Using Web Services

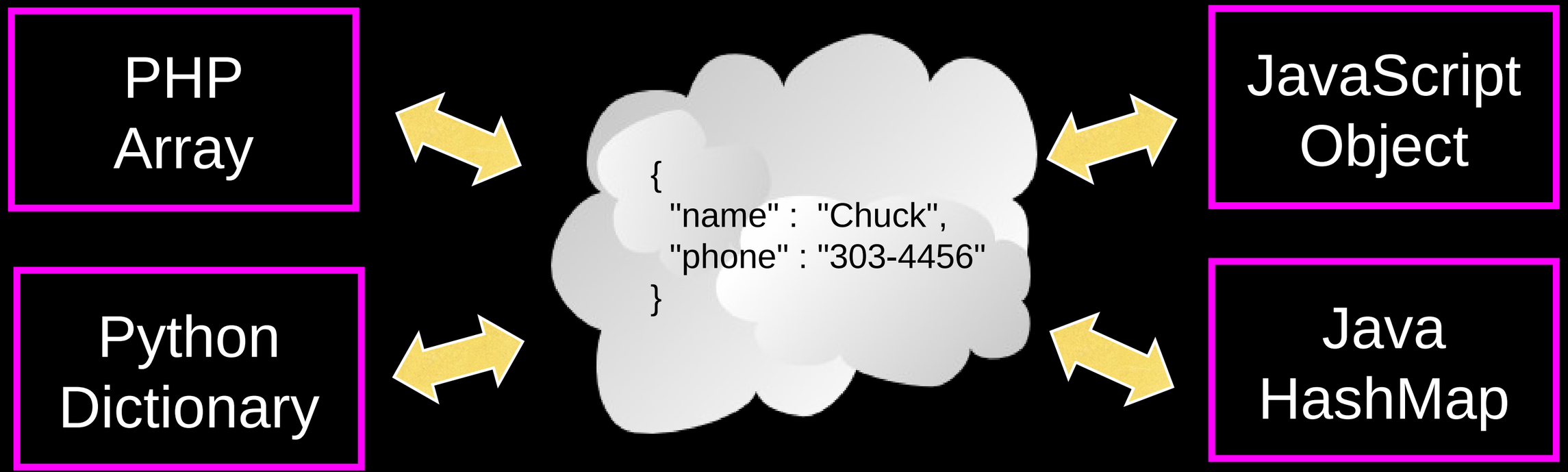
Chapter 13

Python for Everybody
www.py4e.com

Data on the Web

- With the HTTP Request/Response well understood and well supported, there was a natural move toward exchanging data between programs using these protocols
- We needed to come up with an agreed way to represent data going between applications and across networks
- There are two commonly used formats: XML and JSON

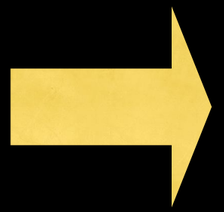
Sending Data Across the “Net”



a.k.a. “Wire Protocol” - What we send on the “wire”

Agreeing on a “Wire Format”

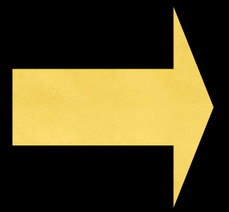
Python Dictionary



Serialize

```
<person>
  <name>
    Chuck
  </name>
  <phone>
    303 4456
  </phone>
</person>
```

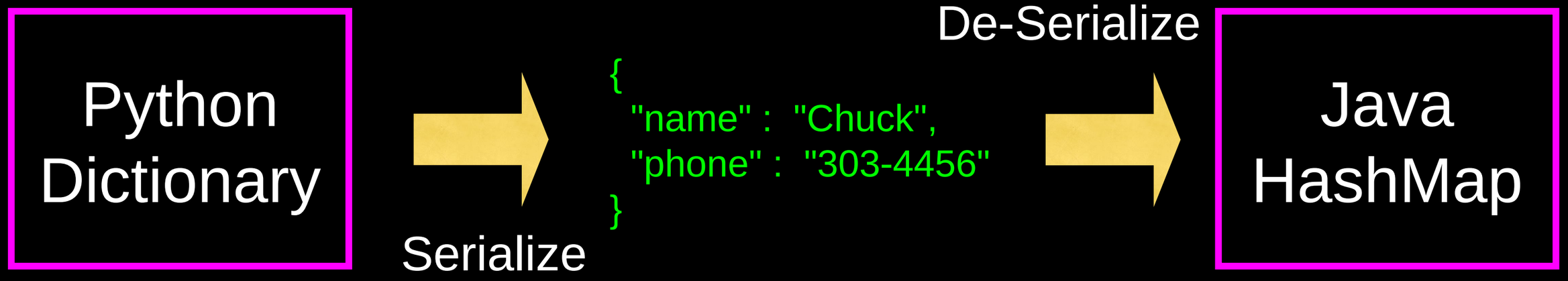
De-Serialize



Java HashMap

XML

Agreeing on a “Wire Format”



JSON

XML

Marking up data to send across the network...

http://en.wikipedia.org/wiki/XML

XML “Elements” (or Nodes)

- Simple Element
- Complex Element

```
<people>
  <person>
    <name>Chuck</name>
    <phone>303 4456</phone>
  </person>
  <person>
    <name>Noah</name>
    <phone>622 7421</phone>
  </person>
</people>
```

eXtensible Markup Language

- Primary purpose is to help information systems share structured data
- It started as a simplified subset of the Standard Generalized Markup Language (SGML), and is designed to be relatively human-legible

http://en.wikipedia.org/wiki/XML

XML Basics

- Start Tag
- End Tag
- Text Content
- Attribute
- Self Closing Tag

```
<person>
  <name>Chuck</name>
  <phone type="intl">
     +1 734 303 4456
   </phone>
   <email hide="yes" />
</person>
```

White Space

```
<person>
  <name>Chuck</name>
  <phone type="intl">
     +1 734 303 4456
   </phone>
   <email hide="yes" />
</person>
```

Line ends do not matter.
White space is generally discarded on text elements.
We indent only to be readable.

```
<person>
  <name>Chuck</name>
  <phone type="intl">+1 734 303 4456</phone>
  <email hide="yes" />
</person>
```

XML Terminology

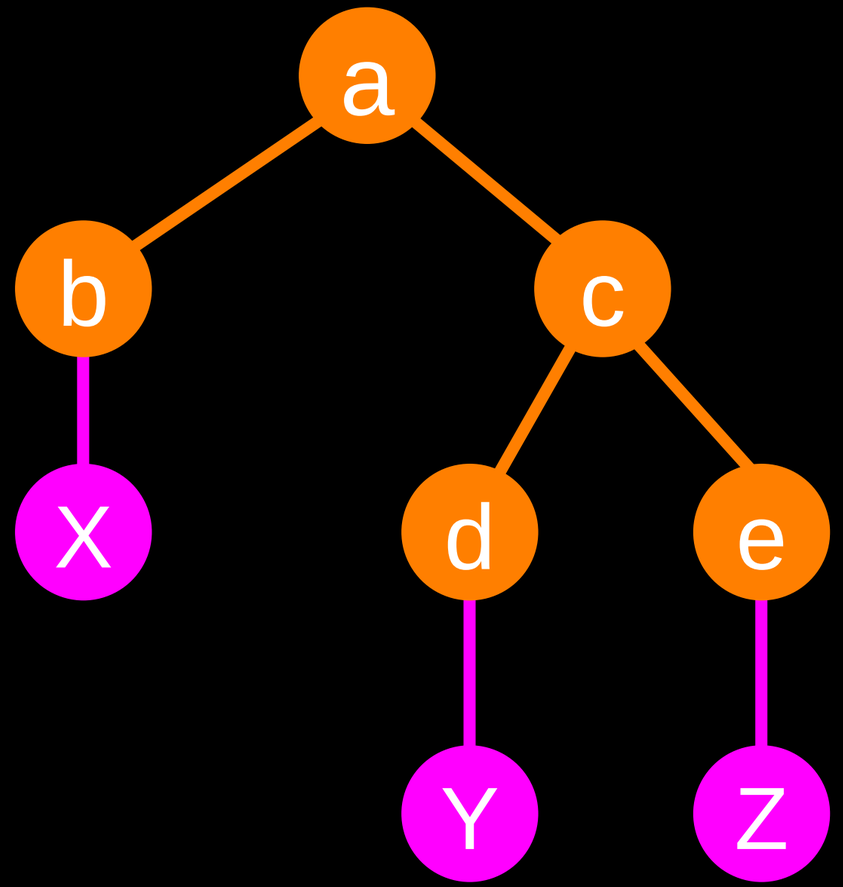
- Tags indicate the beginning and ending of elements
- Attributes - Keyword/value pairs on the opening tag of XML
- Serialize / De-Serialize - Convert data in one program into a common format that can be stored and/or transmitted between systems in a programming language-independent manner

http://en.wikipedia.org/wiki/Serialization

XML as a Tree

```
<a>
  <b>X</b>
  <c>
    <d>Y</d>
    <e>Z</e>
  </c>
</a>
```

