Advanced Geospatial Data Analytics:

MapReduce and Geospatial data handling

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Outline

- Python programing basics
- Hadoop Streaming API with Python
  - Take advantage of the mapper for parallel processing
- Geospatial processing in Hadoop
  - Case study
  - Existing tools and frameworks
  - Write your own geospatial processing pipeline with Python
  - Leveraging the existing geospatial libraries as packages in Python

Python Programing Basics

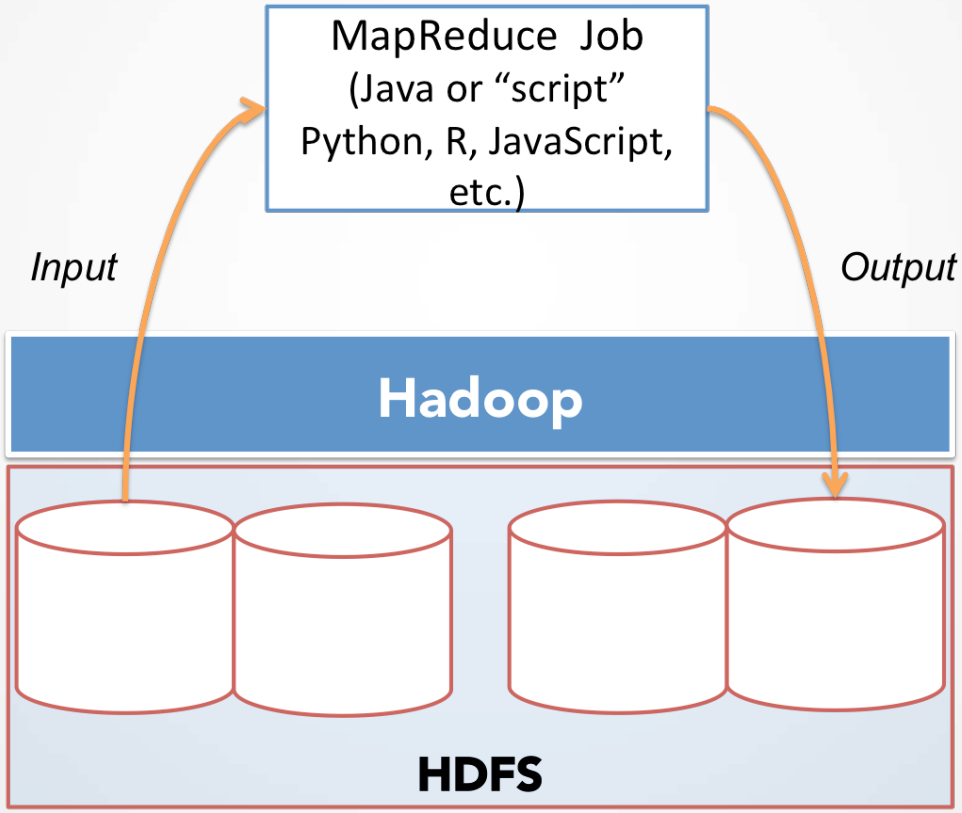
- For this unit, let's follow the attached document and review some basics in Python programing
- Different coding environments
  - Choose your favorite code editor

Hadoop Streaming API with Python

MapReduce

- Let's recap on what is the MapReduce paradigm
- Can you separate each step as individual process
  - If yes, how?
- Can you come up with some scenarios?

Delegation of Map and Reduce tasks



Example

```
import time
import datetime

mFile = open("ny_taxi_2013.csv","rb")
mOutput = open("ny_taxi_2013_unix.csv","wb")

for line in mFile:
    lineArray = line.split(',')
    pickup = lineArray[5]
    dropoff = lineArray[6]
    pickup_date = pickup.split(" ")[0]
    dropoff_date = dropoff.split(" ")[0]
    pickup_unix = datetime.datetime.strptime(pickup,"%Y-%m-%d %H:%M:%S").strftime("%s")
    if pickup_date > '2013-03-09' and pickup_date < '2013-11-03':
        pickup_final = int(pickup_unix) - 5 * 3600
    else:
        pickup_final = int(pickup_unix) - 6 * 3600
    ...
    newLine = line.replace("\n",",") + str(pickup_final) + ',' + str(dropoff_final) + '\n‘
    mOutput.write(newLine)
```

