REST

Service-Oriented Architecture

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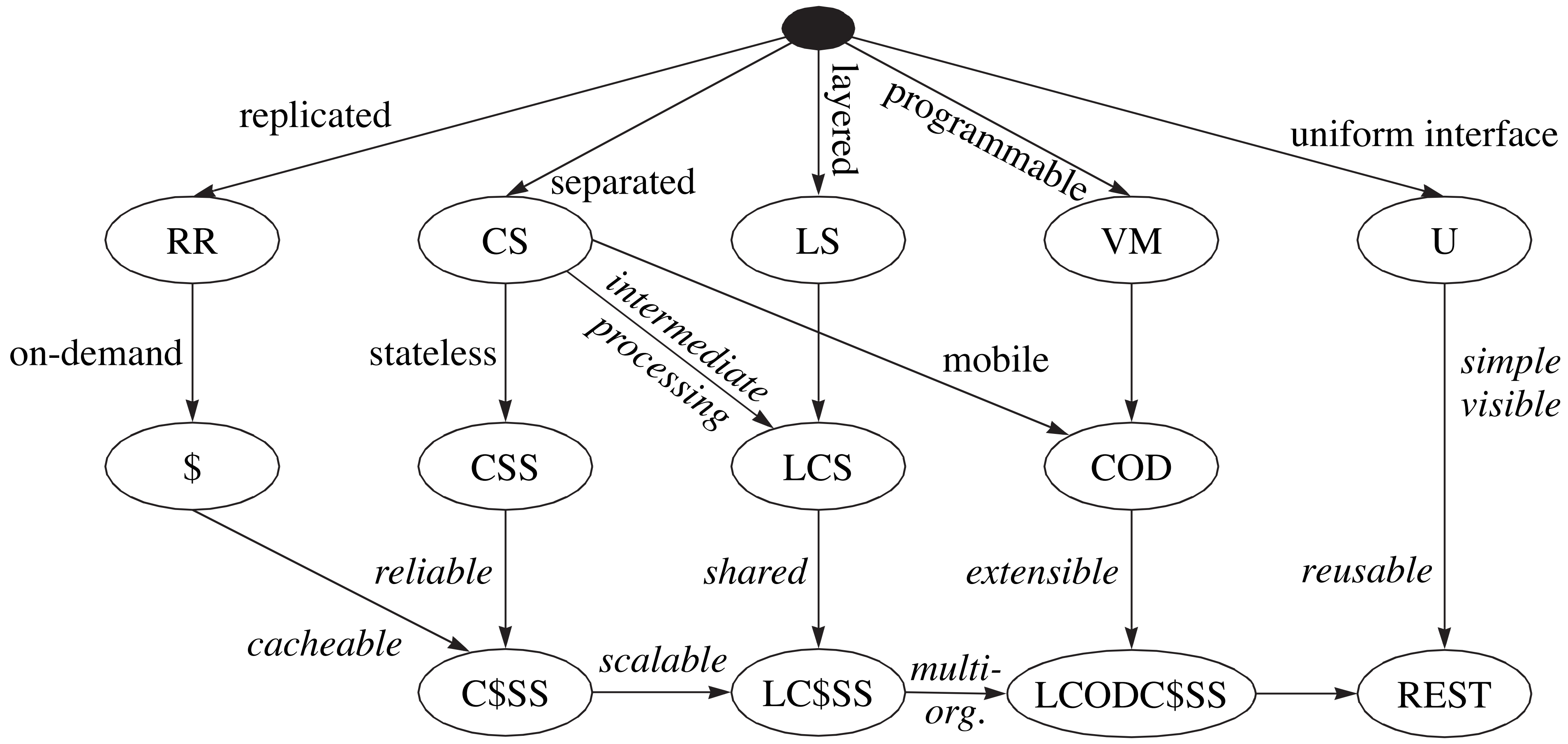
1 Representational state transfer (REST)

- Roy Fielding, a principal author of HTTP
- PhD thesis *Architectural Styles and the Design of Network-based Software Architectures* (2000)

  more about evaluation than a cookbook
- subsequent article *Principled Design of the Modern Web Architecture* (ACM TOIT 2:2, 2002)
- Richardson & Ruby, *RESTful Web Services*
- architectural patterns of the web
- taking HTTP seriously as a distributed computing protocol: fixed few verbs, emphasis on the nouns