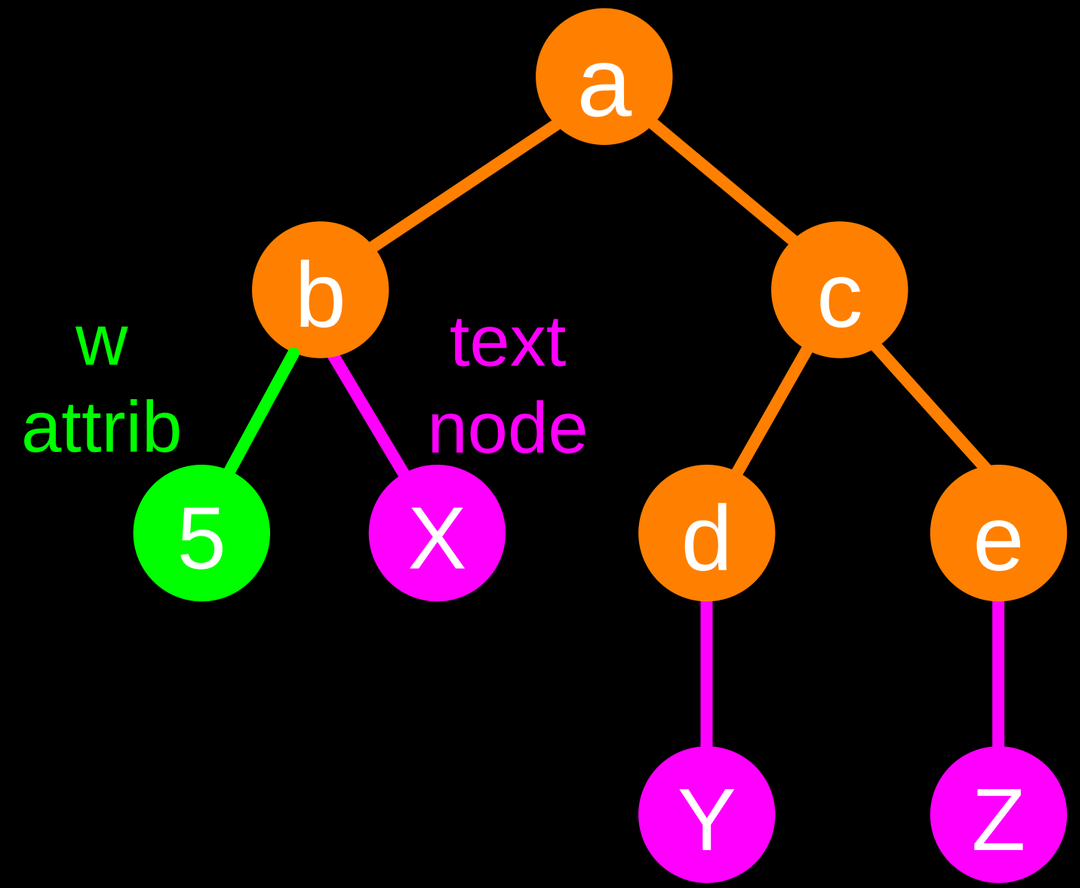
Elements Text



XML Text and Attributes

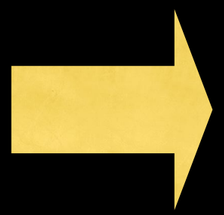
```
<a>
  <b w="5">X</b>
  <c>
    <d>Y</d>
    <e>Z</e>
  </c>
</a>
```

Elements Text

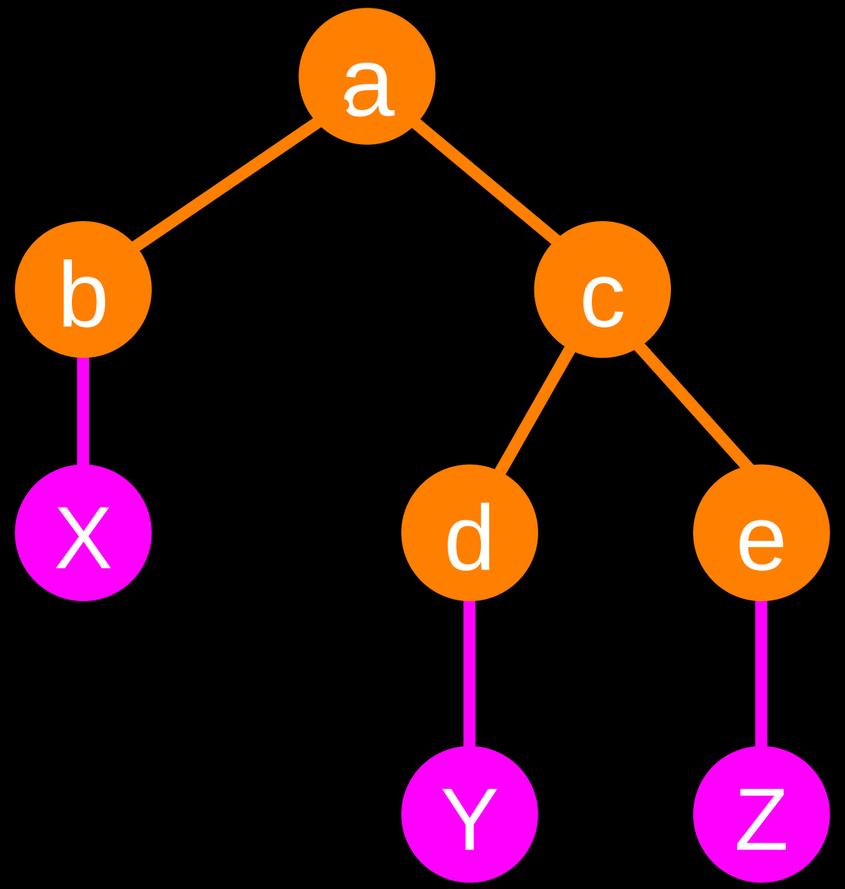


XML as Paths

```
<a>
  <b>X</b>
  <c>
    <d>Y</d>
    <e>Z</e>
  </c>
</a>
```



/a/b	X
/a/c/d	Y
/a/c/e	Z



Elements Text

XML Schema

Describing a “contract” as to what is acceptable XML

http://en.wikipedia.org/wiki/Xml_schema

http://en.wikibooks.org/wiki/XML_Schema

XML Schema

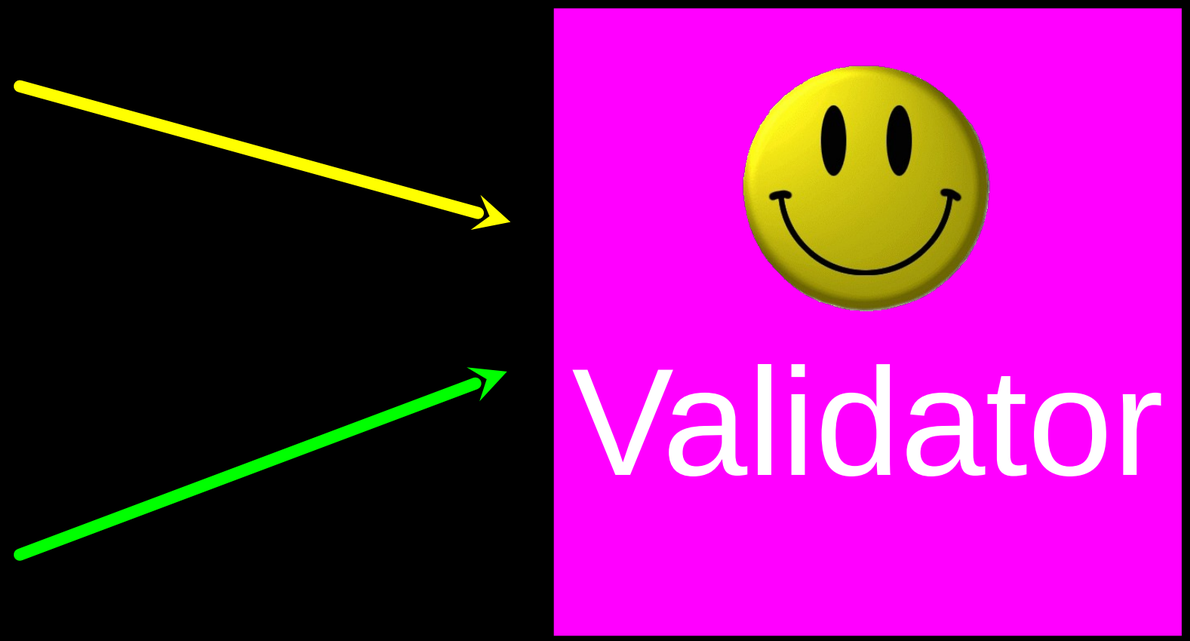
- Description of the legal format of an XML document
- Expressed in terms of constraints on the structure and content of documents
- Often used to specify a “contract” between systems - “My system will only accept XML that conforms to this particular Schema.”
- If a particular piece of XML meets the specification of the Schema - it is said to “validate”

