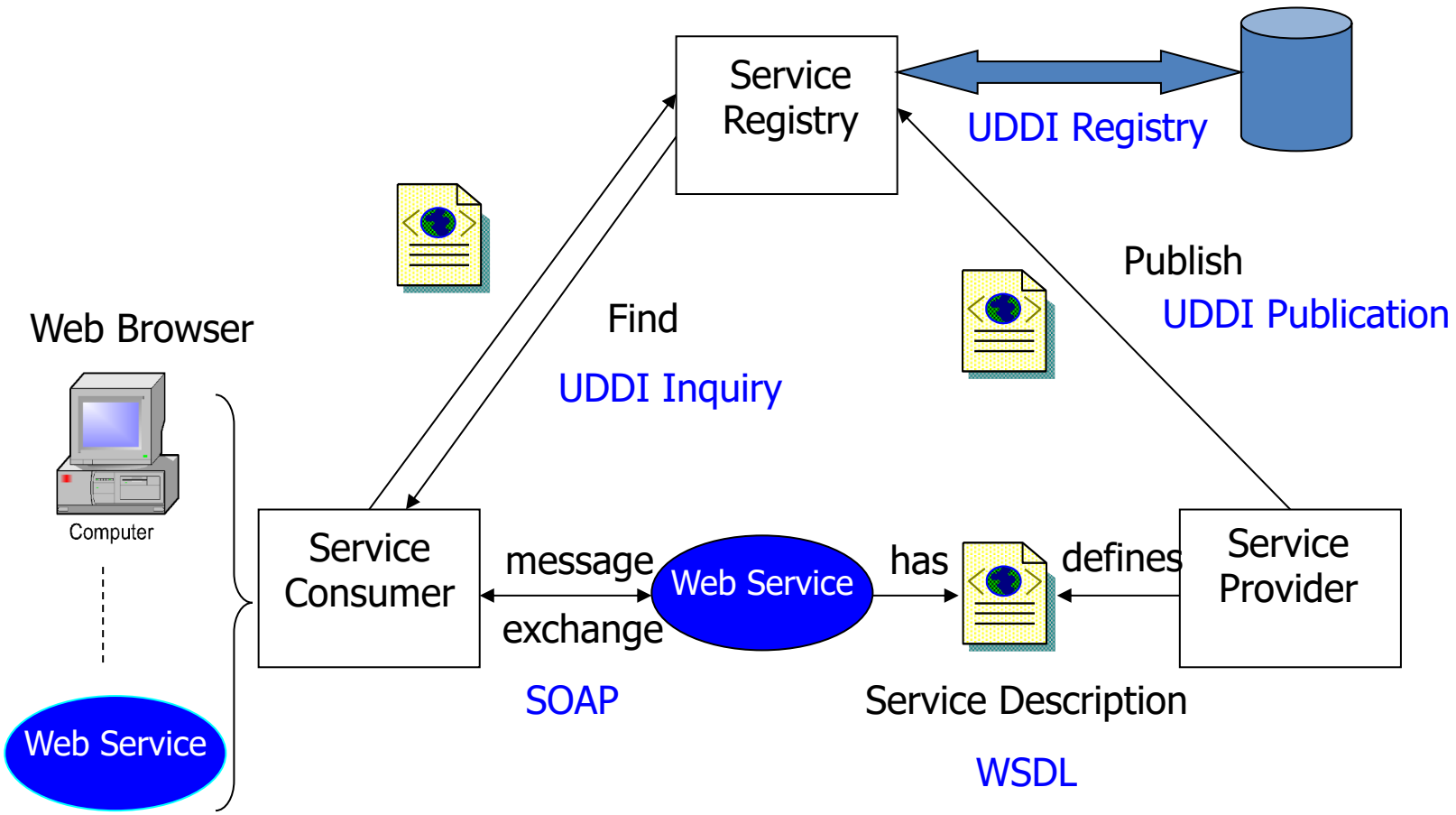
Service-Oriented Programming

Basic Concepts/Standards/Technologies

SOA, XML, WSDL, SOAP, REST

SOP Basis: Service-Oriented Architecture (SOA)

