Building RESTful Web Services with Erlang and Yaws

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QCon San Francisco

20 November 2008

Erlang

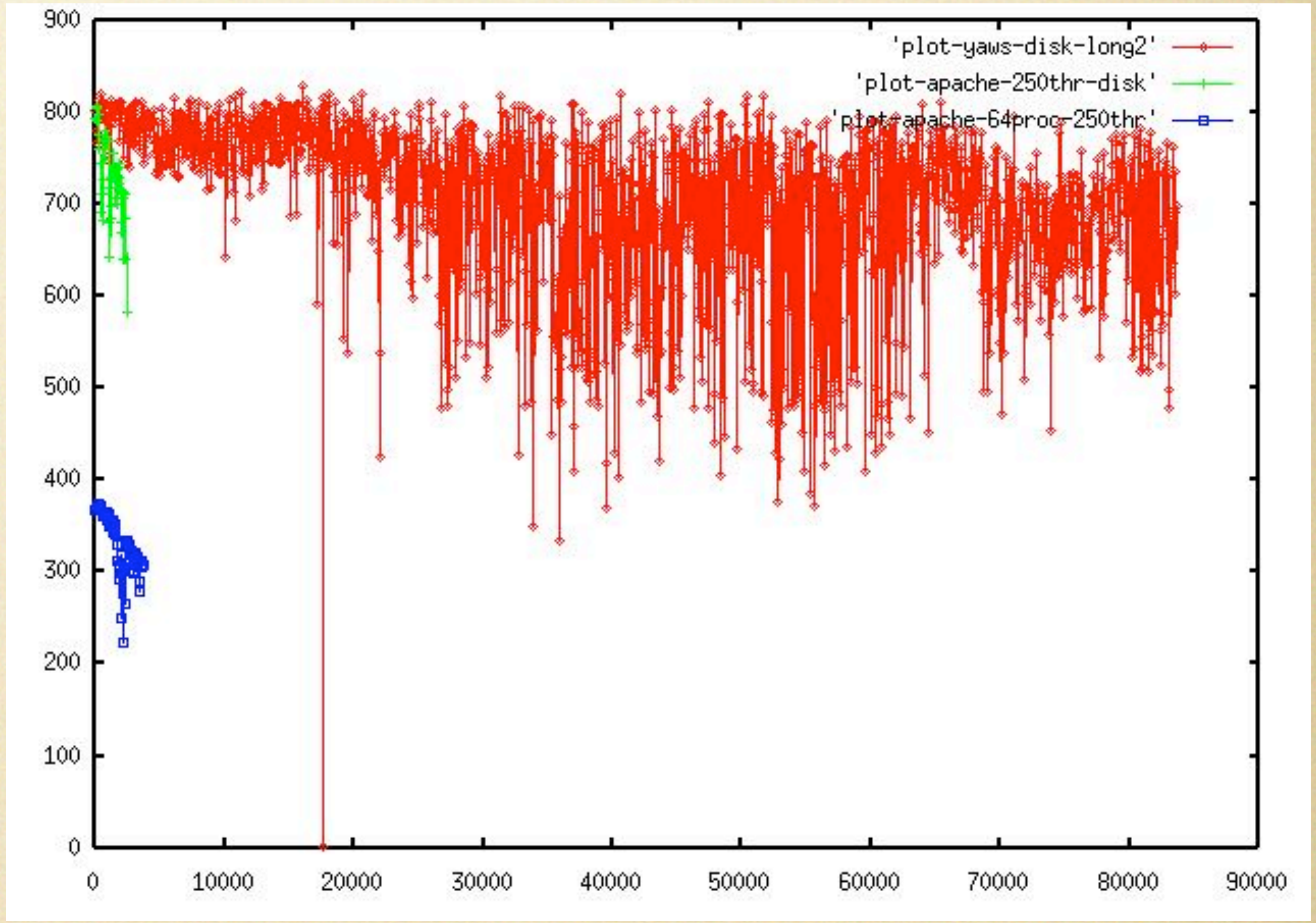
- Functional programming language created in 1986 at Ericsson
- Focuses on long-running, concurrent, distributed, highly reliable systems
- Small language that enables big productivity

Yaws

- "Yet Another Web Server" implemented starting in early 2002 by Claes "Klacke" Wikström, long-time Erlang expert
- Perhaps best known outside the Erlang community for the "Apache vs. Yaws" graphs
- Excellent for serving dynamic content
- Can run stand-alone or embedded within a larger Erlang application
- http://yaws.hyber.org/