http://en.wikipedia.org/wiki/Xml_schema

XML Validation

XML
Document

XML Schema
Contract



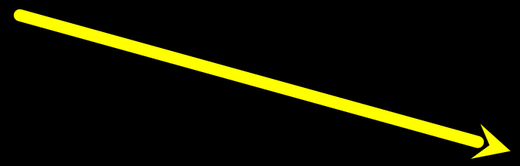
XML Validation

XML Document

```
<person>
  <lastname>Severance</lastname>
  <age>17</age>
  <dateborn>2001-04-17</dateborn>
</person>
```

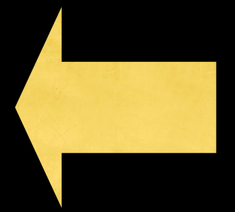
XML Schema Contract

```
<xs:complexType name=”person”>
 <xs:sequence>
  <xs:element name="lastname" type="xs:string"/>
  <xs:element name="age" type="xs:integer"/>
  <xs:element name="dateborn" type="xs:date"/>
 </xs:sequence>
</xs:complexType>
```



Many XML Schema Languages

- Document Type Definition (DTD)
  - http://en.wikipedia.org/wiki/Document_Type_Definition
- Standard Generalized Markup Language (ISO 8879:1986 SGML)
  - http://en.wikipedia.org/wiki/SGML
- XML Schema from W3C - (XSD)
  - http://en.wikipedia.org/wiki/XML_Schema_(W3C)



http://en.wikipedia.org/wiki/Xml_schema

XSD XML Schema (W3C spec)

- We will focus on the World Wide Web Consortium (W3C) version
- It is often called “W3C Schema” because “Schema” is considered generic
- More commonly it is called XSD because the file names end in .xsd

http://www.w3.org/XML/Schema

http://en.wikipedia.org/wiki/XML_Schema_(W3C)

XSD Structure

- xs:element
- xs:sequence
- xs:complexType

```
<person>
  <lastname>Severance</lastname>
  <age>17</age>
  <dateborn>2001-04-17</dateborn>
</person>
```

```
<xs:complexType name=”person”>
 <xs:sequence>
  <xs:element name="lastname" type="xs:string"/>
  <xs:element name="age" type="xs:integer"/>
  <xs:element name="dateborn" type="xs:date"/>
 </xs:sequence>
</xs:complexType>
```

XSD Constraints

```
<xs:element name="person">
  <xs:complexType>
    <xs:sequence>
      <xs:element name="full_name" type="xs:string"
          minOccurs="1" maxOccurs="1" />
      <xs:element name="child_name" type="xs:string"
           minOccurs="0" maxOccurs="10" />
    </xs:sequence>
  </xs:complexType>
</xs:element>
```

```
<person>
  <full_name>Tove Refsnes</full_name>
  <child_name>Hege</child_name>
  <child_name>Stale</child_name>
  <child_name>Jim</child_name>
  <child_name>Borge</child_name>
</person>
```

http://www.w3schools.com/Schema/schema_complex_indicators.asp

XSD Data Types

```
<xs:element name="customer" type="xs:string"/>
<xs:element name="start" type="xs:date"/>
<xs:element name="startdate" type="xs:dateTime"/>
<xs:element name="prize" type="xs:decimal"/>
<xs:element name="weeks" type="xs:integer"/>
```

It is common to represent time in UTC/GMT, given that servers are often scattered around the world

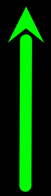
```
<customer>John Smith</customer>
<start>2002-09-24</start>
<startdate>2002-05-30T09:30:10Z</startdate>
<prize>999.50</prize>
<weeks>30</weeks>
```

http://www.w3schools.com/Schema/schema_dtypes_numeric.asp

ISO 8601 Date/Time Format

2002-05-30T09:30:10Z

Year-month-day



Time of day

Timezone - typically specified in UTC / GMT rather than local time zone

http://en.wikipedia.org/wiki/ISO_8601

http://en.wikipedia.org/wiki/Coordinated_Universal_Time

```xml
<?xml version="1.0" encoding="utf-8" ?>
<xs:schema elementFormDefault="qualified" xmlns:xs="http://www.w3.org/2001/XMLSchema">
  <xs:element name="Address">
    <xs:complexType>
      <xs:sequence>
        <xs:element name="Recipient" type="xs:string" />
        <xs:element name="House" type="xs:string" />
        <xs:element name="Street" type="xs:string" />
        <xs:element name="Town" type="xs:string" />
        <xs:element minOccurs="0" name="County" type="xs:string" />
        <xs:element name="PostCode" type="xs:string" />
        <xs:element name="Country">
          <xs:simpleType>
            <xs:restriction base="xs:string">
              <xs:enumeration value="FR" />
              <xs:enumeration value="DE" />
              <xs:enumeration value="ES" />
              <xs:enumeration value="UK" />
              <xs:enumeration value="US" />
            </xs:restriction>
          </xs:simpleType>
        </xs:element>
      </xs:sequence>
    </xs:complexType>
  </xs:element>
</xs:schema>
```



```xml
<?xml version="1.0" encoding="utf-8"?>
<Address
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:noNamespaceSchemaLocation="SimpleAddress.xsd">
  <Recipient>Mr. Walter C. Brown</Recipient>
  <House>49</House>
  <Street>Featherstone Street</Street>
  <Town>LONDON</Town>
  <PostCode>EC1Y 8SY</PostCode>
  <Country>UK</Country>
</Address>
```

```
<?xml version="1.0" encoding="ISO-8859-1" ?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema">
<xs:element name="shiporder">
 <xs:complexType>
  <xs:sequence>
   <xs:element name="orderperson" type="xs:string"/>
   <xs:element name="shipto">
    <xs:complexType>
     <xs:sequence>
      <xs:element name="name" type="xs:string"/>
      <xs:element name="address" type="xs:string"/>
      <xs:element name="city" type="xs:string"/>
      <xs:element name="country" type="xs:string"/>
     </xs:sequence>
    </xs:complexType>
   </xs:element>
   <xs:element name="item" maxOccurs="unbounded">
    <xs:complexType>
     <xs:sequence>
      <xs:element name="title" type="xs:string"/>
      <xs:element name="note" type="xs:string" minOccurs="0"/>
      <xs:element name="quantity" type="xs:positiveInteger"/>
      <xs:element name="price" type="xs:decimal"/>
     </xs:sequence>
    </xs:complexType>
   </xs:element>
  </xs:sequence>
  <xs:attribute name="orderid" type="xs:string" use="required"/>
 </xs:complexType>
</xs:element>
</xs:schema>
```

http://www.w3schools.com/Schema/schema_example.asp

xml1.py

```
import xml.etree.ElementTree as ET
data = '''<person>
  <name>Chuck</name>
  <phone type="intl">
     +1 734 303 4456
   </phone>
   <email hide="yes"/>
</person>'''

tree = ET.fromstring(data)
print('Name:',tree.find('name').text)
print('Attr:',tree.find('email').get('hide'))
```

