Building RESTful Services with Erlang and Yaws

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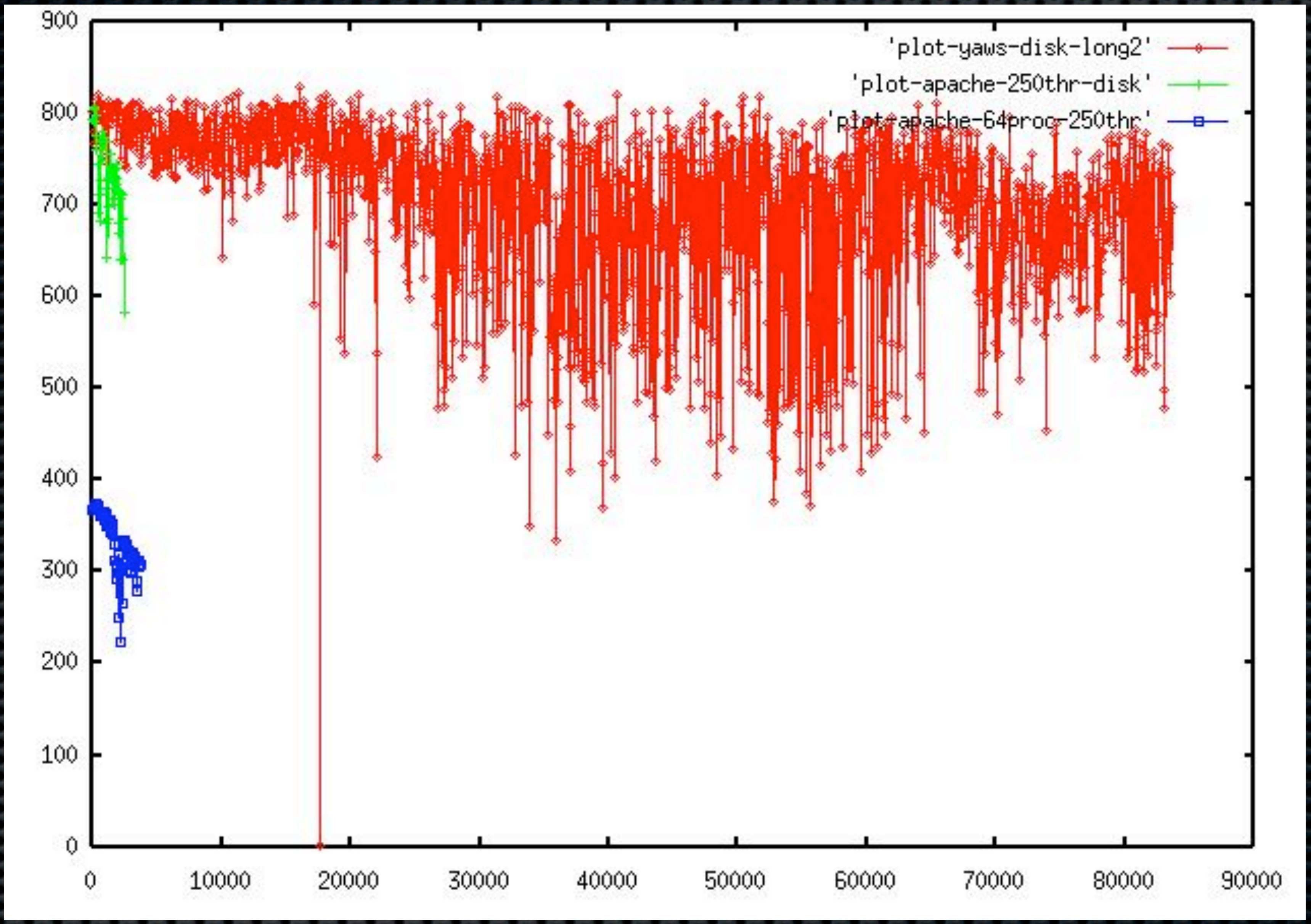
Why Yaws? ("Yet Another Web Server")



http://www.sics.se/~joe/apachevsyaws.html

Here we see Yaws handling 80000 concurrent connections, but Apache dying at 4000

Yaws is Written in Erlang

- Erlang began life in 1986 for developing highly reliable distributed concurrent systems
- Developed at Ericsson for telecom equipment
- Open sourced in 1998, it’s been used to develop systems with guaranteed nine nines reliability (31.5ms downtime per year)
- Under active development, version R12B-2 came out in April 2008

Erlang Reliability

- Enabling highly reliable systems is a primary goal for Erlang (designed for “concurrent programs that run forever” — Joe Armstrong, creator of Erlang)
- It encourages designs that accept that failure will occur and must be dealt with
  - Processes can be arranged in distributed supervision trees, supervisors watch and restart failed processes
- Code can be loaded into running systems
- The Open Telecom Platform (OTP) libraries provide common application behaviors supporting reliability

