=====DATSCIW261 ASSIGNMENT #7=====

MIDS UC Berkeley, Machine Learning at Scale

DATSCIW261 ASSIGNMENT #7

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W261 - 2 , ASSIGNMENT #7

Submission Date :

Group : 4

In [2]:

```
%load_ext autoreload
%autoreload 2
%matplotlib inline
```

HW 7.0: Shortest path graph distances (toy networks)

In this part of your assignment you will develop the base of your code for the week.

Write MRJob classes to find shortest path graph distances,
as described in the lectures. In addition to finding the distances,
your code should also output a distance-minimizing path between the source and target.
Work locally for this part of the assignment, and use
both of the undirected and directed toy networks.

To proof you code's function, run the following jobs

- shortest path in the undirected network from node 1 to node 4
Solution: 1,5,4

- shortest path in the directed network from node 1 to node 5
Solution: 1,2,4,5

and report your output---make sure it is correct!

Init function: convert an input file into an SSSP file

SSSP File format:

```
JSON representaton of:
node id \t [ {adj-list dict}, [path from src], cost from src, status ]

e.g.
3       [{"2": 1, "4": 1}, [], 92233720368547758O7, "U"]
```

In [20]:

```
%%writefile MrInitSssp.py
from numpy import argmin, array, random
import re
import numpy as np
from mrjob.job import MRJob, MRStep
import mrjob
import json
import sys

class MrInitSssp(MRJob):

    SORT_VALUES = True  # Need 2nd sort
    def initValues(self, node):
        status = 'U'
        sps = [] # Unknown
        costFromSrc = sys.maxint # Unknown

        return (sps, costFromSrc, status)

    def mapper(self, _, line):
        # input format:
        # Json object:
        # 1       {'2': 1, '6': 1}

        fields = line.strip().split('\t')
        node = int(fields[0])

        # JSON uses double quote for string
        adjList = json.loads(fields[1].replace("'", '"'))

        sps, costFromSrc, status = self.initValues(node)

        # Output for the node, which is an outbound node
        yield node, [0, adjList, sps, costFromSrc, status]

        # Also need to output an empty entry for every nodes in the adjList.
        # It is needed for directed graph, so that in the reducer we can generat
e
```

```
        # an entry for nodes which don't have an outbound link.
        for key in adjList.keys():
            yield int(key), [1]

    def reducer(self, node, values):
        value = values.next()

        # An outbound node will be seen first because we use 2nd sorting
        if value[0] == 0:
            # It's an outbound record
            yield node, value[1:]
        else:
            # For directed graph, generate an entry for a node which doesn't hav
e an outbound
            # link.
            sps, costFromSrc, status = self.initValues(node)
            yield node, [{}, sps, costFromSrc, status]


if __name__ == '__main__':
    MrInitSssp.run()
```

```
Overwriting MrInitSssp.py
```

MRJob for find shortest path

In [26]:

```
%%writefile MrSssp_hw70.py
from numpy import argmin, array, random
import re
import numpy as np
from mrjob.job import MRJob, MRStep
from itertools import chain
import mrjob
import sys

class MrSssp_hw70(MRJob):
    INPUT_PROTOCOL = mrjob.protocol.JSONProtocol
    SORT_VALUES = True # Need to do secondary sort

    def configure_options(self):
        super(MrSssp_hw70, self).configure_options()
        self.add_passthrough_option(
            '--initSrcNode', type='int', default=None,
            help='The source node to initialize.')

    def initValues(self, node):
        if node == self.options.srcNode:
            # This is the source node
            status = 'Q'
            sps = [node] # shortest path from source
```

```
            costFromSrc = 0

        else:
            # Other nodes
            status = 'U'
            sps = [] # Unknown
            costFromSrc = sys.maxint # Unknown

        return (sps, costFromSrc, status)

    def mapper(self, nodeId, data):
        # data format:
        # Json object:
        # [ {adj-list dict}, [path from src], cost from src, status ]

        #print >> sys.stderr, "input data:", data
        nodeId = int(nodeId)
        adjList, pathFromSrc, costFromSrc, status = data

        if nodeId == self.options.initSrcNode:
            # This is the source node, and we're asked to initialize it
            status = 'Q'
            pathFromSrc = [nodeId] # shortest path from source
            costFromSrc = 0

        if status == "Q":
            # The node is in Queued mode.  It's a frontier node.
            # Need to process its neighbours
            for neighbor, weight in adjList.items():
                neighbor = int(neighbor)
                neighborPathFromSrc = pathFromSrc + [neighbor]
                neighborCostFromSrc = costFromSrc + weight

                # Put 0 in the front for secondary sorting purpose
                yield neighbor, (0, None, neighborPathFromSrc, neighborCostFromS
rc, "Q")

            # Lastly, change its own status to visited
            status = "V"

        # Put 0 in the front for secondary sorting purpose
        yield nodeId, (1, adjList, pathFromSrc, costFromSrc, status)

    def reducer(self, key, values):
        minCostFromSrc = sys.maxint
        emitted = False

        for data in values:
            assert not emitted, "Should not see more records after we've emitted
result"

            sortkey, adjList, pathFromSrc, costFromSrc, status = data

            if adjList is None:
```

```
                assert status == 'Q', "status must be Q for record emitted by ne

ighbor"

                # It is a record emitted from a neighbor
                if costFromSrc < minCostFromSrc:
                    minCostFromSrc = costFromSrc
                    minPathFromSrc = pathFromSrc
            else:

                if minCostFromSrc < costFromSrc:
                    # Its 'cost from Src' becomes smaller.  Put it to the fronti

er.
                    status = "Q"
                    costFromSrc = minCostFromSrc
                    pathFromSrc = minPathFromSrc

                yield key, [adjList, pathFromSrc, costFromSrc, status]

                emitted = True

if __name__ == '__main__':
    MrSssp_hw70.run()
```

```
Overwriting MrSssp_hw70.py
```