xml2.py

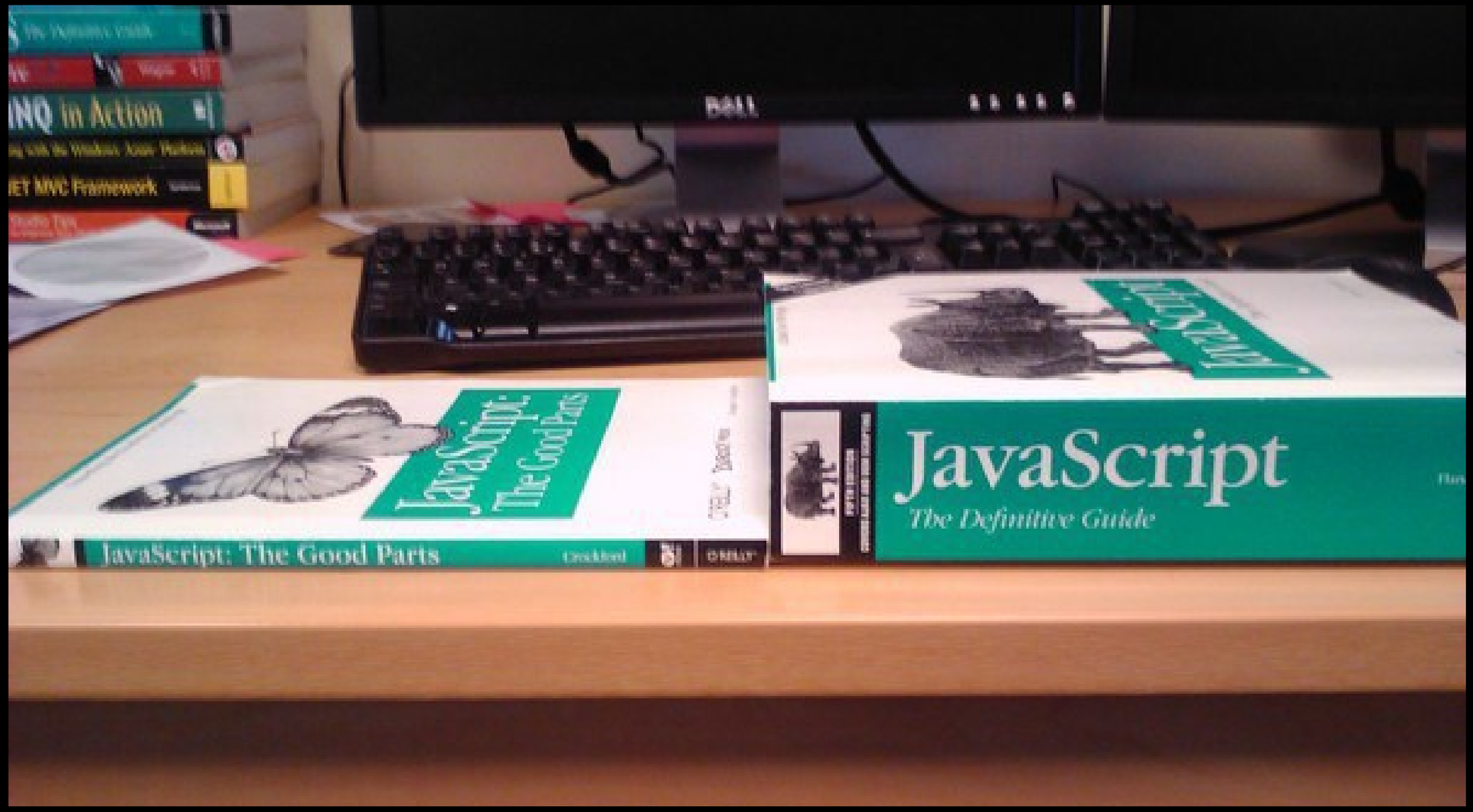
```
import xml.etree.ElementTree as ET
input = '''<stuff>
    <users>
        <user x="2">
            <id>001</id>
            <name>Chuck</name>
        </user>
        <user x="7">
            <id>009</id>
            <name>Brent</name>
        </user>
    </users>
</stuff>'''

stuff = ET.fromstring(input)
lst = stuff.findall('users/user')
print('User count:', len(lst))
for item in lst:
    print('Name', item.find('name').text)
    print('Id', item.find('id').text)
    print('Attribute', item.get("x"))
```

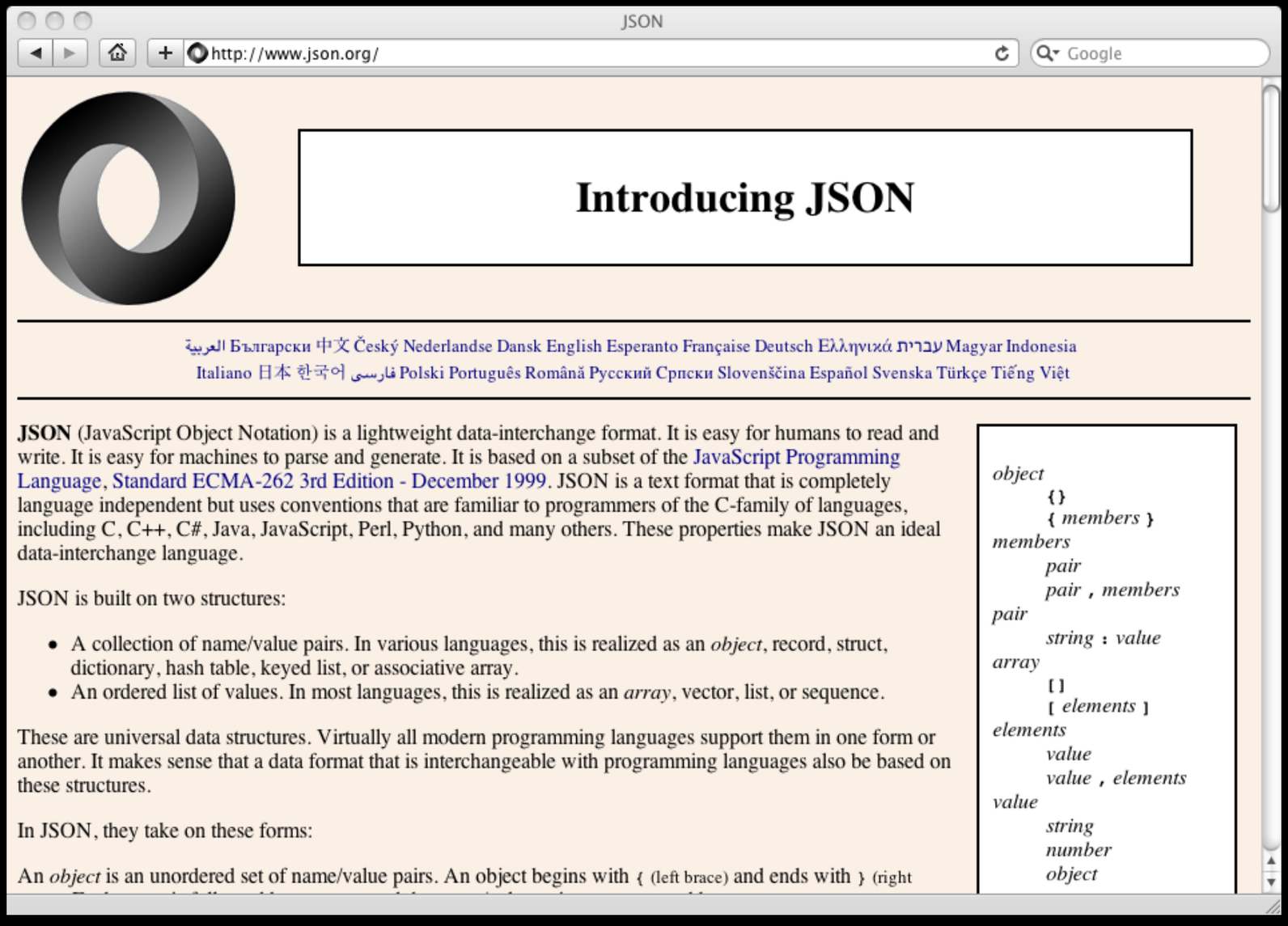
JavaScript Object Notation

JavaScript Object Notation

- Douglas Crockford - “Discovered” JSON
- Object literal notation in JavaScript

http://www.youtube.com/watch?v=kc8BAR7SHJI


NQ in Action
ET MVC Framework
JavaScript: The Good Parts
O'REILLY
JavaScript
The Definitive Guide


