server:
- Can also use write profiles when running ‘go test’
  - ex: **go test -cpuprofile=cpu.out; go tool pprof presentation.test cpu.out**

```
~:502 $ go tool pprof stage-api0:8085/debug/pprof/profile
Fetching profile from http://stage-api0:8085/debug/pprof/profile
Please wait... (30s)
Saved profile in /Users/johnpotocny/pprof/pprof.api-metrics.stage-api0:8085.samples.cpu.001.pb.gz
Entering interactive mode (type "help" for commands)
(pprof) top
570ms of 1520ms total (37.50%)
Showing top 10 nodes out of 174 (cum >= 60ms)
      flat  flat%   sum%        cum   cum%
      80ms  5.26%  5.26%      140ms  9.21%  encoding/json.(*decodeState).scanWhile
      70ms  4.61%  9.87%      920ms 60.53%  encoding/json.(*decodeState).object
      70ms  4.61% 14.47%      140ms  9.21%  runtime.scanobject
      60ms  3.95% 18.42%      120ms  7.89%  reflect.(*rtype).Name
      60ms  3.95% 22.37%       90ms  5.92%  runtime.mapaccess1
```

Add the binary for more visibility!

```
presentation:504 $ go tool pprof --seconds=120 presentation localhost:8080/debug/pprof/profile
Fetching profile from http://localhost:8080/debug/pprof/profile?seconds=120
Please wait... (2m0s)
Saved profile in /Users/johnpotocny/pprof/pprof.presentation.localhost:8080.samples.cpu.004.pb.gz
Entering interactive mode (type "help" for commands)
(pprof) list handler
Total: 6.26s
ROUTINE ======================== main.handler in /Users/johnpotocny/vividcortex/go/src/github.com/
         0       10ms (flat, cum)  0.16% of Total
         .          .     31:   http.ListenAndServe("localhost:8080", nil)
         .          .     32:}
         .          .     33:
         .          .     34:func handler(w http.ResponseWriter, r *http.Request) {
         .          .     35:   latest := incrementCounter()
         .       10ms     36:   _, err := io.WriteString(w, fmt.Sprint(latest))
         .          .     37:   if err != nil {
         .          .     38:           log.Println("error writing response:", err)
         .          .     39:   }
         .          .     40:}
```

