Experience on implementing a Web server in Haskell

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Why a New Web Server?

In last fall, I needed a Web server for our research.
It should be able to be modified as I want.

Apache is first choice but large and complicated.
And I was tired from reading/writing in C.

Yes, I wanted a Web server in Haskell.
But I didn't know any Web servers in Haskell.

So, I started programming from scratch.
My web server is "Mighttpd" (called mighty)

Three Goals of Mighttpd

Functionality: Mighttpd should provide enough functionality to replace Apache on my domain "Mew.org".

Modularity: Mighttpd should be able to be modified easily for our research.

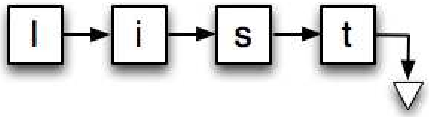
Performance: Mighttpd should exceed Apache on static contents.

Two Ideas for Performance

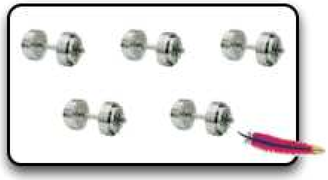
ByteString

User thread

Traditional `String` in Haskell is very slow.



Kernel thread is heavy.



`ByteString` is faster like `char[]` in C.

User thread is light.

HTTP and thread programming

Network protocol	Message oriented	Stream oriented
	DNS	SMTP, HTTP
Network programming	Event driven	Threading
	`select,kqueue,epoll`	`fork,pthread_create`

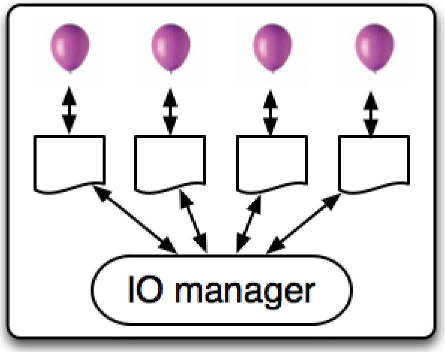
😬 Event driven programming for stream oriented protocol is messy.

🙂 Thread programming for stream oriented protocol is concise.

😈 I want to implement HTTP on threading. Simplicity is a good thing.

User Thread is Real Thread

- 😐 GHC has an IO manager as a user thread.
  It is event-driven.
- 😐 It takes care of buffering and wakes up blocked user threads.
- 🙂 So, using user threads is really thread programming.