Apache vs. Yaws

- Yaws (in red) vs. Apache (green and blue)
    - X axis: number of connections
    - Y axis: throughput (kB/sec)



- Find details of the experiment at http://www.sics.se/~joe/apachevsyaws.html

Topics

- Trying to cover Erlang, Yaws, and REST in depth in an hour doesn’t work (I’ve tried)
- Instead:
    - explain general Yaws capabilities
    - cover several areas to focus on when building RESTful web services
    - describe how to implement each of those areas using Yaws and Erlang

Yaws Dynamic Content

- One way is to embed Erlang code in <erl> ... </erl> tags in your HTML

```
<html>
  <body>
    <p>
      <erl>
        out(Arg) ->
          {html, "Hello, World!"}.
      </erl>
    </p>
  </body>
<html>
```

- Place this into a ".yaws" file and Yaws calls "out" which generates HTML to replace <erl> ... </erl>

“Out” Functions

- Yaws calls application “out” functions in various contexts to produce dynamic content
  - written as “out/1” in Erlang notation, since “out” takes 1 argument
- The argument to “out” is an “arg” record
  - supplies access to all details of the incoming request — URI, methods, HTTP headers, etc.
- Depending on the calling context, out/1 returns either part or all of the response

Ehtml

- Returning HTML-formatted strings from out/1 is painful
  - embedded tags can get messy
- Yaws provides ehtml as a better alternative
  - essentially HTML in Erlang syntax
  - Tuple consisting of the atom `ehtml` and a list of HTML elements

Ehtml Example

- `{ehtml, `*`list-of-tags`*`}`
- list-of-tags:
  `[{`*`html-tag`*`, `*`list-of-attributes`*`, `*`list-of-values`*`}]`
- Rewrite the previous <erl> ... </erl> example:

```
<erl>
out(Arg) ->
  {ehtml,
    [{html,[],
      [{body,[],
        [{p,[],"Hello, World!"}]}]}]}.
</erl>
```

Appmods

- A Yaws appmod ("application module") is an Erlang module that:
  - exports an out/1 function
  - is tied into one or more URI paths
- When it encounters a path element with an associated appmod, Yaws calls the appmod out/1 function to process the rest of the URI
- Appmods are specified in the Yaws config file

Appmod Example

- First set the appmod configuration in yaws.conf:

```
<server test>
  port = 8000
  listen = 127.0.0.1
  docroot = /usr/local/var/yaws/www
 appmods = <foo, foo>
</server>
```

Appmod foo

```
-module(foo).
-export([out/1]).
-include("yaws_api.hrl").

out(Arg) ->
 {ehtml,
  [{html, [],
   [{body, [],
    [{h1, [], "Appmod Data"},
     {p, [],
      yaws_api:f("appmoddata = ~s",
                 [Arg#arg.appmoddata])},
     {p, [],
      yaws_api:f("appmod_prepath = ~s",
 [Arg#arg.appmod_prepath])}]}]}]}.
```

Invoking appmod foo

- Results of running
  curl http://localhost:8000/tmp/foo/bar/baz/

```
<html>
 <body>
  <h1>Appmod Data</h1>
  <p>appmoddata = bar/baz/</p>
  <p>appmod_prepath = /tmp/</p>
 </body>
</html>
```

- Appmod prepath is /tmp/, appmod data is bar/baz/
- Could also access the rest of Arg to get query

Yapps

- Yapps — “yaws applications”
- Makes use of full Erlang/OTP application design principles for supervision, auto-restart, etc.
  - Yapps reside in the same Erlang VM instance with the Yaws application
- Yapps are tied to URIs like appmods, and they also have appmods under them
  - appmod: just a module
  - yapp: application comprising multiple modules, some of which are appmods

Yapp Framework

- The Yapp application itself is an optional framework under Yaws which manages user yapps
- By default it persistently stores registrations for user yapps in mnesia (Erlang's distributed fault-tolerant datastore)
  - easy to replace the mnesia default (e.g., I use an in-memory registry with boostrapped yapps)
- For details on installing and using yapps, see http://yaws.hyber.org/yapp_intro.yaws

Focus Areas for RESTful Services

- Resources and identifiers
- Representations and media types
- Hypermedia and linking
- HTTP Methods
- Conditional GET

Dealing with URIs

- Some advise spending time designing “nice” URIs, some argue against it
  - Arguments against say it doesn’t matter because with proper use of hypermedia, clients don’t care
  - But I argue for good URI design because it affects your server implementation
- We’ve seen how appmods and yapps allow us to take over URI processing

