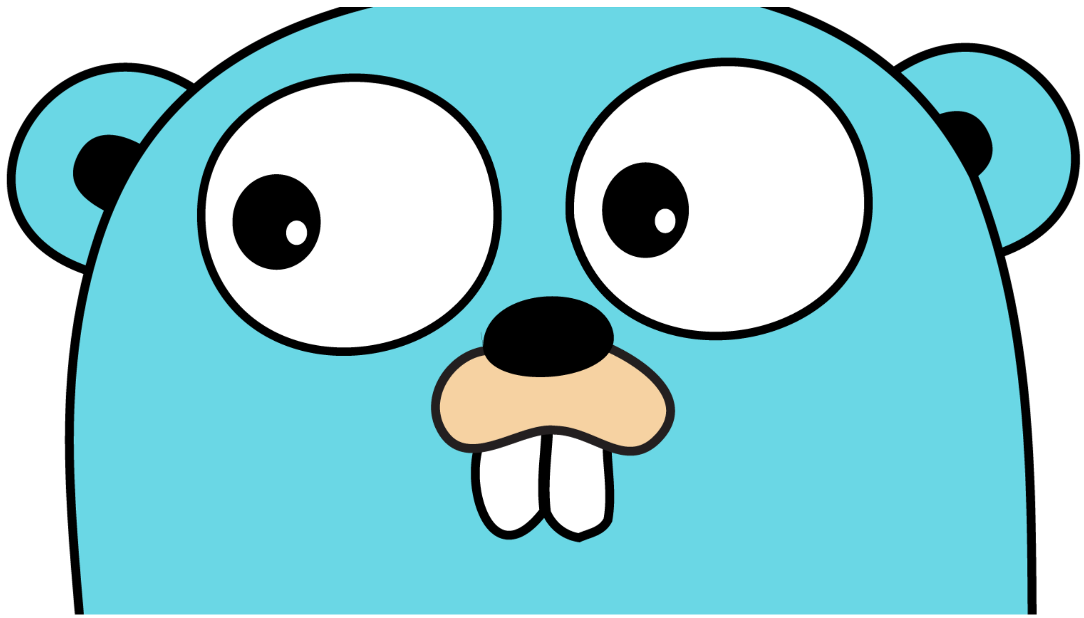

Go`ing, go`ing.. gone!

Some bits on the Go runtime

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Peter Kieltyka / peter@pressly.com

Personal exploration

- Writing backend software for the last 10 years
- Started with writing small UNIX network apps in C
- Wrote web apps with PHP for a few years, discovered and fell in <3 with Ruby, tried to make it fast for years after that
- Tried Node, Scala..
- Found Go

Go’s goal: to make writing concurrent server software easy, safe and fun

Go’s concurrency model

- Inspired by Tony Hoare’s CSP (Communicating Sequential Processes)
- Message passing vs. shared state
- The concurrency primitives offered by Go:
  - goroutines & channels
- No “thread” api for application developers; thats all under the hood (runtime)

The two important pieces for fast network applications

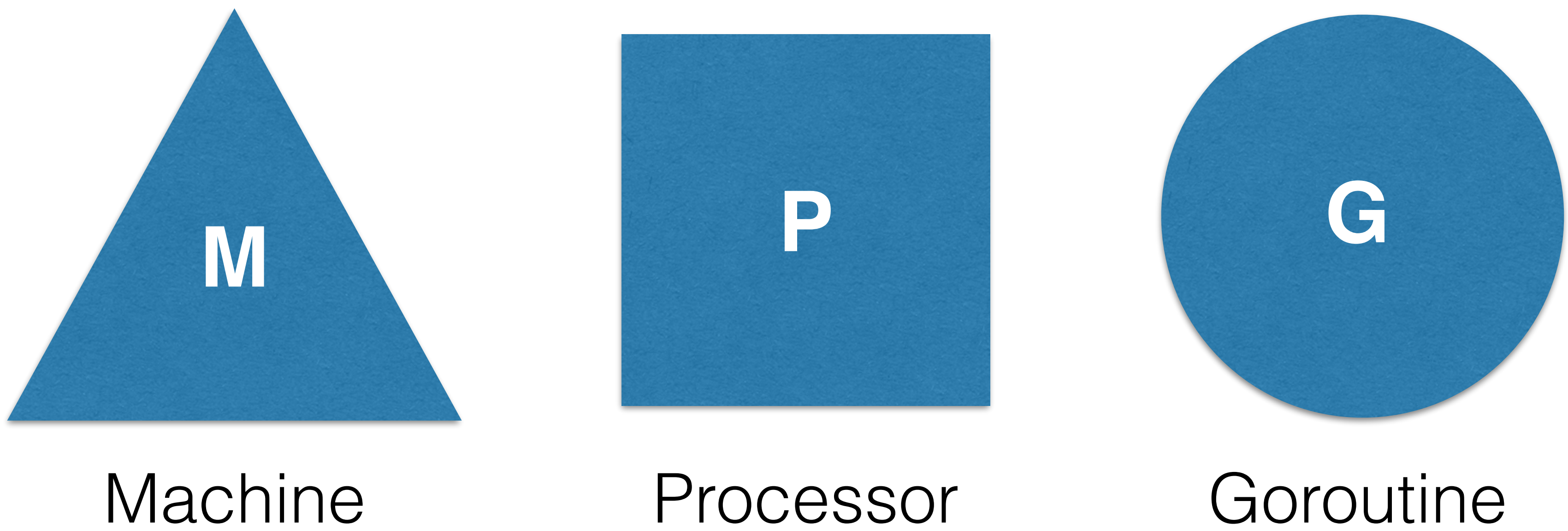
		managed by..
Threading model	→	Scheduler (src/pkg/runtime/proc.c)
Network I/O	→	Netpoller (src/pkg/runtime/netpoll*.goc)