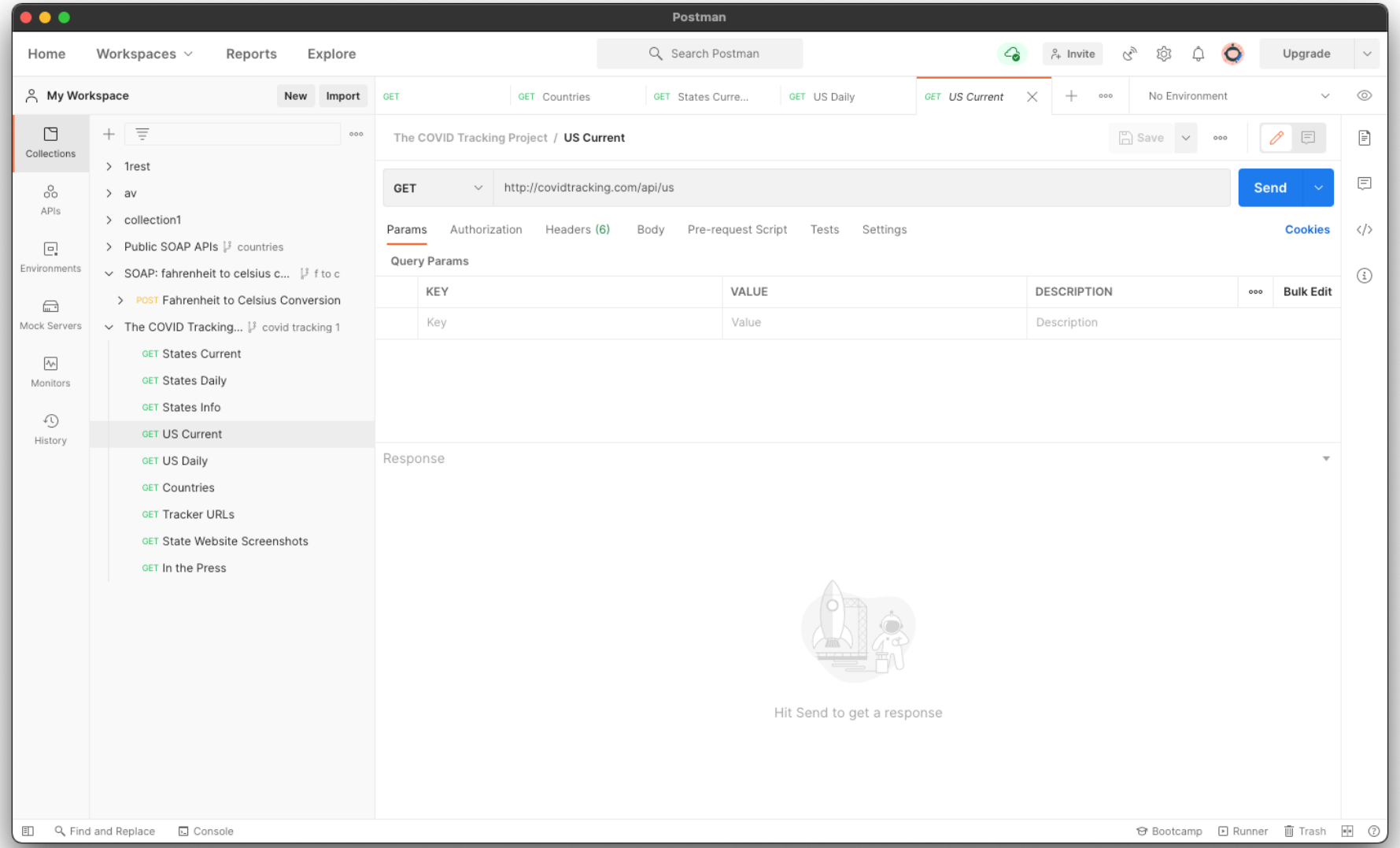


SOA: Roles of Interaction

- Web services provider
  - Owns Web service and implements business logic
  - Hosts and controls access to the service
    - Examples: Microsoft, Amazon, Facebook, …
- Web services requestor
  - Requires the certain functions to be satisfied
  - Looks for and invokes the service
    - Examples: a client, a server, or another web service
- Web services registry
  - Searchable directory where service descriptions can be published and searched
    - Examples: UDDI registry