MRJob for checking terminating condition

In [22]:

```
%%writefile MrCheckTermination.py
from mrjob.job import MRJob, MRStep
import mrjob
import sys

class MrCheckTermination(MRJob):
    def configure_options(self):
        super(MrCheckTermination, self).configure_options()
        self.add_passthrough_option(
            '--destNode', type='int', default=None, help='The destination Node.'

)

    INPUT_PROTOCOL = mrjob.protocol.JSONProtocol

    def mapper(self, nodeId, data):
        # Input format:
        # Json object:
        # 5       [{"1": 1, "2": 1, "4": 1}, [1, 2, 4, 5], 3, "V"]
        assert self.options.destNode is not None, "Needs to have a destination n

ode specified"

        if int(nodeId) == self.options.destNode and data[3] == "V":
            # We're done!
```

```
        yield 0, [nodeId] + data


    elif data[3] == "Q":
        yield 1, None

def reducer_init(self):
    self.QueuedSeen = False
    self.Finished = False

def reducer(self, key, values):
    if self.Finished:
        return

    if key == 0:
        # We're done
        self.Finished = True
        yield 1, values.next()

    elif not self.QueuedSeen:
        assert key == 1
        self.QueuedSeen = True

def reducer_final(self):
    if not self.Finished and not self.QueuedSeen:
        # Not a single Queued node
        yield 0, None


if __name__ == '__main__':
    MrCheckTermination.run()
```

```
Overwriting MrCheckTermination.py
```

Driver for finding shortest path

In [23]:

```
%%writefile Driver_Hw70.py
from numpy import random
from MrSssp_hw70 import MrSssp_hw70
from MrInitSssp import MrInitSssp
from MrCheckTermination import MrCheckTermination
import json
import sys
import shutil

import argparse
parser = argparse.ArgumentParser()
parser.add_argument("--initFile", type=str)
parser.add_argument("--destNode", type=str)
parser.add_argument("--srcNode", type=str)
args = parser.parse_args()
```

```
shutil.copy(args.initFile, 'sssp.txt')

mrArgsBase = ['sssp.txt', '--strict-protocols',
            '-r', 'inline']

mr_job1 = MrSssp_hw70(args = ["--initSrcNode", args.srcNode] + mrArgsBase)
mr_job2 = MrCheckTermination(args = ["--destNode", args.destNode] + mrArgsBase)

i = 1
finished = False

while(not finished):
    print "iteration"+str(i)+":"

    with mr_job1.make_runner() as runner:
        runner.run()

        # Generate the new sssp.txt based on job's output
        with open('sssp.txt', 'w') as f:
            for line in runner.stream_output():
                key, value =  mr_job1.parse_output_line(line)
                f.write("%s\t%s\n" % (key,json.dumps(value)))

    # Check if we have reached termination state
    with mr_job2.make_runner() as runner:
        runner.run()

        for line in runner.stream_output():
            key, value =  mr_job2.parse_output_line(line)
            if key == 1:
                print
                print "Result:", value
            else:
                assert key == 0
                print
                print "Not Found"

            finished = True
    i += 1

    mr_job1 = MrSssp_hw70(args = mrArgsBase)
```

```
Overwriting Driver_Hw70.py
```

Run it for undirected_toy.txt

In [27]:

```
!python MrInitSssp.py undirected_toy.txt -q -r inline --no-strict-protocols \
> initSssp.txt
```

In [28]:

```
!python Driver_Hw70.py --initFile initSssp.txt --srcNode 1 --destNode 4
```

```
iteration1:
No handlers could be found for logger "mrjob.sim"
iteration2:
iteration3:

Result: [4, {'3': 1, '2': 1, '5': 1}, [1, 2, 4], 2, 'V']
```

Answer:
From the output, you can see that the paths from 1 to 4 is: 1, 2, 4

(It is different from the standard solution, but it is okay because there is more than one path from 1 to 4.)

Run it for directed_toy.txt

In [30]:

```
!python MrInitSssp.py directed_toy.txt -q -r inline --no-strict-protocols \
> initSssp.txt
```

In [31]:

```
!python Driver_Hw70.py --initFile initSssp.txt --srcNode 1 --destNode 5
```

```
iteration1:
No handlers could be found for logger "mrjob.sim"
iteration2:
iteration3:
iteration4:

Result: [5, {'1': 1, '2': 1, '4': 1}, [1, 2, 4, 5], 3, 'V']
```

Answer:
From the output, you can see that the paths from 1 to 5 is: 1, 2, 4, 5

HW 7.1: Exploratory data analysis (NLTK synonyms)

Using MRJob, explore the synonyms network data.
Consider plotting the degree distribution (does it follow a power law?),
and determine some of the key features, like:

number of nodes,
number links,
or the average degree (i.e., the average number of links per node),
etc...

