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```
import urllib.request, urllib.parse, urllib.error
from bs4 import BeautifulSoup
import ssl

# Ignore SSL certificate errors
ctx = ssl.create_default_context()
ctx.check_hostname = False
ctx.verify_mode = ssl.CERT_NONE

url = input('Enter - ')
html = urllib.request.urlopen(url, context=ctx).read()
soup = BeautifulSoup(html, 'html.parser')

# Retrieve all of the anchor tags
tags = soup('a')
for tag in tags:
    print(tag.get('href', None))

# Code: http://www.py4e.com/code3/urllinks.py
```

The program prompts for a web address, then opens the web page, reads the data and passes the data to the BeautifulSoup parser, and then retrieves all of the anchor tags and prints out the `href` attribute for each tag.

When the program runs, it produces the following output:

```
Enter - https://docs.python.org
genindex.html
py-modindex.html
https://www.python.org/
#
whatsnew/3.6.html
whatsnew/index.html
tutorial/index.html
library/index.html
reference/index.html
using/index.html
howto/index.html
installing/index.html
distributing/index.html
extending/index.html
c-api/index.html
faq/index.html
py-modindex.html
genindex.html
glossary.html
search.html
contents.html
bugs.html
about.html
license.html
copyright.html
download.html
```

```
https://docs.python.org/3.8/
https://docs.python.org/3.7/
https://docs.python.org/3.5/
https://docs.python.org/2.7/
https://www.python.org/doc/versions/
https://www.python.org/dev/peps/
https://wiki.python.org/moin/BeginnersGuide
https://wiki.python.org/moin/PythonBooks
https://www.python.org/doc/av/
genindex.html
py-modindex.html
https://www.python.org/
#
copyright.html
https://www.python.org/psf/donations/
bugs.html
http://sphinx.pocoo.org/
```

This list is much longer because some HTML anchor tags are relative paths (e.g., tutorial/index.html) or in-page references (e.g., '#') that do not include "http://" or "https://", which was a requirement in our regular expression.

You can use also BeautifulSoup to pull out various parts of each tag:

```
# To run this, download the BeautifulSoup zip file
# http://www.py4e.com/code3/bs4.zip
# and unzip it in the same directory as this file

from urllib.request import urlopen
from bs4 import BeautifulSoup
import ssl

# Ignore SSL certificate errors
ctx = ssl.create_default_context()
ctx.check_hostname = False
ctx.verify_mode = ssl.CERT_NONE

url = input('Enter - ')
html = urlopen(url, context=ctx).read()
soup = BeautifulSoup(html, "html.parser")

# Retrieve all of the anchor tags
tags = soup('a')
for tag in tags:
    # Look at the parts of a tag
    print('TAG:', tag)
    print('URL:', tag.get('href', None))
    print('Contents:', tag.contents[0])
    print('Attrs:', tag.attrs)

# Code: http://www.py4e.com/code3/urllink2.py
```

```
python urllink2.py
```

```
Enter - http://www.dr-chuck.com/page1.htm
TAG: <a href="http://www.dr-chuck.com/page2.htm">
Second Page</a>
URL: http://www.dr-chuck.com/page2.htm
Content: ['\nSecond Page']
Attrs: [('href', 'http://www.dr-chuck.com/page2.htm')]
```

`html.parser` is the HTML parser included in the standard Python 3 library. Information on other HTML parsers is available at:

http://www.crummy.com/software/BeautifulSoup/bs4/doc/#installing-a-parser

These examples only begin to show the power of BeautifulSoup when it comes to parsing HTML.

12.9 Bonus section for Unix / Linux users

If you have a Linux, Unix, or Macintosh computer, you probably have commands built in to your operating system that retrieves both plain text and binary files using the HTTP or File Transfer (FTP) protocols. One of these commands is `curl`:

```
$ curl -O http://www.py4e.com/cover.jpg
```

The command `curl` is short for "copy URL" and so the two examples listed earlier to retrieve binary files with `urllib` are cleverly named `curl1.py` and `curl2.py` on www.py4e.com/code3 as they implement similar functionality to the `curl` command. There is also a `curl3.py` sample program that does this task a little more effectively, in case you actually want to use this pattern in a program you are writing.

A second command that functions very similarly is `wget`:

```
$ wget http://www.py4e.com/cover.jpg
```

Both of these commands make retrieving webpages and remote files a simple task.

12.10 Glossary

BeautifulSoup A Python library for parsing HTML documents and extracting data from HTML documents that compensates for most of the imperfections in the HTML that browsers generally ignore. You can download the BeautifulSoup code from www.crummy.com.

port A number that generally indicates which application you are contacting when you make a socket connection to a server. As an example, web traffic usually uses port 80 while email traffic uses port 25.

scrape When a program pretends to be a web browser and retrieves a web page, then looks at the web page content. Often programs are following the links in one page to find the next page so they can traverse a network of pages or a social network.

socket A network connection between two applications where the applications can send and receive data in either direction.

spider The act of a web search engine retrieving a page and then all the pages linked from a page and so on until they have nearly all of the pages on the Internet which they use to build their search index.

12.11 Exercises

Exercise 1: Change the socket program `socket1.py` to prompt the user for the URL so it can read any web page. You can use `split('/')` to break the URL into its component parts so you can extract the host name for the socket `connect` call. Add error checking using `try` and `except` to handle the condition where the user enters an improperly formatted or non-existent URL.

Exercise 2: Change your socket program so that it counts the number of characters it has received and stops displaying any text after it has shown 3000 characters. The program should retrieve the entire document and count the total number of characters and display the count of the number of characters at the end of the document.

Exercise 3: Use `urllib` to replicate the previous exercise of (1) retrieving the document from a URL, (2) displaying up to 3000 characters, and (3) counting the overall number of characters in the document. Don't worry about the headers for this exercise, simply show the first 3000 characters of the document contents.

Exercise 4: Change the `urllinks.py` program to extract and count paragraph (p) tags from the retrieved HTML document and display the count of the paragraphs as the output of your program. Do not display the paragraph text, only count them. Test your program on several small web pages as well as some larger web pages.

Exercise 5: (Advanced) Change the socket program so that it only shows data after the headers and a blank line have been received. Remember that `recv` receives characters (newlines and all), not lines.

Chapter 13

Using Web Services

Once it became easy to retrieve documents and parse documents over HTTP using programs, it did not take long to develop an approach where we started producing documents that were specifically designed to be consumed by other programs (i.e., not HTML to be displayed in a browser).

There are two common formats that we use when exchanging data across the web. eXtensible Markup Language (XML) has been in use for a very long time and is best suited for exchanging document-style data. When programs just want to exchange dictionaries, lists, or other internal information with each other, they use JavaScript Object Notation (JSON) (see www.json.org). We will look at both formats.

13.1 eXtensible Markup Language - XML

XML looks very similar to HTML, but XML is more structured than HTML. Here is a sample of an XML document:

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

Each pair of opening (e.g., `<person>`) and closing tags (e.g., `</person>`) represents a *element* or *node* with the same name as the tag (e.g., `person`). Each element can have some text, some attributes (e.g., `hide`), and other nested elements. If an XML element is empty (i.e., has no content), then it may be depicted by a self-closing tag (e.g., `<email />`).

Often it is helpful to think of an XML document as a tree structure where there is a top element (here: `person`), and other tags (e.g., `phone`) are drawn as *children* of their *parent* elements.

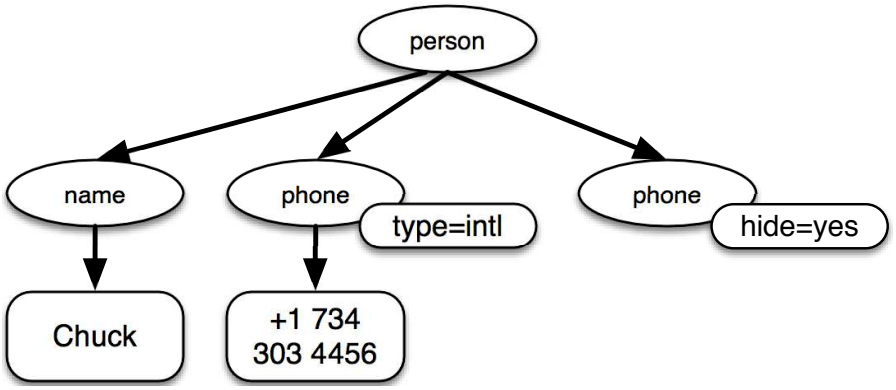

Figure 13.1: A Tree Representation of XML

13.2 Parsing XML

Here is a simple application that parses some XML and extracts some data elements from the XML:

```
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'))

# Code: http://www.py4e.com/code3/xml1.py
```

The triple single quote (`'''`), as well as the triple double quote (`"""`), allow for the creation of strings that span multiple lines.

Calling `fromstring` converts the string representation of the XML into a "tree" of XML elements. When the XML is in a tree, we have a series of methods we can call to extract portions of data from the XML string. The `find` function searches through the XML tree and retrieves the element that matches the specified tag.

```
Name: Chuck
Attr: yes
```

Using an XML parser such as `ElementTree` has the advantage that while the XML in this example is quite simple, it turns out there are many rules regarding

valid XML, and using `ElementTree` allows us to extract data from XML without worrying about the rules of XML syntax.

13.3 Looping through nodes

Often the XML has multiple nodes and we need to write a loop to process all of the nodes. In the following program, we loop through all of the `user` nodes:

```
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'))

# Code: http://www.py4e.com/code3/xml2.py
```

The `findall` method retrieves a Python list of subtrees that represent the `user` structures in the XML tree. Then we can write a `for` loop that looks at each of the user nodes, and prints the `name` and `id` text elements as well as the `x` attribute from the `user` node.

```
User count: 2
Name Chuck
Id 001
Attribute 2
Name Brent
Id 009
Attribute 7
```

It is important to include all parent level elements in the `findall` statement except for the top level element (e.g., `users/user`). Otherwise, Python will not find any desired nodes.

```
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))

lst2 = stuff.findall('user')
print('User count:', len(lst2))
```

`lst` stores all `user` elements that are nested within their `users` parent. `lst2` looks for `user` elements that are not nested within the top level `stuff` element where there are none.

```
User count: 2
User count: 0
```

13.4 JavaScript Object Notation - JSON

The JSON format was inspired by the object and array format used in the JavaScript language. But since Python was invented before JavaScript, Python's syntax for dictionaries and lists influenced the syntax of JSON. So the format of JSON is nearly identical to a combination of Python lists and dictionaries.

Here is a JSON encoding that is roughly equivalent to the simple XML from above:

```
{
  "name" : "Chuck",
  "phone" : {
    "type" : "intl",
    "number" : "+1 734 303 4456"
```

```
    },
    "email" : {
      "hide" : "yes"
    }
}
```

You will notice some differences. First, in XML, we can add attributes like "intl" to the "phone" tag. In JSON, we simply have key-value pairs. Also the XML "person" tag is gone, replaced by a set of outer curly braces.

In general, JSON structures are simpler than XML because JSON has fewer capabilities than XML. But JSON has the advantage that it maps *directly* to some combination of dictionaries and lists. And since nearly all programming languages have something equivalent to Python's dictionaries and lists, JSON is a very natural format to have two cooperating programs exchange data.

JSON is quickly becoming the format of choice for nearly all data exchange between applications because of its relative simplicity compared to XML.

13.5 Parsing JSON

We construct our JSON by nesting dictionaries and lists as needed. In this example, we represent a list of users where each user is a set of key-value pairs (i.e., a dictionary). So we have a list of dictionaries.

In the following program, we use the built-in `json` library to parse the JSON and read through the data. Compare this closely to the equivalent XML data and code above. The JSON has less detail, so we must know in advance that we are getting a list and that the list is of users and each user is a set of key-value pairs. The JSON is more succinct (an advantage) but also is less self-describing (a disadvantage).

```
import json

data = '''
[
  { "id" : "001",
    "x" : "2",
    "name" : "Chuck"
  } ,
  { "id" : "009",
    "x" : "7",
    "name" : "Brent"
  }
]'''

info = json.loads(data)
print('User count:', len(info))

for item in info:
    print('Name', item['name'])
```

```
    print('Id', item['id'])
    print('Attribute', item['x'])

# Code: http://www.py4e.com/code3/json2.py
```

If you compare the code to extract data from the parsed JSON and XML you will see that what we get from `json.loads()` is a Python list which we traverse with a `for` loop, and each item within that list is a Python dictionary. Once the JSON has been parsed, we can use the Python index operator to extract the various bits of data for each user. We don't have to use the JSON library to dig through the parsed JSON, since the returned data is simply native Python structures.

The output of this program is exactly the same as the XML version above.