Hadoop streaming API with Python

```
#!/usr/bin/env python
import sys
import os
import time
import datetime

for line in sys.stdin:
    lineArray = line.strip().split(',')
    pickup = lineArray[5]
    dropoff = lineArray[6]
    ...
    newLine = line.replace("\n",",") + str(pickup_final) + ',' + str(dropoff_final) + '\n‘

    print newLine
```

Run Hadoop Streaming Job

- **hadoop jar** /usr/hdp/2.3.2.0-2602/hadoop-mapreduce/hadoop-streaming-2.7.1.2.3.2.0-2602.jar **-file** mapper.py **-mapper** mapper.py **-input** ny_taxi_2013.csv **-output** ny_taxi_2013_unix.csv

- **yarn jar** /usr/hdp/2.3.2.0-2602/hadoop-mapreduce/hadoop-streaming-2.7.1.2.3.2.0-2602.jar **-file** mapper.py **-mapper** mapper.py **-input** ny_taxi_2013.csv **-output** ny_taxi_2013_unix.csv

Using Python libraries for data analytics

- One step further
  - Numpy, Scipy, Pandas, scikit-learn
- Problems
  - Module load does not work
  - Each node in Hadoop cluster should have the python framework enabled
- Solution
  - Virutalenv (python virtual environment)

Using Python libraries for data analytics

- >>> virtualenv-2.7 demoenv
- New python executable in demoenv/bin/python2.7 ... done.
- >>> virtualenv-2.7 --relocatable demoenv
- >>> source demoenv/bin/activate
- >>> pip install “some module”
- >>> zip –r ../demoenv.zip *
- >>> hdfs dfs –copyFromLocal demoenv.zip