As you develop your code, please be sure to run it locally first (though o
n the whole dataset).
Once you have gotten you code to run locally, deploy it on AWS as a system
s test
in preparation for our next dataset (which will require AWS).

In [4]:

```
%%writefile MrExplore_hw71.py
from __future__ import division
from numpy import argmin, array, random
import re
import numpy as np
from mrjob.job import MRJob, MRStep
from itertools import chain
import mrjob
import sys
import json

class MrExplore_hw71(MRJob):
    def steps(self):
        return [
            MRStep(
                   mapper=self.mapper,
                   combiner = self.reducer,
                   reducer=self.reducer
            )
               ]

    def mapper(self, _, data):
        # data format:
        # 1       {'2': 1, '3': 1, '4': 1}
        yield "n", 1 # for total number of nodes

        # JSON uses double quote for string
        fields = data.strip().split('\t')
        adjList = json.loads(fields[1].replace("'", '"'))
        degree = len(adjList)
        yield "l", degree # for total number of links

        yield "d" + str(degree), 1  # for distribution of degree

    def reducer(self, key, values):
        total = sum([v for v in values])
        yield key, total

if __name__ == '__main__':
    MrExplore_hw71.run()
```

```
Overwriting MrExplore_hw71.py
```

Run it locally

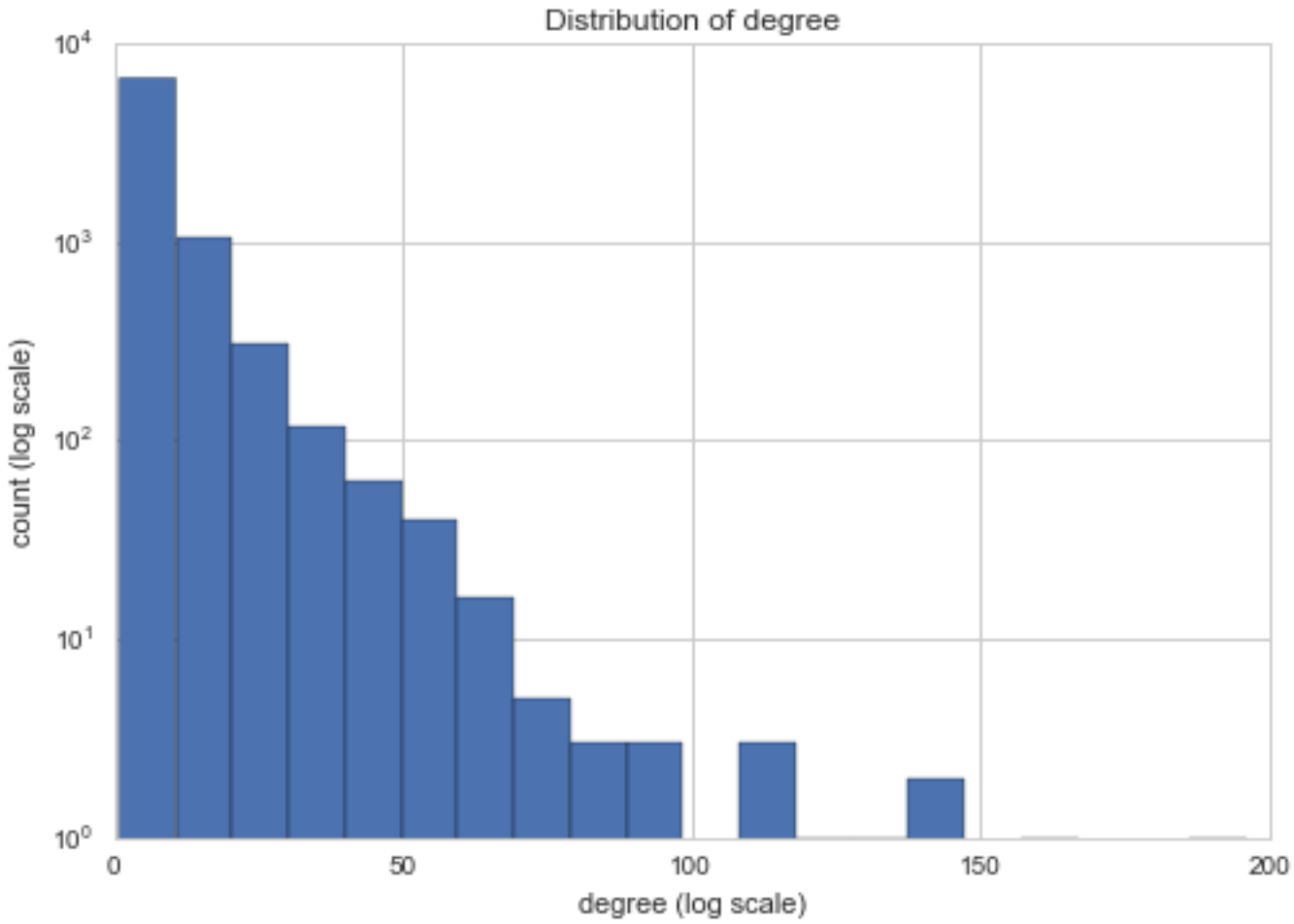
In [74]:

```
!python MrExplore_hw71.py synNet.txt \
-r inline \
--strict-protocol \
-q \
> hw71_result.txt
```