Sidebar: Erlang Pattern Matching

- Erlang allows you to overload functions based on matching function arity and argument values

- For example, in raising a value N to a power M, we end the recursion with a version of the pow/3 function for which M == 0:

```
pow(N, M) -> pow(N, M, 1).

pow(_N, 0, Total) -> Total;

pow(N, M, Total) ->
  pow(N, M-1, Total*N).
```

Handling URIs with Pattern Matching

- Consider this out/1 function:

```
out(Arg) ->
   Uri = yaws_api:request_url(Arg),
   Uri_path = Uri#url.path,
   Path = string:tokens(Uri_path, "/"),
   out(Arg, Uri, Path).
```

- Breaks the target URI path into a list of path elements
- Invokes a different function, out/3, with more detail and returns its result
  - pass Arg and Uri for further access in called function

Handling URIs with Pattern Matching

- out/3 might look like this:

```
out(Arg, Uri, ["order"]) ->
  %% handles path order/;

out(Arg, Uri, ["order", Order_id]) ->
  %% handles path order/{order_id}/;

out(Arg, Uri, ["customer", Cust_id]) ->
  %% handles path customer/{cust_id}/

out(_Arg, _Uri, _Path) ->
  {status, 404}.
```

- Pattern-matching the URI path list lets us dispatch to specific handlers for each URI path

Designing URIs

- So, yes, I would argue that you *do* want to design your URIs well if possible
- Doing so allows you to make use of Erlang's pattern-matching feature to assist with URI processing and dispatching
- Can be combined with appmods as necessary to split processing and dispatching across different modules

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Representations and Media Types

- Each resource can have one or more representations
- Representation types are indicated by MIME types in the Content-type HTTP header
- Clients can negotiate content types by sending preferred types in Accept headers
  - preferences can be indicated using quality (“q”) parameters

Example Accept Headers

- Safari 3.2:
  text/xml,application/xml,application/xhtml+xml,text/html;q=0.9,text/plain;q=0.8,image/png,*/*;q=0.5
- Firefox 3.0.4:
  text/html,application/xhtml+xml,application/xml;q=0.9,*/*;q=0.8
- IE 7.0.5730.13:
  image/gif, image/x-xbitmap, image/jpeg, image/pjpeg, application/x-shockwave-flash, application/vnd.ms-excel, application/vnd.ms-powerpoint, application/msword, */*
- curl: */*

Service Clients and Accept Headers*

- As we can see, browser Accept headers tend to be long strings that contain so many options they're almost meaningless
- Web service client Accept headers are not like this
    - they tend to either ask for exactly what they want...
    - ...or they don't send an Accept header at all

* this slide was added after the QCon presentation based on feedback from Mark Nottingham

Parsing That Mess

- If your service handles both browser clients and service clients, you have to handle Accept
- A few years ago Joe Gregorio wrote mimeparse in Python to parse these header values
  - http://www.xml.com/pub/a/2005/06/08/restful.html
- I recently ported it to Erlang, available here:
  - http://code.google.com/p/mimeparse/
- Also available in Ruby and PHP, same location

Using mimeparse

- For each resource, decide which MIME type(s) you want to support
- Pass a list of those types and the Accept header to `mimeparse:best_match/2`:

```
Want = ["application/json", "text/html"],
Accept = (A#arg.headers)#headers.accept,
Best = mimeparse:best_match(Want, Accept)
```

- Handles quality parameters, etc.
- Returns empty list if no match

Dealing with MIME Types

- For the requested resource, determine the representation type the client wants
  - if there's no Accept header then choose a default
  - if there's an Accept header but no match with what you support, return HTTP status 406 ("Not Acceptable")
- Use pattern matching again to dispatch to the right handler

MIME Type Dispatching

- Change our out/3 function to out/4, adding the MIME type:

```
out(Arg,Uri,"text/html",["order"]) ->
  %% handles HTML repr for path order/;

out(Arg,Uri,"application/atom+xml",
      ["order"]) ->
  %% handles Atom repr for path order/;

out(_Arg, _Uri, _Other, ["order"]) ->
  {status, 406}.
```

Handling Common Representations

- Various packages allow you to natively handle common service resource representations in Erlang
- JSON:
  - Yaws supplies a json module
  - Mochiweb (another Erlang web framework) supplies mochijson and mochijson2
- XML:
  - xmerl, part of the Erlang system
  - erlsom, more modern and faster than xmerl