Using Python libraries for data analytics

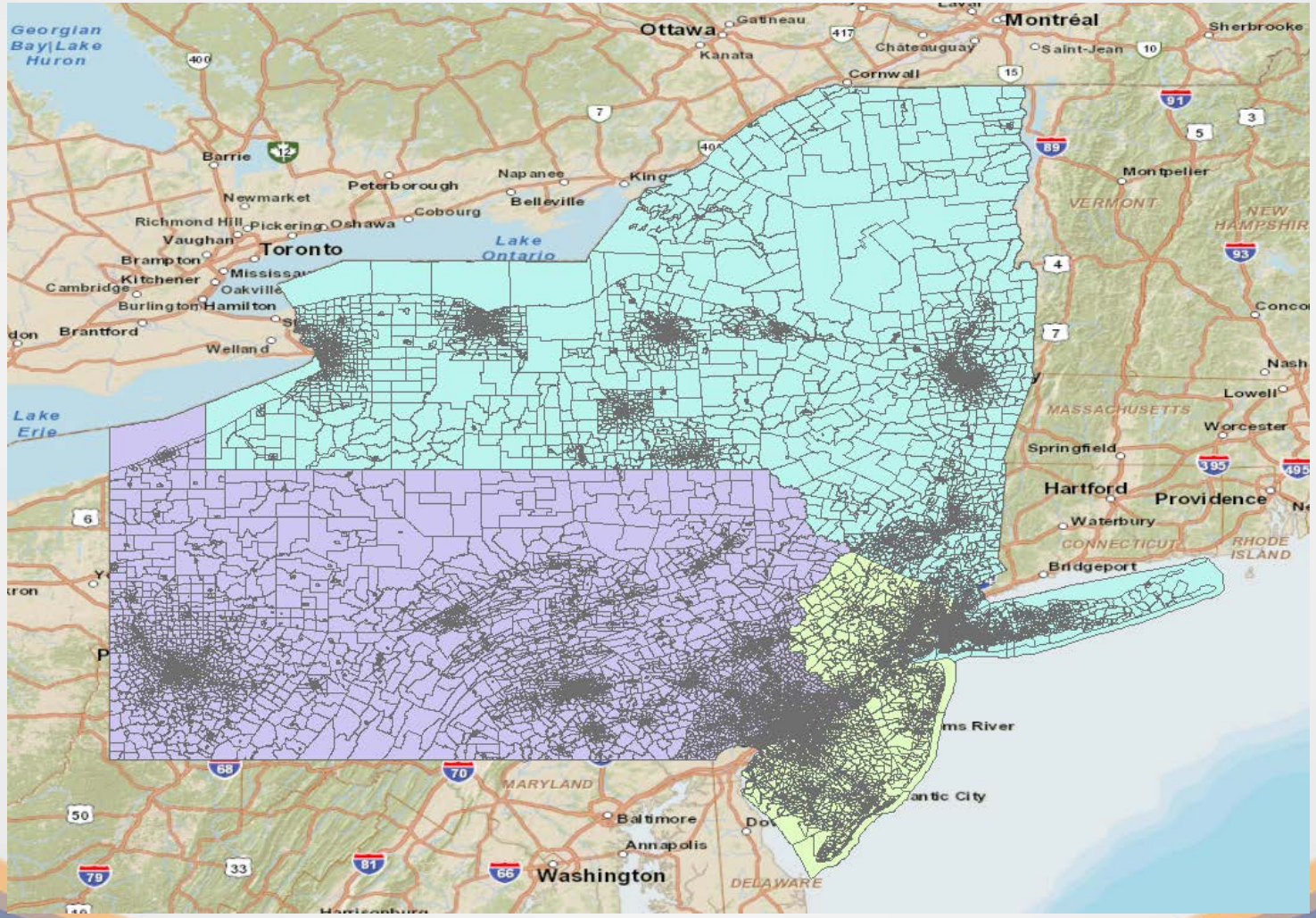
```
hadoop jar /usr/hdp/2.3.2.0-2602/hadoop-mapredu
    ce/hadoop-streaming-2.7.1.2.3.2.0-2602.jar
....files
-archives hdfs://cg-hm11.ncsa.illinois.edu/user/jyn/
    demoenv.zip#demoenv
```