Message Passing

- Erlang avoids shared state, uses message passing instead
  - the type of message passing originally intended for OO languages
  - very fast, asynchronous, same host or across hosts
- Erlang variables cannot be re-assigned; they're bound once and that's it, to avoid mutable state
- No explicit code for concurrency guards, locks, synchronization etc. required

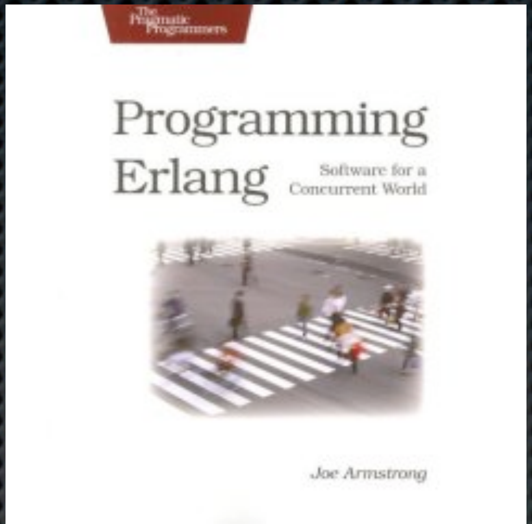
Pattern Matching

- In Erlang, X = 3 is a pattern matching operation
  - if X is unbound, it's bound to the value 3
  - if X is already bound, it's an error unless it's bound to the value 3
  - avoids mutable state and the need to guard it
- Pattern matching is a significant and important feature of Erlang
  - used for assignment, checking for values, receiving messages, function selection

Yet Another Web Server (Yaws)

- Yaws was written and is maintained by Claes "Klacke" Wikström, and is open source available from http://yaws.hyber.org/
- Written in Erlang as an OTP application
- Takes advantage of Erlang's concurrency and distribution capabilities to provide significant scalability
- Testimonials often state that Yaws handles on a single host loads that other web servers need multiple hosts to handle

Erlang Details



- We don't have enough time for an Erlang tutorial
- Get Joe Armstrong's book *Programming Erlang*
  - very readable
  - both an introduction and a language reference
- Lots of information at http://www.erlang.org/
- *erlang-questions* mailing list (available from above link)

RESTful Design

- Name your resources with URIs
- For each resource, decide:
  - what each HTTP method does and what status codes it returns
  - what media types to support
  - how each representation of the resource guides the client through its application state
  - how to handle conditional GET (etags, last-modified)

REST Basics

- The term “Representational State Transfer” was coined by Roy T. Fielding in his Ph.D. thesis, published in 2000: “Architectural Styles and the Design of Network-based Software Architectures”
- REST is an architectural style that targets large-scale distributed hypermedia systems
- It imposes certain constraints to achieve desirable properties for such systems

Desired System Properties

- Performance, scalability, portability
- Simplicity: simple systems are easier to build, maintain, more likely to operate correctly
- Visibility: monitoring, mediation
- Modifiability: ease of changing, evolving, extending, configuring, and reusing the system
- Reliability: handling failure and partial failure, and allowing for load balancing, failover, redundancy

Constraints Induce Desired Properties

- REST intentionally places constraints on the system to induce these properties
- In general, software architecture is about
  - imposing constraints and
  - choosing from the resulting trade-offs in order to achieve desired properties

REST Constraints

- Client-Server
- Statelessness
- Caching
- Layered System
- Uniform Interface
- Code-on-demand

Uniform Interface Constraint

- What: all servers present the same general interface to clients
  - In HTTP, this interface comprises the protocol's verbs: GET, PUT, POST, DELETE
- Why: important for implementation hiding, visibility of interactions, intermediaries, scalability
- This constraint induces several more constraints, described later

HTTP Verbs are Methods

Method	Purpose	Idempotent?
GET	Retrieve resource state representation	Yes (no side effects)
PUT	Provide resource state representation	Yes
POST	Create or extend a resource	No
DELETE	Delete a resource	Yes

Uniform Interface Benefits

- Enables visibility into interactions
  - including caching, monitoring, mediation applicable across all resources
- Provides strong implementation hiding, independent evolvability
- Simplified overall architecture

Uniform Interface Sub-Constraints

- Resource identification via URIs
- Resource manipulation through the exchange of resource state representations
- Self-describing messages with potentially multiple representation formats
- Hypermedia as the engine of application state (a.k.a. HATEOAS, or hypermedia constraint)

Representations

- Method payloads are representations of resource state
  - hence the name "Representational State Transfer"
- REST separates methods and data formats
  - Fixed set of methods, many standardized data formats, multiple formats possible per method per resource

Media Types

- Representation formats are identified using media (MIME) types
- These types are standardized/registered through the IANA (http://www.iana.org/assignments/media-types/)
- Allows reusable libraries and tools in a variety of programming languages to handle various MIME types

Hypermedia Constraint

- Resources keep resource state, clients keep application state
- Resources provide URIs in their state to guide clients through the application state
- Clients need “know” only a single URI to enter an application, can get other needed URIs from resource representations