Types of Profiles: CPU



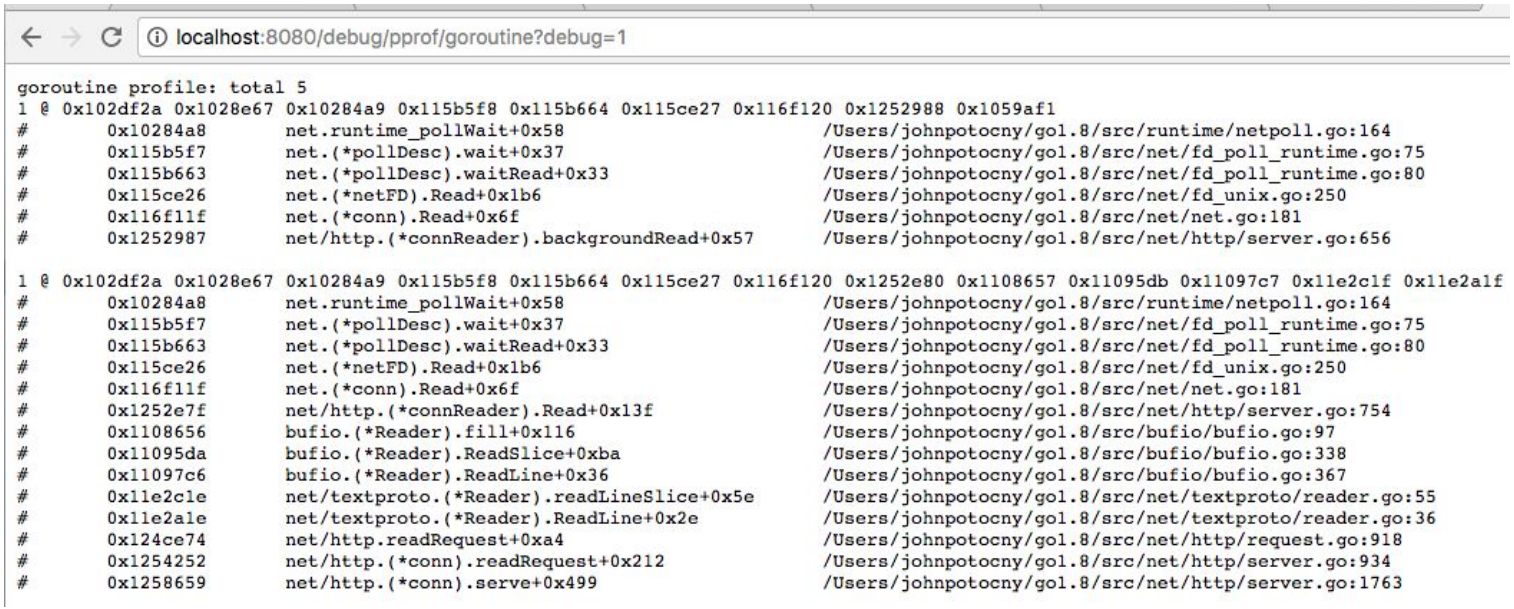
Types of Profiles: Heap

- 4 different modes to view
  - --inuse_space (default): shows live heap memory in bytes
  - --inuse_objects: shows # of live heap objects
  - --alloc_objects: shows # of allocated objects
  - --alloc_space: shows allocated bytes over time

```
presentation:507 $ go tool pprof --alloc_objects presentation localhost:8080/debug/pprof/heap
Fetching profile from http://localhost:8080/debug/pprof/heap
Saved profile in /Users/johnpotocny/pprof/pprof.presentation.localhost:8080.alloc_objects.allo
Entering interactive mode (type "help" for commands)
(pprof) top
3623085 of 4861308 total (74.53%)
Dropped 10 nodes (cum <= 24306)
Showing top 10 nodes out of 53 (cum >= 190068)
      flat  flat%   sum%        cum   cum%
    742786 15.28% 15.28%    1045005 21.50%  context.WithCancel
    655368 13.48% 28.76%     655368 13.48%  runtime.rawstringtmp
    349540  7.19% 35.95%     349540  7.19%  runtime.makemap
    327694  6.74% 42.69%     327694  6.74%  net.sockaddrToTCP
    327689  6.74% 49.43%     327689  6.74%  syscall.anyToSockaddr
    290276  5.97% 55.40%    2475559 50.92%  net/http.(*conn).readRequest
```

Types of Profiles: Goroutine

- List goroutines aggregated by stack
- Use debug=2 to have all routines separated, with current state included.



Types of Profiles: ThreadCreate

- Shows which goroutines lead to creation of threads in an app
  - Broken? See https://github.com/golang/go/issues/6104


```
threadcreate profile: total 6
6 @
#       0x0
```

```
demo4:505 $ go tool pprof demo4 localhost:8080/debug/pprof/threadcreate
Fetching profile from http://localhost:8080/debug/pprof/threadcreate
Saved profile in /Users/johnpotocny/pprof/pprof.demo4.localhost:8080.thr
Entering interactive mode (type "help" for commands)
(pprof) top
0 of 6 total (    0%)
      flat  flat%   sum%        cum   cum%
(pprof)
```

Types of Profiles: Block

- Shows time spent blocked on synchronization (mutexes, channels, etc.)
- Not enabled by default call runtime.SetBlockProfileRate() to enable
  - Argument is rate in ns to sample blocked routines
  - 1 = sample all events
  - 0 = disable
  - 100 = sample every 100ns

Types of Profiles: Block (cont.)