In your python script

```
#!./demoenv/bin/python
import your_module
```

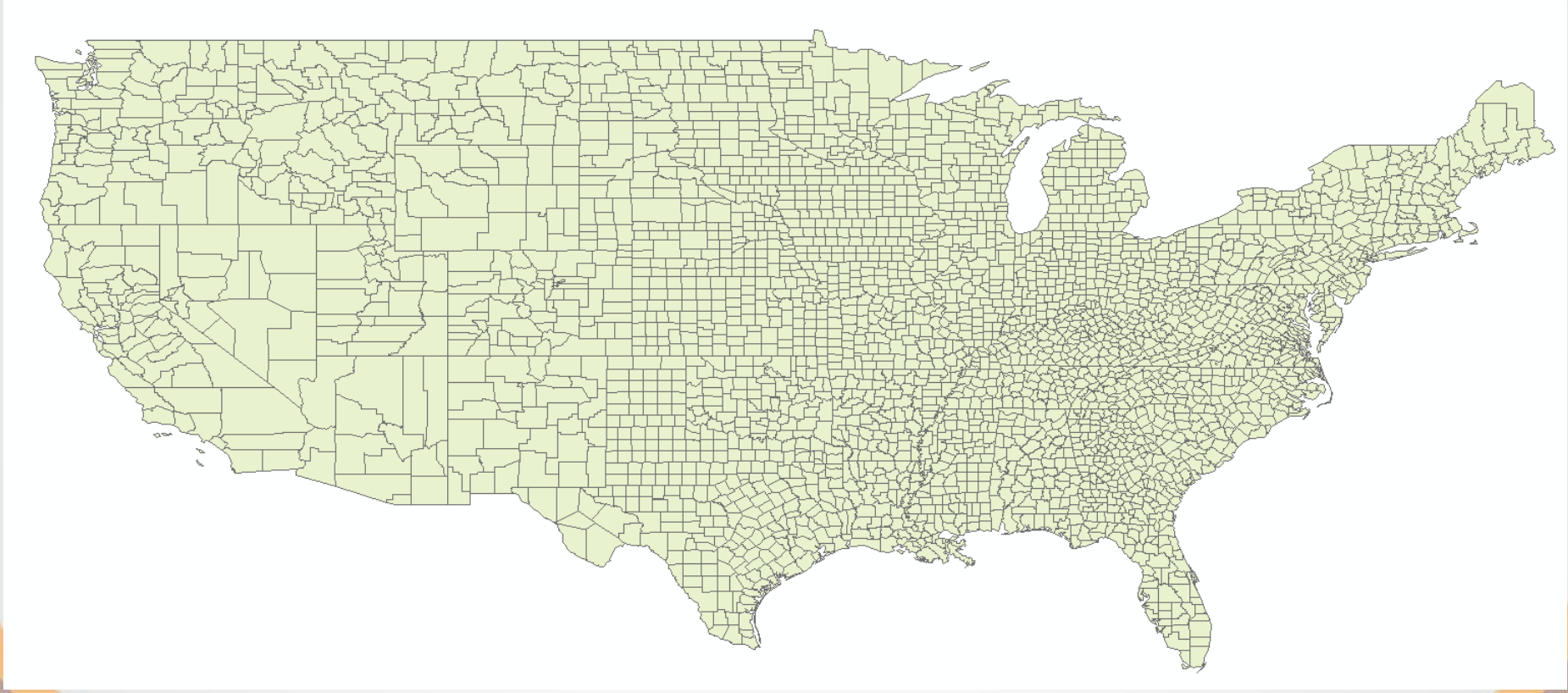
Geospatial processing in Hadoop

Case study



Aggregating New York taxi records to traffic analysis zones

Case study



Aggregating Twitter data to the corresponding county

Ideas?

Geospatial Operations

- Topology operations
  - Validating geometry, geometry relationships
  - Intersection
  - Intersect
  - Overlapping
  - Touch (sharing a boundary)
  - etc.
- Spatial Query
  - Geo-within (Range query)
  - K-NN (nearest neighbors)
  - etc.

Open Source Geospatial Libraries

- SDBMS (spatial database management system)
- QGIS
- ArcGIS
- GRASS GIS

- Open source libraries: OSGeo
  - GDAL
  - Fiona
  - Shapely
  - Shapefile.py

Existing distributed computing resources

- SpatialHadoop
  - http://spatialhadoop.cs.umn.edu/
- SpatialSpark
  - https://github.com/syoummer/SpatialSpark

Shapefile.py

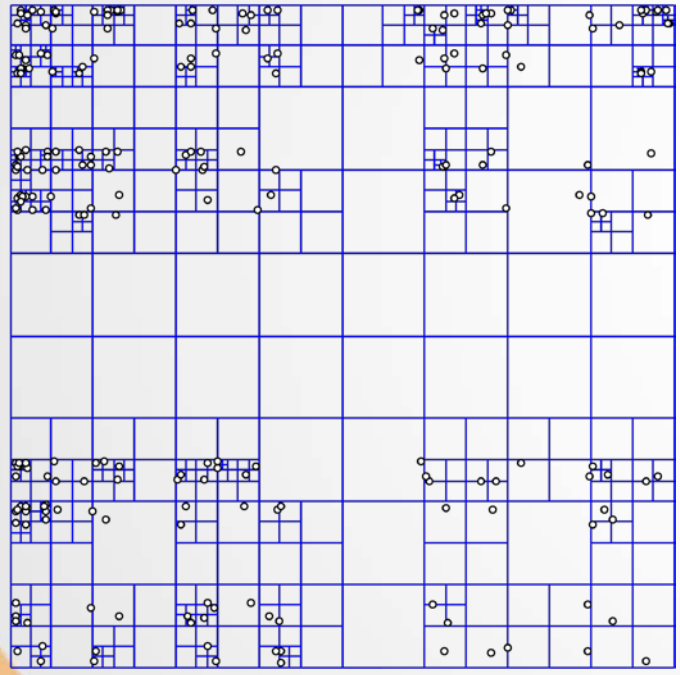
- Basically, instead of
- https://pypi.python.org/pypi/pyshp