DEMO

- Postman consuming a SOAP web service


Postman
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Public SOAP APIs countries
SOAP: fahrenheit to celsius c... f to c
POST Fahrenheit to Celsius Conversion
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GET States Current
GET States Daily
GET States Info
GET US Current
GET US Daily
GET Countries
GET Tracker URLs
GET State Website Screenshots
GET In the Press
The COVID Tracking Project / US Current
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Send
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DESCRIPTION
Bulk Edit
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Description
Response
Hit Send to get a response
Find and Replace
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Bootcamp
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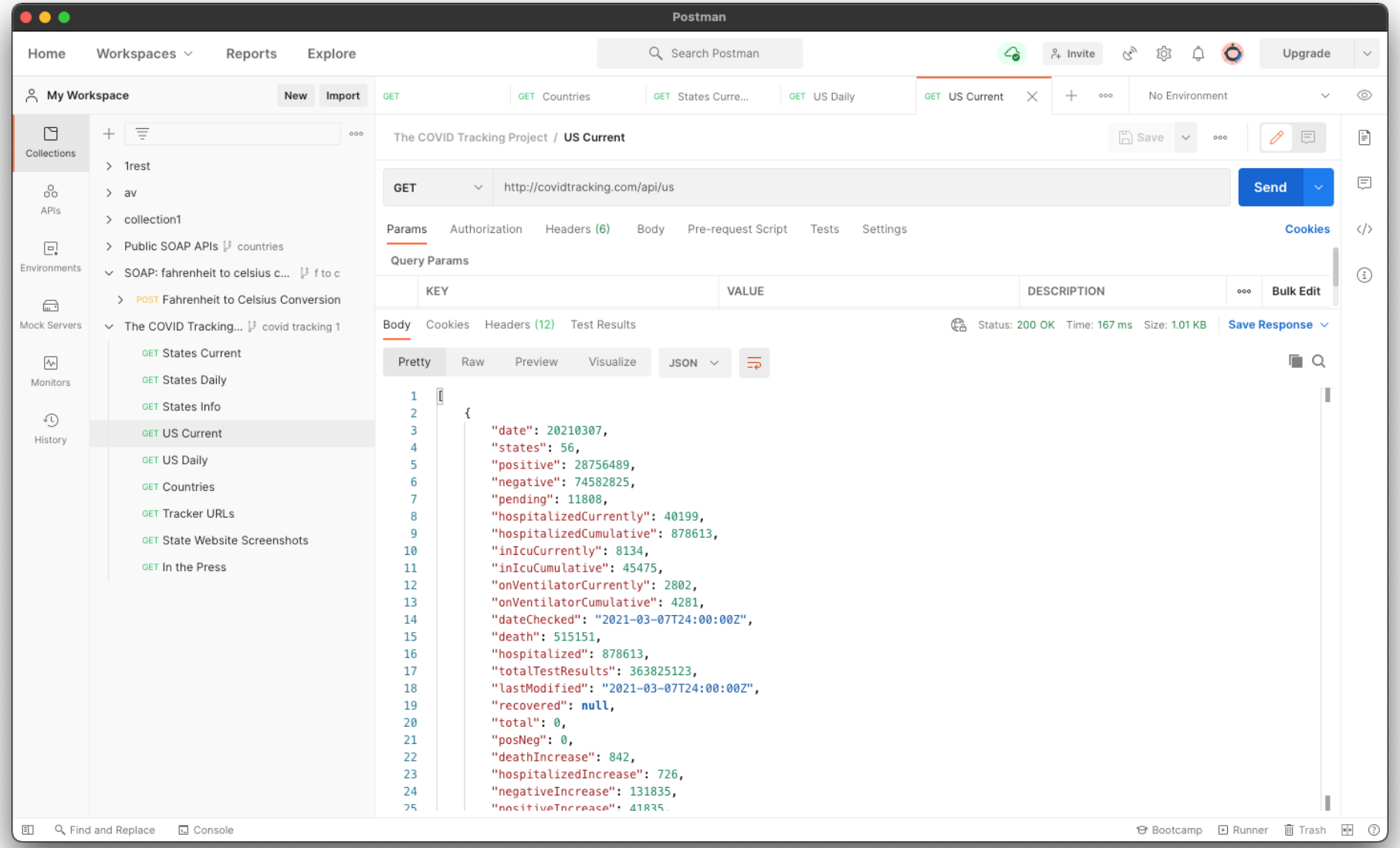
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Bulk Edit
Body
Cookies
Headers (12)
Test Results
Status: 200 OK
Time: 167 ms
Size: 1.01 KB
Save Response
Pretty
Raw
Preview
Visualize
JSON
{
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"states": 56,
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"negative": 74582825,
"pending": 11808,
"hospitalizedCurrently": 40199,
"hospitalizedCumulative": 878613,
"inIcuCurrently": 8134,
"inIcuCumulative": 45475,
"onVentilatorCurrently": 2802,
"onVentilatorCumulative": 4281,
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"death": 515151,
"hospitalized": 878613,
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"lastModified": "2021-03-07T24:00:00Z",
"recovered": null,
"total": 0,
"posNeg": 0,
"deathIncrease": 842,