2 Architectural styles



2.1 Client–server (CS)

- server offers services, listens for requests
- client sends request, waits for response
- transient, triggering client; persistent, reactive server
- separation of concerns: user interface from behaviour
- improves *portability* to a new user interface
- improves *scalability* by simplifying components
- improves *evolvability* by allowing independent evolution of components

2.2 Replication (RR) and caching ($)

- *replicated repository*: multiple servers provide same service
- present the illusion of a single, centralized service
- improves *performance*: latency, redundancy
- *maintaining consistency* the primary challenge

- a variation: *caching* responses for later reuse
- effectively a replication of a fragment (typically, potential data set is huge or infinite)
- responses explicitly or implicitly labelled cacheable or not
- lazy or active replication
- less effective than full replication, but cheaper and simpler

2.3 Stateless (S)

- each request from client must carry all necessary context
- no *session state* stored on server — kept entirely on client
- (*resource state* is a different matter)
- improves *visibility* for monitoring
- improves *reliability* by simplifying recovery from partial failure
- improves *scalability* by allowing server to free resources quickly
- improves *evolvability* by simplifying server, cache
- decreases *performance* by increasing overhead

2.4 Layered systems (LS)

- hierarchical arrangement
- layer provides services to layer above, uses services from layer below
- improves *evolvability* and *reusability* through abstraction
- decreases *performance* through overhead, latency

- layered-client-server (LCS) adds proxy and gateway components to CS
- *proxy* acts as shared server for one or more clients, forwarding (maybe translated) requests
- *gateway* appears as normal server, but forwards (maybe translated) requests to lower layers: load balancing, security

2.5 Uniform interface (U)

- improves *simplicity* and *visibility*
- decreases *efficiency* through possible data translations

- for REST, optimized for large-grain hypermedia data transfer
- identification of *resources*
- manipulation of resources through *representations*
- *self-descriptive* messages
- hypermedia as the engine of application *state*

2.6 Virtual machine (VM) and code-on-demand (COD)

- mobile code
- dynamically relocate processing between data source and destination
- improves *performance* by relocating code near data
- data element must be transformed into component

- extend client functionality by downloading applets/scripts
- virtual machine to provide controlled environment
- improves *simplicity* and *extensibility* of client
- reduces *visibility*
- not a big part of REST-based SOA (yet: cf AJAX)

3 The REST architectural style

- ‘uniform, layered, cached-client, stateless-server, with code-on-demand’
- data elements
- connectors
- components
- some good reading at `http://www.prescod.net/rest/`

3.1 Resources

- key idea: every data element is a *resource*
  - named document
  - temporal service (‘today’s lunch menu at Rewley’)
  - collection of other resources
  - non-virtual object (‘Marilyn Monroe’)
  - anything you might want reference, annotate, or act upon
  - abstractly, just a time-dependent set of values
- resources referenced by URIs
- generality
- late binding of reference to representation
- insulation of reference from representation
- quality of identifier proportional to effort spent maintaining validity

3.2 Representations

- state of resource captured and transferred between components
- might be current or desired future state
- represented as data plus metadata (name–value pairs)
- think document+headers, or HTTP message
- metadata includes control data, media type
- one resource might have several representations
- selected via separate URIs, or via *content negotiation*

3.3 Interaction

- abstract interface for component communication
- stateless interactions:
  - connectors need not retain application state between requests
  - interactions can be processed in parallel, naively
  - intermediary may view and understand request in isolation
  - reusability of cached response can be determined from response itself
- request parameters: control data, target URI, optional representation
- response parameters: control data, optional resource metadata, optional representation

3.4 Connectors

- initiating *client*
- reactive *server*
- *cache*, either at client or at server, maybe shared
- *resolver* translates URIs into locations (eg DNS, DOI)
- *tunnel*, relaying communication across a connection boundary