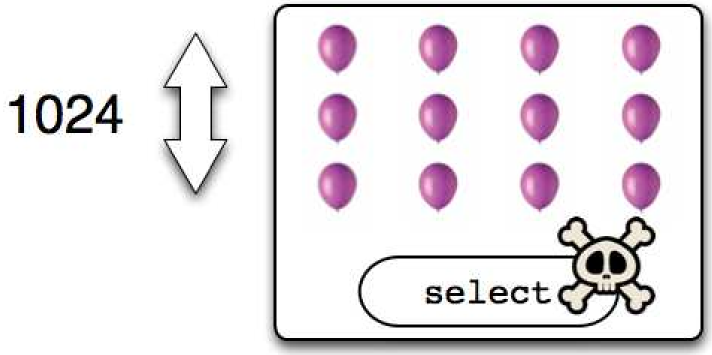
hGet — User thread

Handle — Buffering

Socket — Event driven

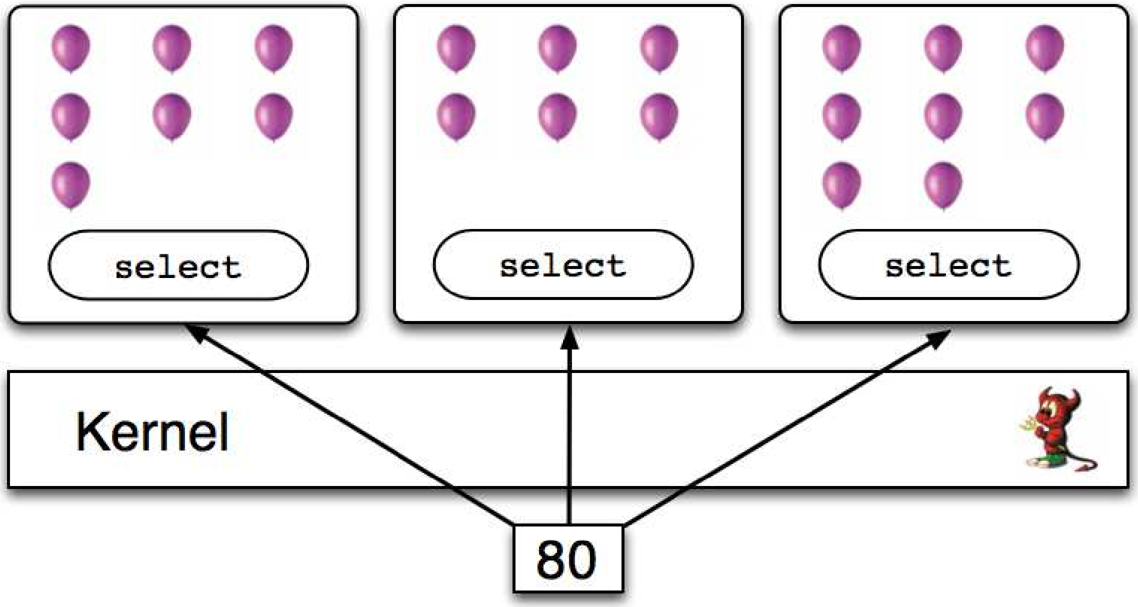
The barrier of 1,024 connections

- The IO manager is implemented using `select`.
- `select` cannot handle over 1,024 files/connections.
- If GHC 6.12 receives over 1,024 connections, resource exhaustion exception happens.



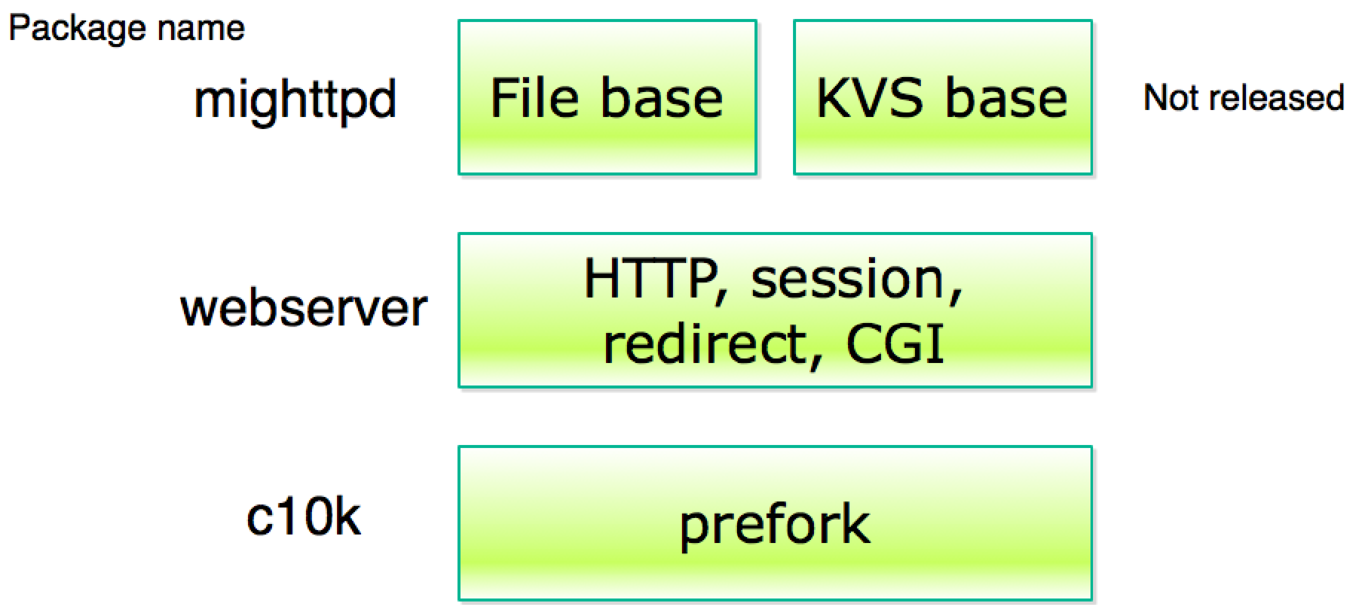
Prefork library

Prefork is a technique to share a listening port among forked processes.



Now, GHC 6.12 can accept any number of connections!