Returning Content

- To return content from your service, just return a “content” tuple from your out/1 function:

```
out(Arg,Uri,"application/json",Path) ->
  Json = {struct, [{name, "Steve Vinoski"},
                   {company, "Verivue"}]},
  Data = json:encode(Json),
  {content, "application/json", Data}.
```

- Sets the Content-type HTTP header to the MIME type you supply as the second tuple element

Supporting Multiple Representations

- Resources can have multiple representations
- Return the appropriate content type from each of your out/4 functions for that resource
- But set the Vary header to alert intermediaries of how the representation varies
- You can return HTTP status, headers, and content all at once like this:

```
out(Arg,Uri,"application/json",Path) ->
  Json = {struct, [{name, "Steve Vinoski"},
                   {company, "Verivue"}]},
  Data = json:encode(Json),
  [{status, 200},
   {header, {"Vary", "Accept"}},
   {content, "application/json", Data}].
```

Representations and Hypermedia

- A critical REST constraint is "hypermedia as the engine of application state" (HATEOAS)
    - Representations provide URIs to further resources to drive clients through their application state
- This works only if the client understands that something in the representation is a URI
- Common repr types like application/xml and application/json alone do not support HATEOAS!
    - XLink helps XML, and JSON making progress, see http://json-schema.org/

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Handling the HTTP Method

- For each resource, decide which HTTP methods it supports
    - GET, PUT, POST, DELETE, OPTIONS, HEAD
- You get the method for a given request from the http_request record via the Arg record:

```
Method = (Arg#arg.req)#http_request.method
```

- If a client invokes an unsupported method on a resource, return HTTP status 405 (“Method Not Allowed”)

Dispatching HTTP Methods

- You guessed it: more pattern matching
- Change our out/4 function to out/5, adding the HTTP method:

```
out(Arg,Uri,'GET',
     "text/html",["order"]) ->
  %% handles GET HTML repr for order/;

out(Arg,Uri,'POST',
     "text/html",["order"]) ->
  %% handles POST HTML repr for order/;
```

Retrieving Query and POST Data

- yaws_api:parse_post(Arg) returns a property list of name,value POST data pairs
- yaws_api:postvar(Arg, Name) looks up Name in POST data
- yaws_api:parse_query(Arg) returns a property list of name,value query string pairs
- yaws_api:queryvar(Arg, Name) looks up Name in the query string

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Conditional GET

- Conditional GET and caching are critical to web scalability
- Read Mark Nottingham's excellent "Caching Tutorial for Web Authors and Webmasters" for details (http://www.mnot.net/cache_docs/)
- Read Richardson's and Ruby's *RESTful Web Services* to learn about conditional GET

Conditional GET Return Headers

- Outgoing: set HTTP Etag and Last-modified headers
    - Etag is a hash-like string that uniquely identifies a representation
    - Last-modified is the date string of the resource's most recent modification
- Set these like any other header, using a header tuple as part of your out/5 return value:

```
[{header, {"Etag", Etag_value}},
 {header, {"Last-modified", Last_mod_val}}]
```

Conditional GET Incoming Headers

- To perform a conditional GET, client will send:
  - Last-modified value back in the If-modified-since header
  - Etag value back in the If-none-match header
  - or both, but Etag takes precedence
- Your code needs to look for these and handle them appropriately

Conditional GET Incoming Headers

- For incoming Etag values, if one matches the requested representation’s Etag...
- ...or for incoming modification dates, if the resource hasn’t changed since that date...
- ...then your service should return status 304 (“Not Modified”)
- This avoids creating potentially expensive-to-create representations and avoids returning potentially large representations

Development Concerns

- Yaws is *very* stable and robust
    - uses Erlang/OTP supervision and monitoring capabilities, and can auto-restart if any problems arise
- Provides interactive mode with debug output for tracking down issues with your code
- Full power of Erlang/OTP under it, so you can load new code on the fly for your yapps and appmods

Yaws Community

- Documentation and downloads available at http://yaws.hyber.org/
- Code is on sourceforge: http://sourceforge.net/projects/erlyaws
- Find the erlyaws mailing list there as well
- Since code is very stable, doesn't change much
  - I recently added better support for the HTTP OPTIONS method
  - Current projects Klacke and I are working on: adding sendfile linked-in driver support, and general testing

But Wait, There's More

- but not today :-)
- Read the Yaws documentation, lots there to discover
- Any final questions?