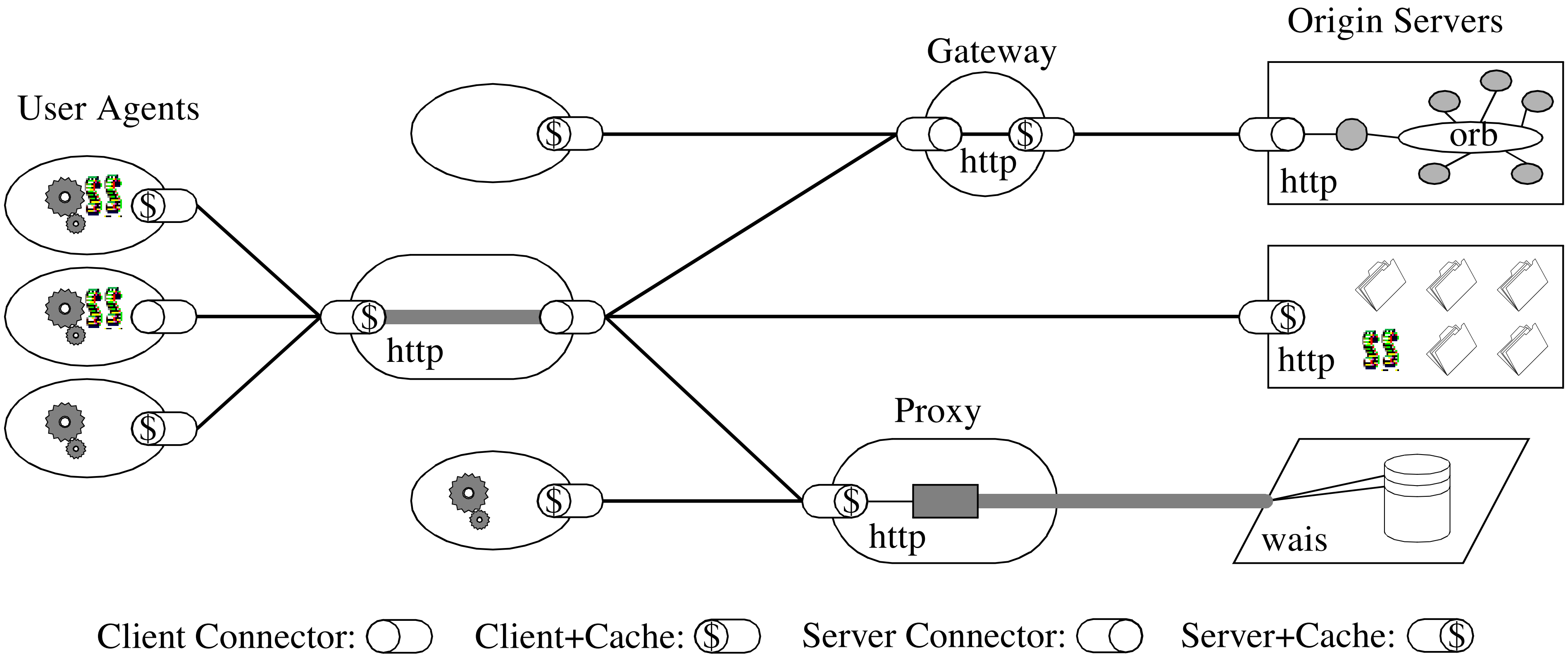
3.5 Components

- *user agent* uses client connector to initiate response (eg browser)
- *origin server* uses server connector to govern namespace for requested resource
- *proxy* and *gateway* act as both client and server

3.6 State transitions

- control state concentrated into resource representations
- embedded resource identifiers indicate possible next states
- allows user to directly manipulate state (eg through browser history, context switching)
- model application is therefore *an engine that moves from state to state by selecting from alternative transitions in current set of representations*

3.7 REST-based architecture



4 Resource-oriented architecture

- after Richardson & Ruby, *RESTful WS*
- action identified in HTTP method, not in payload
- scoping information in URI

```
GET reports/open-bugs HTTP/1.1
```

- in contrast to RPC-style interaction

```
POST /rpc HTTP/1.1
Host: www.upcdatabase.com

<?xml version="1.0">
<methodCall>
  <methodName>lookupUPC</methodName> ...
</methodCall>
```

- . . . or hybrid

```
http://www.flickr.com/services/rest?method=search&tags=cat
```

4.1 RESTful operations

CRUD verb	*HTTP method*	*arguments*
create	PUT	fresh representation
retrieve	GET	
update	PUT	revised representation
delete	DELETE	

4.2 PUT vs POST

- actually, creation by either PUT to new URI or POST to existing URI
- typically, create a subordinate resource with a POST to its parent
- use PUT when client chooses URI; use POST when server chooses
- successful POST returns code 201 ‘Created’ with `Location` header
- (POST also sometimes used for form submission, but this can be non-uniform)