Multithreading models..

1:1	N:1	M:N
Kernel-level threading	User-level threading	Hybrid threading
OS threads	Green threads	OS threads + green threads
OS Scheduler	App runtime scheduler	OS / App runtime scheduler
Threads are expensive (initial size, 1 to 8 mb per thread)	Fast context switching, but, what about the other cores?	Difficult to implement, balance of language syntax / runtime

Go’s Scheduler

The scheduler's job is to distribute ready-to-run goroutines over worker threads. The main pieces:



G Goroutine

```
struct  G {
    int64       goid;         // Go id
    uintptr     stackbase;    // The stack
    uintptr     stack0;       // Stack pointer
    uintptr     stacksize;    // Stack size
    int16       status;       // Current state in runtime
    …
} // src/pkg/runtime/runtime.h
```

- The `go fn()` we all know and love; spawn a coroutine to later execute ‘fn’. Puts a G on the local run queue.
- 8KB per goroutine on initial size (Go 1.2 and 1.3)
- Stack grows and shrinks as necessary
- main() is also a G
- Status (runtime.h): Idle, Runnable, Running, Syscall, Waiting, Dead
- Executes on an **M**achine in the context of a **P**rocessor

M Machine

```
struct  M {
    int32   id;             // Machine id
    bool    spinning;       // M is out of work and is actively looking for work
    bool    blocked;        // M is blocked
    int32   gcing;          // M is garbage collecting
    G*      curg;           // Current running goroutine
    P*      p;              // Attached P for executing Go code (nil if not executing Go code)
    …
} // src/pkg/runtime/runtime.h
```

- Managed OS Thread for executing Go code
- Start/stop new M's (threads), as necessary, managed by the runtime not the developer
- A thread cache for efficiency
- Special rules for when blocking on a Syscall or executing a CGO function

P

Processor

```
struct  P {
    int32       id;          // Processor id
    uint32      status;      // Current state: Idle, Running, Syscall, Gcstop, Dead
    M*          m;           // Current associated Machine
    G*          runq[256];   // Goroutines queue
    …
} // src/pkg/runtime/runtime.h
```

- Exactly `GOMAXPROCS` P’s
- P schedules Goroutines to run on an attached M in FIFO order
- Context for scheduling G’s on M’s, must attach to an M to execute a new G (code)
- P has local run queue of Goroutines, as well periodically checks a global queue of G’s
- and, when a P’s go run queue is empty, it will steal work from other busy P’s

Peak under the hood

ex.go

```
package main

import (
	"fmt"
	"time"
)

func main() {
	fmt.Println("hey hey, my main G")
	go myFn("hey, wait up")
	time.Sleep(10e6) // give it a sec..
}

func myFn(s string) {
	fmt.Println(s)
}
```

./ex (from proc.c)