Mighttpd implementation



Package name

mighttpd

File base

KVS base

Not released

webserver

HTTP, session, redirect, CGI

c10k

prefork

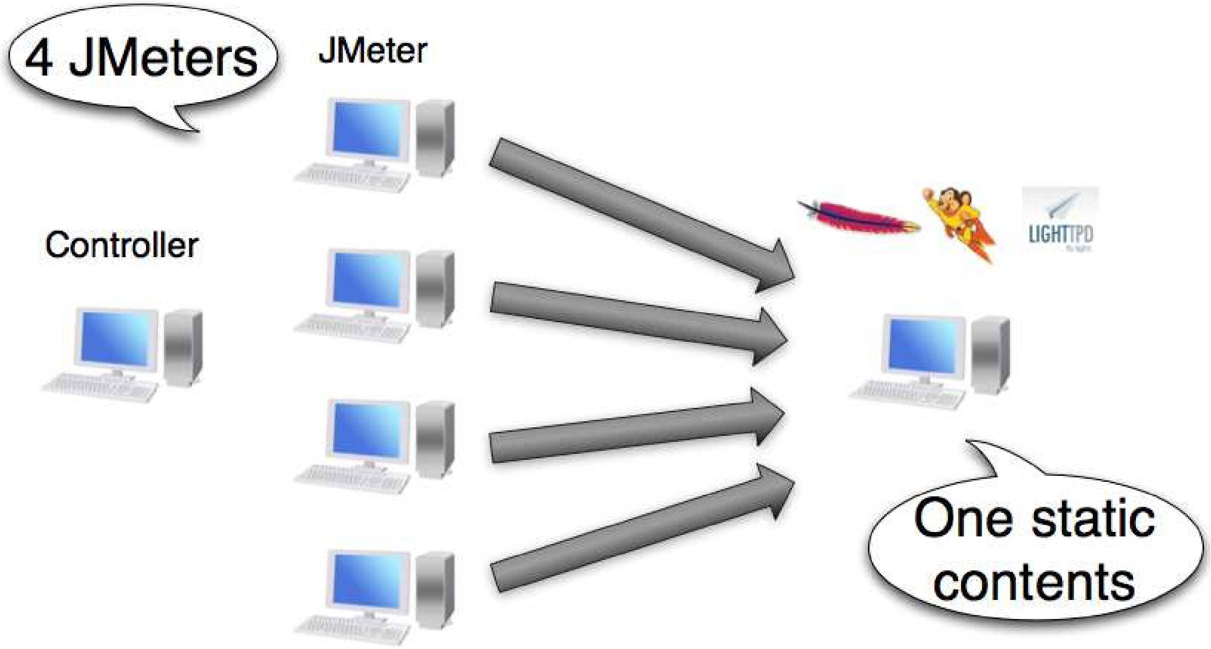
Modularity

"webserver" is designed to handle any storage systems.