4.3 Designing a ROA (Richardson & Ruby)

- figure out dataset
- split dataset into resources

and for each resource:

- name the resource with URI(s)
- expose (a subset of) the uniform interface
- design representations accepted from client
- design representations served to client
- integrate with other resources, using links
- consider typical course of events
- consider exceptional conditions

4.4 Asynchronous operations

- HTTP is synchronous: request–response
- what about long-running requests? *deferred synchronous* interaction
- client POSTs request (because not idempotent)

  ```
  POST /queue HTTP/1.1
  Host: jobservice.com

  Please tell me whether 2ˆ43,112,609 - 1 is prime.
  ```

- server queues task, returns code 202 'Accepted' with URI:

  ```
  202 Accepted
  Location: http://jobservice.com/queue/job11a4f9
  ```

- client polls resource:

  ```
  GET /queue/job11a4f9 HTTP/1.1
  ```

  getting either status report or result

4.5 URI design

- URIs should be meaningful and well-structured
- client should be able to construct URI to access a resource (increases *surface area*)
- use paths to separate elements of hierarchy, general to specific
- use punctuation to separate items at same hierarchical level
- commas when order matters (eg coordinates), semicolons otherwise
- use query variables only for ‘arguments’
- URIs denote resources, not operations (unless the operation is itself something you might CRUD)
- some (eg TBL) say URIs should be opaque. . . why?

4.6 Representations

- may be human-readable, but should be computer-oriented
- eg collection of values, not picture of graph (unless graphing is the service!)
- need not be XML: plain text, key–value pairs, JSON, . . .
- outgoing representations should be acceptable as incoming too: client may GET, update, PUT
- use return codes, not outgoing representations, for error conditions

4.7 Conditional GET

- save bandwidth by not resending unchanged representations
- requires collaboration between client and server
- server sends `Last-Modified` header with representation
- client requests `If-Modified-Since`
- server may return code 304 ‘Not Modified’, and no representation
- similarly, `ETag` (hashcode) and `If-None-Match`
- if client requests both `If-Modified-Since` and `If-None-Match`, server should send representation only if representation is modified and has different entity tag

4.8 The trouble with cookies

- opaque data sent by server to client
- often a key into server-side table of session state
- violates principles of statelessness (ie, a hack)
  - client cannot control their own session state (breaks the ‘back’ button on the browser)
  - server must store this state (indefinitely)
  - much easier for client and server to get out of sync