"hospitalizedIncrease": 726,
"negativeIncrease": 131835,
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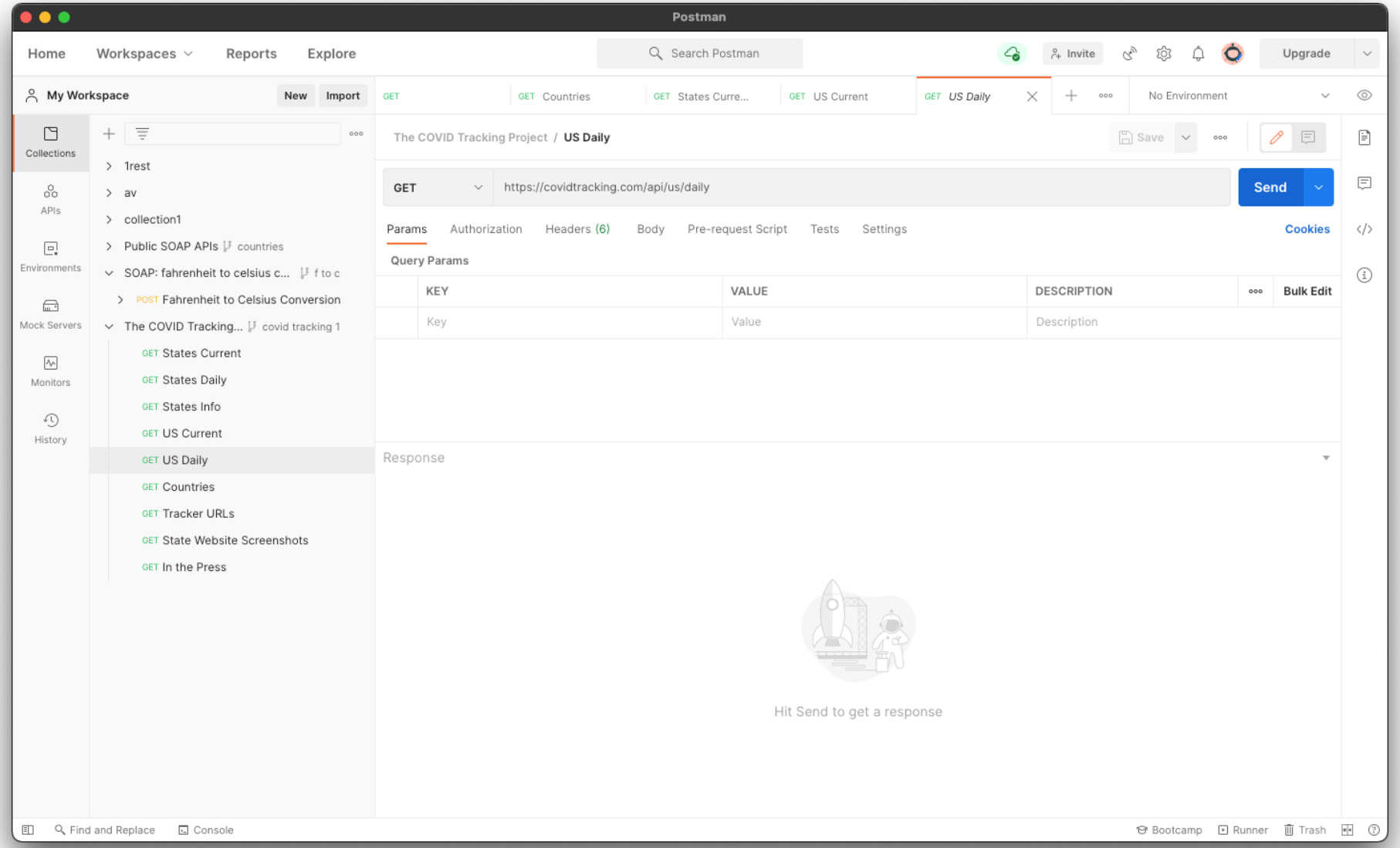
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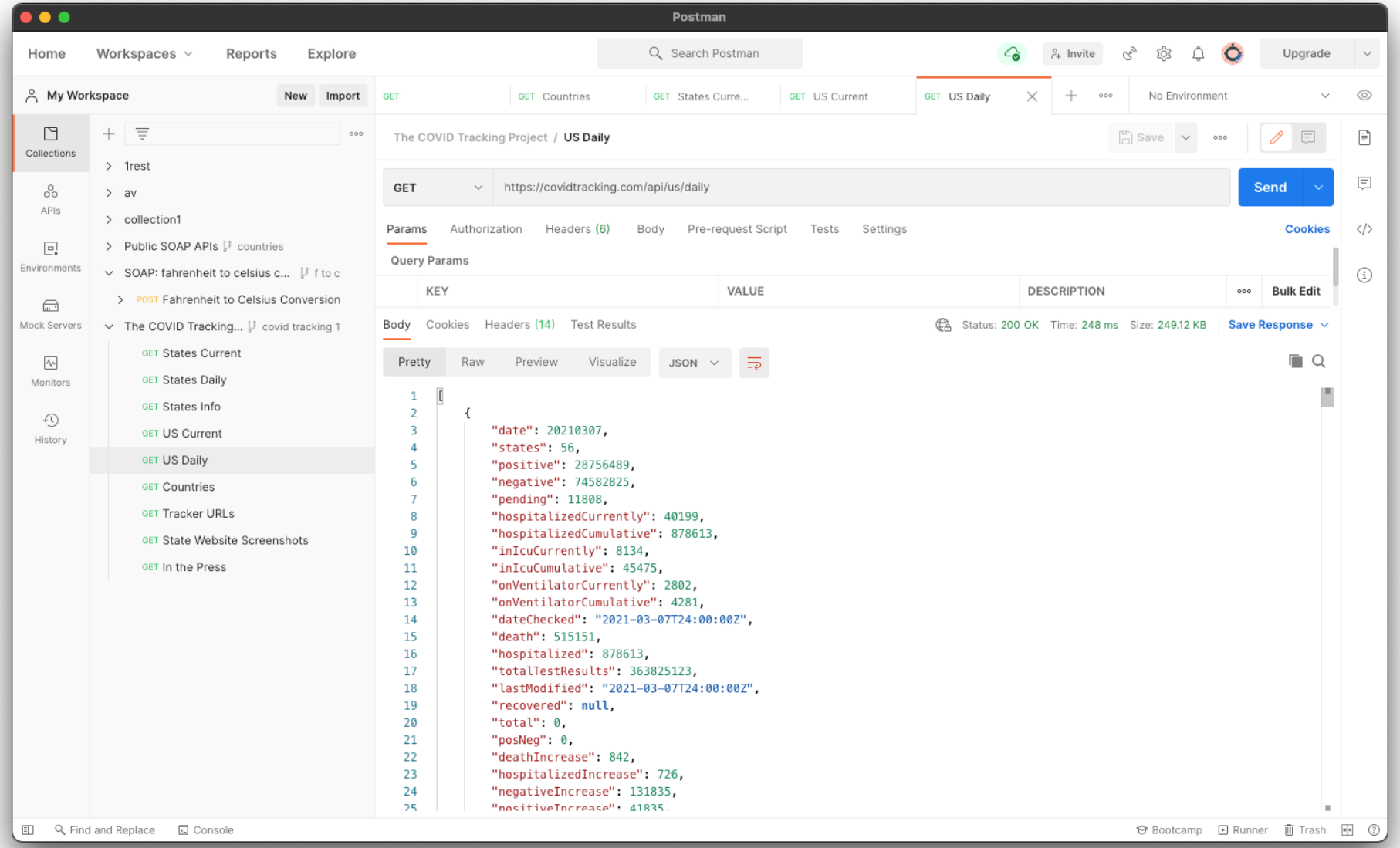
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Headers (14)
Test Results
Status: 200 OK
Time: 248 ms
Size: 249.12 KB
Save Response
Pretty
Raw
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JSON
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"pending": 11808,
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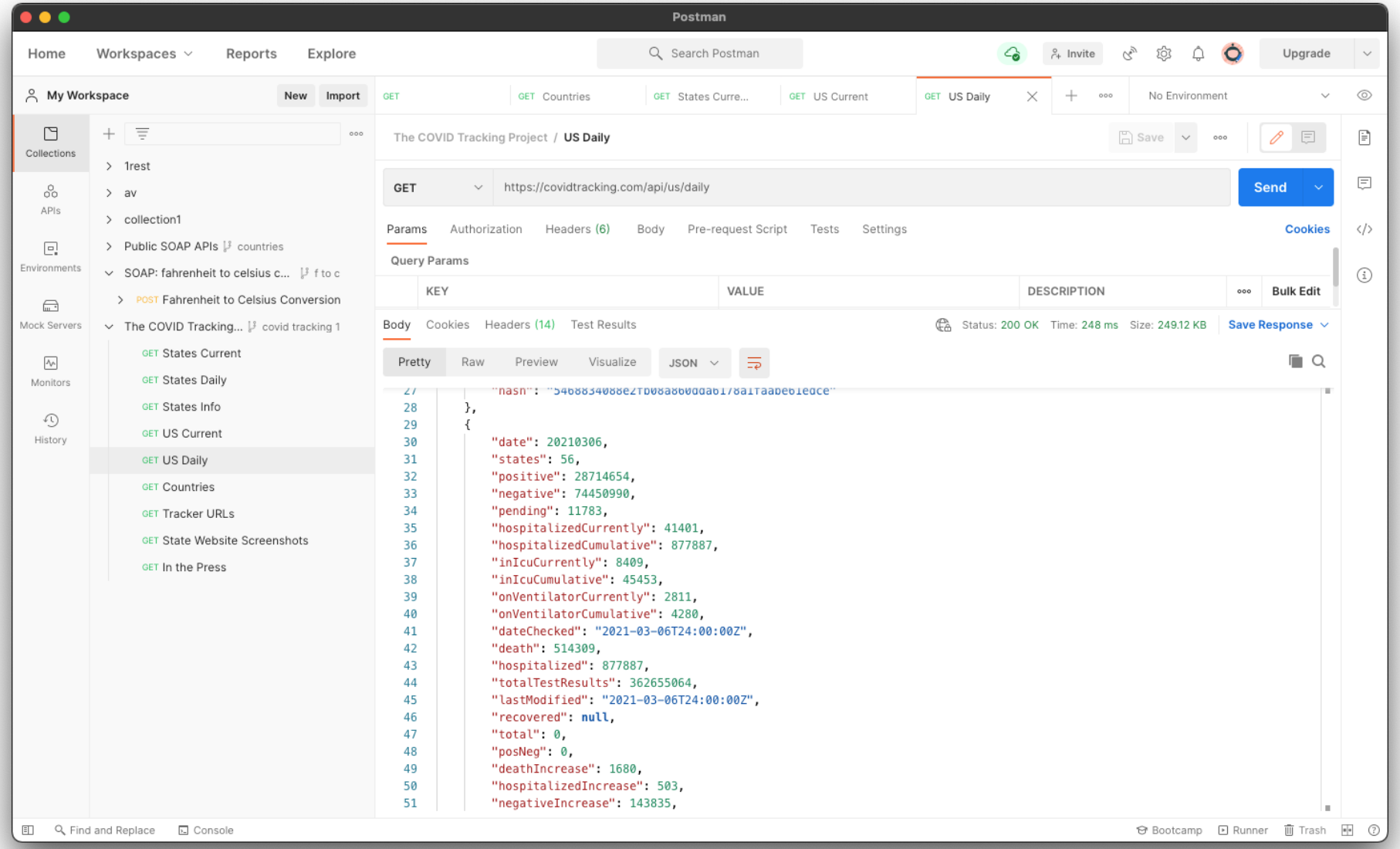
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Test Results
Status: 200 OK
Time: 248 ms
Size: 249.12 KB
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JSON
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},
{
"date": 20210306,
"states": 56,
"positive": 28714654,
"negative": 74450990,
"pending": 11783,
"hospitalizedCurrently": 41401,
"hospitalizedCumulative": 877887,
"inIcuCurrently": 8409,
"inIcuCumulative": 45453,
"onVentilatorCurrently": 2811,
"onVentilatorCumulative": 4280,
"dateChecked": "2021-03-06T24:00:00Z",
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Find and Replace
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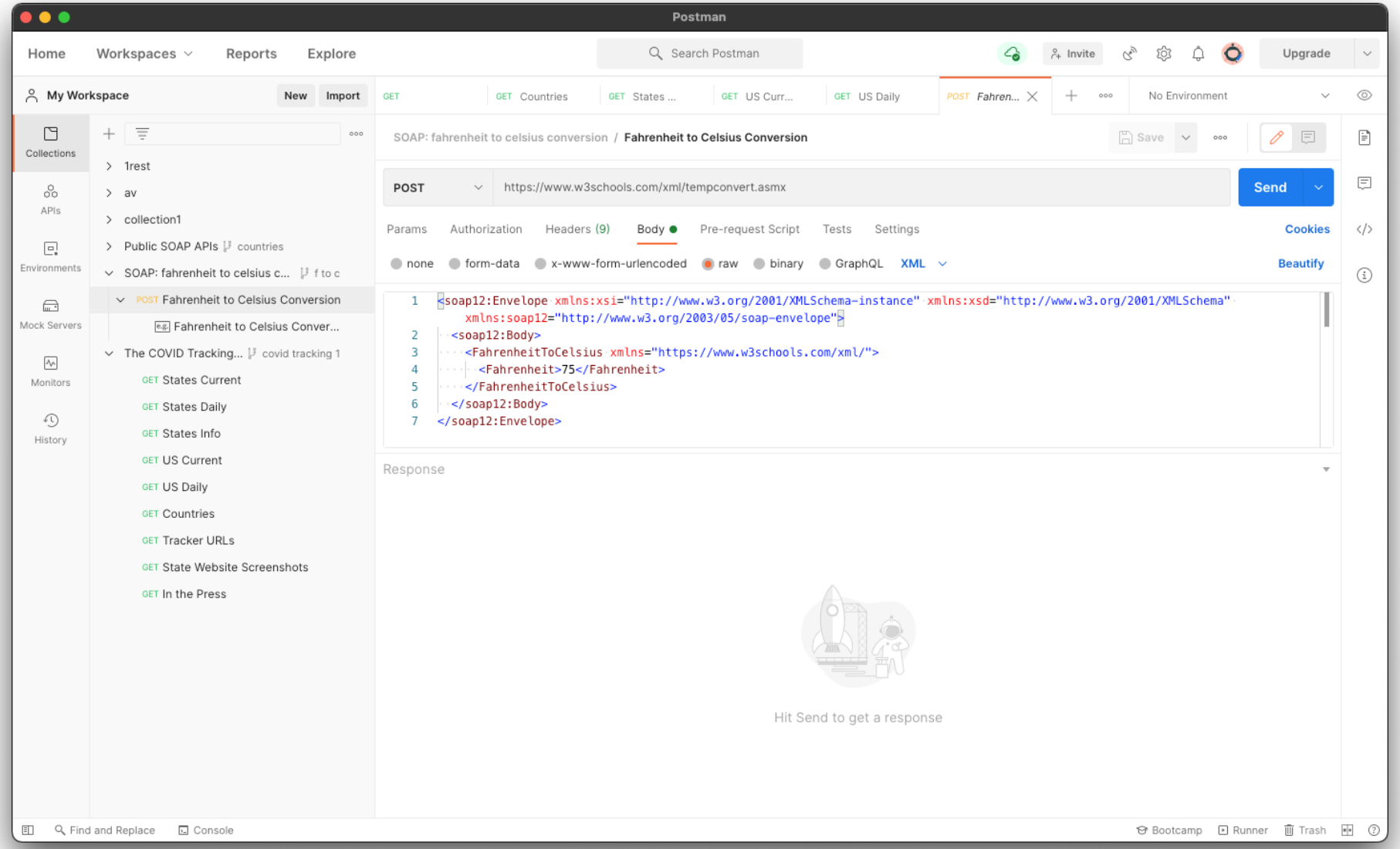
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GET US Daily
GET Countries
GET Tracker URLs
GET State Website Screenshots
GET In the Press
SOAP: fahrenheit to celsius conversion / Fahrenheit to Celsius Conversion
Save
POST
https://www.w3schools.com/xml/tempconvert.asmx
Send
Params
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Headers (9)