JSON
http://www.json.org/
Google
Introducing JSON
العربية Български 中文 Český Nederlandse Dansk English Esperanto Française Deutsch Ελληνικά עברית Magyar Indonesia
Italiano 日本 한국어 فارسی Polski Português Română Русский Српски Slovenščina Español Svenska Türkçe Tiếng Việt
JSON (JavaScript Object Notation) is a lightweight data-interchange format. It is easy for humans to read and write. It is easy for machines to parse and generate. It is based on a subset of the JavaScript Programming Language, Standard ECMA-262 3rd Edition - December 1999. JSON is a text format that is completely language independent but uses conventions that are familiar to programmers of the C-family of languages, including C, C++, C#, Java, JavaScript, Perl, Python, and many others. These properties make JSON an ideal data-interchange language.
JSON is built on two structures:
A collection of name/value pairs. In various languages, this is realized as an object, record, struct, dictionary, hash table, keyed list, or associative array.
An ordered list of values. In most languages, this is realized as an array, vector, list, or sequence.
These are universal data structures. Virtually all modern programming languages support them in one form or another. It makes sense that a data format that is interchangeable with programming languages also be based on these structures.
In JSON, they take on these forms:
An object is an unordered set of name/value pairs. An object begins with { (left brace) and ends with } (right
object
{}
{ members }
members
pair
pair , members
pair
string : value
array
[]
[elements]
elements
value
value , elements
value
string
number
object

json1.py

```
import json
data = '''{
  "name" : "Chuck",
  "phone" : {
    "type" : "intl",
    "number" : "+1 734 303 4456"
   },
   "email" : {
     "hide" : "yes"
   }
}'''

info = json.loads(data)
print('Name:',info["name"])
print('Hide:',info["email"]["hide"])
```

JSON represents data as nested “lists” and “dictionaries”

json2.py

```
import json
input = '''[
  { "id" : "001",
    "x" : "2",
    "name" : "Chuck"
  } ,
  { "id" : "009",
    "x" : "7",
    "name" : "Chuck"
  }
]'''

info = json.loads(input)
print('User count:', len(info))
for item in info:
    print('Name', item['name'])
    print('Id', item['id'])
    print('Attribute', item['x'])
```

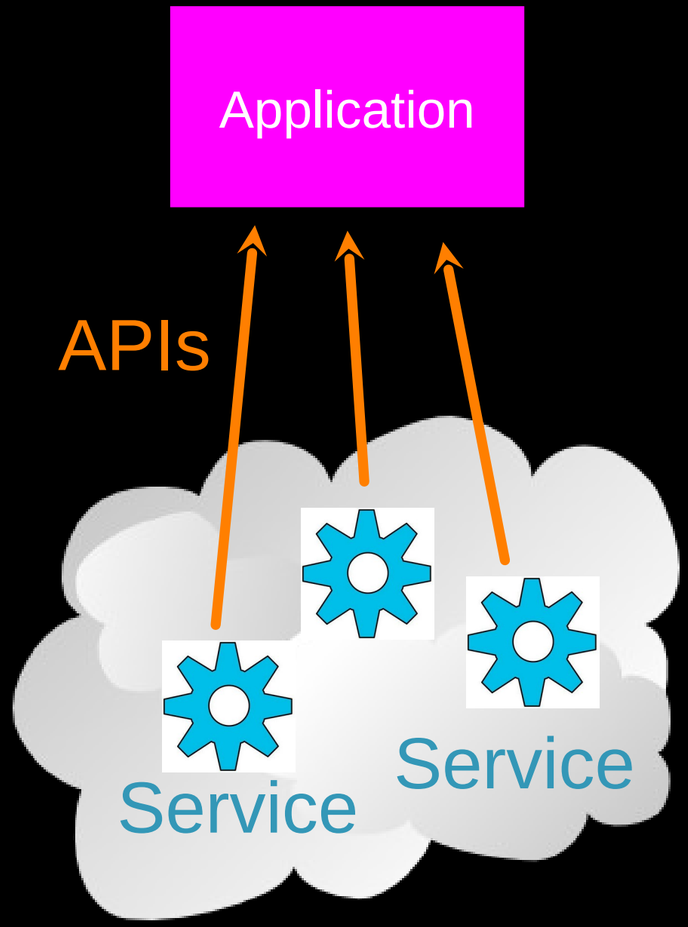
JSON represents data as nested “lists” and “dictionaries”

Service Oriented Approach

http://en.wikipedia.org/wiki/Service-oriented_architecture

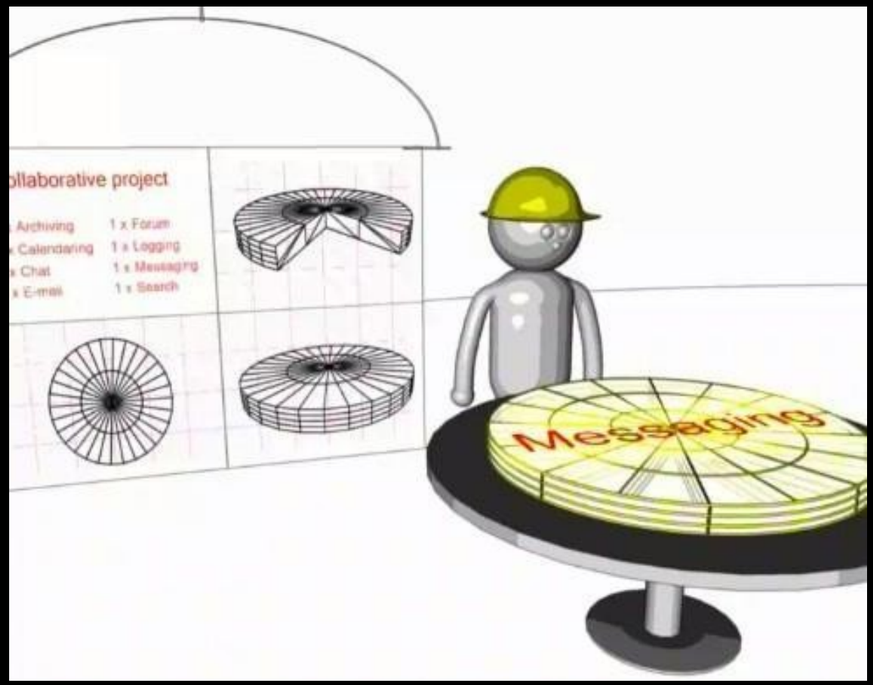
Service Oriented Approach

- Most non-trivial web applications use services
- They use services from other applications
  - Credit Card Charge
  - Hotel Reservation systems
- Services publish the “rules” applications must follow to make use of the service (API)



Multiple Systems

- Initially - two systems cooperate and split the problem
- As the data/service becomes useful - multiple applications want to use the information / application