```
User count: 2
Name Chuck
Id 001
Attribute 2
Name Brent
Id 009
Attribute 7
```

In general, there is an industry trend away from XML and towards JSON for web services. Because the JSON is simpler and more directly maps to native data structures we already have in programming languages, the parsing and data extraction code is usually simpler and more direct when using JSON. But XML is more self-descriptive than JSON and so there are some applications where XML retains an advantage. For example, most word processors store documents internally using XML rather than JSON.

13.6 Application Programming Interfaces

We now have the ability to exchange data between applications using HyperText Transport Protocol (HTTP) and a way to represent complex data that we are sending back and forth between these applications using eXtensible Markup Language (XML) or JavaScript Object Notation (JSON).

The next step is to begin to define and document "contracts" between applications using these techniques. The general name for these application-to-application contracts is *Application Program Interfaces* (APIs). When we use an API, generally one program makes a set of *services* available for use by other applications and publishes the APIs (i.e., the "rules") that must be followed to access the services provided by the program.

When we begin to build our programs where the functionality of our program includes access to services provided by other programs, we call the approach a *Service-oriented architecture* (SOA). A SOA approach is one where our overall application makes use of the services of other applications. A non-SOA approach is where the application is a single standalone application which contains all of the code necessary to implement the application.

We see many examples of SOA when we use the web. We can go to a single web site and book air travel, hotels, and automobiles all from a single site. The data for hotels is not stored on the airline computers. Instead, the airline computers contact the services on the hotel computers and retrieve the hotel data and present it to the user. When the user agrees to make a hotel reservation using the airline site, the airline site uses another web service on the hotel systems to actually make the reservation. And when it comes time to charge your credit card for the whole transaction, still other computers become involved in the process.

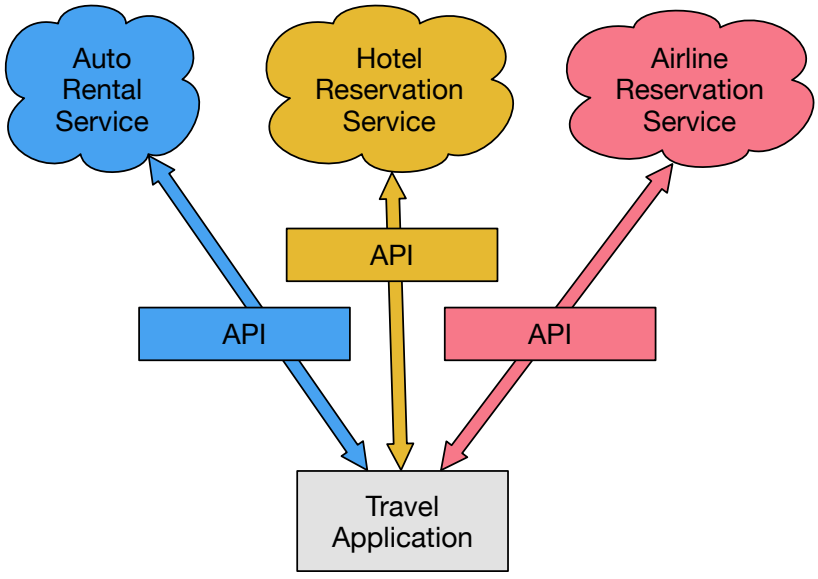

Figure 13.2: Service-oriented architecture

A Service-oriented architecture has many advantages, including: (1) we always maintain only one copy of data (this is particularly important for things like hotel reservations where we do not want to over-commit) and (2) the owners of the data can set the rules about the use of their data. With these advantages, an SOA system must be carefully designed to have good performance and meet the user's needs.

When an application makes a set of services in its API available over the web, we call these *web services*.

13.7 Security and API usage

It is quite common that you need an API key to make use of a vendor's API. The general idea is that they want to know who is using their services and how much each user is using. Perhaps they have free and pay tiers of their services or have a policy that limits the number of requests that a single individual can make during a particular time period.

Sometimes once you get your API key, you simply include the key as part of POST data or perhaps as a parameter on the URL when calling the API.

Other times, the vendor wants increased assurance of the source of the requests and so they expect you to send cryptographically signed messages using shared keys and secrets. A very common technology that is used to sign requests over the Internet is called *OAuth*. You can read more about the OAuth protocol at www.oauth.net.

Thankfully there are a number of convenient and free OAuth libraries so you can avoid writing an OAuth implementation from scratch by reading the specification. These libraries are of varying complexity and have varying degrees of richness. The OAuth web site has information about various OAuth libraries.

13.8 Glossary

API Application Program Interface - A contract between applications that defines the patterns of interaction between two application components.

ElementTree A built-in Python library used to parse XML data.

JSON JavaScript Object Notation. A format that allows for the markup of structured data based on the syntax of JavaScript Objects.

SOA Service-Oriented Architecture. When an application is made of components connected across a network.

XML eXtensible Markup Language. A format that allows for the markup of structured data.

13.9 Application 1: Google geocoding web service

Google has an excellent web service that allows us to make use of their large database of geographic information. We can submit a geographical search string like "Ann Arbor, MI" to their geocoding API and have Google return its best guess as to where on a map we might find our search string and tell us about the landmarks nearby.

The geocoding service is free but rate limited so you cannot make unlimited use of the API in a commercial application. But if you have some survey data where an end user has entered a location in a free-format input box, you can use this API to clean up your data quite nicely.

When you are using a free API like Google's geocoding API, you need to be respectful in your use of these resources. If too many people abuse the service, Google might drop or significantly curtail its free service.

You can read the online documentation for this service, but it is quite simple and you can even test it using a browser by typing the following URL into your browser:

http://maps.googleapis.com/maps/api/geocode/json?address=Ann+Arbor%2C+MI

Make sure to unwrap the URL and remove any spaces from the URL before pasting it into your browser.

The following is a simple application to prompt the user for a search string, call the Google geocoding API, and extract information from the returned JSON.

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

api_key = False
# If you have a Google Places API key, enter it here
# api_key = 'AIzaSy___IDByT70'
# https://developers.google.com/maps/documentation/geocoding/intro

if api_key is False:
    api_key = 42
    serviceurl = 'http://py4e-data.dr-chuck.net/json?'
else :
    serviceurl = 'https://maps.googleapis.com/maps/api/geocode/json?'

# Ignore SSL certificate errors
ctx = ssl.create_default_context()
ctx.check_hostname = False
ctx.verify_mode = ssl.CERT_NONE

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

    parms = dict()
    parms['address'] = address
    if api_key is not False: parms['key'] = api_key
    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')

    try:
        js = json.loads(data)
    except:
        js = None

    if not js or 'status' not in js or js['status'] != 'OK':
        print('==== Failure To Retrieve ====')
        print(data)
        continue

    print(json.dumps(js, indent=4))

    lat = js['results'][0]['geometry']['location']['lat']
    lng = js['results'][0]['geometry']['location']['lng']
    print('lat', lat, 'lng', lng)
    location = js['results'][0]['formatted_address']
    print(location)
```

```
# Code: http://www.py4e.com/code3/geojson.py
```

The program takes the search string and constructs a URL with the search string as a properly encoded parameter and then uses `urllib` to retrieve the text from the Google geocoding API. Unlike a fixed web page, the data we get depends on the parameters we send and the geographical data stored in Google's servers.

Once we retrieve the JSON data, we parse it with the `json` library and do a few checks to make sure that we received good data, then extract the information that we are looking for.

The output of the program is as follows (some of the returned JSON has been removed):

```
$ python3 geojson.py
Enter location: Ann Arbor, MI
Retrieving http://py4e-data.dr-chuck.net/json?address=Ann+Arbor%2C+MI&key=42
Retrieved 1736 characters
```

```
{
    "results": [
        {
            "address_components": [
                {
                    "long_name": "Ann Arbor",
                    "short_name": "Ann Arbor",
                    "types": [
                        "locality",
                        "political"
                    ]
                },
                {
                    "long_name": "Washtenaw County",
                    "short_name": "Washtenaw County",
                    "types": [
                        "administrative_area_level_2",
                        "political"
                    ]
                },
                {
                    "long_name": "Michigan",
                    "short_name": "MI",
                    "types": [
                        "administrative_area_level_1",
                        "political"
                    ]
                },
                {
                    "long_name": "United States",
                    "short_name": "US",
```

```
                    "types": [
                        "country",
                        "political"
                    ]
                }
            ],
            "formatted_address": "Ann Arbor, MI, USA",
            "geometry": {
                "bounds": {
                    "northeast": {
                        "lat": 42.3239728,
                        "lng": -83.6758069
                    },
                    "southwest": {
                        "lat": 42.222668,
                        "lng": -83.799572
                    }
                },
                "location": {
                    "lat": 42.2808256,
                    "lng": -83.7430378
                },
                "location_type": "APPROXIMATE",
                "viewport": {
                    "northeast": {
                        "lat": 42.3239728,
                        "lng": -83.6758069
                    },
                    "southwest": {
                        "lat": 42.222668,
                        "lng": -83.799572
                    }
                }
            },
            "place_id": "ChIJMx9D1A2wPIgR4rXIhkb5Cds",
            "types": [
                "locality",
                "political"
            ]
        }
    ],
    "status": "OK"
}
lat 42.2808256 lng -83.7430378
Ann Arbor, MI, USA

Enter location:
```


You can download www.py4e.com/code3/geoxml.py to explore the XML variant of the Google geocoding API.

Exercise 1: Change either geojson.py or geoxml.py to print out the two-character country code from the retrieved data. Add error checking so your program does not traceback if the country code is not there. Once you have it working, search for "Atlantic Ocean" and make sure it can handle locations that are not in any country.

13.10 Application 2: Twitter

As the Twitter API became increasingly valuable, Twitter went from an open and public API to an API that required the use of OAuth signatures on each API request.

For this next sample program, download the files *twurl.py*, *hidden.py*, *oauth.py*, and *twitter1.py* from www.py4e.com/code and put them all in a folder on your computer.

To make use of these programs you will need to have a Twitter account, and authorize your Python code as an application, set up a key, secret, token and token secret. You will edit the file *hidden.py* and put these four strings into the appropriate variables in the file:

```
# Keep this file separate

# https://apps.twitter.com/
# Create new App and get the four strings

def oauth():
    return {"consumer_key": "h7Lu...Ng",
            "consumer_secret": "dNKenAC3New...mmn7Q",
            "token_key": "10185562-eibxCp9n2...P4GEQQOSGI",
            "token_secret": "H0ycCFemmC4wyf1...qoIpBo"}

# Code: http://www.py4e.com/code3/hidden.py
```

The Twitter web service are accessed using a URL like this:

https://api.twitter.com/1.1/statuses/user_timeline.json

But once all of the security information has been added, the URL will look more like:

```
https://api.twitter.com/1.1/statuses/user_timeline.json?count=2
&oauth_version=1.0&oauth_token=101...SGI&screen_name=drchuck
&oauth_nonce=09239679&oauth_timestamp=1380395644
&oauth_signature=rLK...BoD&oauth_consumer_key=h7Lu...GNg
&oauth_signature_method=HMAC-SHA1
```

You can read the OAuth specification if you want to know more about the meaning of the various parameters that are added to meet the security requirements of OAuth.

For the programs we run with Twitter, we hide all the complexity in the files *oauth.py* and *twurl.py*. We simply set the secrets in *hidden.py* and then send the desired URL to the *twurl.augment()* function and the library code adds all the necessary parameters to the URL for us.

This program retrieves the timeline for a particular Twitter user and returns it to us in JSON format in a string. We simply print the first 250 characters of the string:

```
import urllib.request, urllib.parse, urllib.error
import twurl
import ssl

# https://apps.twitter.com/
# Create App and get the four strings, put them in hidden.py

TWITTER_URL = 'https://api.twitter.com/1.1/statuses/user_timeline.json'

# Ignore SSL certificate errors
ctx = ssl.create_default_context()
ctx.check_hostname = False
ctx.verify_mode = ssl.CERT_NONE

while True:
    print('')
    acct = input('Enter Twitter Account:')
    if (len(acct) < 1): break
    url = twurl.augment(TWITTER_URL,
                        {'screen_name': acct, 'count': '2'})
    print('Retrieving', url)
    connection = urllib.request.urlopen(url, context=ctx)
    data = connection.read().decode()
    print(data[:250])
    headers = dict(connection.getheaders())
    # print headers
    print('Remaining', headers['x-rate-limit-remaining'])

# Code: http://www.py4e.com/code3/twitter1.py
```

When the program runs it produces the following output:

```
Enter Twitter Account:drchuck
Retrieving https://api.twitter.com/1.1/ ...
[{"created_at":"Sat Sep 28 17:30:25 +0000 2013","
id":384007200990982144,"id_str":"384007200990982144",
"text":"RT @fixpert: See how the Dutch handle traffic
intersections: http:\/\/t.co\/tIiVWtEhj4\n#brilliant",
"source":"web","truncated":false,"in_rep
Remaining 178

Enter Twitter Account:fixpert
```

```
Retrieving https://api.twitter.com/1.1/ ...
[{"created_at":"Sat Sep 28 18:03:56 +0000 2013",
"id":384015634108919808,"id_str":"384015634108919808",
"text":"3 months after my freak bocce ball accident,
my wedding ring fits again! :)\n\nhttps:\/\/t.co\/2XmHPx7kgX",
"source":"web","truncated":false,
Remaining 177

Enter Twitter Account:
```

Along with the returned timeline data, Twitter also returns metadata about the request in the HTTP response headers. One header in particular, `x-rate-limit-remaining`, informs us how many more requests we can make before we will be shut off for a short time period. You can see that our remaining retrievals drop by one each time we make a request to the API.

In the following example, we retrieve a user's Twitter friends, parse the returned JSON, and extract some of the information about the friends. We also dump the JSON after parsing and "pretty-print" it with an indent of four characters to allow us to pore through the data when we want to extract more fields.

```
import urllib.request, urllib.parse, urllib.error
import twurl
import json
import ssl

# https://apps.twitter.com/
# Create App and get the four strings, put them in hidden.py

TWITTER_URL = 'https://api.twitter.com/1.1/friends/list.json'

# Ignore SSL certificate errors
ctx = ssl.create_default_context()
ctx.check_hostname = False
ctx.verify_mode = ssl.CERT_NONE

while True:
    print('')
    acct = input('Enter Twitter Account:')
    if (len(acct) < 1): break
    url = twurl.augment(TWITTER_URL,
                        {'screen_name': acct, 'count': '5'})
    print('Retrieving', url)
    connection = urllib.request.urlopen(url, context=ctx)
    data = connection.read().decode()

    js = json.loads(data)
    print(json.dumps(js, indent=2))

    headers = dict(connection.getheaders())
    print('Remaining', headers['x-rate-limit-remaining'])
```

```
    for u in js['users']:
        print(u['screen_name'])
        if 'status' not in u:
            print('   * No status found')
            continue
        s = u['status']['text']
        print('  ', s[:50])

# Code: http://www.py4e.com/code3/twitter2.py
```

Since the JSON becomes a set of nested Python lists and dictionaries, we can use a combination of the index operation and `for` loops to wander through the returned data structures with very little Python code.