Body
Pre-request Script
Tests
Settings
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none
form-data
x-www-form-urlencoded
raw
binary
GraphQL
XML
Beautify
1 <soap12:Envelope xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:xsd="http://www.w3.org/2001/XMLSchema"
xmlns:soap12="http://www.w3.org/2003/05/soap-envelope">
2 <soap12:Body>
3 <FahrenheitToCelsius xmlns="https://www.w3schools.com/xml/">
4 <Fahrenheit>75</Fahrenheit>
5 </FahrenheitToCelsius>
6 </soap12:Body>
7 </soap12:Envelope>
Response
Hit Send to get a response
Find and Replace
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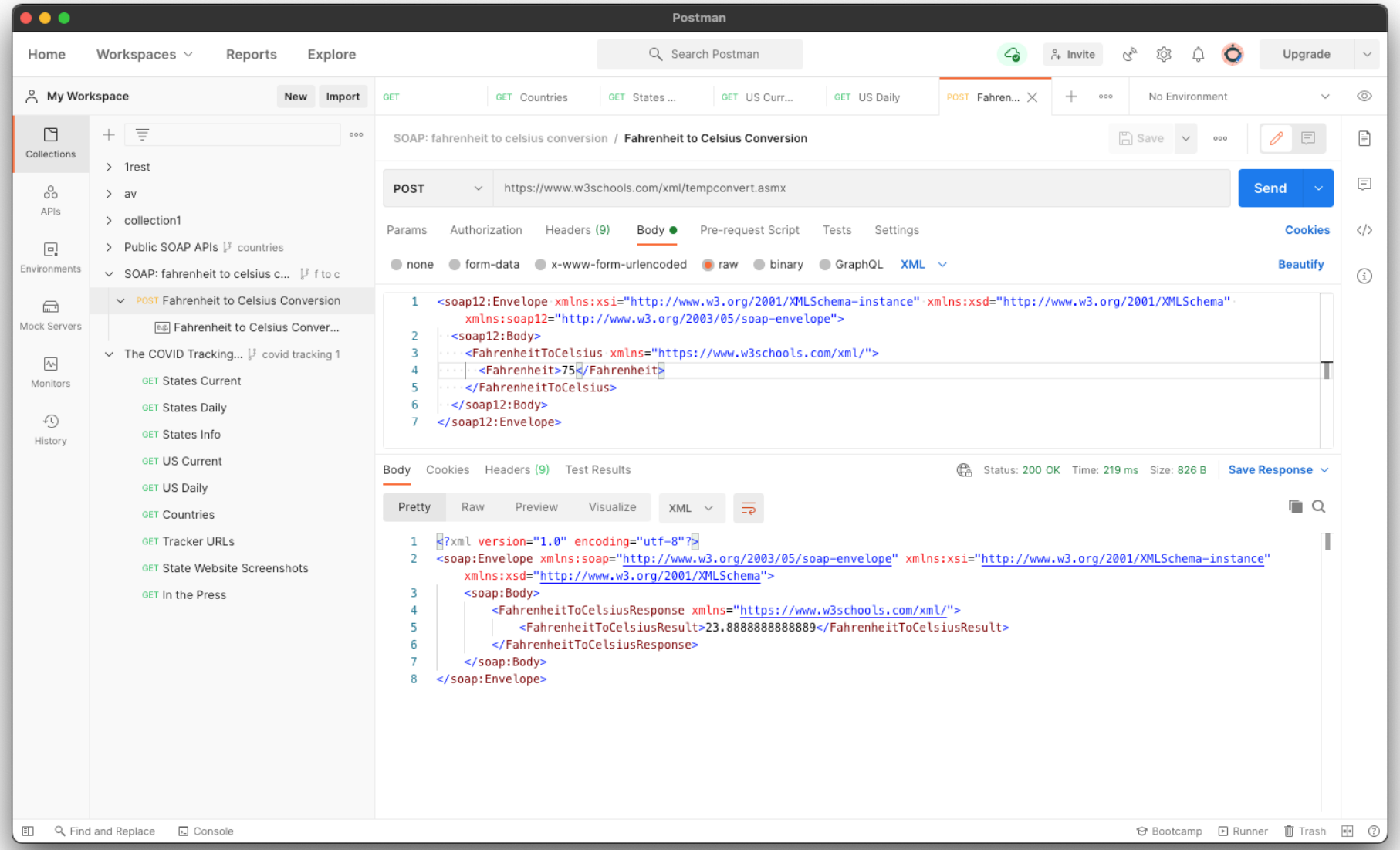
Trash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<soap12:Envelope xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:xsd="http://www.w3.org/2001/XMLSchema"
xmlns:soap12="http://www.w3.org/2003/05/soap-envelope">
<soap12:Body>
<FahrenheitToCelsius xmlns="https://www.w3schools.com/xml/">
<Fahrenheit>75</Fahrenheit>
</FahrenheitToCelsius>
</soap12:Body>
</soap12:Envelope>
Body
Cookies
Headers (9)
Test Results
Status: 200 OK
Time: 219 ms
Size: 826 B
Save Response
Pretty
Raw
Preview
Visualize
XML
<?xml version="1.0" encoding="utf-8"?>
<soap:Envelope xmlns:soap="http://www.w3.org/2003/05/soap-envelope" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns:xsd="http://www.w3.org/2001/XMLSchema">
<soap:Body>
<FahrenheitToCelsiusResponse xmlns="https://www.w3schools.com/xml/">
<FahrenheitToCelsiusResult>23.8888888888889</FahrenheitToCelsiusResult>
</FahrenheitToCelsiusResponse>
</soap:Body>
</soap:Envelope>
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XML