For Example

- Consider a bug-tracking system
  - HTML representations for interactive viewing, additions, modifications
  - Excel or CSV representations for statistical tracking by importing into other tools
  - XML (e.g. AtomPub) or JSON to allow integration with other tools
  - Atom feeds for watching bug activity
- Existing clients that understand these formats can easily adapt to use them — serendipity

RESTful Design With Yaws

- Design URIs for your resources
- For each resource, decide:
  - what each HTTP method does and what status codes it returns
  - what media types to support
  - how each representation of the resource guides the client through its application state
  - how to handle conditional GET (etags, last-modified)

URI Design

- URIs must be designed from an application perspective, not from a server perspective
  - in the old days URIs corresponded to file pathnames on the web server
  - that's still possible, but RESTful services often don't deal with files at all
- URIs name the resources the client will access and manipulate
- URIs collectively form an application state space the client can navigate

URI Examples

- Bugs for project "Phoenix" might be found here:

  http://example.com/projects/Phoenix/bugs/
- The specific bug numbered 12345 might be here:

  http://example.com/projects/Phoenix/bugs/12345/
- Bugs for user jsmith might be here:

  http://example.com/projects/Phoenix/users/jsmith/bugs/

Representation Generation

- Yaws provides three ways for your code to generate resource representations:
  - .yaws pages
  - application modules (appmods)
  - Yaws applications (yapps)

.yaws Pages

- Enclose a function named “out” taking an Arg (HTTP request argument) within <erl></erl> tags in a file
  - in Erlang we refer to this function as out/1
  - function named “out” with arity 1 (i.e., 1 argument)
- Give the file a “.yaws” extension
- When the file is requested Yaws executes the out/1 function and replaces <erl>...</erl> with the output of the function
- Mainly useful for relatively static content
- URIs are controlled by where .yaws file is placed relative to the document root

Application Modules (appmods)

- Lets application code take control of URIs
- An Erlang module exporting an out/1 function is configured in the Yaws config file to correspond to a URI path element
- When Yaws sees a request for that path element, it calls the out/1 function passing the HTTP request details, then returns the result of the function
- Such URIs need not correspond to file system artifacts

Yaws Applications (yapps)

- Similar to appmods, but a yapp is a full Erlang/OTP application
- This means it can run an init function, can have state, can support on-the-fly code changes, can be controlled by a supervisor, etc.
- Useful for talking to back-end services, e.g. maintaining connections to the back-end

HTTP Request Details (#arg)

- All out/1 functions receive an #arg record (basically a tuple) containing details of the HTTP request for which they're being invoked
- #arg provides details such as HTTP headers and various forms of URI path information
- For example, to get the request URI:

```
out(Arg) ->
    Uri = yaws_api:request_url(Arg),
```

URI-based Dispatching

- Use Erlang's pattern matching to dispatch to the right function to handle a given URI

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

out(Arg, ["projects", "Phoenix", "bugs"]) ->
    % handle the bugs URI here;

out(Arg, ["projects", "Phoenix", "bugs", Bug]) ->
    % handle bug number "Bug" here.
```

Handling HTTP Methods

- Same pattern matching approach can be used to dispatch on HTTP method

```
out(Arg) ->
    % get Uri and Path as in previous example
    Method = (Arg#arg.req)#http_request.method,
    out(Arg, Method, Path).
out(Arg, 'GET', ["projects", "Phoenix", "bugs"]) ->
    % return representation of bug list;
out(Arg, 'POST', ["projects", "Phoenix", "bugs"]) ->
    % add new bug to the list;
out(Arg, Method, ["projects", "Phoenix", "bugs"]) ->
    [{status, 405}];  % other methods not allowed
```

Same Again for MIME Types

- Representation the client wants is in the Accept header

```
out(Arg) ->
    % get Uri, Path, Method as in previous examples
    Accept_hdr = (Arg#arg.headers)#headers.accept,
    out(Arg, Method, Accept_hdr, Path).
out(Arg, 'GET', "text/html", ["projects", "Phoenix", "bugs"]) ->
    % return HTML representation of bug list;
out(Arg, 'GET', "application/xml", ["projects", "Phoenix", "bugs"]) ->
    % return XML representation of bug list;
out(Arg, 'GET', Accept, ["projects", "Phoenix", "bugs"]) ->
    [{status, 406}];  % other representations not acceptable
```

Conditional GET Support

- Whenever possible, design your RESTful service to return Last-modified and/or Etag HTTP headers
  - allows clients to cache and do conditional GETs based on whether the resource has changed since they last retrieved it
  - if no change, server returns status 304 with no payload — big scalability win
  - can be tricky to design this so that computing Etags has reasonable cost

For More Information

- *RESTful Web Services* teaches you everything you need to know about developing using the REST style
- My InfoQ article "RESTful Services with Erlang and Yaws" (http://www.infoq.com/articles/vinoski-erlang-rest)
- My "Toward Integration" columns in IEEE Internet Computing (all available from http://steve.vinoski.net/)
- yaws.hyber.org and erlang.org
- ErlyWeb (http://code.google.com/p/erlyweb/), a Yaws-based framework for database-based web systems