The output of the program looks as follows (some of the data items are shortened to fit on the page):

```
Enter Twitter Account:drchuck
Retrieving https://api.twitter.com/1.1/friends ...
Remaining 14


{
  "next_cursor": 1444171224491980205,
  "users": [
    {
      "id": 662433,
      "followers_count": 28725,
      "status": {
        "text": "@jazzychad I just bought one .__.",
        "created_at": "Fri Sep 20 08:36:34 +0000 2013",
        "retweeted": false,
      },
      "location": "San Francisco, California",
      "screen_name": "leahculver",
      "name": "Leah Culver",
    },
    {
      "id": 40426722,
      "followers_count": 2635,
      "status": {
        "text": "RT @WSJ: Big employers like Google ...",
        "created_at": "Sat Sep 28 19:36:37 +0000 2013",
      },
      "location": "Victoria Canada",
      "screen_name": "_valeriei",
      "name": "Valerie Irvine",
    }
  ],
 "next_cursor_str": "1444171224491980205"
}
```

```
leahculver
   @jazzychad I just bought one .__.
_valeriei
   RT @WSJ: Big employers like Google, AT&amp;amp;T are h
ericbollens
   RT @lukew: sneak peek: my LONG take on the good &a
halherzog
   Learning Objects is 10. We had a cake with the LO,
scweeker
   @DeviceLabDC love it! Now where so I get that "etc

Enter Twitter Account:
```

The last bit of the output is where we see the for loop reading the five most recent "friends" of the *@drchuck* Twitter account and printing the most recent status for each friend. There is a great deal more data available in the returned JSON. If you look in the output of the program, you can also see that the "find the friends" of a particular account has a different rate limitation than the number of timeline queries we are allowed to run per time period.

These secure API keys allow Twitter to have solid confidence that they know who is using their API and data and at what level. The rate-limiting approach allows us to do simple, personal data retrievals but does not allow us to build a product that pulls data from their API millions of times per day.

Chapter 14

Object-oriented programming

14.1 Managing larger programs

At the beginning of this book, we came up with four basic programming patterns which we use to construct programs:

- Sequential code
- Conditional code (if statements)
- Repetitive code (loops)
- Store and reuse (functions)

In later chapters, we explored simple variables as well as collection data structures like lists, tuples, and dictionaries.

As we build programs, we design data structures and write code to manipulate those data structures. There are many ways to write programs and by now, you probably have written some programs that are "not so elegant" and other programs that are "more elegant". Even though your programs may be small, you are starting to see how there is a bit of art and aesthetic to writing code.

As programs get to be millions of lines long, it becomes increasingly important to write code that is easy to understand. If you are working on a million-line program, you can never keep the entire program in your mind at the same time. We need ways to break large programs into multiple smaller pieces so that we have less to look at when solving a problem, fix a bug, or add a new feature.

In a way, object oriented programming is a way to arrange your code so that you can zoom into 50 lines of the code and understand it while ignoring the other 999,950 lines of code for the moment.

14.2 Getting started

Like many aspects of programming, it is necessary to learn the concepts of object oriented programming before you can use them effectively. You should approach this chapter as a way to learn some terms and concepts and work through a few simple examples to lay a foundation for future learning.

The key outcome of this chapter is to have a basic understanding of how objects are constructed and how they function and most importantly how we make use of the capabilities of objects that are provided to us by Python and Python libraries.

14.3 Using objects

As it turns out, we have been using objects all along in this book. Python provides us with many built-in objects. Here is some simple code where the first few lines should feel very simple and natural to you.

```
stuff = list()
stuff.append('python')
stuff.append('chuck')
stuff.sort()
print (stuff[0])
print (stuff.__getitem__(0))
print (list.__getitem__(stuff,0))

# Code: http://www.py4e.com/code3/party1.py
```

Instead of focusing on what these lines accomplish, let's look at what is really happening from the point of view of object-oriented programming. Don't worry if the following paragraphs don't make any sense the first time you read them because we have not yet defined all of these terms.

The first line *constructs* an object of type `list`, the second and third lines *call* the `append()` *method*, the fourth line calls the `sort()` method, and the fifth line *retrieves* the item at position 0.

The sixth line calls the `__getitem__()` method in the `stuff` list with a parameter of zero.

```
print (stuff.__getitem__(0))
```

The seventh line is an even more verbose way of retrieving the 0th item in the list.

```
print (list.__getitem__(stuff,0))
```

In this code, we call the `__getitem__` method in the `list` class and *pass* the list and the item we want retrieved from the list as parameters.

The last three lines of the program are equivalent, but it is more convenient to simply use the square bracket syntax to look up an item at a particular position in a list.

We can take a look at the capabilities of an object by looking at the output of the `dir()` function:

```
>>> stuff = list()
>>> dir(stuff)
['__add__', '__class__', '__contains__', '__delattr__',
'__delitem__', '__dir__', '__doc__', '__eq__',
'__format__', '__ge__', '__getattribute__', '__getitem__',
'__gt__', '__hash__', '__iadd__', '__imul__', '__init__',
'__iter__', '__le__', '__len__', '__lt__', '__mul__',
'__ne__', '__new__', '__reduce__', '__reduce_ex__',
'__repr__', '__reversed__', '__rmul__', '__setattr__',
'__setitem__', '__sizeof__', '__str__', '__subclasshook__',
'append', 'clear', 'copy', 'count', 'extend', 'index',
'insert', 'pop', 'remove', 'reverse', 'sort']
>>>
```

The rest of this chapter will define all of the above terms so make sure to come back after you finish the chapter and re-read the above paragraphs to check your understanding.

14.4 Starting with programs

A program in its most basic form takes some input, does some processing, and produces some output. Our elevator conversion program demonstrates a very short but complete program showing all three of these steps.

```
usf = input('Enter the US Floor Number: ')
wf = int(usf) - 1
print('Non-US Floor Number is',wf)

# Code: http://www.py4e.com/code3/elev.py
```

If we think a bit more about this program, there is the "outside world" and the program. The input and output aspects are where the program interacts with the outside world. Within the program we have code and data to accomplish the task the program is designed to solve.

One way to think about object-oriented programming is that it separates our program into multiple "zones." Each zone contains some code and data (like a program) and has well defined interactions with the outside world and the other zones within the program.

If we look back at the link extraction application where we used the BeautifulSoup library, we can see a program that is constructed by connecting different objects together to accomplish a task:

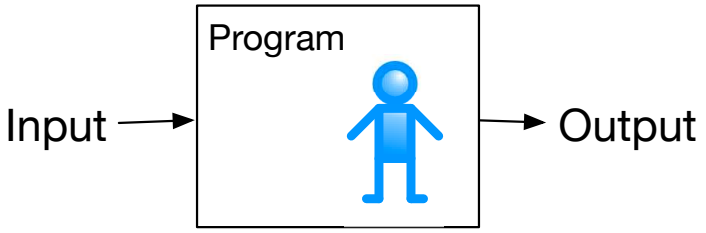

Figure 14.1: A Program

```
# To run this, download the BeautifulSoup zip file
# http://www.py4e.com/code3/bs4.zip
# and unzip it in the same directory as this file

import urllib.request, urllib.parse, urllib.error
from bs4 import BeautifulSoup
import ssl

# Ignore SSL certificate errors
ctx = ssl.create_default_context()
ctx.check_hostname = False
ctx.verify_mode = ssl.CERT_NONE

url = input('Enter - ')
html = urllib.request.urlopen(url, context=ctx).read()
soup = BeautifulSoup(html, 'html.parser')

# Retrieve all of the anchor tags
tags = soup('a')
for tag in tags:
    print(tag.get('href', None))

# Code: http://www.py4e.com/code3/urllinks.py
```

We read the URL into a string and then pass that into `urllib` to retrieve the data from the web. The `urllib` library uses the `socket` library to make the actual network connection to retrieve the data. We take the string that `urllib` returns and hand it to BeautifulSoup for parsing. BeautifulSoup makes use of the object `html.parser`[1] and returns an object. We call the `tags()` method on the returned object that returns a dictionary of tag objects. We loop through the tags and call the `get()` method for each tag to print out the `href` attribute.

We can draw a picture of this program and how the objects work together.

The key here is not to understand perfectly how this program works but to see how we build a network of interacting objects and orchestrate the movement of information between the objects to create a program. It is also important to note that when you looked at that program several chapters back, you could fully understand what was going on in the program without even realizing that the

[1] https://docs.python.org/3/library/html.parser.html

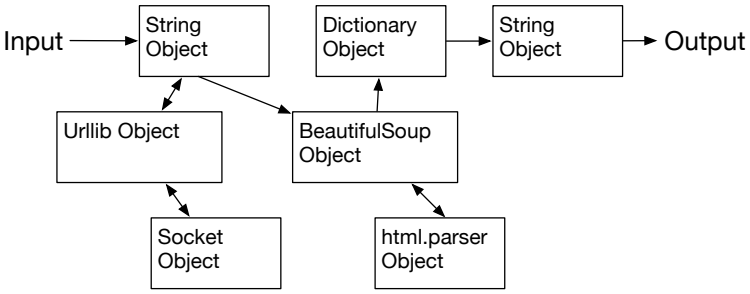

Figure 14.2: A Program as Network of Objects

program was "orchestrating the movement of data between objects." It was just lines of code that got the job done.

14.5 Subdividing a problem

One of the advantages of the object-oriented approach is that it can hide complexity. For example, while we need to know how to use the `urllib` and BeautifulSoup code, we do not need to know how those libraries work internally. This allows us to focus on the part of the problem we need to solve and ignore the other parts of the program.

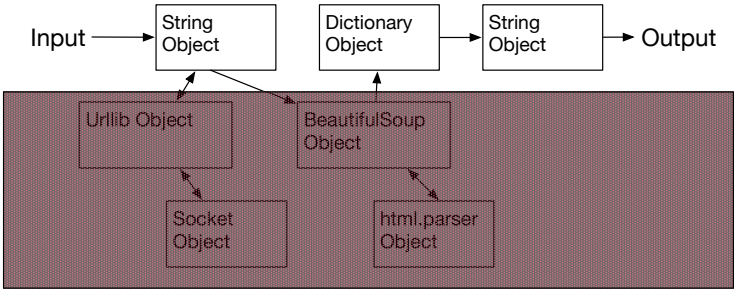

Figure 14.3: Ignoring Detail When Using an Object

This ability to focus exclusively on the part of a program that we care about and ignore the rest is also helpful to the developers of the objects that we use. For example, the programmers developing BeautifulSoup do not need to know or care about how we retrieve our HTML page, what parts we want to read, or what we plan to do with the data we extract from the web page.

14.6 Our first Python object

At a basic level, an object is simply some code plus data structures that are smaller than a whole program. Defining a function allows us to store a bit of code and give it a name and then later invoke that code using the name of the function.

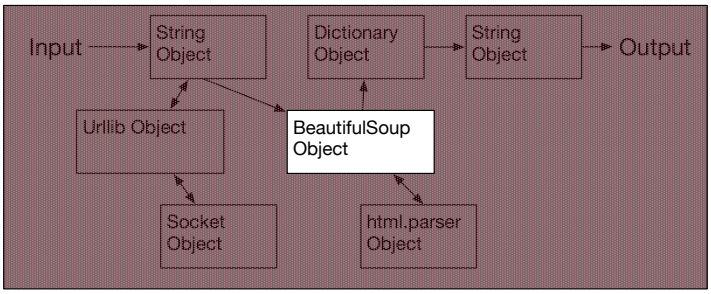

Figure 14.4: Ignoring Detail When Building an Object

An object can contain a number of functions (which we call *methods*) as well as data that is used by those functions. We call data items that are part of the object *attributes*.

We use the `class` keyword to define the data and code that will make up each of the objects. The class keyword includes the name of the class and begins an indented block of code where we include the attributes (data) and methods (code).

```
class PartyAnimal:
   x = 0

   def party(self) :
     self.x = self.x + 1
     print("So far",self.x)

an = PartyAnimal()
an.party()
an.party()
an.party()
PartyAnimal.party(an)

# Code: http://www.py4e.com/code3/party2.py
```

Each method looks like a function, starting with the `def` keyword and consisting of an indented block of code. This object has one attribute (`x`) and one method (`party`). The methods have a special first parameter that we name by convention `self`.

Just as the `def` keyword does not cause function code to be executed, the `class` keyword does not create an object. Instead, the `class` keyword defines a template indicating what data and code will be contained in each object of type `PartyAnimal`. The class is like a cookie cutter and the objects created using the class are the cookies[2]. You don't put frosting on the cookie cutter; you put frosting on the cookies, and you can put different frosting on each cookie.

If we continue through this sample program, we see the first executable line of code:

[2]Cookie image copyright CC-BY https://www.flickr.com/photos/dinnerseries/23570475099

Figure 14.5: A Class and Two Objects

```
an = PartyAnimal()
```

This is where we instruct Python to construct (i.e., create) an *object* or *instance* of the class `PartyAnimal`. It looks like a function call to the class itself. Python constructs the object with the right data and methods and returns the object which is then assigned to the variable `an`. In a way this is quite similar to the following line which we have been using all along:

```
counts = dict()
```

Here we instruct Python to construct an object using the `dict` template (already present in Python), return the instance of dictionary, and assign it to the variable `counts`.

When the `PartyAnimal` class is used to construct an object, the variable `an` is used to point to that object. We use `an` to access the code and data for that particular instance of the `PartyAnimal` class.

Each Partyanimal object/instance contains within it a variable `x` and a method/function named `party`. We call the `party` method in this line:

```
an.party()
```

When the `party` method is called, the first parameter (which we call by convention `self`) points to the particular instance of the PartyAnimal object that `party` is called from. Within the `party` method, we see the line:

```
self.x = self.x + 1
```

This syntax using the *dot* operator is saying 'the x within self.' Each time `party()` is called, the internal `x` value is incremented by 1 and the value is printed out.

The following line is another way to call the `party` method within the `an` object:

```
PartyAnimal.party(an)
```

In this variation, we access the code from within the class and explicitly pass the object pointer `an` as the first parameter (i.e., `self` within the method). You can think of `an.party()` as shorthand for the above line.

When the program executes, it produces the following output:

```
So far 1
So far 2
So far 3
So far 4
```

The object is constructed, and the `party` method is called four times, both incrementing and printing the value for `x` within the `an` object.

14.7 Classes as types

As we have seen, in Python all variables have a type. We can use the built-in `dir` function to examine the capabilities of a variable. We can also use `type` and `dir` with the classes that we create.

```
class PartyAnimal:
   x = 0

   def party(self) :
     self.x = self.x + 1
     print("So far",self.x)

an = PartyAnimal()
print ("Type", type(an))
print ("Dir ", dir(an))
print ("Type", type(an.x))
print ("Type", type(an.party))

# Code: http://www.py4e.com/code3/party3.py
```

When this program executes, it produces the following output:

```
Type <class '__main__.PartyAnimal'>
Dir  ['__class__', '__delattr__', ...
'__sizeof__', '__str__', '__subclasshook__',
'__weakref__', 'party', 'x']
Type <class 'int'>
Type <class 'method'>
```

You can see that using the `class` keyword, we have created a new type. From the `dir` output, you can see both the `x` integer attribute and the `party` method are available in the object.