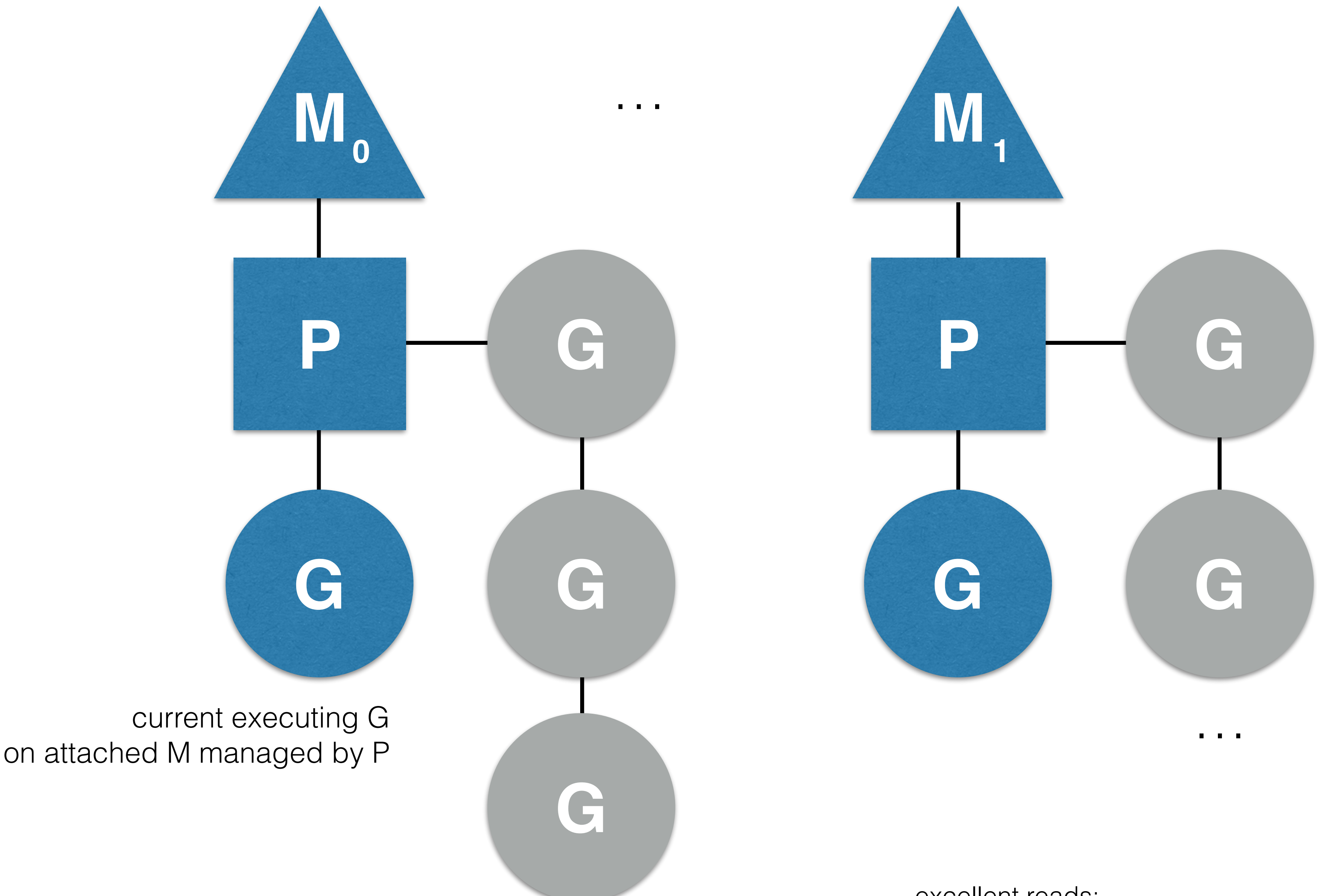
Bootstrap:

- runtime·args()
- runtime·osinit()
    - Set runtime·ncpu
- runtime·schedinit()
    - Set max M count (10k default)
    - Set args / env vars
    - Init first P
- runtime·newproc(&mainFn())
    - Make a new G and queue it
    - Effectively calling `go main()`
- runtime·mstart()
    - Init a new M
    - Find a new G to run
    - Execute the G

Exec main G:

- fmt.Println(..)
- runtime·newproc(&myFn())
    - Make a new G for call to myFn and queue it
- time.Sleep(..)

Scheduler visual; GOMAXPROCS=2



waiting G's
...

excellent reads:
http://morsmachine.dk/go-scheduler
http://golang.org/s/go11sched

Here’s whats really interesting (IMO)..