- XML: eXtensible Markup Language
- Universal format for structured documents and data on the Web
- Common data format of Web services
- Supports semi-structured data model

Example

<book price = “95” currency = “USD”>
    <title> Programming Language Pragmatics</title>
    <author> Michael Scott </author>
    <publisher> Morgan Kaufmann </publisher>
    <edition> 3rd </edition>
        …
    <year> 2009 </year>
</book>

XML: Key Concepts

- Document
- Elements
- Attributes, e.g. Text
- Others
  - Namespace declarations, comments, processing instructions, …

Elements

- Enclosed in tags:
  - Book, title, author, …
  - Start tag: <book> End tag: </book>
- Empty element <red></red> OR <red/>
- Elements are ordered, may be repeated or nested

Basic XML Tag Syntax

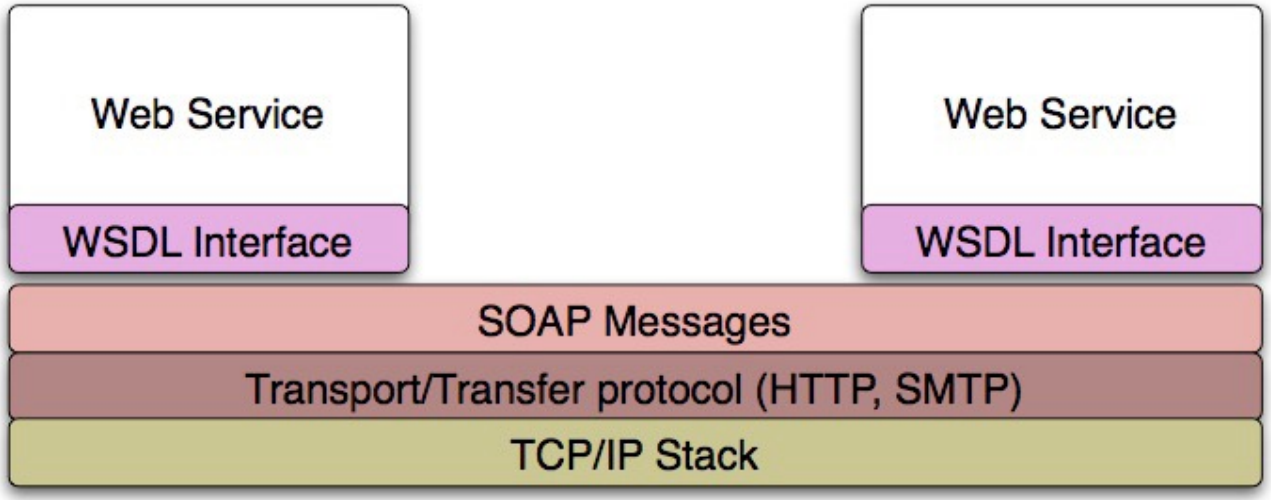
- Tags written as with HTML, but …
  - Case-sensitive names
  - Always need end tags
  - Special empty-element
  - Always quote attribute values
- Some other constraints for tags
  - Start with a letter or underscore
  - After first character, numbers, -, and . are allowed
  - Cannot contain white-spaces

Attributes

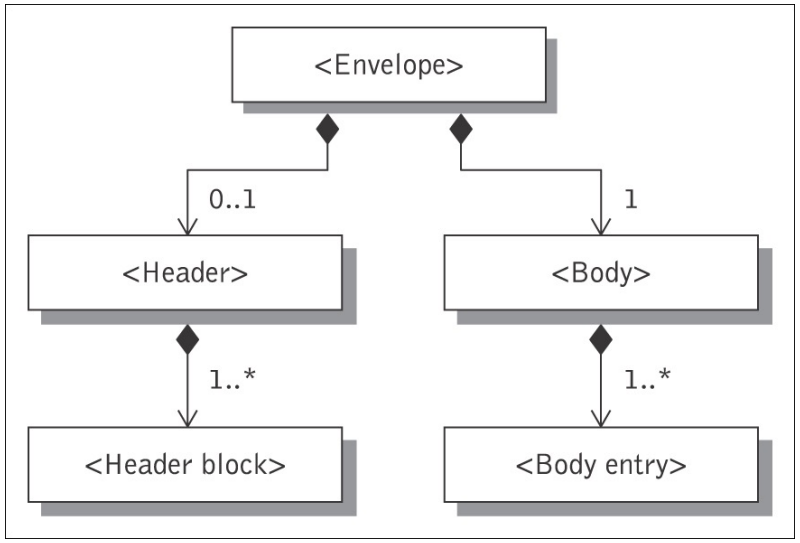
- Associated to Elements, …
  - <book price="20">
- Attributes
  - Unordered
  - Names must be unique
  - Cannot be nested
  - Provide metadata for element
  - Value enclosed in " "
- Multiple attributes separated by spaces
- Same naming conventions as elements