14.8 Object lifecycle

In the previous examples, we define a class (template), use that class to create an instance of that class (object), and then use the instance. When the program finishes, all of the variables are discarded. Usually, we don't think much about the creation and destruction of variables, but often as our objects become more complex, we need to take some action within the object to set things up as the object is constructed and possibly clean things up as the object is discarded.

If we want our object to be aware of these moments of construction and destruction, we add specially named methods to our object:

```
class PartyAnimal:
   x = 0

   def __init__(self):
     print('I am constructed')

   def party(self) :
     self.x = self.x + 1
     print('So far',self.x)

   def __del__(self):
     print('I am destructed', self.x)

an = PartyAnimal()
an.party()
an.party()
an = 42
print('an contains',an)

# Code: http://www.py4e.com/code3/party4.py
```

When this program executes, it produces the following output:

```
I am constructed
So far 1
So far 2
I am destructed 2
an contains 42
```

As Python constructs our object, it calls our `__init__` method to give us a chance to set up some default or initial values for the object. When Python encounters the line:

```
an = 42
```

It actually "thows our object away" so it can reuse the `an` variable to store the value 42. Just at the moment when our `an` object is being "destroyed" our destructor

code (`__del__`) is called. We cannot stop our variable from being destroyed, but we can do any necessary cleanup right before our object no longer exists.

When developing objects, it is quite common to add a constructor to an object to set up initial values for the object. It is relatively rare to need a destructor for an object.

14.9 Multiple instances

So far, we have defined a class, constructed a single object, used that object, and then thrown the object away. However, the real power in object-oriented programming happens when we construct multiple instances of our class.

When we construct multiple objects from our class, we might want to set up different initial values for each of the objects. We can pass data to the constructors to give each object a different initial value:

```
class PartyAnimal:
   x = 0
   name = ''
   def __init__(self, nam):
     self.name = nam
     print(self.name,'constructed')

   def party(self) :
     self.x = self.x + 1
     print(self.name,'party count',self.x)

s = PartyAnimal('Sally')
j = PartyAnimal('Jim')

s.party()
j.party()
s.party()

# Code: http://www.py4e.com/code3/party5.py
```

The constructor has both a `self` parameter that points to the object instance and additional parameters that are passed into the constructor as the object is constructed:

```
s = PartyAnimal('Sally')
```

Within the constructor, the second line copies the parameter (`nam`) that is passed into the `name` attribute within the object instance.

```
self.name = nam
```

The output of the program shows that each of the objects (`s` and `j`) contain their own independent copies of `x` and `nam`:

```
Sally constructed
Sally party count 1
Jim constructed
Jim party count 1
Sally party count 2
```

14.10 Inheritance

Another powerful feature of object-oriented programming is the ability to create a new class by extending an existing class. When extending a class, we call the original class the *parent class* and the new class the *child class*.

For this example, we move our `PartyAnimal` class into its own file. Then, we can 'import' the `PartyAnimal` class in a new file and extend it, as follows:

```
from party import PartyAnimal

class CricketFan(PartyAnimal):
   points = 0
   def six(self):
      self.points = self.points + 6
      self.party()
      print(self.name,"points",self.points)

s = PartyAnimal("Sally")
s.party()
j = CricketFan("Jim")
j.party()
j.six()
print(dir(j))

# Code: http://www.py4e.com/code3/party6.py
```

When we define the `CricketFan` class, we indicate that we are extending the `PartyAnimal` class. This means that all of the variables (`x`) and methods (`party`) from the `PartyAnimal` class are *inherited* by the `CricketFan` class. For example, within the `six` method in the `CricketFan` class, we call the `party` method from the `PartyAnimal` class.

As the program executes, we create `s` and `j` as independent instances of `PartyAnimal` and `CricketFan`. The `j` object has additional capabilities beyond the `s` object.

```
Sally constructed
Sally party count 1
Jim constructed
Jim party count 1
Jim party count 2
Jim points 6
['__class__', '__delattr__', ... '__weakref__',
'name', 'party', 'points', 'six', 'x']
```

In the `dir` output for the `j` object (instance of the `CricketFan` class), we see that it has the attributes and methods of the parent class, as well as the attributes and methods that were added when the class was extended to create the `CricketFan` class.

14.11 Summary

This is a very quick introduction to object-oriented programming that focuses mainly on terminology and the syntax of defining and using objects. Let's quickly review the code that we looked at in the beginning of the chapter. At this point you should fully understand what is going on.

```
stuff = list()
stuff.append('python')
stuff.append('chuck')
stuff.sort()
print (stuff[0])
print (stuff.__getitem__(0))
print (list.__getitem__(stuff,0))

# Code: http://www.py4e.com/code3/party1.py
```

The first line constructs a `list` *object*. When Python creates the `list` object, it calls the *constructor* method (named `__init__`) to set up the internal data attributes that will be used to store the list data. We have not passed any parameters to the *constructor*. When the constructor returns, we use the variable `stuff` to point to the returned instance of the `list` class.

The second and third lines call the `append` method with one parameter to add a new item at the end of the list by updating the attributes within `stuff`. Then in the fourth line, we call the `sort` method with no parameters to sort the data within the `stuff` object.

We then print out the first item in the list using the square brackets which are a shortcut to calling the `__getitem__` method within the `stuff`. This is equivalent to calling the `__getitem__` method in the `list` *class* and passing the `stuff` object as the first parameter and the position we are looking for as the second parameter.

At the end of the program, the `stuff` object is discarded but not before calling the *destructor* (named `__del__`) so that the object can clean up any loose ends as necessary.

Those are the basics of object-oriented programming. There are many additional details as to how to best use object-oriented approaches when developing large applications and libraries that are beyond the scope of this chapter.[3]

[3] If you are curious about where the `list` class is defined, take a look at (hopefully the URL won't change) https://github.com/python/cpython/blob/master/Objects/listobject.c - the list class is written in a language called "C". If you take a look at that source code and find it curious you might want to explore a few Computer Science courses.

14.12 Glossary

attribute A variable that is part of a class.

class A template that can be used to construct an object. Defines the attributes and methods that will make up the object.

child class A new class created when a parent class is extended. The child class inherits all of the attributes and methods of the parent class.

constructor An optional specially named method (`__init__`) that is called at the moment when a class is being used to construct an object. Usually this is used to set up initial values for the object.

destructor An optional specially named method (`__del__`) that is called at the moment just before an object is destroyed. Destructors are rarely used.

inheritance When we create a new class (child) by extending an existing class (parent). The child class has all the attributes and methods of the parent class plus additional attributes and methods defined by the child class.

method A function that is contained within a class and the objects that are constructed from the class. Some object-oriented patterns use 'message' instead of 'method' to describe this concept.

object A constructed instance of a class. An object contains all of the attributes and methods that were defined by the class. Some object-oriented documentation uses the term 'instance' interchangeably with 'object'.

parent class The class which is being extended to create a new child class. The parent class contributes all of its methods and attributes to the new child class.

Chapter 15

Using Databases and SQL

15.1 What is a database?

A *database* is a file that is organized for storing data. Most databases are organized like a dictionary in the sense that they map from keys to values. The biggest difference is that the database is on disk (or other permanent storage), so it persists after the program ends. Because a database is stored on permanent storage, it can store far more data than a dictionary, which is limited to the size of the memory in the computer.

Like a dictionary, database software is designed to keep the inserting and accessing of data very fast, even for large amounts of data. Database software maintains its performance by building *indexes* as data is added to the database to allow the computer to jump quickly to a particular entry.

There are many different database systems which are used for a wide variety of purposes including: Oracle, MySQL, Microsoft SQL Server, PostgreSQL, and SQLite. We focus on SQLite in this book because it is a very common database and is already built into Python. SQLite is designed to be *embedded* into other applications to provide database support within the application. For example, the Firefox browser also uses the SQLite database internally as do many other products.

http://sqlite.org/

SQLite is well suited to some of the data manipulation problems that we see in Informatics such as the Twitter spidering application that we describe in this chapter.

15.2 Database concepts

When you first look at a database it looks like a spreadsheet with multiple sheets. The primary data structures in a database are: *tables*, *rows*, and *columns*.

In technical descriptions of relational databases the concepts of table, row, and column are more formally referred to as *relation*, *tuple*, and *attribute*, respectively. We will use the less formal terms in this chapter.

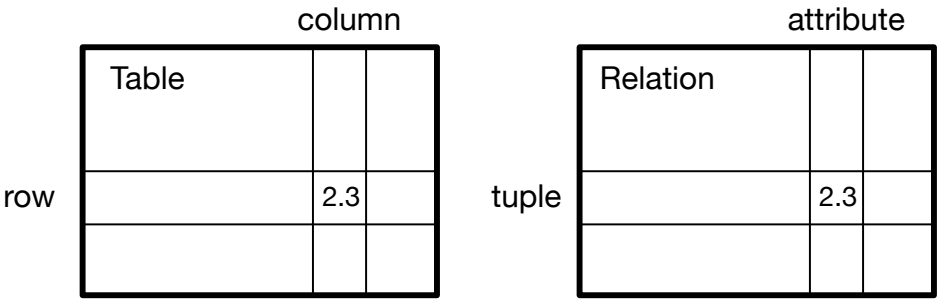

Figure 15.1: Relational Databases

15.3 Database Browser for SQLite

While this chapter will focus on using Python to work with data in SQLite database files, many operations can be done more conveniently using software called the *Database Browser for SQLite* which is freely available from:

http://sqlitebrowser.org/

Using the browser you can easily create tables, insert data, edit data, or run simple SQL queries on the data in the database.

In a sense, the database browser is similar to a text editor when working with text files. When you want to do one or very few operations on a text file, you can just open it in a text editor and make the changes you want. When you have many changes that you need to do to a text file, often you will write a simple Python program. You will find the same pattern when working with databases. You will do simple operations in the database manager and more complex operations will be most conveniently done in Python.

15.4 Creating a database table

Databases require more defined structure than Python lists or dictionaries[1].

When we create a database *table* we must tell the database in advance the names of each of the *columns* in the table and the type of data which we are planning to store in each *column*. When the database software knows the type of data in each column, it can choose the most efficient way to store and look up the data based on the type of data.

You can look at the various data types supported by SQLite at the following url:

http://www.sqlite.org/datatypes.html

Defining structure for your data up front may seem inconvenient at the beginning, but the payoff is fast access to your data even when the database contains a large amount of data.

[1] SQLite actually does allow some flexibility in the type of data stored in a column, but we will keep our data types strict in this chapter so the concepts apply equally to other database systems such as MySQL.

The code to create a database file and a table named `Tracks` with two columns in the database is as follows:

```
import sqlite3

conn = sqlite3.connect('music.sqlite')
cur = conn.cursor()

cur.execute('DROP TABLE IF EXISTS Tracks')
cur.execute('CREATE TABLE Tracks (title TEXT, plays INTEGER)')

conn.close()

# Code: http://www.py4e.com/code3/db1.py
```

The `connect` operation makes a "connection" to the database stored in the file `music.sqlite` in the current directory. If the file does not exist, it will be created. The reason this is called a "connection" is that sometimes the database is stored on a separate "database server" from the server on which we are running our application. In our simple examples the database will just be a local file in the same directory as the Python code we are running.

A *cursor* is like a file handle that we can use to perform operations on the data stored in the database. Calling `cursor()` is very similar conceptually to calling `open()` when dealing with text files.

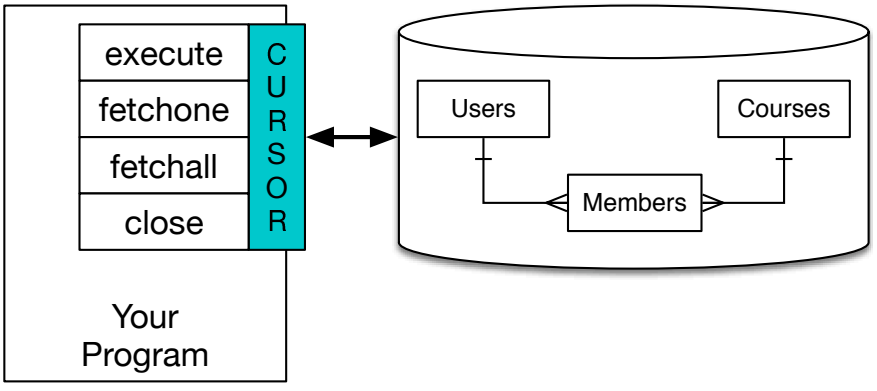

Figure 15.2: A Database Cursor

Once we have the cursor, we can begin to execute commands on the contents of the database using the `execute()` method.

Database commands are expressed in a special language that has been standardized across many different database vendors to allow us to learn a single database language. The database language is called *Structured Query Language* or *SQL* for short.

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

In our example, we are executing two SQL commands in our database. As a convention, we will show the SQL keywords in uppercase and the parts of the

command that we are adding (such as the table and column names) will be shown in lowercase.

The first SQL command removes the `Tracks` table from the database if it exists. This pattern is simply to allow us to run the same program to create the `Tracks` table over and over again without causing an error. Note that the `DROP TABLE` command deletes the table and all of its contents from the database (i.e., there is no "undo").

```
cur.execute('DROP TABLE IF EXISTS Tracks ')
```

The second command creates a table named `Tracks` with a text column named `title` and an integer column named `plays`.

```
cur.execute('CREATE TABLE Tracks (title TEXT, plays INTEGER)')
```

Now that we have created a table named `Tracks`, we can put some data into that table using the SQL `INSERT` operation. Again, we begin by making a connection to the database and obtaining the `cursor`. We can then execute SQL commands using the cursor.