In [84]:

```
import matplotlib.pyplot as plt
import matplotlib.ticker as ticker

degreeDist = {}

with open("hw71_result.txt", "r") as f:
    for line in f:
        fields = line.strip().split('\t')
        key = fields[0].replace('"', '')
        value = fields[1]
        if key == "l":
            totalLinks = int(value)
        elif key == "n":
            totalNodes = int(value)
        else:
            # format: "d3"
            degree = int(key[1:])
            degreeDist[degree] = int(value)

print "Number of nodes =", totalNodes
print "Number of links =", totalLinks

degrees = [int(x) for x in degreeDist.keys()]
counts = degreeDist.values()

fig, ax = plt.subplots()

ax.hist(degrees, weights = counts, bins = 20, log=True, align='mid')
plt.xlabel('degree (log scale)')
plt.ylabel('count (log scale)')
plt.title('Distribution of degree')
plt.show()
```

```
Number of nodes = 8271
Number of links = 61134
```



HW 7.2: Shortest path graph distances (NLTK synonyms)

Write (reuse your code from 7.0) an MRJob class to find shortest path grap
h distances,
and apply it to the NLTK synonyms network dataset.

Proof your code's function by running the job:

- shortest path starting at "walk" (index=7827) and ending at "make" (inde
x=536),

and showing you code's output. Once again, your output should include the
path and the distance.

As you develop your code, please be sure to run it locally first (though o
n the whole dataset).
Once you have gotten you code to run locally, deploy it on AWS as a system
s test
in preparation for our next dataset (which will require AWS).

In [71]:

```
%%writefile Driver_Hw72.py
```

```
from numpy import random

from MrSssp_hw70 import MrSssp_hw70
from MrCheckTermination import MrCheckTermination
import json
import sys
import boto3
import botocore
import shutil
import time

import argparse
parser = argparse.ArgumentParser()
parser.add_argument("--initFile", type=str)
parser.add_argument("--srcNode", type=str, help="The source node", default=None)
parser.add_argument("--destNode", type=str, help="The destination node", default
=None)
parser.add_argument("--interSsspFolder", type=str, default=None)
parser.add_argument("--ec2-instance-type", type=str, default=None)
parser.add_argument("--num-ec2-instances", type=str, default=None)
parser.add_argument("-r", "--run", type=str)
args = parser.parse_args()

jobArgsBase = ['-r', args.run,
               '--no-strict-protocols']

if args.run == "emr":
    jobArgsBase += ["--pool-emr-job-flows"]

    if args.ec2_instance_type is not None:
        jobArgsBase += ["--ec2-instance-type", args.ec2_instance_type]

    if args.num_ec2_instances is not None:
        jobArgsBase += ["--num-ec2-instances", args.num_ec2_instances]


i = 1
startTime = time.time()
finished = False
interSsspFile = args.initFile # Use the initialized sssp in the first iteration
srcNodeInit = False

while(not finished):
    print "iteration %d: (%d sec since started)" % (i, time.time() - startTime)

    jobArgs = [interSsspFile] + jobArgsBase

    # Switch to use a different SSSP file name for subsequent iterations
    if args.run == "inline" or args.run == "local":
        interSsspFile = "_interSssp.txt"
    else:
        interSsspFile = args.interSsspFolder + "iter" + str(i) + "/"
        jobArgs += ["--no-output", "--output-dir", interSsspFile]
```

```
# Have to initialize the source node during the first iteration

job1_args = jobArgs
if not srcNodeInit:
    job1_args += ["--initSrcNode", args.srcNode]
    srcNodeInit = True

mr_job1 = MrSssp_hw70(args=job1_args)

with mr_job1.make_runner() as runner:
    runner.run()

    if args.run == "inline" or args.run == "local":
        # Generate the new SSSP based on job's output
        with open(interSsspFile, 'w') as f:
            for line in runner.stream_output():
                key, value =  mr_job1.parse_output_line(line)
                f.write("%s\t%s\n" % (key,json.dumps(value)))

# Check if we have reached termination state
jobArgs = [interSsspFile, '--destNode', args.destNode] + jobArgsBase
mr_job2 = MrCheckTermination(args=jobArgs)

with mr_job2.make_runner() as runner:
    runner.run()

    for line in runner.stream_output():
            key, value =  mr_job2.parse_output_line(line)
            if key == 1:
                print
                print "Shortest path:", value[2], "; Cost:", value[3]
            else:
                assert key == 0
                print
                print "Not Found"

            finished = True
    i += 1

print
print "Total time: %d sec" % (time.time() - startTime)
```

```
Overwriting Driver_Hw72.py
```

Run it locally

In [49]:

```
!python MrInitSssp.py synNet.txt -q -r inline --no-strict-protocols \
> initSssp.txt
```

In [50]:

```
!python Driver_Hw72.py -r local --initFile initSssp.txt --srcNode 7827 --destNod
e 536
```

```
iteration 1: (0 sec since started)
No handlers could be found for logger "mrjob.sim"
iteration 2: (3 sec since started)
iteration 3: (5 sec since started)
iteration 4: (8 sec since started)

Shortest path: [7827, 1426, 1668, 536] ; Cost: 3

Total time: 11 sec
```