Demo2

```
demo2:622 $ go tool pprof demo2 localhost:8080/debug/pprof/block
Fetching profile from http://localhost:8080/debug/pprof/block
Saved profile in /Users/johnpotocny/pprof/pprof.demo2.localhost:8080.contentions.delay.008.pb.gz
Entering interactive mode (type "help" for commands)
(pprof) list handler
Total: 837.85ms
ROUTINE ======================== main.handler in /Users/johnpotocny/vividcortex/go/src/github.com/
emo2.go
         0   366.91ms (flat, cum) 43.79% of Total
         .          .     33:   return latest
         .          .     34:}
         .          .     35:
         .          .     36:func handler(w http.ResponseWriter, r *http.Request) {
         .          .     37:   // Introduce a 1us block.
         .   366.76ms     38:   <-time.After(time.Microsecond)
         .   150.92us     39:   _, err := io.WriteString(w, fmt.Sprint(incrementCounter()))
         .          .     40:   if err != nil {
         .          .     41:           log.Println("error writing response:", err)
         .          .     42:   }
         .          .     43:}
(pprof)
```

Types of Profiles: Mutex

- Added in Go1.8
- Block showed us blocked routines; Mutex profile shows us blockers
  - Specifically, which routines spend time holding a mutex

Type of Profiles: Mutex (cont.)

Demo3

```
demo3:629 $ go tool pprof demo3 localhost:8080/debug/pprof/mutex
Fetching profile from http://localhost:8080/debug/pprof/mutex
Saved profile in /Users/johnpotocny/pprof/pprof.demo3.localhost:8080.contentions.delay.003.pb.gz
Entering interactive mode (type "help" for commands)
(pprof) list handle
Total: 8.49ms
ROUTINE ======================== main.handleReadCounter in /Users/johnpotocny/vividcortex/go/src/
on/demo3/demo3.go
         0     8.49ms (flat, cum)   100% of Total
         .          .     42:   globalCounter.Lock()
         .          .     43:   _, err := io.WriteString(w, fmt.Sprintln(globalCounter.count))
         .          .     44:   if err != nil {
         .          .     45:           log.Println("error writing response:", err)
         .          .     46:   }
         .     8.49ms     47:   globalCounter.Unlock()
         .          .     48:}
(pprof)
```

Types of Profiles: Mutex (cont.)

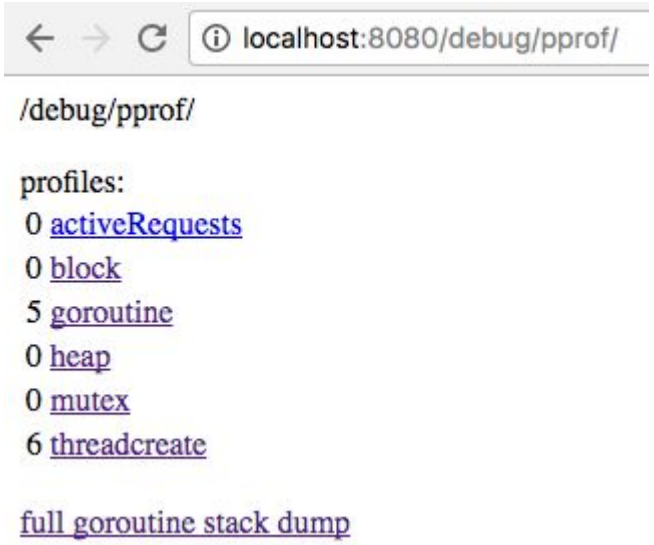
- What if we use a RWMutex?
  - RLock/RUnlock are not tracked; RWMutex.Lock/Unlock are though
  - Milestone for Go1.9; https://github.com/golang/go/issues/18496

```
demo3:634 $ go tool pprof demo3 localhost:8080/debug/pprof/mutex
Fetching profile from http://localhost:8080/debug/pprof/mutex
Saved profile in /Users/johnpotocny/pprof/pprof.demo3.localhost:8080.
Entering interactive mode (type "help" for commands)
(pprof) list handle
profile is empty
(pprof) top
profile is empty
(pprof)
```

Types of Profiles: Custom!