The SQL `INSERT` command indicates which table we are using and then defines a new row by listing the fields we want to include `(title, plays)` followed by the `VALUES` we want placed in the new row. We specify the values as question marks `(?, ?)` to indicate that the actual values are passed in as a tuple `( 'My Way', 15 )` as the second parameter to the `execute()` call.

```
import sqlite3

conn = sqlite3.connect('music.sqlite')
cur = conn.cursor()

cur.execute('INSERT INTO Tracks (title, plays) VALUES (?, ?)',
    ('Thunderstruck', 20))
cur.execute('INSERT INTO Tracks (title, plays) VALUES (?, ?)',
    ('My Way', 15))
conn.commit()

print('Tracks:')
cur.execute('SELECT title, plays FROM Tracks')
for row in cur:
     print(row)

cur.execute('DELETE FROM Tracks WHERE plays < 100')
conn.commit()

cur.close()

# Code: http://www.py4e.com/code3/db2.py
```

Tracks

title	plays
Thunderstruck	20
My Way	15

Figure 15.3: Rows in a Table

First we `INSERT` two rows into our table and use `commit()` to force the data to be written to the database file.

Then we use the `SELECT` command to retrieve the rows we just inserted from the table. On the `SELECT` command, we indicate which columns we would like `(title, plays)` and indicate which table we want to retrieve the data from. After we execute the `SELECT` statement, the cursor is something we can loop through in a `for` statement. For efficiency, the cursor does not read all of the data from the database when we execute the `SELECT` statement. Instead, the data is read on demand as we loop through the rows in the `for` statement.

The output of the program is as follows:

```
Tracks:
('Thunderstruck', 20)
('My Way', 15)
```

Our `for` loop finds two rows, and each row is a Python tuple with the first value as the `title` and the second value as the number of `plays`.

Note: You may see strings starting with `u'` *in other books or on the Internet. This was an indication in Python 2 that the strings are* Unicode* strings that are capable of storing non-Latin character sets. In Python 3, all strings are unicode strings by default.*

At the very end of the program, we execute an SQL command to `DELETE` the rows we have just created so we can run the program over and over. The `DELETE` command shows the use of a `WHERE` clause that allows us to express a selection criterion so that we can ask the database to apply the command to only the rows that match the criterion. In this example the criterion happens to apply to all the rows so we empty the table out so we can run the program repeatedly. After the `DELETE` is performed, we also call `commit()` to force the data to be removed from the database.

15.5 Structured Query Language summary

So far, we have been using the Structured Query Language in our Python examples and have covered many of the basics of the SQL commands. In this section, we look at the SQL language in particular and give an overview of SQL syntax.

Since there are so many different database vendors, the Structured Query Language (SQL) was standardized so we could communicate in a portable manner to database systems from multiple vendors.

A relational database is made up of tables, rows, and columns. The columns generally have a type such as text, numeric, or date data. When we create a table, we indicate the names and types of the columns:

```
CREATE TABLE Tracks (title TEXT, plays INTEGER)
```

To insert a row into a table, we use the SQL `INSERT` command:

```
INSERT INTO Tracks (title, plays) VALUES ('My Way', 15)
```

The `INSERT` statement specifies the table name, then a list of the fields/columns that you would like to set in the new row, and then the keyword `VALUES` and a list of corresponding values for each of the fields.

The SQL `SELECT` command is used to retrieve rows and columns from a database. The `SELECT` statement lets you specify which columns you would like to retrieve as well as a `WHERE` clause to select which rows you would like to see. It also allows an optional `ORDER BY` clause to control the sorting of the returned rows.

```
SELECT * FROM Tracks WHERE title = 'My Way'
```

Using `*` indicates that you want the database to return all of the columns for each row that matches the `WHERE` clause.

Note, unlike in Python, in a SQL `WHERE` clause we use a single equal sign to indicate a test for equality rather than a double equal sign. Other logical operations allowed in a `WHERE` clause include `<`, `>`, `<=`, `>=`, `!=`, as well as `AND` and `OR` and parentheses to build your logical expressions.

You can request that the returned rows be sorted by one of the fields as follows:

```
SELECT title,plays FROM Tracks ORDER BY title
```

To remove a row, you need a `WHERE` clause on an SQL `DELETE` statement. The `WHERE` clause determines which rows are to be deleted:

```
DELETE FROM Tracks WHERE title = 'My Way'
```

It is possible to `UPDATE` a column or columns within one or more rows in a table using the SQL `UPDATE` statement as follows:

```
UPDATE Tracks SET plays = 16 WHERE title = 'My Way'
```

The `UPDATE` statement specifies a table and then a list of fields and values to change after the `SET` keyword and then an optional `WHERE` clause to select the rows that are to be updated. A single `UPDATE` statement will change all of the rows that match the `WHERE` clause. If a `WHERE` clause is not specified, it performs the `UPDATE` on all of the rows in the table.

These four basic SQL commands (INSERT, SELECT, UPDATE, and DELETE) allow the four basic operations needed to create and maintain data.

15.6 Spidering Twitter using a database

In this section, we will create a simple spidering program that will go through Twitter accounts and build a database of them. *Note: Be very careful when running this program. You do not want to pull too much data or run the program for too long and end up having your Twitter access shut off.*

One of the problems of any kind of spidering program is that it needs to be able to be stopped and restarted many times and you do not want to lose the data that you have retrieved so far. You don't want to always restart your data retrieval at the very beginning so we want to store data as we retrieve it so our program can start back up and pick up where it left off.

We will start by retrieving one person's Twitter friends and their statuses, looping through the list of friends, and adding each of the friends to a database to be retrieved in the future. After we process one person's Twitter friends, we check in our database and retrieve one of the friends of the friend. We do this over and over, picking an "unvisited" person, retrieving their friend list, and adding friends we have not seen to our list for a future visit.

We also track how many times we have seen a particular friend in the database to get some sense of their "popularity".

By storing our list of known accounts and whether we have retrieved the account or not, and how popular the account is in a database on the disk of the computer, we can stop and restart our program as many times as we like.

This program is a bit complex. It is based on the code from the exercise earlier in the book that uses the Twitter API.

Here is the source code for our Twitter spidering application:

```
from urllib.request import urlopen
import urllib.error
import twurl
import json
import sqlite3
import ssl

TWITTER_URL = 'https://api.twitter.com/1.1/friends/list.json'

conn = sqlite3.connect('spider.sqlite')
cur = conn.cursor()

cur.execute('''
            CREATE TABLE IF NOT EXISTS Twitter
            (name TEXT, retrieved INTEGER, friends INTEGER)''')

# Ignore SSL certificate errors
ctx = ssl.create_default_context()
ctx.check_hostname = False
ctx.verify_mode = ssl.CERT_NONE
```

```
while True:
    acct = input('Enter a Twitter account, or quit: ')
    if (acct == 'quit'): break
    if (len(acct) < 1):
        cur.execute('SELECT name FROM Twitter WHERE retrieved = 0 LIMIT 1')
        try:
            acct = cur.fetchone()[0]
        except:
            print('No unretrieved Twitter accounts found')
            continue

    url = twurl.augment(TWITTER_URL, {'screen_name': acct, 'count': '5'})
    print('Retrieving', url)
    connection = urlopen(url, context=ctx)
    data = connection.read().decode()
    headers = dict(connection.getheaders())

    print('Remaining', headers['x-rate-limit-remaining'])
    js = json.loads(data)
    # Debugging
    # print json.dumps(js, indent=4)

    cur.execute('UPDATE Twitter SET retrieved=1 WHERE name = ?', (acct, ))

    countnew = 0
    countold = 0
    for u in js['users']:
        friend = u['screen_name']
        print(friend)
        cur.execute('SELECT friends FROM Twitter WHERE name = ? LIMIT 1',
                    (friend, ))
        try:
            count = cur.fetchone()[0]
            cur.execute('UPDATE Twitter SET friends = ? WHERE name = ?',
                        (count+1, friend))
            countold = countold + 1
        except:
            cur.execute('''INSERT INTO Twitter (name, retrieved, friends)
                        VALUES (?, 0, 1)''', (friend, ))
            countnew = countnew + 1
    print('New accounts=', countnew, ' revisited=', countold)
    conn.commit()

cur.close()

# Code: http://www.py4e.com/code3/twspider.py
```

Our database is stored in the file `spider.sqlite` and it has one table named `Twitter`. Each row in the `Twitter` table has a column for the account name, whether we have retrieved the friends of this account, and how many times this account has been "friended".

In the main loop of the program, we prompt the user for a Twitter account name or "quit" to exit the program. If the user enters a Twitter account, we retrieve the list of friends and statuses for that user and add each friend to the database if not already in the database. If the friend is already in the list, we add 1 to the `friends` field in the row in the database.

If the user presses enter, we look in the database for the next Twitter account that we have not yet retrieved, retrieve the friends and statuses for that account, add them to the database or update them, and increase their `friends` count.

Once we retrieve the list of friends and statuses, we loop through all of the `user` items in the returned JSON and retrieve the `screen_name` for each user. Then we use the `SELECT` statement to see if we already have stored this particular `screen_name` in the database and retrieve the friend count (`friends`) if the record exists.

```
countnew = 0
countold = 0
for u in js['users'] :
    friend = u['screen_name']
    print(friend)
    cur.execute('SELECT friends FROM Twitter WHERE name = ? LIMIT 1',
        (friend, ) )
    try:
        count = cur.fetchone()[0]
        cur.execute('UPDATE Twitter SET friends = ? WHERE name = ?',
            (count+1, friend) )
        countold = countold + 1
    except:
        cur.execute('''INSERT INTO Twitter (name, retrieved, friends)
            VALUES ( ?, 0, 1 )''', ( friend, ) )
        countnew = countnew + 1
print('New accounts=',countnew,' revisited=',countold)
conn.commit()
```

Once the cursor executes the `SELECT` statement, we must retrieve the rows. We could do this with a `for` statement, but since we are only retrieving one row (`LIMIT 1`), we can use the `fetchone()` method to fetch the first (and only) row that is the result of the `SELECT` operation. Since `fetchone()` returns the row as a *tuple* (even though there is only one field), we take the first value from the tuple using to get the current friend count into the variable `count`.

If this retrieval is successful, we use the SQL `UPDATE` statement with a `WHERE` clause to add 1 to the `friends` column for the row that matches the friend's account. Notice that there are two placeholders (i.e., question marks) in the SQL, and the second parameter to the `execute()` is a two-element tuple that holds the values to be substituted into the SQL in place of the question marks.

If the code in the `try` block fails, it is probably because no record matched the `WHERE name = ?` clause on the SELECT statement. So in the `except` block, we use the SQL `INSERT` statement to add the friend's `screen_name` to the table with an indication that we have not yet retrieved the `screen_name` and set the friend count to zero.

So the first time the program runs and we enter a Twitter account, the program runs as follows:

```
Enter a Twitter account, or quit: drchuck
Retrieving http://api.twitter.com/1.1/friends ...
New accounts= 20  revisited= 0
Enter a Twitter account, or quit: quit
```

Since this is the first time we have run the program, the database is empty and we create the database in the file `spider.sqlite` and add a table named `Twitter` to the database. Then we retrieve some friends and add them all to the database since the database is empty.

At this point, we might want to write a simple database dumper to take a look at what is in our `spider.sqlite` file:

```
import sqlite3

conn = sqlite3.connect('spider.sqlite')
cur = conn.cursor()
cur.execute('SELECT * FROM Twitter')
count = 0
for row in cur:
    print(row)
    count = count + 1
print(count, 'rows.')
cur.close()

# Code: http://www.py4e.com/code3/twdump.py
```

This program simply opens the database and selects all of the columns of all of the rows in the table `Twitter`, then loops through the rows and prints out each row.

If we run this program after the first execution of our Twitter spider above, its output will be as follows:

```
('opencontent', 0, 1)
('lhawthorn', 0, 1)
('steve_coppin', 0, 1)
('davidkocher', 0, 1)
('hrheingold', 0, 1)
...
20 rows.
```

We see one row for each `screen_name`, that we have not retrieved the data for that `screen_name`, and everyone in the database has one friend.

Now our database reflects the retrieval of the friends of our first Twitter account (*drchuck*). We can run the program again and tell it to retrieve the friends of the next "unprocessed" account by simply pressing enter instead of a Twitter account as follows:

```
Enter a Twitter account, or quit:
Retrieving http://api.twitter.com/1.1/friends ...
New accounts= 18  revisited= 2
Enter a Twitter account, or quit:
Retrieving http://api.twitter.com/1.1/friends ...
New accounts= 17  revisited= 3
Enter a Twitter account, or quit: quit
```

Since we pressed enter (i.e., we did not specify a Twitter account), the following code is executed:

```
if ( len(acct) < 1 ) :
    cur.execute('SELECT name FROM Twitter WHERE retrieved = 0 LIMIT 1')
    try:
        acct = cur.fetchone()[0]
    except:
        print('No unretrieved twitter accounts found')
        continue
```

We use the SQL `SELECT` statement to retrieve the name of the first (`LIMIT 1`) user who still has their "have we retrieved this user" value set to zero. We also use the `fetchone()[0]` pattern within a try/except block to either extract a `screen_name` from the retrieved data or put out an error message and loop back up.

If we successfully retrieved an unprocessed `screen_name`, we retrieve their data as follows:

```
url=twurl.augment(TWITTER_URL,{'screen_name': acct,'count': '20'})
print('Retrieving', url)
connection = urllib.urlopen(url)
data = connection.read()
js = json.loads(data)

cur.execute('UPDATE Twitter SET retrieved=1 WHERE name = ?',(acct, ))
```

Once we retrieve the data successfully, we use the `UPDATE` statement to set the `retrieved` column to 1 to indicate that we have completed the retrieval of the friends of this account. This keeps us from retrieving the same data over and over and keeps us progressing forward through the network of Twitter friends.

If we run the friend program and press enter twice to retrieve the next unvisited friend's friends, then run the dumping program, it will give us the following output:

```
('opencontent', 1, 1)
('lhawthorn', 1, 1)
('steve_coppin', 0, 1)
('davidkocher', 0, 1)
('hrheingold', 0, 1)
...
('cnxorg', 0, 2)
('knoop', 0, 1)
```

```
('kthanos', 0, 2)
('LectureTools', 0, 1)
...
55 rows.
```

We can see that we have properly recorded that we have visited `lhawthorn` and `opencontent`. Also the accounts `cnxorg` and `kthanos` already have two followers. Since we now have retrieved the friends of three people (`drchuck`, `opencontent`, and `lhawthorn`) our table has 55 rows of friends to retrieve.

Each time we run the program and press enter it will pick the next unvisited account (e.g., the next account will be `steve_coppin`), retrieve their friends, mark them as retrieved, and for each of the friends of `steve_coppin` either add them to the end of the database or update their friend count if they are already in the database.