Run it on Hadoop with HDFS

Initialize input file

In [36]:

```
!hdfs dfs -rm -r hw72_init

!python MrInitSssp.py synNet.txt -q -r hadoop --no-strict-protocols \
--output-dir hdfs://127.0.0.1/user/patrickng/hw72_init \
--no-output \
--no-strict-protocols \
```

```
16/03/10 11:36:07 WARN util.NativeCodeLoader: Unable to load native-
hadoop library for your platform... using builtin-java classes where
applicable
Deleted hw72_init
```

In [37]:

```
!hdfs dfs -ls hdfs://127.0.0.1/user/patrickng/hw72_init
```

```
16/03/10 11:36:53 WARN util.NativeCodeLoader: Unable to load native-
hadoop library for your platform... using builtin-java classes where
applicable
Found 2 items
-rw-r--r--   1 patrickng supergroup          0 2016-03-10 11:36 hdfs
://127.0.0.1/user/patrickng/hw72_init/_SUCCESS
-rw-r--r--   1 patrickng supergroup     969970 2016-03-10 11:36 hdfs
://127.0.0.1/user/patrickng/hw72_init/part-00000
```

Run the MrJob on Hadoop

In [39]:

```
!hdfs dfs -rm -r hw72_inter

!python Driver_Hw72.py -r hadoop \
--initFile hdfs://127.0.0.1/user/patrickng/hw72_init \
--interSsspFolder hdfs://127.0.0.1/user/patrickng/hw72_inter/ \
--destNode 536 \
--srcNode 7827 \
```

```
16/03/10 11:37:20 WARN util.NativeCodeLoader: Unable to load native-
hadoop library for your platform... using builtin-java classes where
applicable
rm: `hw72_inter': No such file or directory
iteration 1: (0 sec since started)
No handlers could be found for logger "mrjob.compat"
iteration 2: (73 sec since started)
iteration 3: (141 sec since started)
iteration 4: (213 sec since started)

Shortest path: [7827, 1426, 1668, 536]

Total time: 289 sec
```

Run it on EMR

Initialize input file

In [44]:

```
!aws s3 mb s3://patng323-w261-hw72
!aws s3 cp synNet.txt s3://patng323-w261-hw72/input/
!aws s3 ls s3://patng323-w261-hw72/input/
```

```
make_bucket: s3://patng323-w261-hw72/
upload: ./synNet.txt to s3://patng323-w261-hw72/input/synNet.txt
2016-03-10 11:08:52        111 directed_toy.txt
2016-03-10 11:45:50     705298 synNet.txt
```

In [51]:

```
!aws s3 rm --recursive s3://patng323-w261-hw72/init
!echo "Wait 5.0s sec for S3 eventual consistency"
!sleep 5

!python MrInitSssp.py \
s3://patng323-w261-hw72/input/synNet.txt \
-r emr \
--pool-emr-job-flows \
--num-ec2-instances=1 \
--ec2-instance-type=m1.large \
--no-strict-protocols \
--no-output \
--output-dir s3://patng323-w261-hw72/init/ \
```

```
delete: s3://patng323-w261-hw72/init/_SUCCESS
delete: s3://patng323-w261-hw72/init/part-00000
Wait 5.0s sec for S3 eventual consistency
Got unexpected keyword arguments: ssh_tunnel
using configs in /Users/patrickng/.mrjob.conf
using existing scratch bucket mrjob-0c26425c25d7acc1
using s3://mrjob-0c26425c25d7acc1/tmp/ as our scratch dir on S3
creating tmp directory /var/folders/dm/nsw7wjf91f1c74hgl17ldw040000g
n/T/MrInitSssp.patrickng.20160310.035925.358808
writing master bootstrap script to /var/folders/dm/nsw7wjf91f1c74hgl
17ldw040000gn/T/MrInitSssp.patrickng.20160310.035925.358808/b.py
Copying non-input files into s3://mrjob-0c26425c25d7acc1/tmp/MrInitS
ssp.patrickng.20160310.035925.358808/files/
Attempting to find an available job flow...
hash_object() is deprecated and will be removed in v0.5
Adding our job to existing job flow j-358X2FTMOOO57
Job launched 32.0s ago, status RUNNING: Running step (MrInitSssp.pat
rickng.20160310.035925.358808: Step 1 of 1)
Job launched 64.1s ago, status RUNNING: Running step (MrInitSssp.pat
rickng.20160310.035925.358808: Step 1 of 1)
Job launched 96.4s ago, status RUNNING: Running step (MrInitSssp.pat
rickng.20160310.035925.358808: Step 1 of 1)
Job launched 128.6s ago, status RUNNING: Running step (MrInitSssp.pa
trickng.20160310.035925.358808: Step 1 of 1)
Job launched 161.5s ago, status RUNNING: Running step (MrInitSssp.pa
trickng.20160310.035925.358808: Step 1 of 1)
Job completed.
Running time was 150.0s (not counting time spent waiting for the EC2
instances)
ec2_key_pair_file not specified, going to S3
Fetching counters from S3...
Waiting 5.0s for S3 eventual consistency
Counters from step 1:
  File Input Format Counters :
    Bytes Read: 742804
  File Output Format Counters :
```

```
    Bytes Written: 969970
  FileSystemCounters:
    FILE_BYTES_READ: 388706
    FILE_BYTES_WRITTEN: 937787
    HDFS_BYTES_READ: 372
    S3_BYTES_READ: 742804
    S3_BYTES_WRITTEN: 969970
  Job Counters :
    Launched map tasks: 4
    Launched reduce tasks: 1
    Rack-local map tasks: 4
    SLOTS_MILLIS_MAPS: 114358
    SLOTS_MILLIS_REDUCES: 49049
    Total time spent by all maps waiting after reserving slots (ms):
0
    Total time spent by all reduces waiting after reserving slots (m
s): 0
  Map-Reduce Framework:
    CPU time spent (ms): 26360
    Combine input records: 0
    Combine output records: 0
    Map input bytes: 705298
    Map input records: 8271
    Map output bytes: 1601536
    Map output materialized bytes: 415387
    Map output records: 69405
    Physical memory (bytes) snapshot: 895913984
    Reduce input groups: 16542
    Reduce input records: 69405
    Reduce output records: 8271
    Reduce shuffle bytes: 415387
    SPLIT_RAW_BYTES: 372
    Spilled Records: 138810
    Total committed heap usage (bytes): 620118016
    Virtual memory (bytes) snapshot: 3105779712
removing tmp directory /var/folders/dm/nsw7wjf91f1c74hgl17ldw040000g
n/T/MrInitSssp.patrickng.20160310.035925.358808
Removing all files in s3://mrjob-0c26425c25d7acc1/tmp/MrInitSssp.pat
rickng.20160310.035925.358808/


In [52]:
```

```
!aws s3 ls s3://patng323-w261-hw72/init/
```

```
2016-03-10 12:02:25          0 _SUCCESS
2016-03-10 12:02:19     969970 part-00000
```