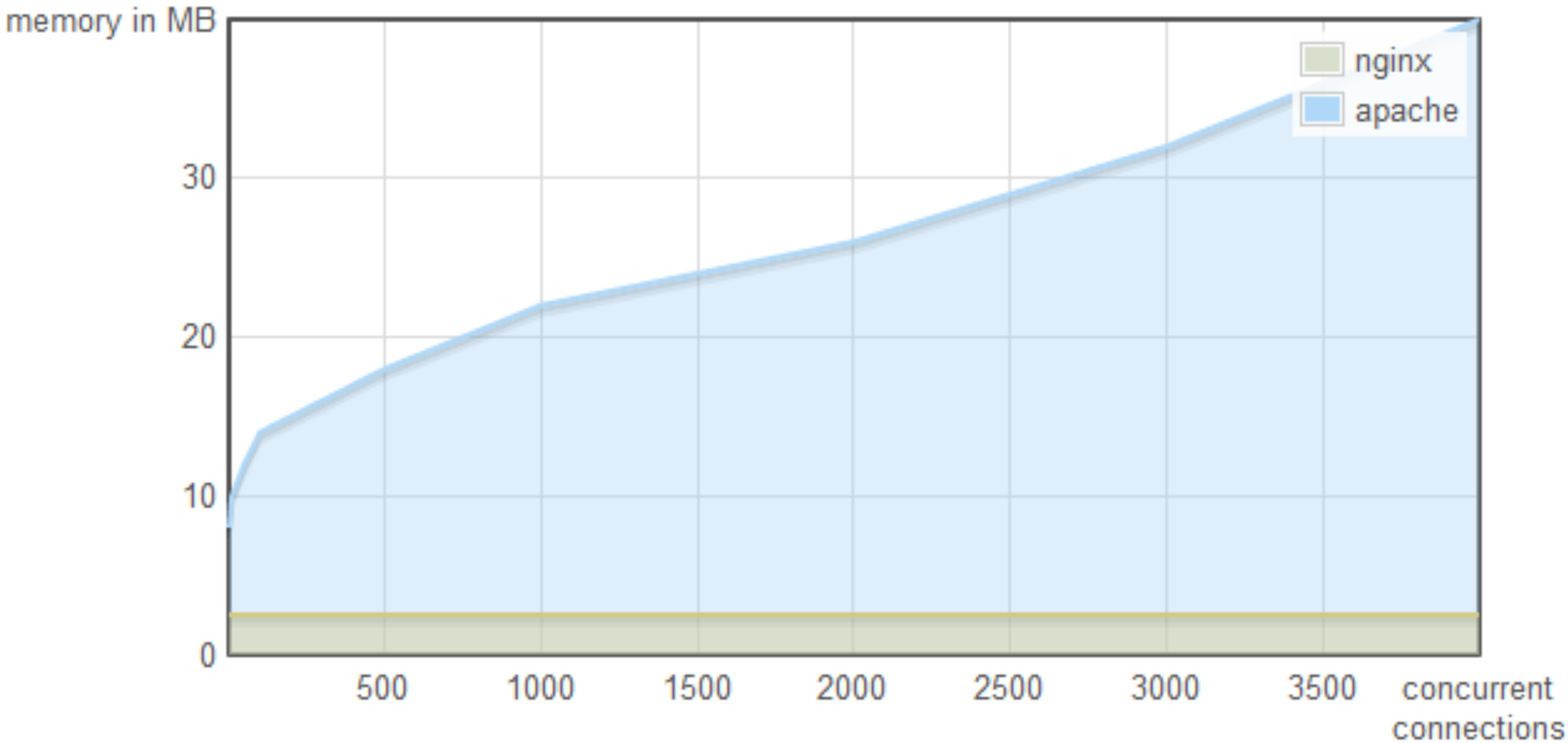
- So, the scheduler abstracts threads with Goroutines, and manages their execution across multiple cores

- On a network operation, a Goroutine will block, and be put back on the run queue until its ready

- Blocking..? how is it so efficient and fast?

- Go actually uses an evented IO under the hood whenever performing network operations.. just like Nodejs, Scala, etc.

A real world example of evented IO kicking butt



*Google it

Netpoller

- Network IO interface to kqueue, epoll, IOCompletionPort
- Kernel-level stateful file descriptor monitoring and event notification of readiness and completion
- As opposed to using select()/poll() which have to check each fd each iteration
  - With thousands of operations, this becomes expensive

Example

```
//…package, imports..
func main() {
	go func() {
		for {
			time.Sleep(10 * time.Millisecond)
			fmt.Println("tick..")
		}
	}()

	var wg sync.WaitGroup
	wg.Add(1)
	go func() {
		resp, _ := http.Get("http://www.google.ca/")
		defer resp.Body.Close()
		fmt.Println(resp.Status)
		wg.Done()
	}()

	wg.Wait()
}
```

Block G on network io operations;
put the G back on the local runq and set
g->status = waiting

The beauty of Go to me is in the design of language (syntax), the threading model and evented network IO

Writing speedy servers has never been easier.

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Thanks!

peter@pressly.com | @peterk