http://www.youtube.com/watch?v=mj-kCFzF0ME

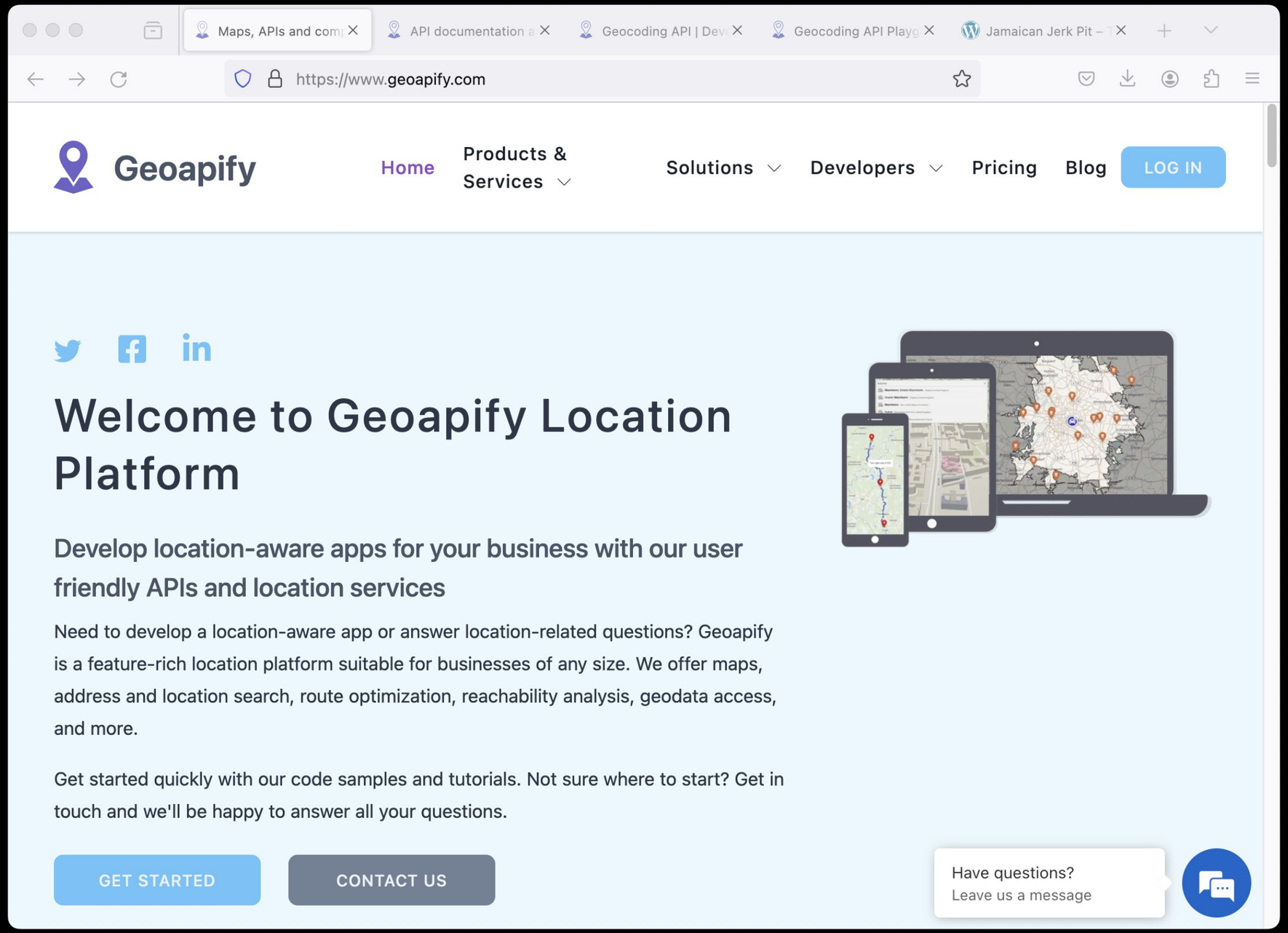
5:15

APIs

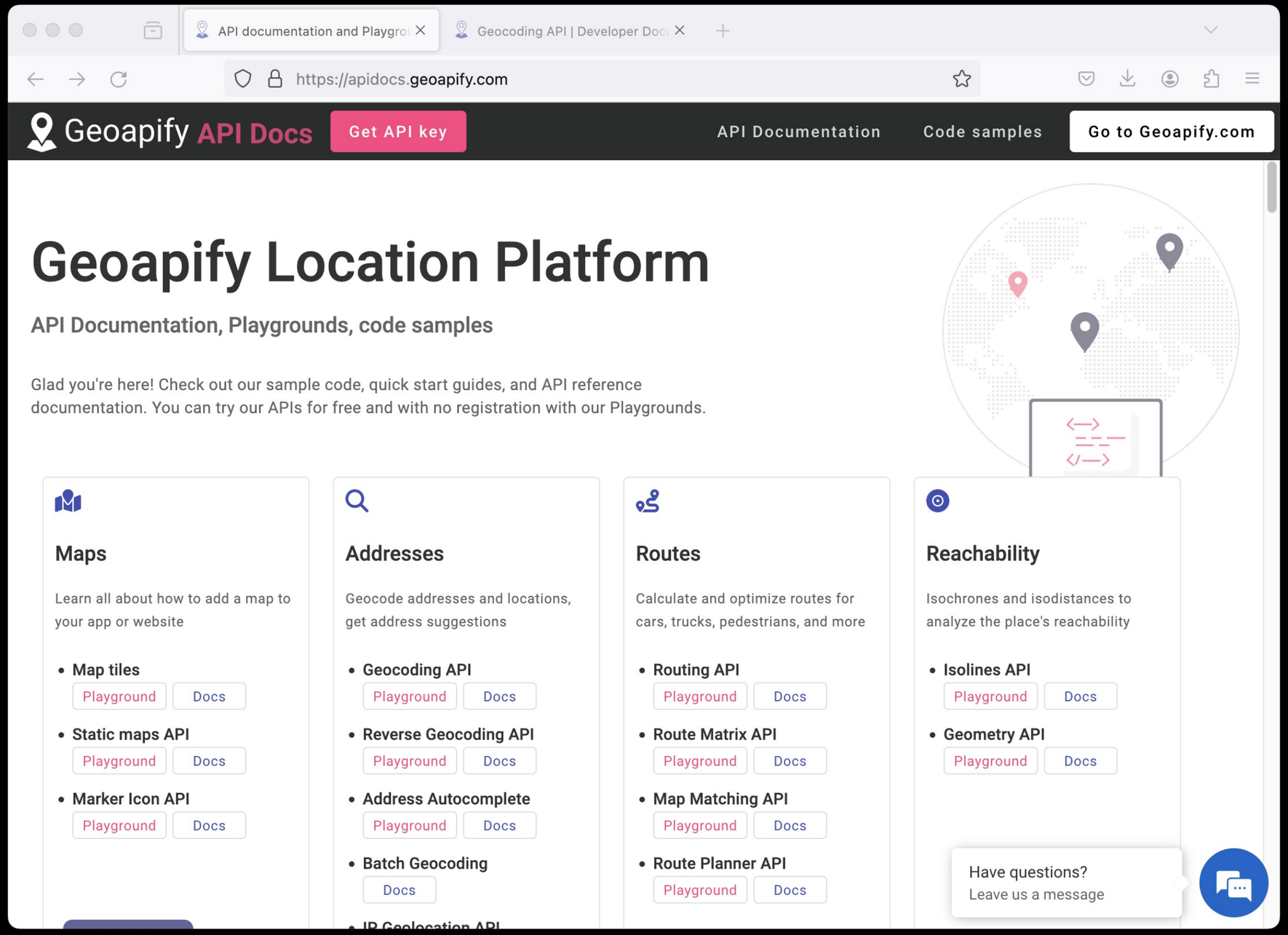
http://en.wikipedia.org/wiki/Web_services

There Are Many APIs

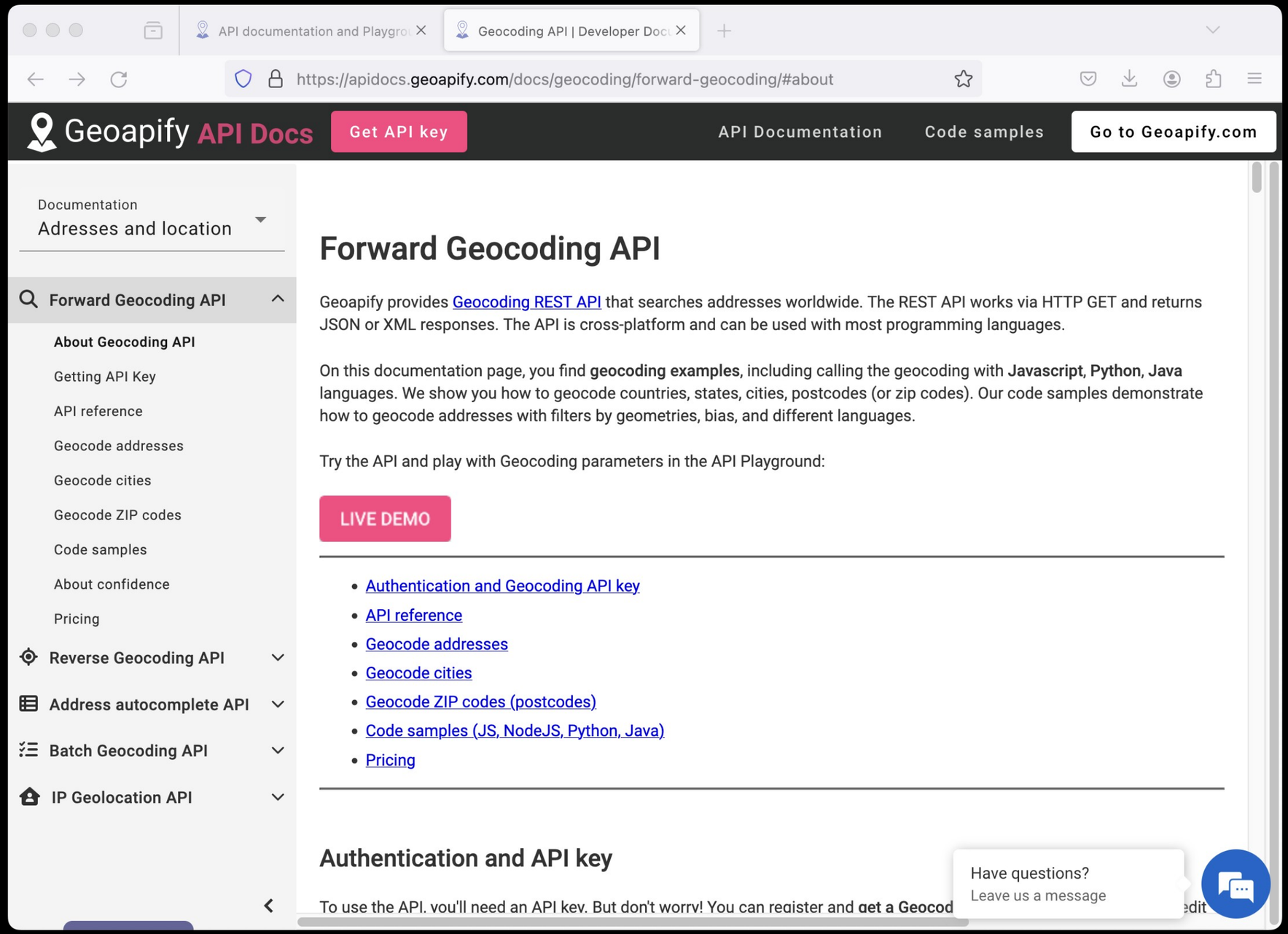
- There are organizations that put up public APIs and sell access to those APIs
- We will explore a geocoding API based on the OpenStreetMap data
- You need an account to access this API
- There is a free level of requests over time
- You pay above that rate of usage