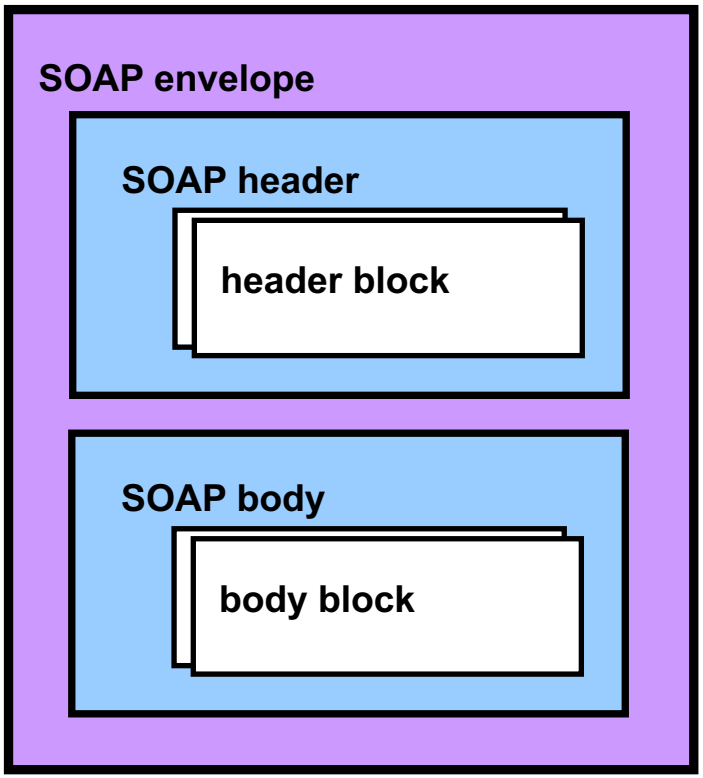
Simple Object Access Protocol

- Standard messaging protocol used by web services
- Supports inter-application communication



SOAP Message





- SOAP messages are seen as enveloper where the application encloses the data to be sent
- Consists of an <Envelope> element containing an optional <Header> and a mandatory <Body> element

SOAP Request (Example)

```
<SOAP-ENV:Envelope
  xmlns:SOAP-ENV="http://schemas.xmlsoap.org/soap/envelope/"
  SOAP-ENV:encodingStyle="http://schemas.xmlsoap.org/soap/encoding/">
  <SOAP-ENV:Header>
    <t:transId xmlns:t="http://a.com/trans">345</t:transId>
  </SOAP-ENV:Header>
  <SOAP-ENV:Body>
    <m:Add xmlns:m="http://a.com/Calculator">
      <n1>3</n1>
      <n2>4</n2>
    </m:Add>
  </SOAP-ENV:Body>
</SOAP-ENV:Envelope>
```

SOAP Response (Example)

```
<SOAP-ENV:Envelope
  xmlns:SOAP-ENV="http://schemas.xmlsoap.org/soap/envelope/"
  SOAP-ENV:encodingStyle="http://schemas.xmlsoap.org/soap/encoding/">
  <SOAP-ENV:Header>
    <t:transId xmlns:t="http://a.com/trans">345</t:transId>
  </SOAP-ENV:Header>
  <SOAP-ENV:Body>
    <m:AddResponse xmlns:m="http://a.com/Calculator">
      <result>7</result>
    </m:AddResponse>
  </SOAP-ENV:Body>
</SOAP-ENV:Envelope>
```

Another Example

- Sample SOAP Request and Response Message for Google's Web Service Interface
  - http://www.w3.org/2004/06/03-google-soap-wsdl.html

For illustration only

WSDL

- WSDL: Web Service Description Language
- Pronounced “Whiz Dull”
- XML-based
- Why we need WSDL for web services?
  - Web services are designed to support machine-to-machine interaction
  - No human in the loop
  - Needs a specified and self-explanatory programming interface

Contents of a WSDL File (1)

- WSDL describes a service's functionality
  - A service interface
    - Operations that can be invoked by service users
  - For each operation
    - Input parameters whose values are provided by service users, such as zipcode, address, …
    - Output parameters whose value will be returned to service users, such as directions, map image, …
- By parsing a WSDL file, a program can …
  - Determine if service is suitable, how to format the request, and how to handle the response

Contents of a WSDL File (2)

- Describes how to bind a service
  - Messaging style
  - Formatting (encoding) style
  - Transport protocol such as http, smtp, soap
- Describes where to locate a web service
  - A set of ports
    - A port defines the location of a web service, e.g., network address location or URL
- By parsing a WSDL file, a program can:
  - Locate and bind a web service

WSDL Document Content

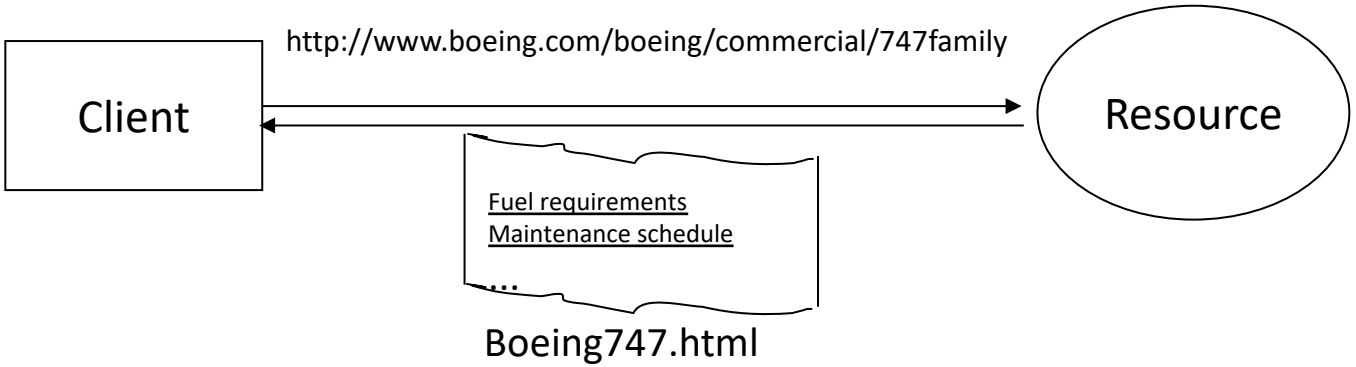
- Abstract (interface) definitions
  - <types> data type definitions
  - <message> operation parameters
  - <operation> abstract description of service actions
  - <portType> set of operation definitions
- Concrete (implementation) definitions
  - <binding> operation bindings
  - <port> association of endpoint with a binding
  - <service>location/address for each binding
- Example
  - http://webservices.amazon.com/AWSECommerceService/AWSECommerceService.wsdl