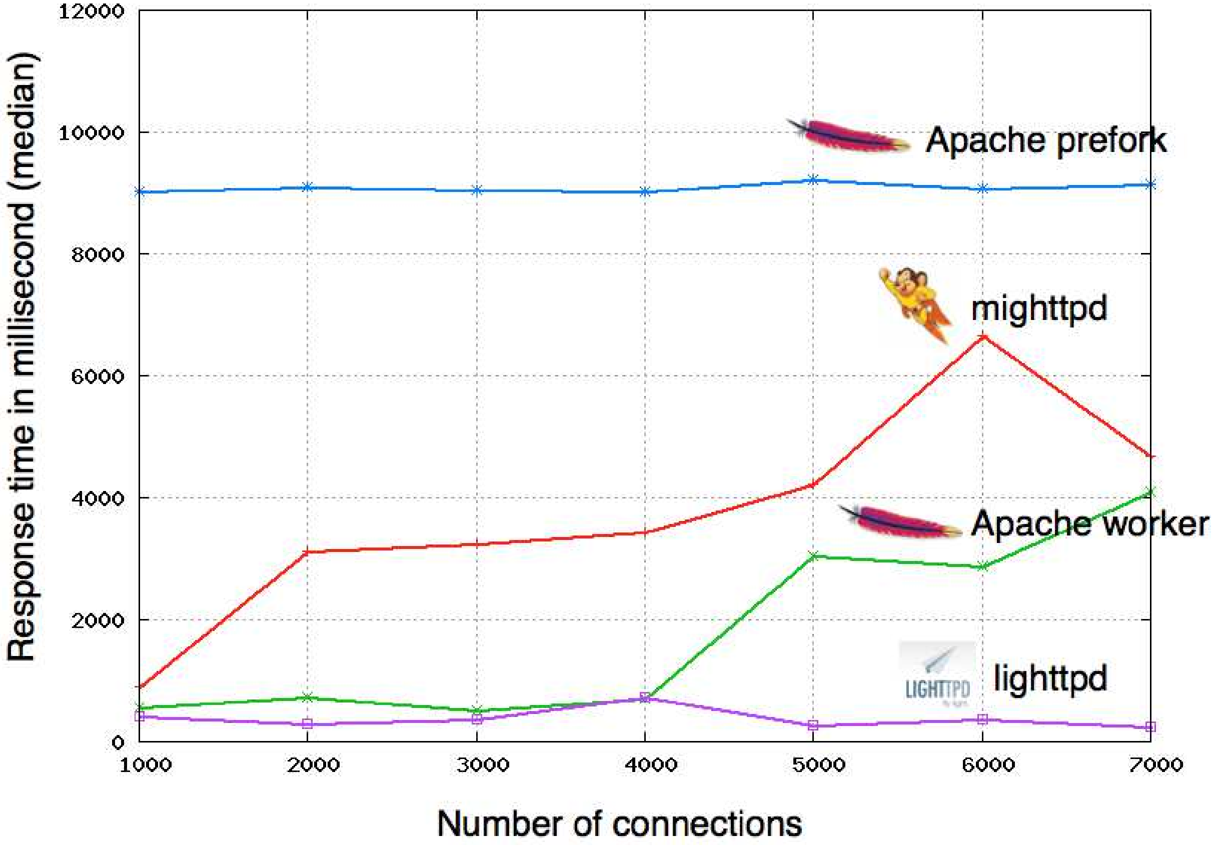
Functionality

"mighttpd" works on Mew.org now!

Benchmark Environment



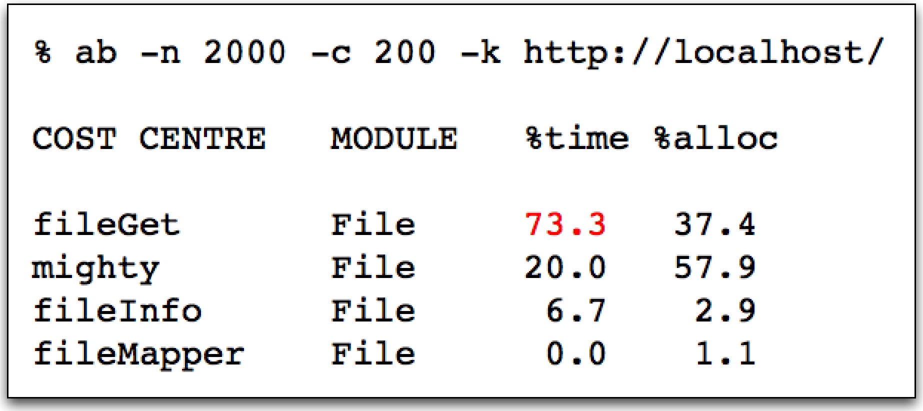
Benchmark Result



- Benchmark is unstable, so don’t fully trust this result.

Profiling

😠 File IO is dominant.
Why, Mighttpd slower than Apache?