Since the program's data is all stored on disk in a database, the spidering activity can be suspended and resumed as many times as you like with no loss of data.

15.7 Basic data modeling

The real power of a relational database is when we create multiple tables and make links between those tables. The act of deciding how to break up your application data into multiple tables and establishing the relationships between the tables is called *data modeling*. The design document that shows the tables and their relationships is called a *data model*.

Data modeling is a relatively sophisticated skill and we will only introduce the most basic concepts of relational data modeling in this section. For more detail on data modeling you can start with:

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

Let's say for our Twitter spider application, instead of just counting a person's friends, we wanted to keep a list of all of the incoming relationships so we could find a list of everyone who is following a particular account.

Since everyone will potentially have many accounts that follow them, we cannot simply add a single column to our `Twitter` table. So we create a new table that keeps track of pairs of friends. The following is a simple way of making such a table:

```
CREATE TABLE Pals (from_friend TEXT, to_friend TEXT)
```

Each time we encounter a person who `drchuck` is following, we would insert a row of the form:

```
INSERT INTO Pals (from_friend,to_friend) VALUES ('drchuck', 'lhawthorn')
```

As we are processing the 20 friends from the `drchuck` Twitter feed, we will insert 20 records with "drchuck" as the first parameter so we will end up duplicating the string many times in the database.

This duplication of string data violates one of the best practices for *database normalization* which basically states that we should never put the same string data in the database more than once. If we need the data more than once, we create a numeric *key* for the data and reference the actual data using this key.

In practical terms, a string takes up a lot more space than an integer on the disk and in the memory of our computer, and takes more processor time to compare and sort. If we only have a few hundred entries, the storage and processor time hardly matters. But if we have a million people in our database and a possibility of 100 million friend links, it is important to be able to scan data as quickly as possible.

We will store our Twitter accounts in a table named `People` instead of the `Twitter` table used in the previous example. The `People` table has an additional column to store the numeric key associated with the row for this Twitter user. SQLite has a feature that automatically adds the key value for any row we insert into a table using a special type of data column (`INTEGER PRIMARY KEY`).

We can create the `People` table with this additional `id` column as follows:

```
CREATE TABLE People
    (id INTEGER PRIMARY KEY, name TEXT UNIQUE, retrieved INTEGER)
```

Notice that we are no longer maintaining a friend count in each row of the `People` table. When we select `INTEGER PRIMARY KEY` as the type of our `id` column, we are indicating that we would like SQLite to manage this column and assign a unique numeric key to each row we insert automatically. We also add the keyword `UNIQUE` to indicate that we will not allow SQLite to insert two rows with the same value for `name`.

Now instead of creating the table `Pals` above, we create a table called `Follows` with two integer columns `from_id` and `to_id` and a constraint on the table that the *combination* of `from_id` and `to_id` must be unique in this table (i.e., we cannot insert duplicate rows) in our database.

```
CREATE TABLE Follows
    (from_id INTEGER, to_id INTEGER, UNIQUE(from_id, to_id) )
```

When we add `UNIQUE` clauses to our tables, we are communicating a set of rules that we are asking the database to enforce when we attempt to insert records. We are creating these rules as a convenience in our programs, as we will see in a moment. The rules both keep us from making mistakes and make it simpler to write some of our code.

In essence, in creating this `Follows` table, we are modelling a "relationship" where one person "follows" someone else and representing it with a pair of numbers indicating that (a) the people are connected and (b) the direction of the relationship.

15.8 Programming with multiple tables

We will now redo the Twitter spider program using two tables, the primary keys, and the key references as described above. Here is the code for the new version of the program:

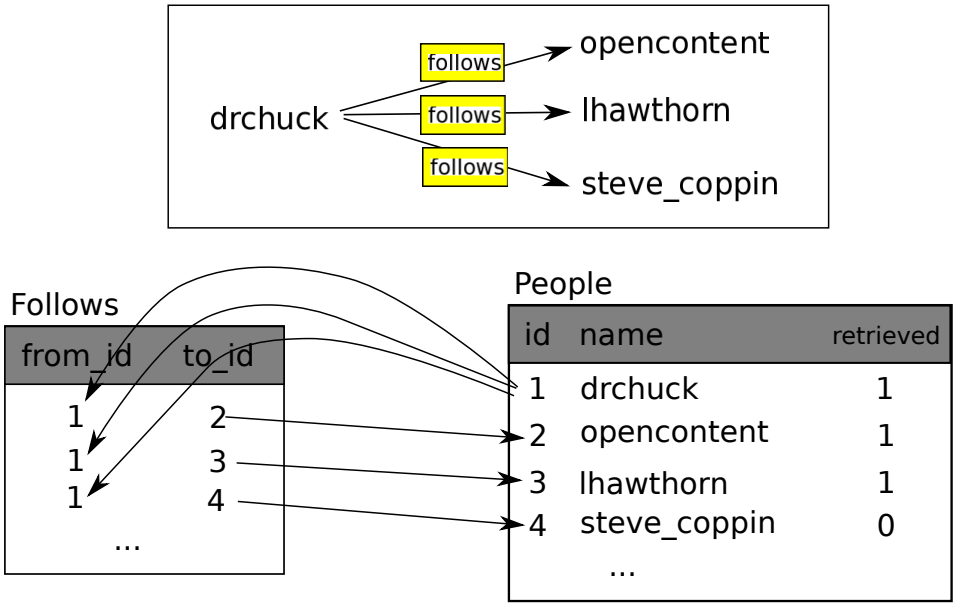

Figure 15.4: Relationships Between Tables

```
import urllib.request, urllib.parse, urllib.error
import twurl
import json
import sqlite3
import ssl

TWITTER_URL = 'https://api.twitter.com/1.1/friends/list.json'

conn = sqlite3.connect('friends.sqlite')
cur = conn.cursor()

cur.execute('''CREATE TABLE IF NOT EXISTS People
            (id INTEGER PRIMARY KEY, name TEXT UNIQUE, retrieved INTEGER)''')
cur.execute('''CREATE TABLE IF NOT EXISTS Follows
            (from_id INTEGER, to_id INTEGER, UNIQUE(from_id, to_id))''')

# Ignore SSL certificate errors
ctx = ssl.create_default_context()
ctx.check_hostname = False
ctx.verify_mode = ssl.CERT_NONE

while True:
    acct = input('Enter a Twitter account, or quit: ')
    if (acct == 'quit'): break
    if (len(acct) < 1):
        cur.execute('SELECT id, name FROM People WHERE retrieved=0 LIMIT 1')
        try:
            (id, acct) = cur.fetchone()
```

```
        except:
            print('No unretrieved Twitter accounts found')
            continue
    else:
        cur.execute('SELECT id FROM People WHERE name = ? LIMIT 1',
                    (acct, ))
        try:
            id = cur.fetchone()[0]
        except:
            cur.execute('''INSERT OR IGNORE INTO People
                        (name, retrieved) VALUES (?, 0)''', (acct, ))
            conn.commit()
            if cur.rowcount != 1:
                print('Error inserting account:', acct)
                continue
            id = cur.lastrowid

    url = twurl.augment(TWITTER_URL, {'screen_name': acct, 'count': '100'})
    print('Retrieving account', acct)
    try:
        connection = urllib.request.urlopen(url, context=ctx)
    except Exception as err:
        print('Failed to Retrieve', err)
        break

    data = connection.read().decode()
    headers = dict(connection.getheaders())

    print('Remaining', headers['x-rate-limit-remaining'])

    try:
        js = json.loads(data)
    except:
        print('Unable to parse json')
        print(data)
        break

    # Debugging
    # print(json.dumps(js, indent=4))

    if 'users' not in js:
        print('Incorrect JSON received')
        print(json.dumps(js, indent=4))
        continue

    cur.execute('UPDATE People SET retrieved=1 WHERE name = ?', (acct, ))

    countnew = 0
    countold = 0
    for u in js['users']:
        friend = u['screen_name']
```

```
        print(friend)
        cur.execute('SELECT id FROM People WHERE name = ? LIMIT 1',
                    (friend, ))
        try:
            friend_id = cur.fetchone()[0]
            countold = countold + 1
        except:
            cur.execute('''INSERT OR IGNORE INTO People (name, retrieved)
                        VALUES (?, 0)''', (friend, ))
            conn.commit()
            if cur.rowcount != 1:
                print('Error inserting account:', friend)
                continue
            friend_id = cur.lastrowid
            countnew = countnew + 1
        cur.execute('''INSERT OR IGNORE INTO Follows (from_id, to_id)
                    VALUES (?, ?)''', (id, friend_id))
    print('New accounts=', countnew, ' revisited=', countold)
    print('Remaining', headers['x-rate-limit-remaining'])
    conn.commit()
cur.close()

# Code: http://www.py4e.com/code3/twfriends.py
```

This program is starting to get a bit complicated, but it illustrates the patterns that we need to use when we are using integer keys to link tables. The basic patterns are:

1. Create tables with primary keys and constraints.
2. When we have a logical key for a person (i.e., account name) and we need the `id` value for the person, depending on whether or not the person is already in the `People` table we either need to: (1) look up the person in the `People` table and retrieve the `id` value for the person or (2) add the person to the `People` table and get the `id` value for the newly added row.
3. Insert the row that captures the "follows" relationship.

We will cover each of these in turn.

15.8.1 Constraints in database tables

As we design our table structures, we can tell the database system that we would like it to enforce a few rules on us. These rules help us from making mistakes and introducing incorrect data into out tables. When we create our tables:

```
cur.execute('''CREATE TABLE IF NOT EXISTS People
    (id INTEGER PRIMARY KEY, name TEXT UNIQUE, retrieved INTEGER)''')
cur.execute('''CREATE TABLE IF NOT EXISTS Follows
    (from_id INTEGER, to_id INTEGER, UNIQUE(from_id, to_id))''')
```

We indicate that the `name` column in the `People` table must be `UNIQUE`. We also indicate that the combination of the two numbers in each row of the `Follows` table must be unique. These constraints keep us from making mistakes such as adding the same relationship more than once.

We can take advantage of these constraints in the following code:

```
cur.execute('''INSERT OR IGNORE INTO People (name, retrieved)
    VALUES ( ?, 0)''', ( friend, ) )
```

We add the `OR IGNORE` clause to our `INSERT` statement to indicate that if this particular `INSERT` would cause a violation of the "`name` must be unique" rule, the database system is allowed to ignore the `INSERT`. We are using the database constraint as a safety net to make sure we don't inadvertently do something incorrect.

Similarly, the following code ensures that we don't add the exact same `Follows` relationship twice.

```
cur.execute('''INSERT OR IGNORE INTO Follows
    (from_id, to_id) VALUES (?, ?)''', (id, friend_id) )
```

Again, we simply tell the database to ignore our attempted `INSERT` if it would violate the uniqueness constraint that we specified for the `Follows` rows.

15.8.2 Retrieve and/or insert a record

When we prompt the user for a Twitter account, if the account exists, we must look up its `id` value. If the account does not yet exist in the `People` table, we must insert the record and get the `id` value from the inserted row.

This is a very common pattern and is done twice in the program above. This code shows how we look up the `id` for a friend's account when we have extracted a `screen_name` from a `user` node in the retrieved Twitter JSON.

Since over time it will be increasingly likely that the account will already be in the database, we first check to see if the `People` record exists using a `SELECT` statement.

If all goes well[2] inside the `try` section, we retrieve the record using `fetchone()` and then retrieve the first (and only) element of the returned tuple and store it in `friend_id`.

If the `SELECT` fails, the `fetchone()[0]` code will fail and control will transfer into the `except` section.

```
    friend = u['screen_name']
    cur.execute('SELECT id FROM People WHERE name = ? LIMIT 1',
        (friend, ) )
    try:
```

[2] In general, when a sentence starts with "if all goes well" you will find that the code needs to use try/except.

```
        friend_id = cur.fetchone()[0]
        countold = countold + 1
    except:
        cur.execute('''INSERT OR IGNORE INTO People (name, retrieved)
            VALUES ( ?, 0)''', ( friend, ) )
        conn.commit()
        if cur.rowcount != 1 :
            print('Error inserting account:',friend)
            continue
        friend_id = cur.lastrowid
        countnew = countnew + 1
```

If we end up in the `except` code, it simply means that the row was not found, so we must insert the row. We use `INSERT OR IGNORE` just to avoid errors and then call `commit()` to force the database to really be updated. After the write is done, we can check the `cur.rowcount` to see how many rows were affected. Since we are attempting to insert a single row, if the number of affected rows is something other than 1, it is an error.

If the `INSERT` is successful, we can look at `cur.lastrowid` to find out what value the database assigned to the `id` column in our newly created row.

15.8.3 Storing the friend relationship

Once we know the key value for both the Twitter user and the friend in the JSON, it is a simple matter to insert the two numbers into the `Follows` table with the following code:

```
cur.execute('INSERT OR IGNORE INTO Follows (from_id, to_id) VALUES (?, ?)',
    (id, friend_id) )
```

Notice that we let the database take care of keeping us from "double-inserting" a relationship by creating the table with a uniqueness constraint and then adding `OR IGNORE` to our `INSERT` statement.

Here is a sample execution of this program:

```
Enter a Twitter account, or quit:
No unretrieved Twitter accounts found
Enter a Twitter account, or quit: drchuck
Retrieving http://api.twitter.com/1.1/friends ...
New accounts= 20  revisited= 0
Enter a Twitter account, or quit:
Retrieving http://api.twitter.com/1.1/friends ...
New accounts= 17  revisited= 3
Enter a Twitter account, or quit:
Retrieving http://api.twitter.com/1.1/friends ...
New accounts= 17  revisited= 3
Enter a Twitter account, or quit: quit
```

We started with the drchuck account and then let the program automatically pick the next two accounts to retrieve and add to our database.

The following is the first few rows in the People and Follows tables after this run is completed:

```
People:
(1, 'drchuck', 1)
(2, 'opencontent', 1)
(3, 'lhawthorn', 1)
(4, 'steve_coppin', 0)
(5, 'davidkocher', 0)
55 rows.
Follows:
(1, 2)
(1, 3)
(1, 4)
(1, 5)
(1, 6)
60 rows.
```

You can see the id, name, and visited fields in the People table and you see the numbers of both ends of the relationship in the Follows table. In the People table, we can see that the first three people have been visited and their data has been retrieved. The data in the Follows table indicates that drchuck (user 1) is a friend to all of the people shown in the first five rows. This makes sense because the first data we retrieved and stored was the Twitter friends of drchuck. If you were to print more rows from the Follows table, you would see the friends of users 2 and 3 as well.