- runtime/pprof exposes an API for creating our own profiles!
- Demo4

```
15
16  const profileName = "activeRequests"
17
18  var myProfile *pprof.Profile
19
20  func init() {
21      // Check that the profile doesn't exist;
22      // if we try to create it twice we get a panic!
23      if myProfile = pprof.Lookup(profileName); myProfile == nil {
24          myProfile = pprof.NewProfile(profileName)
25      }
26  }
```



Custom Profiles (cont.)

```
34  // trackRequest wraps an http handler with tracing information
35  // so we can profile in-flight requests.
36  func trackRequest() func() {
37      // Allocate a byte and use its memory address as a key for the profile.
38      key := new(byte)
39
40      // Add the key to track that we have another request in progress.
41      // Pass skip=1 to omit the myProfile.Add call in the stack recorded;
42      // higher values will remove more calls and start higher up the stack.
43      myProfile.Add(key, 1)
44
45      // Introduce artificial delay in the request we're tracking,
46      // since they don't do much work.
47      time.Sleep(time.Millisecond * 500)
48
49      return func() {
50          // Remove the counter for the now completed request.
51          myProfile.Remove(key)
52      }
53  }
```

```
69  func handleIncCounter(w http.ResponseWriter, r *http.Request) {
70      defer trackRequest()()
71      incrementCounter()
72  }
```

Custom Profiles (cont.)

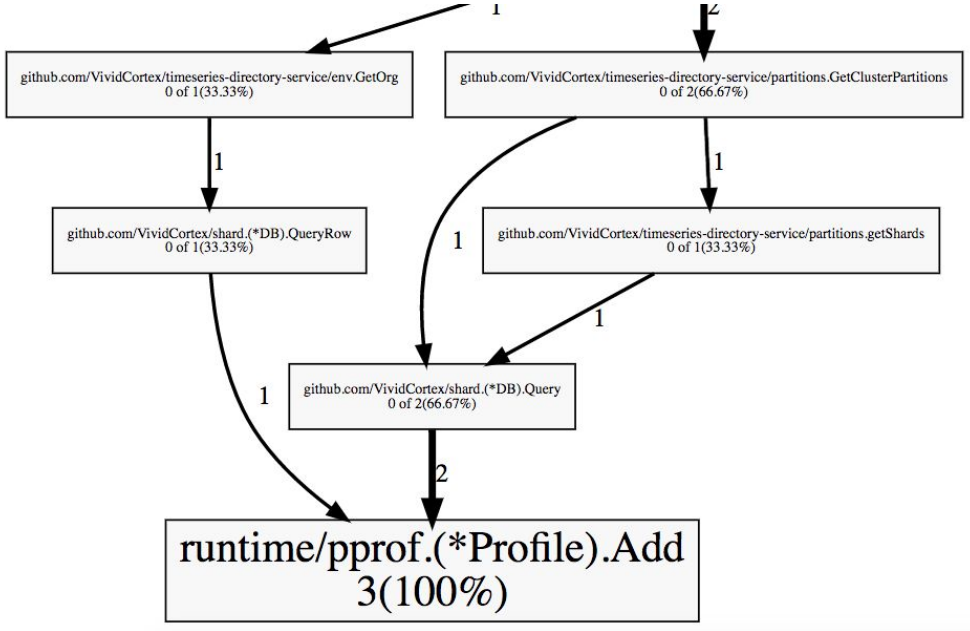
```
(pprof) list handle
Total: 2
ROUTINE ======================== main.handleIncCounter in /Users/johnpotocny/vividcortex/go/s
demo4/demo4.go
         0          1 (flat, cum) 50.00% of Total
         .          .     65:
         .          .     66:   return latest
         .          .     67:}
         .          .     68:
         .          .     69:func handleIncCounter(w http.ResponseWriter, r *http.Request) {
         .          1     70:   defer trackRequest()()
         .          .     71:   incrementCounter()
         .          .     72:}
         .          .     73:
```

When to Use Custom Profiles

- Track a critical resource in your application
  - Open files
  - Active DB handles
  - Open Network sockets
  - In-use worker routines
- Make it easier to identify resource leaks in our apps
- We can also identify contention around bounded resources

Demo: A real-world case for custom Profiles

- I added support for tracking active-queries in a service at VividCortex!
  - Now it's easier for us to track db-concurrency in our apps



What’s next for pprof?

- Support tracking file descriptors? https://github.com/golang/go/issues/16379
- Profile non-heap memory too? https://github.com/golang/go/issues/15848
- Count-oriented custom profiles? https://github.com/golang/go/issues/18454
  - Allow aggregating events forever rather than showing current-state only
  - Accepted proposal, Go1.9 milestone
- Support profiles with labels: https://github.com/golang/go/issues/17280
  - Accepted proposal, Go1.9 milestone

Thank You!