Run the driver

In [59]:

```
!aws s3 rm --recursive s3://patng323-w261-hw72/inter
!echo "Wait 5.0s sec for S3 eventual consistency"
!sleep 5

!python Driver_Hw72.py \
-r emr \
--initFile s3://patng323-w261-hw72/init/ \
--interSsspFolder s3://patng323-w261-hw72/inter/ \
--num-ec2-instances=1 \
--ec2-instance-type=m1.large \
--destNode 536 \
--srcNode 7827
```

```
delete: s3://patng323-w261-hw72/inter/iter1/part-00000
delete: s3://patng323-w261-hw72/inter/iter1/_SUCCESS
Wait 5.0s sec for S3 eventual consistency
iteration 1: (0 sec since started)
No handlers could be found for logger "mrjob.conf"
iteration 2: (395 sec since started)
iteration 3: (828 sec since started)
iteration 4: (1235 sec since started)

Shortest path: [7827, 1426, 1668, 536] ; Cost: 3

Total time: 1668 sec
```

In [83]:

```
%%writefile graph_distance.out
7827
1426
1668
536
```

```
Overwriting graph_distance.out
```

In [134]:

```
%%writefile innerjoin.py

from mrjob.job import MRJob
from mrjob.step import MRStep
import csv, re
from mrjob.protocol import RawProtocol, ReprProtocol

class InnerJoin(MRJob):
    tmp =[]
    left={}
    def steps(self):
        return [
            MRStep(mapper_init=self.mapper_init, mapper=self.mapper,mapper_final
=self.mapper_final)
               ]

    def mapper_init(self):
        with open('graph_distance.out') as f:
            for line in f:
                self.left[line.strip()]=None
                self.tmp.append(line.strip())

    def mapper(self, line_no, line):
        cell = line.strip().split('\t')
        url = self.left.get(cell[1],'NA')
        if url != 'NA':
            self.left[cell[1]]=cell[0]

    def mapper_final(self):
        for i in range(len(self.tmp)):
            if i == len(self.tmp)-1 :
                yield self.left[self.tmp[i]],' '
            else: yield self.left[self.tmp[i]],"->"

if __name__ == '__main__':
    InnerJoin.run()
```

```
Overwriting innerjoin.py
```

In [135]:

```
print "Shortest Path"
!python ./innerjoin.py ./synNet/indices.txt --file graph_distance.out -q
```

```
Shortest Path
"walk"  "->"
"pass"  "->"
"Give"  "->"
"make"  " "
```

HW 7.3: Exploratory data analysis (Wikipedia)

Using MRJob, explore the Wikipedia network data on the AWS cloud. Reuse your code from HW 7.1---does is scale well?
Be cautioned that Wikipedia is a directed network, where links are not symmetric.
So, even though a node may be linked to, it will not appear as a primary record itself if it has no out-links.
This means that you may have to ADJUST your code (depending on its design).
To be sure of your code's functionality in this context, run a systems test on the directed_toy.txt network.