15.9 Three kinds of keys

Now that we have started building a data model putting our data into multiple linked tables and linking the rows in those tables using *keys*, we need to look at some terminology around keys. There are generally three kinds of keys used in a database model.

- A *logical key* is a key that the "real world" might use to look up a row. In our example data model, the name field is a logical key. It is the screen name for the user and we indeed look up a user's row several times in the program using the name field. You will often find that it makes sense to add a UNIQUE constraint to a logical key. Since the logical key is how we look up a row from the outside world, it makes little sense to allow multiple rows with the same value in the table.
- A *primary key* is usually a number that is assigned automatically by the database. It generally has no meaning outside the program and is only used to link rows from different tables together. When we want to look up a row in a table, usually searching for the row using the primary key is the fastest way to find the row. Since primary keys are integer numbers, they take up very little storage and can be compared or sorted very quickly. In our data model, the id field is an example of a primary key.

- A *foreign key* is usually a number that points to the primary key of an associated row in a different table. An example of a foreign key in our data model is the `from_id`.

We are using a naming convention of always calling the primary key field name `id` and appending the suffix `_id` to any field name that is a foreign key.

15.10 Using JOIN to retrieve data

Now that we have followed the rules of database normalization and have data separated into two tables, linked together using primary and foreign keys, we need to be able to build a `SELECT` that reassembles the data across the tables.

SQL uses the `JOIN` clause to reconnect these tables. In the `JOIN` clause you specify the fields that are used to reconnect the rows between the tables.

The following is an example of a `SELECT` with a `JOIN` clause:

```
SELECT * FROM Follows JOIN People
    ON Follows.from_id = People.id WHERE People.id = 1
```

The `JOIN` clause indicates that the fields we are selecting cross both the `Follows` and `People` tables. The `ON` clause indicates how the two tables are to be joined: Take the rows from `Follows` and append the row from `People` where the field `from_id` in `Follows` is the same the `id` value in the `People` table.

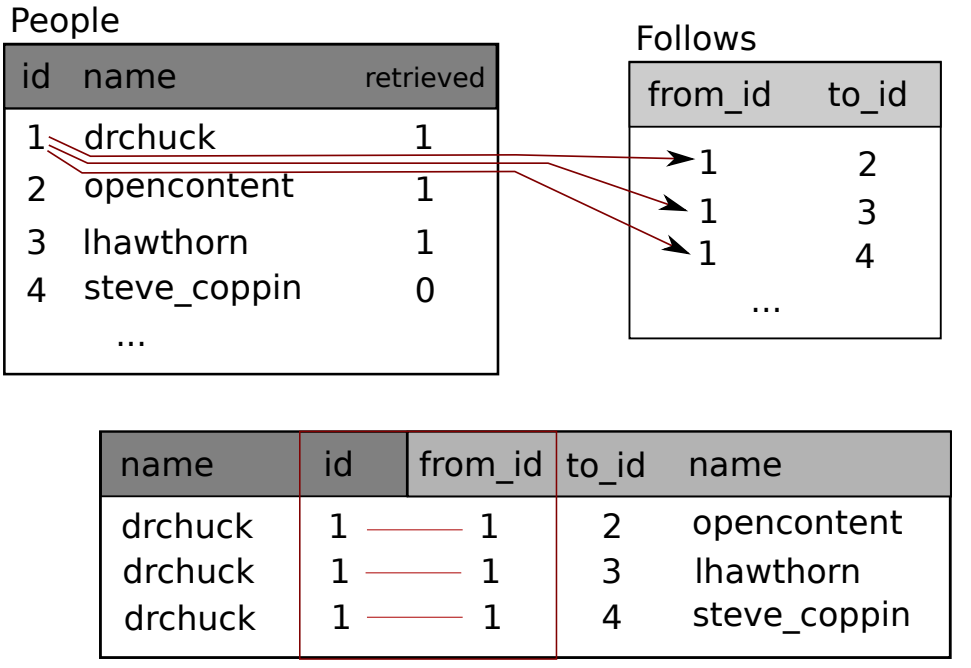

Figure 15.5: Connecting Tables Using JOIN

The result of the JOIN is to create extra-long "metarows" which have both the fields from `People` and the matching fields from `Follows`. Where there is more than one match between the `id` field from `People` and the `from_id` from `People`, then JOIN creates a metarow for *each* of the matching pairs of rows, duplicating data as needed.

The following code demonstrates the data that we will have in the database after the multi-table Twitter spider program (above) has been run several times.

```
import sqlite3

conn = sqlite3.connect('friends.sqlite')
cur = conn.cursor()

cur.execute('SELECT * FROM People')
count = 0
print('People:')
for row in cur:
    if count < 5: print(row)
    count = count + 1
print(count, 'rows.')

cur.execute('SELECT * FROM Follows')
count = 0
print('Follows:')
for row in cur:
    if count < 5: print(row)
    count = count + 1
print(count, 'rows.')

cur.execute('''SELECT * FROM Follows JOIN People
            ON Follows.to_id = People.id
            WHERE Follows.from_id = 2''')
count = 0
print('Connections for id=2:')
for row in cur:
    if count < 5: print(row)
    count = count + 1
print(count, 'rows.')

cur.close()

# Code: http://www.py4e.com/code3/twjoin.py
```

In this program, we first dump out the `People` and `Follows` and then dump out a subset of the data in the tables joined together.

Here is the output of the program:

```
python twjoin.py
People:
```

```
(1, 'drchuck', 1)
(2, 'opencontent', 1)
(3, 'lhawthorn', 1)
(4, 'steve_coppin', 0)
(5, 'davidkocher', 0)
55 rows.
Follows:
(1, 2)
(1, 3)
(1, 4)
(1, 5)
(1, 6)
60 rows.
Connections for id=2:
(2, 1, 1, 'drchuck', 1)
(2, 28, 28, 'cnxorg', 0)
(2, 30, 30, 'kthanos', 0)
(2, 102, 102, 'SomethingGirl', 0)
(2, 103, 103, 'ja_Pac', 0)
20 rows.
```

You see the columns from the `People` and `Follows` tables and the last set of rows is the result of the `SELECT` with the `JOIN` clause.

In the last select, we are looking for accounts that are friends of "opencontent" (i.e., `People.id=2`).

In each of the "metarows" in the last select, the first two columns are from the `Follows` table followed by columns three through five from the `People` table. You can also see that the second column (`Follows.to_id`) matches the third column (`People.id`) in each of the joined-up "metarows".

15.11 Summary

This chapter has covered a lot of ground to give you an overview of the basics of using a database in Python. It is more complicated to write the code to use a database to store data than Python dictionaries or flat files so there is little reason to use a database unless your application truly needs the capabilities of a database. The situations where a database can be quite useful are: (1) when your application needs to make small many random updates within a large data set, (2) when your data is so large it cannot fit in a dictionary and you need to look up information repeatedly, or (3) when you have a long-running process that you want to be able to stop and restart and retain the data from one run to the next.

You can build a simple database with a single table to suit many application needs, but most problems will require several tables and links/relationships between rows in different tables. When you start making links between tables, it is important to do some thoughtful design and follow the rules of database normalization to make the best use of the database's capabilities. Since the primary motivation for using a database is that you have a large amount of data to deal with, it is important to model your data efficiently so your programs run as fast as possible.

15.12 Debugging

One common pattern when you are developing a Python program to connect to an SQLite database will be to run a Python program and check the results using the Database Browser for SQLite. The browser allows you to quickly check to see if your program is working properly.

You must be careful because SQLite takes care to keep two programs from changing the same data at the same time. For example, if you open a database in the browser and make a change to the database and have not yet pressed the "save" button in the browser, the browser "locks" the database file and keeps any other program from accessing the file. In particular, your Python program will not be able to access the file if it is locked.

So a solution is to make sure to either close the database browser or use the *File* menu to close the database in the browser before you attempt to access the database from Python to avoid the problem of your Python code failing because the database is locked.

15.13 Glossary

attribute One of the values within a tuple. More commonly called a "column" or "field".

constraint When we tell the database to enforce a rule on a field or a row in a table. A common constraint is to insist that there can be no duplicate values in a particular field (i.e., all the values must be unique).

cursor A cursor allows you to execute SQL commands in a database and retrieve data from the database. A cursor is similar to a socket or file handle for network connections and files, respectively.

database browser A piece of software that allows you to directly connect to a database and manipulate the database directly without writing a program.

foreign key A numeric key that points to the primary key of a row in another table. Foreign keys establish relationships between rows stored in different tables.

index Additional data that the database software maintains as rows and inserts into a table to make lookups very fast.

logical key A key that the "outside world" uses to look up a particular row. For example in a table of user accounts, a person's email address might be a good candidate as the logical key for the user's data.

normalization Designing a data model so that no data is replicated. We store each item of data at one place in the database and reference it elsewhere using a foreign key.

primary key A numeric key assigned to each row that is used to refer to one row in a table from another table. Often the database is configured to automatically assign primary keys as rows are inserted.

relation An area within a database that contains tuples and attributes. More typically called a "table".

tuple A single entry in a database table that is a set of attributes. More typically called "row".

Chapter 16

Visualizing data

So far we have been learning the Python language and then learning how to use Python, the network, and databases to manipulate data.

In this chapter, we take a look at three complete applications that bring all of these things together to manage and visualize data. You might use these applications as sample code to help get you started in solving a real-world problem.

Each of the applications is a ZIP file that you can download and extract onto your computer and execute.

16.1 Building a Google map from geocoded data

In this project, we are using the Google geocoding API to clean up some user-entered geographic locations of university names and then placing the data on a Google map.

To get started, download the application from:

www.py4e.com/code3/geodata.zip

The first problem to solve is that the free Google geocoding API is rate-limited to a certain number of requests per day. If you have a lot of data, you might need to stop and restart the lookup process several times. So we break the problem into two phases.

In the first phase we take our input "survey" data in the file *where.data* and read it one line at a time, and retrieve the geocoded information from Google and store it in a database *geodata.sqlite*. Before we use the geocoding API for each user-entered location, we simply check to see if we already have the data for that particular line of input. The database is functioning as a local "cache" of our geocoding data to make sure we never ask Google for the same data twice.

You can restart the process at any time by removing the file *geodata.sqlite*.

Run the *geoload.py* program. This program will read the input lines in *where.data* and for each line check to see if it is already in the database. If we don't have the

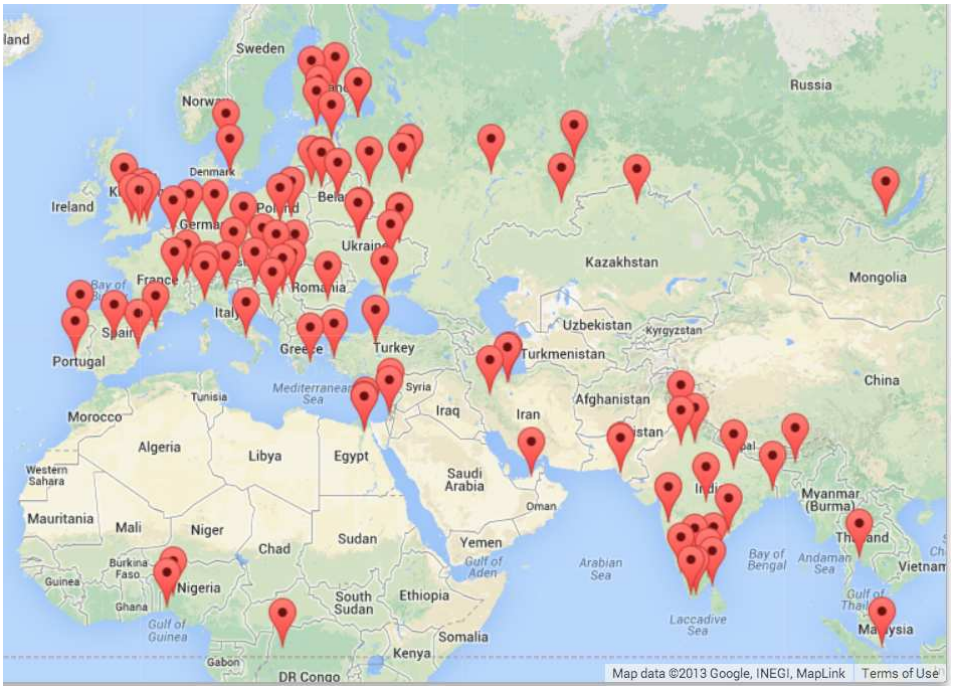

Figure 16.1: A Google Map

data for the location, it will call the geocoding API to retrieve the data and store it in the database.

Here is a sample run after there is already some data in the database:

```
Found in database  Northeastern University
Found in database  University of Hong Kong, ...
Found in database  Technion
Found in database  Viswakarma Institute, Pune, India
Found in database  UMD
Found in database  Tufts University

Resolving Monash University
Retrieving http://maps.googleapis.com/maps/api/
    geocode/json?address=Monash+University
Retrieved 2063 characters {    "results" : [
{'status': 'OK', 'results': ... }

Resolving Kokshetau Institute of Economics and Management
Retrieving http://maps.googleapis.com/maps/api/
    geocode/json?address=Kokshetau+Inst ...
Retrieved 1749 characters {    "results" : [
{'status': 'OK', 'results': ... }
...
```

The first five locations are already in the database and so they are skipped. The program scans to the point where it finds new locations and starts retrieving them.

The *geoload.py* program can be stopped at any time, and there is a counter that you can use to limit the number of calls to the geocoding API for each run. Given that the *where.data* only has a few hundred data items, you should not run into the daily rate limit, but if you had more data it might take several runs over several days to get your database to have all of the geocoded data for your input.

Once you have some data loaded into *geodata.sqlite*, you can visualize the data using the *geodump.py* program. This program reads the database and writes the file *where.js* with the location, latitude, and longitude in the form of executable JavaScript code.