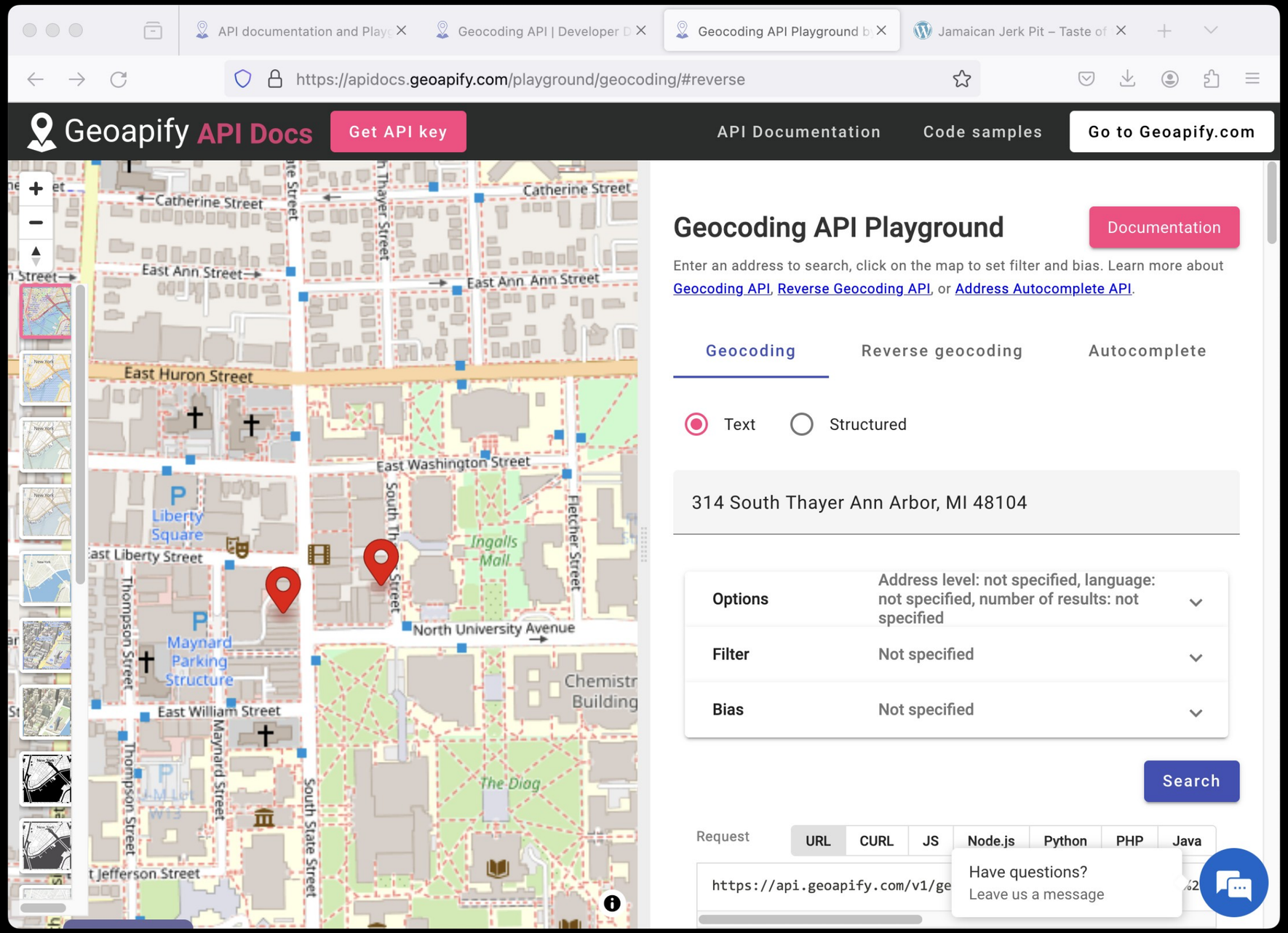
https://www.geoapify.com/



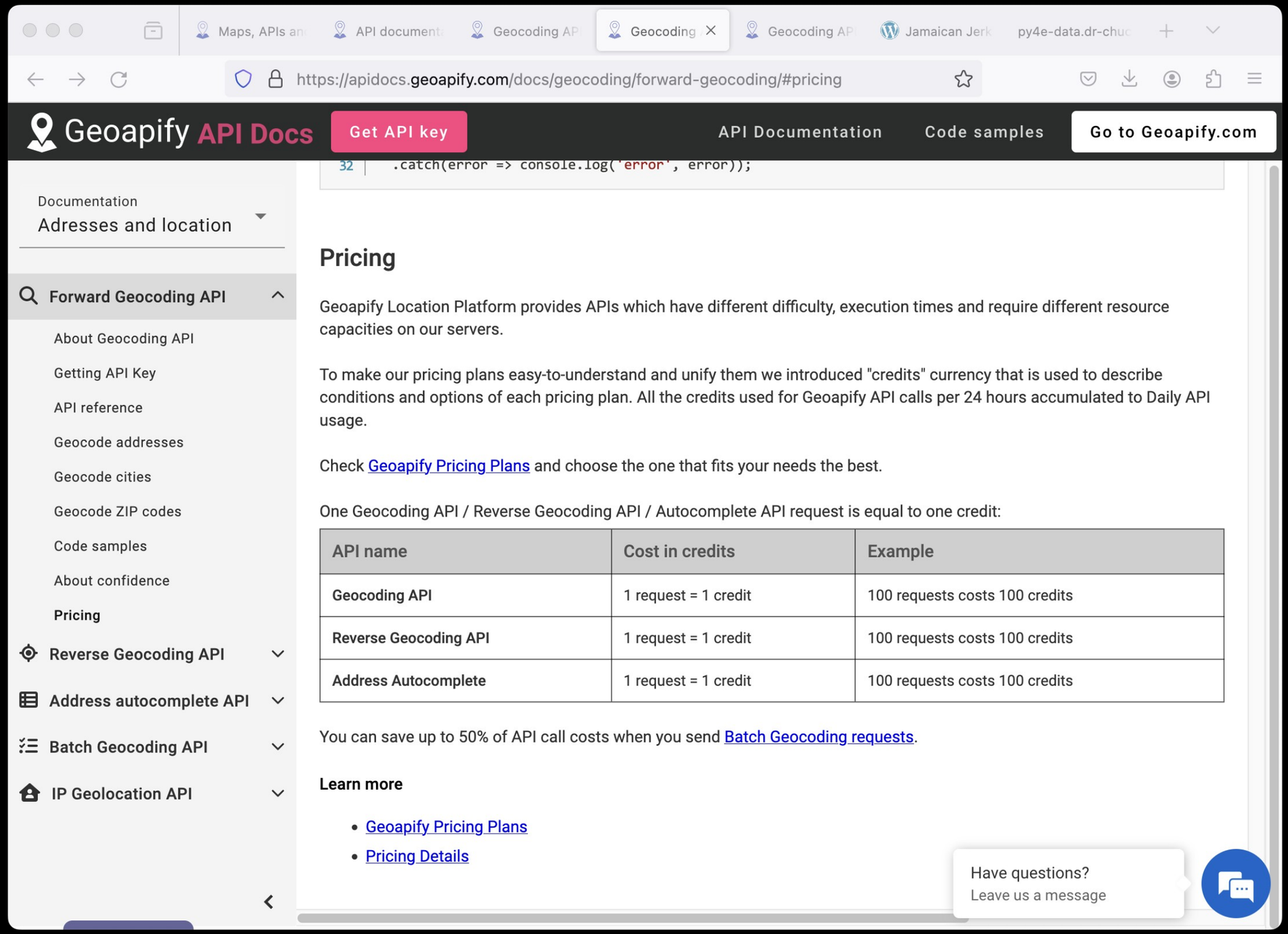
https://apidocs.geoapify.com/



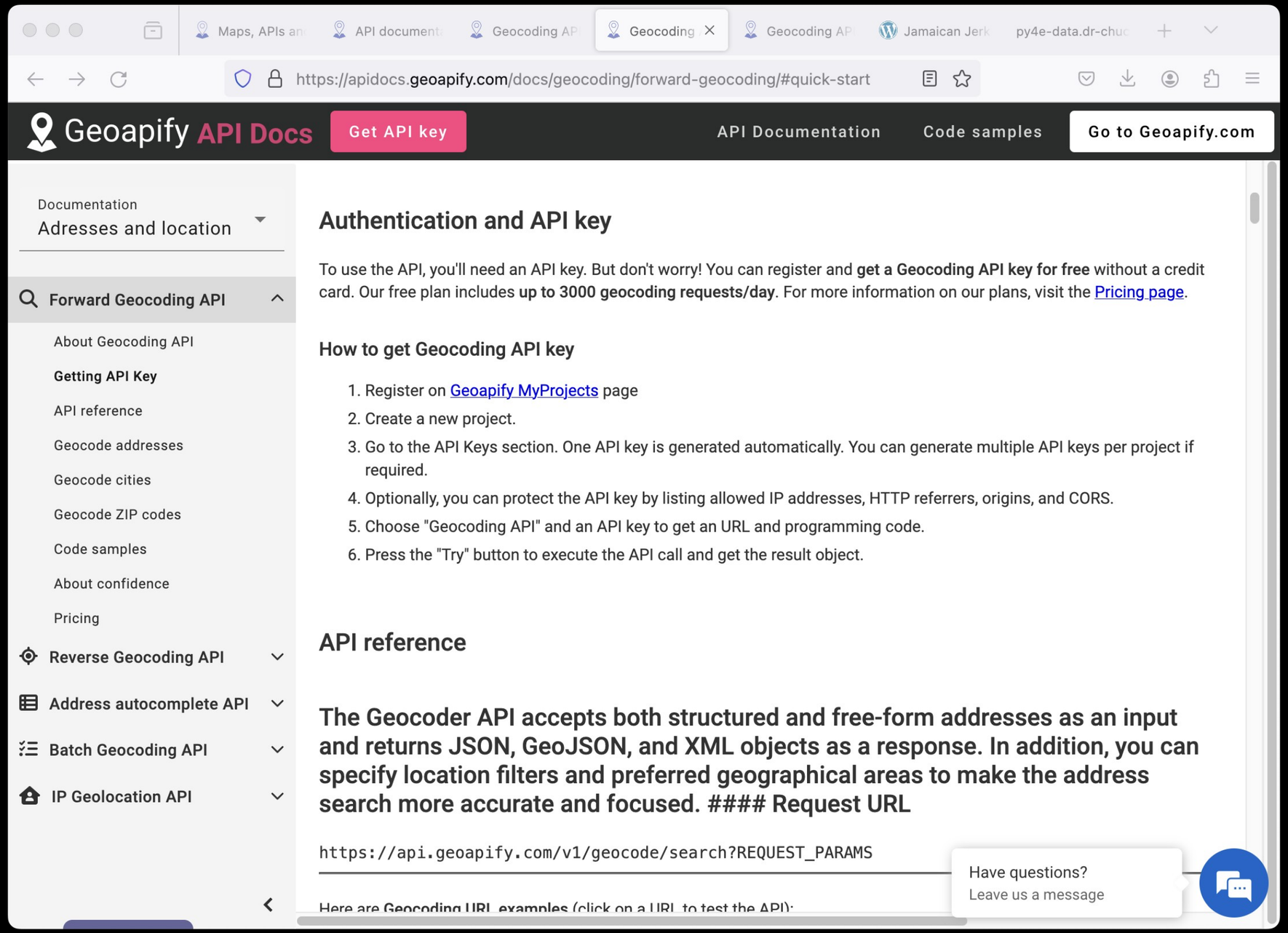
https://apidocs.geoapify.com/



https://apidocs.geoapify.com/



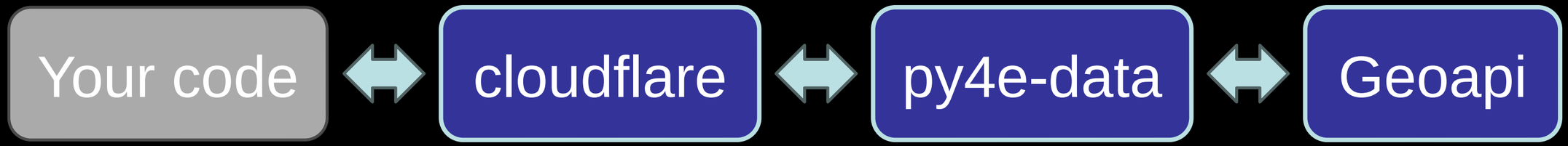
https://apidocs.geoapify.com/



https://apidocs.geoapify.com/

An API Proxy

- To avoid making you get an account, I have a well-hidden web server that acts as a proxy for the Geoapify data
- This proxy does not require a password – but it does have rate limits and is heavily cached using an edge-caching service for performance



```
{
  "type": "FeatureCollection",
  "features": [
    {
      "type": "Feature",
      "properties": {
        "datasource": {
          "sourcename": "openstreetmap",
          "attribution": "© OpenStreetMap contributors",
          "license": "Open Database License",
          "url": "https://www.openstreetmap.org/copyright"
        },
        "country": "United States",
        "country_code": "us",
        "state": "Michigan",
        "county": "Washtenaw County",
        "city": "Ann Arbor",
        "lon": -83.7312291,
        "lat": 42.2681569,
        "state_code": "MI",
        "result_type": "city",
        "formatted": "Ann Arbor, MI, United States of America",
```

http://py4e-data.dr-chuck.net/opengeo?q=Ann+Arbor%2C+MI

Note, for this course, we operate through a proxy of the geoapi data to avoid rate limitation and authentication.

opengeo.py

```