In [ ]:

```
%%writefile simpleExplore.py
# Reads in an adjacency list and converts it to the table format
# we will use for graph analysis.

from mrjob.job import MRJob

import json
import sys

class simpleExplore(MRJob):

    DEFAULT_PROTOCOL = 'json'


    def mapper(self, _, val):


        xList = val.split("\t")
        #name index indegree outdegree
        yield "*node", 1 #one for each unique node

        degree = int(xList[2]) + int(xList[3])
        yield "*degree_sum", degree
        yield degree, 1

    def reducer_init(self):
        self.sum_of_nodes = 0
        self.sum_of_degrees = 0

    def reducer(self, key, val):
        if key == "*degree_sum":
            xList = list(val)
            sum_degrees = sum([int(e) for e in xList])
            self.sum_of_degrees = sum_degrees
```

```
            yield "number of links", sum_degrees

        elif key == "*node":
            xList = list(val)
            sum_nodes = sum([int(e) for e in xList])
            self.sum_of_nodes = sum_nodes
            yield "number of nodes", sum_nodes
            print "sum_nodes", sum_nodes
            if self.sum_of_nodes > 0:
                yield "average degree", self.sum_of_degrees/float(self.sum_of_no
des)
        else:
            xList = list(val)
            sumxL = sum([int(e) for e in xList])
            yield key, sumxL


if __name__ == '__main__':
    simpleExplore.run()
```

In [8]:

```
!python simpleExplore.py -q ./wikipedia/indices.txt > eda.out
```

In [13]:

```
!head -3 eda.out
```

```
"number of links"       370486058
"number of nodes"       15192277
"average degree"        24.38647333773601
```

Plot distribution of article degrees

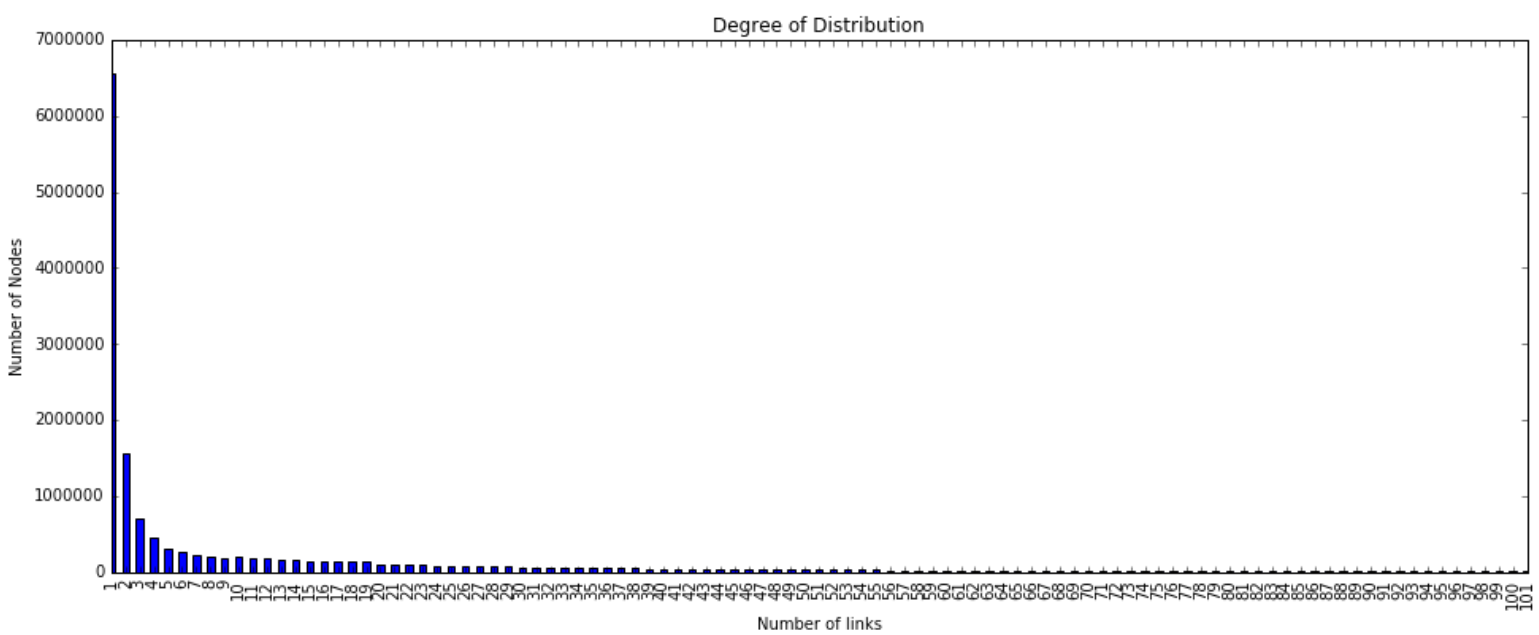
In [17]:

```
import numpy as np
import pandas as pd
%matplotlib inline
import matplotlib.pyplot as plt

# with open("eda.out", "rb") as f:
#     for line in f:
#         if line.startswith('\"'):
#             pass
#         else:
#             line = line.strip()
#             rec = line.split("\t")
#             xs.append(int(rec[0]))
#             ys.append(float(rec[1]))
# fig = plt.figure(figsize=(20,6))
# plt.xlim([0,100])
# plt.bar(xs, ys, color='blue')
# plt.show
fig = plt.figure(figsize=(16,6))
ax = fig.add_subplot(111)
df = pd.read_csv('eda.out',sep='\t',header=None,skiprows=3)
df.columns = ['links','nodes']
df.sort('links',ascending=True,inplace=True)
df.set_index('links',inplace=True)
df.plot(kind='bar',legend=None,title="Degree of Distribution",ax=ax)
plt.xlabel("Number of links")
plt.ylabel("Number of Nodes")
plt.xlim([0, 100])
```

```
/Users/hetal/anaconda/lib/python2.7/site-packages/ipykernel/__main__
.py:23: FutureWarning: sort(columns=....) is deprecated, use sort_va
lues(by=.....)
```