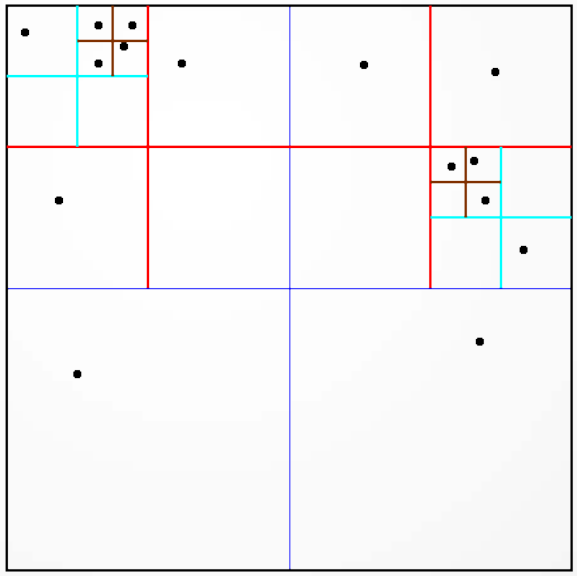
- Example usage
- >>> myshp = open("shapefiles/blockgroups.shp", "rb")
- >>> mydbf = open("shapefiles/blockgroups.dbf", "rb")
- >>> r = shapefile.Reader(shp=myshp, dbf=mydbf)

Improve efficiency with spatial indexing

- The purposes of spatial index
  - Improve search efficiency
  - Deal with multi-dimensional dataset
- Different types of spatial index
  - Quad-Tree
  - R-Tree
  - octree
  - Kd-tree
  - ....
- For this course, we will demonstrate and use Quad-Tree