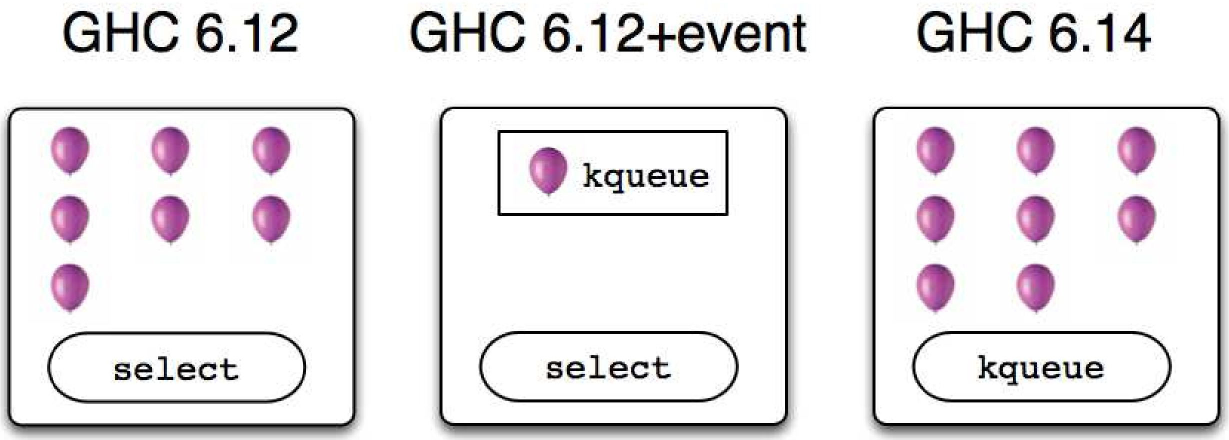
```
% ab -n 2000 -c 200 -k http://localhost/

COST CENTRE    MODULE    %time %alloc

fileGet        File       73.3   37.4
mighty         File       20.0   57.9
fileInfo       File        6.7    2.9
fileMapper     File        0.0    1.1
```

😟 Ah, it's overhead of `select`!

😢 Any hopes?

One Hope

- 🙂 Tibbe and Bos are developing "event" library for `kqueue` and `epoll`.
- 😐 Now we can use it for event-driven network programming.
- 🙂 They are planning to integrate it into the IO manager in GHC 6.14.



GHC 6.12

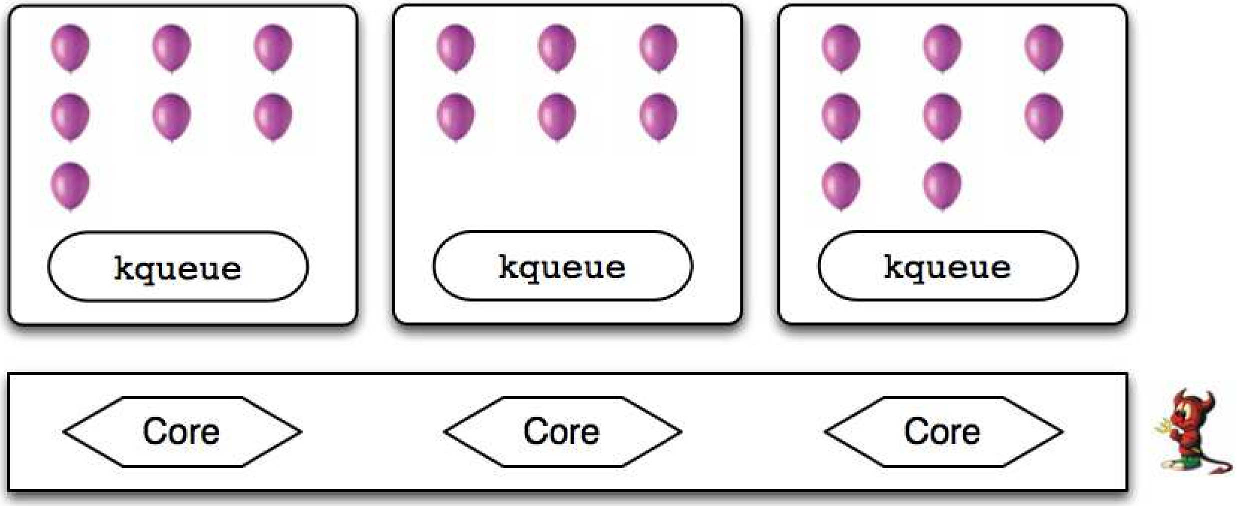
GHC 6.12+event

GHC 6.14

Feture architecture

😬 Since there is only one IO manager,
GHC 6.14 would not balance on multi-core.

😉 But the prefork technique could be used
to balance on multi-core.



Conclusions

- 😃 Network programming in Haskell is fun thanks to user threads!

- 😢 But GHC 6.12 is weak in network programming due to `select`.

- 😴 GHC 6.14 would solve this problem. Let's enjoy user-thread network programming.

- 😉 Prefork library could be used to balance processes on multi-core.

Links

- Mighttpd
  - http://www.mew.org/~kazu/proj/mighttpd/
- My github
  - http://github.com/kazu-yamamoto
- JL Smiley
  - http://jamlog.podzone.org/