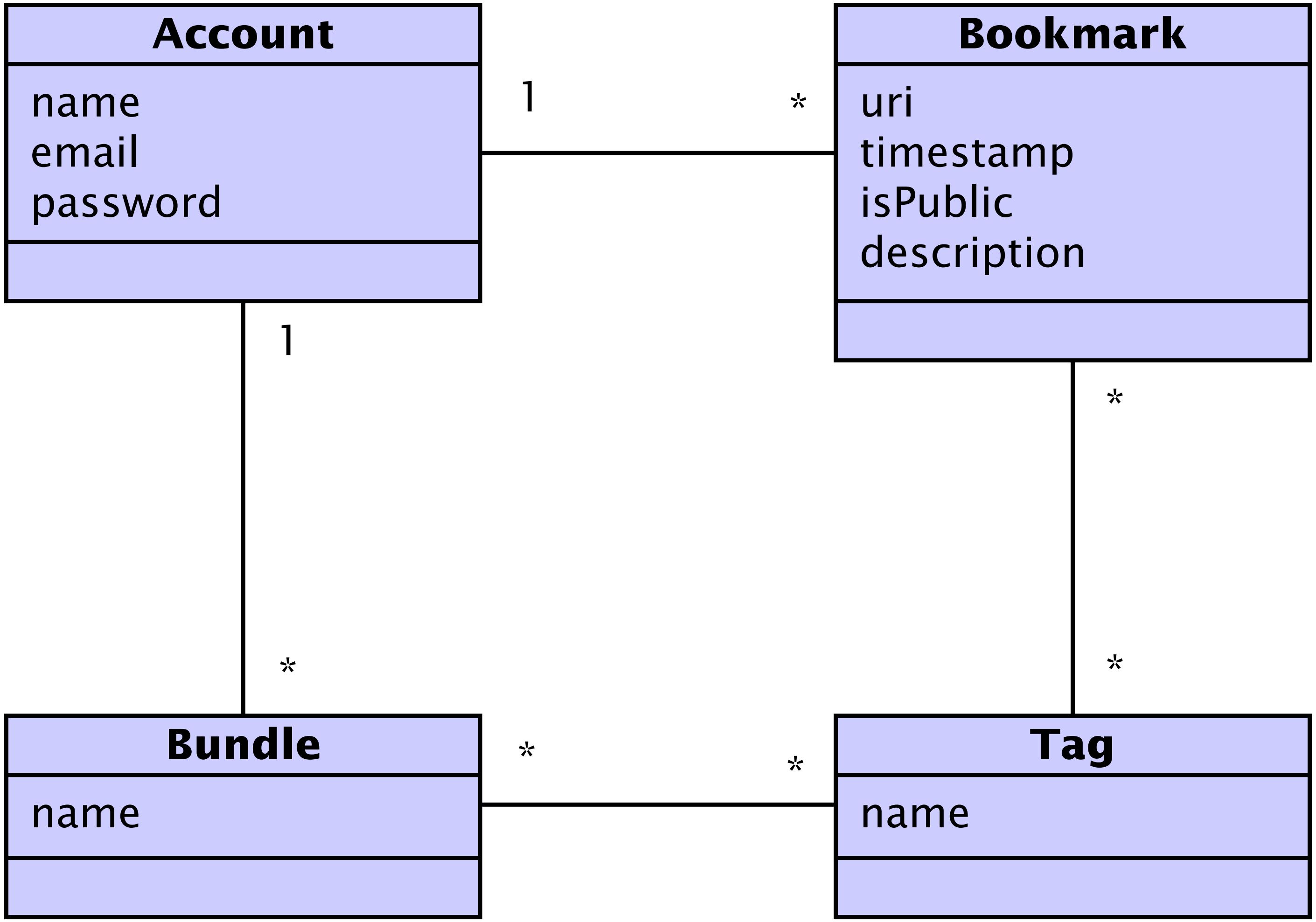
4.9 Interfaces for RESTful services

- how to describe a RESTful web service?
- what is to REST as WSDL is to SOAP?
- *Web Application Description Language* (WADL):
  - site map of resources
  - referential and causal links between resources
  - methods applicable to each resource
  - resource representation formats
  - all machine-processable
- without something like WADL, is REST service-oriented?

5 Example: social bookmarking

- user *accounts*
- *bookmarks*
- *tags* for bookmarks
- *bundles* of tags for a user
- each bookmark accumulates *currency*, *popularity*, *tag cloud* (but we won't model those)

5.1 Structure



5.2 Accounts

intention	*operation*
create account	`POST /users`
view account	`GET /users/<username>`
modify account	`PUT /users/<username>`
delete account	`DELETE /users/<username>`

5.3 Bookmarks

intention	*operation*
post bookmark	`POST /users/<username>/bookmarks`
fetch bookmark	`GET /users/<username>/bookmarks/<uri>`
modify bookmark	`PUT /users/<username>/bookmarks/<uri>`
delete bookmark	`DELETE /users/<username>/bookmarks/<uri>`
user's last post?	use conditional `GET`
user's posting history	`GET /users/<username>/calendar`
fetch filtered history	`GET /users/<username>/calendar/<tag>`

5.4 Searching

intention	*operation*
all user's bookmarks	`GET /users/<username>/bookmarks`
…by tag	`GET /users/<username>/bookmarks/<tag>`
search	`GET /users/<username>/bookmarks?<query>`

5.5 Socialising

intention	*operation*
recent bookmarks	`GET /recent`
. . . by tag	`GET /recent/<tag>`
who bookmarked uri?	`GET /uris/<uri>`

5.6 Tags and bundles

intention	*operation*
user’s vocabulary	`GET /users/<username>/tags`
rename tag	`PUT /users/<username>/tags/<tag>`
user’s bundles	`GET /users/<username>/bundles`
bundle tags	`POST /users/<username>/bundles`
fetch bundle	`GET /users/<username>/bundles/<bundle>`
modify bundle	`PUT /users/<username>/bundles/<bundle>`
delete bundle	`DELETE /users/<username>/bundles/<bundle>`

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Service-Oriented Architecture

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Components	REST	Composition	Architecture	Conclusion
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Web Services	Qualities	Objects	Semantic Web	
tea	tea	tea	tea	
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