Illustration of Quad-Tree for indexing points





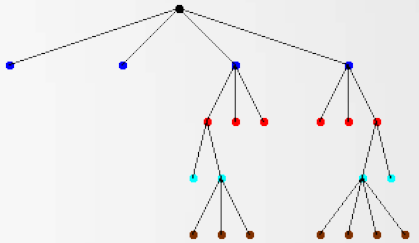
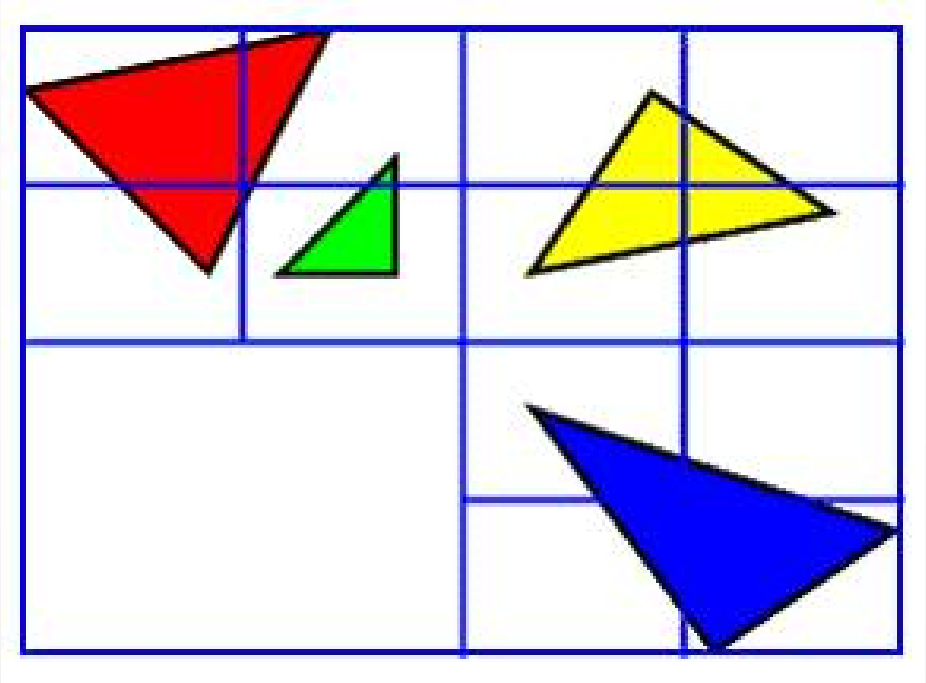
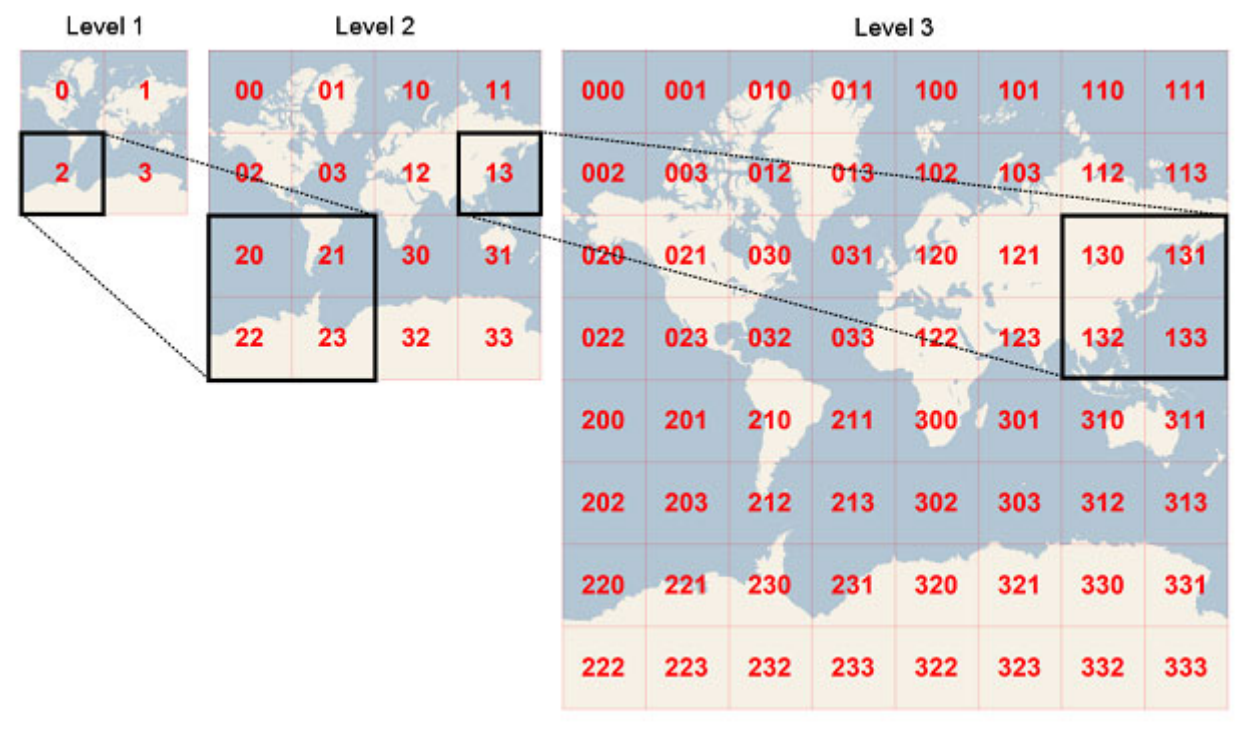