DEMO

- Consuming a SOAP service
  - Python Zeep library
  - Netbeans 8 with Java EJB
- Publishing a SOAP service
  - Python Spyne library
  - Netbeans 8 with Java EJB

REST (Representational State Transfer)

- The Client references a Web resource using a URL
- A resource representation returned (an HTML document)
- Representation (e.g., Boeing747.html) puts client in new state
- When client selects hyperlink in Boeing747.html, it accesses another resource
- New representation places client into yet another state
- Client transfers state with each resource representation



Web Resources

- Information from database
  - invoice, resume, price, phone number,…
- Image
  - map, photo, ...
- Audio
  - song, speech, …
- Video
  - movie clip, …
- Others

Resource Representation

- Each resource is represented as a distinct Uniform Resource Identifier (URI)
  - Uniform Resource Name (URN)
    - e.g., isbn-10: 3642078885
  - Uniform Resource Locator (URL)
    - e.g., http://www.imdb.com/title/tt0068646/?ref_=fn_al_tt_1

REST Design Pattern

- Create a resource for every service
- Uniquely identify each resource with a logical URL
- Design your information to link to other information
  - That is, the information that a resource returns to a client should link to other information in a network of related information

REST Design Pattern (2)

- All interactions between a client and a web service are done with simple operations
- Most web interactions are done using HTTP and just four operations:
  - Retrieve information (HTTP GET)
  - Create information (HTTP PUT)
  - Update information (HTTP POST)
  - Delete information (HTTP DELETE)

An Example of RESTful Web Service

- Service: Get a list of parts
  - Web service makes an available URL to a parts list resource
  - A client uses this URL to get the parts list
    - http://www.parts-depot.com/parts
    - Note
      - How web service generates the parts list is completely transparent to the client
      - This is loose coupling

Data Returned: Parts List

- Each resource is identified as a URL
- Parts list has links to get each part's detailed info
- Key feature of REST design pattern
  - Client transfers from one state to next by examining and choosing from alternative URLs in the response document

```
<?xml version="1.0"?>
<Parts>
    <Part id="00345" href="http://www.parts-depot.com/parts/00345"/>
    <Part id="00346" href="http://www.parts-depot.com/parts/00346"/>
    <Part id="00347" href="http://www.parts-depot.com/parts/00347"/>
    <Part id="00348" href="http://www.parts-depot.com/parts/00348"/>
</Parts>
```

Second Web Service

- Get detailed information about a particular part
  - Web service makes available a URL to each part resource
    - For example, here's how a client requests a specific part:
      - http://www.parts-depot.com/parts/00345
    - Data returned

```
<?xml version="1.0"?>
<Part>
    <Part-ID>00345</Part-ID>
    <Name>Widget-A</Name>
    <Description>This part is used within the frap assembly</Description>
    <Specification href="http://www.parts-depot.com/parts/00345/specification"/>
    <UnitCost currency="USD">0.10</UnitCost>
    <Quantity>10</Quantity>
</Part>
```

Web Service Examples

- Weather service
  - http://vhost3.cs.rit.edu/weather/Service.svc
- IMDB service
  - http://vhost3.cs.rit.edu/IMDB/Service.svc
- Calculator service
  - http://vhost3.cs.rit.edu/Calculator/Service.svc
- Test the services via the following link
  - http://vhost3.cs.rit.edu/Application/
- Some source code and sample services
  - http://vhost3.cs.rit.edu/CentralRepository/index.aspx

Response Formats of RESTful Web Services

- XML: eExtensible Markup Language
  - Universal format for structured documents and data on the Web
  - Common data format of Web services
- JSON: Javascript Object Notation
  - Derived from the JavaScript scripting language
  - Used for serializing and transmitting structured data

XML-Formatted Response Example

<root response="True">
<Movie Title="Titanic" Year="1997" imdbID="tt0120338" Type="movie"/>
<Movie Title="Titanic II" Year="2010" imdbID="tt1640571" Type="movie"/>
<Movie Title="Titanic: The Legend Goes On..." Year="2000" imdbID="tt0330994" Type="movie"/>
<Movie Title="Titanic" Year="1953" imdbID="tt0046435" Type="movie"/>
<Movie Title="Titanic" Year="1996" imdbID="tt0115392" Type="movie"/>
<Movie Title="Raise the Titanic" Year="1980" imdbID="tt0081400" Type="movie"/>
<Movie Title="Titanic" Year="2012" imdbID="tt1869152" Type="series"/>
<Movie Title="The Chambermaid on the Titanic" Year="1997" imdbID="tt0129923" Type="movie"/>
<Movie Title="Titanic: Blood and Steel" Year="2012" imdbID="tt1695366" Type="series"/>
<Movie Title="Titanic" Year="1943" imdbID="tt0036443" Type="movie"/>
</root>

(http://www.omdbapi.com/?s=titanic&r=xml)

Json-Formatted Response Example

- {"Search":[{"Title":"Titanic","Year":"1997","imdbID":"tt0120338","Type":"movie"},{"Title":"Titanic II","Year":"2010","imdbID":"tt1640571","Type":"movie"},{"Title":"Titanic: The Legend Goes On...","Year":"2000","imdbID":"tt0330994","Type":"movie"},{"Title":"Titanic","Year":"1953","imdbID":"tt0046435","Type":"movie"},{"Title":"Titanic","Year":"1996","imdbID":"tt0115392","Type":"movie"},{"Title":"Raise the Titanic","Year":"1980","imdbID":"tt0081400","Type":"movie"},{"Title":"Titanic","Year":"2012","imdbID":"tt1869152","Type":"series"},{"Title":"The Chambermaid on the Titanic","Year":"1997","imdbID":"tt0129923","Type":"movie"},{"Title":"Titanic: Blood and Steel","Year":"2012","imdbID":"tt1695366","Type":"series"},{"Title":"Titanic","Year":"1943","imdbID":"tt0036443","Type":"movie"}]}

- (http://www.omdbapi.com/?s=titanic)

DEMO

- Consuming a REST service
  - CURL Command line
  - Postman
- Publishing a REST service
  - Python Spyne library