A run of the *geodump.py* program is as follows:

```
Northeastern University, ... Boston, MA 02115, USA 42.3396998 -71.08975
Bradley University, 1501 ... Peoria, IL 61625, USA 40.6963857 -89.6160811
...
Technion, Viazman 87, Kesalsaba, 32000, Israel 32.7775 35.0216667
Monash University Clayton ... VIC 3800, Australia -37.9152113 145.134682
Kokshetau, Kazakhstan 53.2833333 69.3833333
...
12 records written to where.js
Open where.html to view the data in a browser
```

The file *where.html* consists of HTML and JavaScript to visualize a Google map. It reads the most recent data in *where.js* to get the data to be visualized. Here is the format of the *where.js* file:

```
myData = [
[42.3396998,-71.08975, 'Northeastern Uni ... Boston, MA 02115'],
[40.6963857,-89.6160811, 'Bradley University, ... Peoria, IL 61625, USA'],
[32.7775,35.0216667, 'Technion, Viazman 87, Kesalsaba, 32000, Israel'],
   ...
];
```

This is a JavaScript variable that contains a list of lists. The syntax for JavaScript list constants is very similar to Python, so the syntax should be familiar to you.

Simply open *where.html* in a browser to see the locations. You can hover over each map pin to find the location that the geocoding API returned for the user-entered input. If you cannot see any data when you open the *where.html* file, you might want to check the JavaScript or developer console for your browser.

16.2 Visualizing networks and interconnections

In this application, we will perform some of the functions of a search engine. We will first spider a small subset of the web and run a simplified version of the Google page rank algorithm to determine which pages are most highly connected, and then visualize the page rank and connectivity of our small corner of the web. We will use the D3 JavaScript visualization library http://d3js.org/ to produce the visualization output.

You can download and extract this application from:

Figure 16.2: A Page Ranking

www.py4e.com/code3/pagerank.zip

The first program (*spider.py*) program crawls a web site and pulls a series of pages into the database (*spider.sqlite*), recording the links between pages. You can restart the process at any time by removing the *spider.sqlite* file and rerunning *spider.py*.

```
Enter web url or enter: http://www.dr-chuck.com/
['http://www.dr-chuck.com']
How many pages:2
1 http://www.dr-chuck.com/ 12
2 http://www.dr-chuck.com/csev-blog/ 57
How many pages:
```

In this sample run, we told it to crawl a website and retrieve two pages. If you restart the program and tell it to crawl more pages, it will not re-crawl any pages already in the database. Upon restart it goes to a random non-crawled page and starts there. So each successive run of *spider.py* is additive.

```
Enter web url or enter: http://www.dr-chuck.com/
['http://www.dr-chuck.com']
How many pages:3
3 http://www.dr-chuck.com/csev-blog 57
4 http://www.dr-chuck.com/dr-chuck/resume/speaking.htm 1
5 http://www.dr-chuck.com/dr-chuck/resume/index.htm 13
How many pages:
```

You can have multiple starting points in the same database—within the program,

these are called "webs". The spider chooses randomly amongst all non-visited links across all the webs as the next page to spider.

If you want to dump the contents of the *spider.sqlite* file, you can run *spdump.py* as follows:

```
(5, None, 1.0, 3, 'http://www.dr-chuck.com/csev-blog')
(3, None, 1.0, 4, 'http://www.dr-chuck.com/dr-chuck/resume/speaking.htm')
(1, None, 1.0, 2, 'http://www.dr-chuck.com/csev-blog/')
(1, None, 1.0, 5, 'http://www.dr-chuck.com/dr-chuck/resume/index.htm')
4 rows.
```

This shows the number of incoming links, the old page rank, the new page rank, the id of the page, and the url of the page. The *spdump.py* program only shows pages that have at least one incoming link to them.

Once you have a few pages in the database, you can run page rank on the pages using the *sprank.py* program. You simply tell it how many page rank iterations to run.

```
How many iterations:2
1 0.546848992536
2 0.226714939664
[(1, 0.559), (2, 0.659), (3, 0.985), (4, 2.135), (5, 0.659)]
```

You can dump the database again to see that page rank has been updated:

```
(5, 1.0, 0.985, 3, 'http://www.dr-chuck.com/csev-blog')
(3, 1.0, 2.135, 4, 'http://www.dr-chuck.com/dr-chuck/resume/speaking.htm')
(1, 1.0, 0.659, 2, 'http://www.dr-chuck.com/csev-blog/')
(1, 1.0, 0.659, 5, 'http://www.dr-chuck.com/dr-chuck/resume/index.htm')
4 rows.
```

You can run *sprank.py* as many times as you like and it will simply refine the page rank each time you run it. You can even run *sprank.py* a few times and then go spider a few more pages with *spider.py* and then run *sprank.py* to reconverge the page rank values. A search engine usually runs both the crawling and ranking programs all the time.

If you want to restart the page rank calculations without respidering the web pages, you can use *spreset.py* and then restart *sprank.py*.

```
How many iterations:50
1 0.546848992536
2 0.226714939664
3 0.0659516187242
4 0.0244199333
5 0.0102096489546
6 0.00610244329379
...
42 0.000109076928206
43 9.91987599002e-05
```

```
44 9.02151706798e-05
45 8.20451504471e-05
46 7.46150183837e-05
47 6.7857770908e-05
48 6.17124694224e-05
49 5.61236959327e-05
50 5.10410499467e-05
[(512, 0.0296), (1, 12.79), (2, 28.93), (3, 6.808), (4, 13.46)]
```

For each iteration of the page rank algorithm it prints the average change in page rank per page. The network initially is quite unbalanced and so the individual page rank values change wildly between iterations. But in a few short iterations, the page rank converges. You should run *sprank.py* long enough that the page rank values converge.

If you want to visualize the current top pages in terms of page rank, run *spjson.py* to read the database and write the data for the most highly linked pages in JSON format to be viewed in a web browser.

```
Creating JSON output on spider.json...
How many nodes? 30
Open force.html in a browser to view the visualization
```

You can view this data by opening the file *force.html* in your web browser. This shows an automatic layout of the nodes and links. You can click and drag any node and you can also double-click on a node to find the URL that is represented by the node.

If you rerun the other utilities, rerun *spjson.py* and press refresh in the browser to get the new data from *spider.json*.

16.3 Visualizing mail data

Up to this point in the book, you have become quite familiar with our *mbox-short.txt* and *mbox.txt* data files. Now it is time to take our analysis of email data to the next level.

In the real world, sometimes you have to pull down mail data from servers. That might take quite some time and the data might be inconsistent, error-filled, and need a lot of cleanup or adjustment. In this section, we work with an application that is the most complex so far and pull down nearly a gigabyte of data and visualize it.

You can download this application from:

www.py4e.com/code3/gmane.zip

We will be using data from a free email list archiving service called www.gmane.org. This service is very popular with open source projects because it provides a nice searchable archive of their email activity. They also have a very liberal policy regarding accessing their data through their API. They have no rate limits, but ask that you don't overload their service and take only the data you need. You can read gmane's terms and conditions at this page:

Figure 16.3: A Word Cloud from the Sakai Developer List

http://gmane.org/export.php

It is very important that you make use of the gmane.org data responsibly by adding delays to your access of their services and spreading long-running jobs over a longer period of time. Do not abuse this free service and ruin it for the rest of us.

When the Sakai email data was spidered using this software, it produced nearly a Gigabyte of data and took a number of runs on several days. The file *README.txt* in the above ZIP may have instructions as to how you can download a pre-spidered copy of the *content.sqlite* file for a majority of the Sakai email corpus so you don't have to spider for five days just to run the programs. If you download the pre-spidered content, you should still run the spidering process to catch up with more recent messages.

The first step is to spider the gmane repository. The base URL is hard-coded in the *gmane.py* and is hard-coded to the Sakai developer list. You can spider another repository by changing that base url. Make sure to delete the *content.sqlite* file if you switch the base url.

The *gmane.py* file operates as a responsible caching spider in that it runs slowly and retrieves one mail message per second so as to avoid getting throttled by gmane. It stores all of its data in a database and can be interrupted and restarted as often as needed. It may take many hours to pull all the data down. So you may need to restart several times.

Here is a run of *gmane.py* retrieving the last five messages of the Sakai developer list:

```
How many messages:10
```

```
http://download.gmane.org/gmane.comp.cms.sakai.devel/51410/51411 9460
    nealcaidin@sakaifoundation.org 2013-04-05 re: [building ...
http://download.gmane.org/gmane.comp.cms.sakai.devel/51411/51412 3379
    samuelgutierrezjimenez@gmail.com 2013-04-06 re: [building ...
http://download.gmane.org/gmane.comp.cms.sakai.devel/51412/51413 9903
    da1@vt.edu 2013-04-05 [building sakai] melete 2.9 oracle ...
http://download.gmane.org/gmane.comp.cms.sakai.devel/51413/51414 349265
    m.shedid@elraed-it.com 2013-04-07 [building sakai] ...
http://download.gmane.org/gmane.comp.cms.sakai.devel/51414/51415 3481
    samuelgutierrezjimenez@gmail.com 2013-04-07 re: ...
http://download.gmane.org/gmane.comp.cms.sakai.devel/51415/51416 0

Does not start with From
```

The program scans *content.sqlite* from one up to the first message number not already spidered and starts spidering at that message. It continues spidering until it has spidered the desired number of messages or it reaches a page that does not appear to be a properly formatted message.

Sometimes gmane.org is missing a message. Perhaps administrators can delete messages or perhaps they get lost. If your spider stops, and it seems it has hit a missing message, go into the SQLite Manager and add a row with the missing id leaving all the other fields blank and restart *gmane.py*. This will unstick the spidering process and allow it to continue. These empty messages will be ignored in the next phase of the process.

One nice thing is that once you have spidered all of the messages and have them in *content.sqlite*, you can run *gmane.py* again to get new messages as they are sent to the list.

The *content.sqlite* data is pretty raw, with an inefficient data model, and not compressed. This is intentional as it allows you to look at *content.sqlite* in the SQLite Manager to debug problems with the spidering process. It would be a bad idea to run any queries against this database, as they would be quite slow.

The second process is to run the program *gmodel.py*. This program reads the raw data from *content.sqlite* and produces a cleaned-up and well-modeled version of the data in the file *index.sqlite*. This file will be much smaller (often 10X smaller) than *content.sqlite* because it also compresses the header and body text.

Each time *gmodel.py* runs it deletes and rebuilds *index.sqlite*, allowing you to adjust its parameters and edit the mapping tables in *content.sqlite* to tweak the data cleaning process. This is a sample run of *gmodel.py*. It prints a line out each time 250 mail messages are processed so you can see some progress happening, as this program may run for a while processing nearly a Gigabyte of mail data.

```
Loaded allsenders 1588 and mapping 28 dns mapping 1
1 2005-12-08T23:34:30-06:00 ggolden22@mac.com
251 2005-12-22T10:03:20-08:00 tpamsler@ucdavis.edu
501 2006-01-12T11:17:34-05:00 lance@indiana.edu
751 2006-01-24T11:13:28-08:00 vrajgopalan@ucmerced.edu
...
```

The *gmodel.py* program handles a number of data cleaning tasks.

Domain names are truncated to two levels for .com, .org, .edu, and .net. Other domain names are truncated to three levels. So si.umich.edu becomes umich.edu and caret.cam.ac.uk becomes cam.ac.uk. Email addresses are also forced to lower case, and some of the @gmane.org address like the following

```
arwhyte-63aXycvo3TyHXe+LvDLADg@public.gmane.org
```

are converted to the real address whenever there is a matching real email address elsewhere in the message corpus.

In the *mapping.sqlite* database there are two tables that allow you to map both domain names and individual email addresses that change over the lifetime of the email list. For example, Steve Githens used the following email addresses as he changed jobs over the life of the Sakai developer list:

```
s-githens@northwestern.edu
sgithens@cam.ac.uk
swgithen@mtu.edu
```

We can add two entries to the Mapping table in *mapping.sqlite* so *gmodel.py* will map all three to one address:

```
s-githens@northwestern.edu ->  swgithen@mtu.edu
sgithens@cam.ac.uk -> swgithen@mtu.edu
```

You can also make similar entries in the DNSMapping table if there are multiple DNS names you want mapped to a single DNS. The following mapping was added to the Sakai data:

```
iupui.edu -> indiana.edu
```

so all the accounts from the various Indiana University campuses are tracked together.

You can rerun the *gmodel.py* over and over as you look at the data, and add mappings to make the data cleaner and cleaner. When you are done, you will have a nicely indexed version of the email in *index.sqlite*. This is the file to use to do data analysis. With this file, data analysis will be really quick.

The first, simplest data analysis is to determine "who sent the most mail?" and "which organization sent the most mail"? This is done using *gbasic.py*:

```
How many to dump? 5
Loaded messages= 51330 subjects= 25033 senders= 1584

Top 5 Email list participants
steve.swinsburg@gmail.com 2657
azeckoski@unicon.net 1742
ieb@tfd.co.uk 1591
csev@umich.edu 1304
david.horwitz@uct.ac.za 1184
```

```
Top 5 Email list organizations
gmail.com 7339
umich.edu 6243
uct.ac.za 2451
indiana.edu 2258
unicon.net 2055
```

Note how much more quickly *gbasic.py* runs compared to *gmane.py* or even *gmodel.py*. They are all working on the same data, but *gbasic.py* is using the compressed and normalized data in *index.sqlite*. If you have a lot of data to manage, a multistep process like the one in this application may take a little longer to develop, but will save you a lot of time when you really start to explore and visualize your data.

You can produce a simple visualization of the word frequency in the subject lines in the file *gword.py*:

```
Range of counts: 33229 129
Output written to gword.js
```

This produces the file *gword.js* which you can visualize using *gword.htm* to produce a word cloud similar to the one at the beginning of this section.

A second visualization is produced by *gline.py*. It computes email participation by organizations over time.

```
Loaded messages= 51330 subjects= 25033 senders= 1584
Top 10 Oranizations
['gmail.com', 'umich.edu', 'uct.ac.za', 'indiana.edu',
'unicon.net', 'tfd.co.uk', 'berkeley.edu', 'longsight.com',
'stanford.edu', 'ox.ac.uk']
Output written to gline.js
```

Its output is written to *gline.js* which is visualized using *gline.htm*.

This is a relatively complex and sophisticated application and has features to do some real data retrieval, cleaning, and visualization.