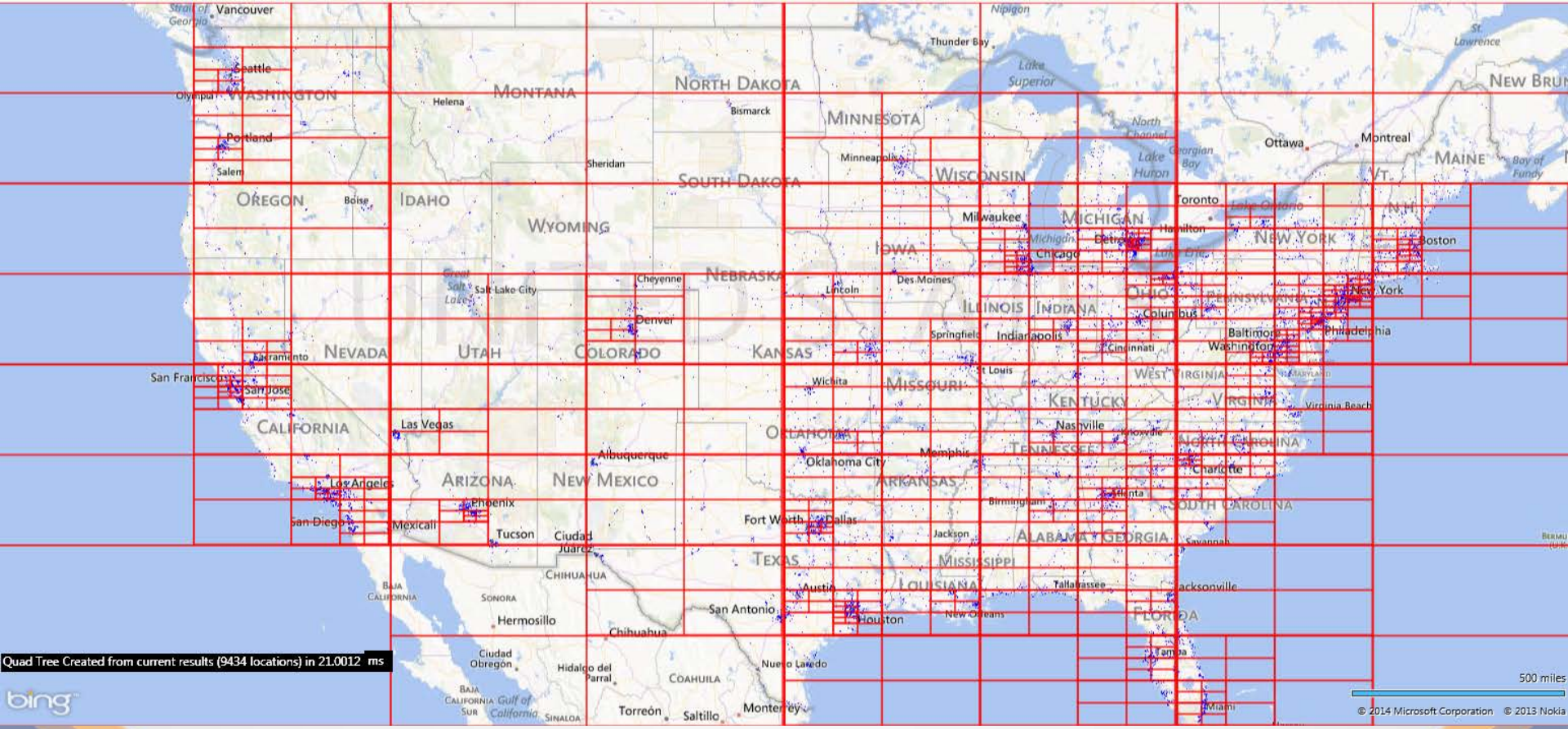
Illustration of Quad-Tree for polygons



Applications of Quad-Tree



Applications of Quad-Tree



Source: *http://softwareunwound.com/2014/03/18/adventures-in-mapping-big-data-sets-in-real-time-map-controls-part-2-enter-the-quadtree/*

Put things together

- Step1
  - We need to create spatial index (quad-tree) for the data we are about to process
  - Which data then? The point data or the polygon layer data?
- Step2
  - What we should do to determine a point belongs to a specific polygon?
  - Which geospatial operation should you pick?
- Step3
  - How can we take advantage of Hadoop Streaming API with Python
- Step4
  - How to run our program?

Notes

The detailed procedures will be practiced in the our lab this Thursday.