import urllib.request, urllib.parse
import http, json, ssl

serviceurl = 'https://py4e-data.dr-chuck.net/opengeo?'

while True:
    address = input('Enter location: ')
    if len(address) < 1: break

    address = address.strip()
    parms = dict()
    parms['q'] = address

    url = serviceurl + urllib.parse.urlencode(parms)

    print('Retrieving', url)
    uh = urllib.request.urlopen(url, context=ctx)
    data = uh.read().decode()
    print('Retrieved', len(data), 'characters', data[:20].replace('\n', ' '))

    js = json.loads(data)

    lat = js['features'][0]['properties']['lat']
    lon = js['features'][0]['properties']['lon']
    print('lat', lat, 'lon', lon)
    location = js['features'][0]['properties']['formatted']
```

```
Enter location: Ann Arbor, MI
Retrieving https://py4e-data.
    dr-chuck.net/opengeo?q=Ann+Arbor%2C+MI
Retrieved 1319 characters {"type":"FeatureColl
lat 42.2681569 lon -83.7312291
Ann Arbor, MI, United States of America
```

opengeo.py

Summary

- Service Oriented Architecture - allows an application to be broken into parts and distributed across a network
- An Application Program Interface (API) is a contract for interaction
- Web Services provide infrastructure for applications cooperating (an API) over a network - SOAP and REST are two styles of web services
- XML and JSON are serialization formats

Acknowledgements / Contributions

Initial Development: Charles Severance, University of Michigan School of Information

… Insert new Contributors here

...