Out[17]:

```
(0, 100)
```



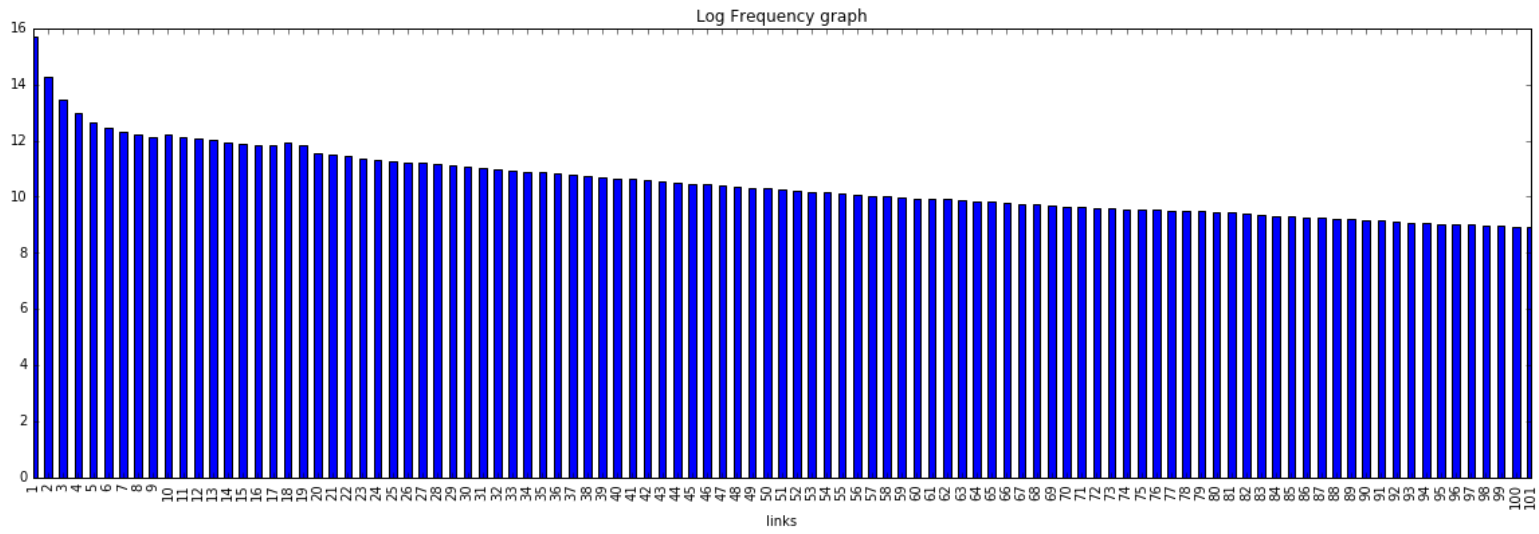
Log frequency graph

In [23]:

```
df['logy']=np.log(df['nodes'])
fig = plt.figure(figsize=(20,6))
ax = fig.add_subplot(111)
df.plot(kind='bar',legend=None,title="Log Frequency graph",ax=ax,y='logy')
plt.xlim([0,100])
```

Out[23]:

```
(0, 100)
```



HW 7.4: Shortest path graph distances (Wikipedia)

Using MRJob, find shortest path graph distances in the Wikipedia network o
n the AWS cloud.
Reuse your code from 7.2, but once again be warned of Wikipedia being a di
rected network.
To be sure of your code's functionality in this context, run a systems tes
t on the directed_toy.txt network.

When running your code on the Wikipedia network, proof its function by run
ning the job:

- shortest path from "Ireland" (index=6176135) to "University of Californi
a, Berkeley" (index=13466359),

and show your code's output. Show the shortest path in terms of just page
IDS but also in terms of the name of page (show of your MapReduce join ski
lls!!)

Once your code is running, find some other shortest paths and report your
results.

Initialize input file

In [63]:

```
!aws s3 mb s3://patng323-w261-hw74
!sleep 3
!aws s3 rm --recursive s3://patng323-w261-hw74/init
!echo "Wait 5.0s sec for S3 eventual consistency"
!sleep 5

!python MrInitSssp.py \
s3://ucb-mids-mls-networks/wikipedia/all-pages-indexed-out.txt \
-r emr \
--pool-emr-job-flows \
--num-ec2-instances=4 \
--ec2-instance-type=m1.large \
--no-strict-protocols \
--no-output \
--output-dir s3://patng323-w261-hw74/init/ \
```

```
make_bucket: s3://patng323-w261-hw74/
Wait 5.0s sec for S3 eventual consistency
```

In [65]:

```
!aws s3 ls s3://patng323-w261-hw74/init/
```

```
2016-03-10 13:45:28          0 _SUCCESS
2016-03-10 13:31:01  535737703 part-00000
2016-03-10 13:31:05  537456160 part-00001
2016-03-10 13:30:54  536055558 part-00002
2016-03-10 13:39:14  537140533 part-00003
2016-03-10 13:39:30  536470791 part-00004
```

Run the driver

In [72]:

```
!aws s3 rm --recursive s3://patng323-w261-hw74/inter
!echo "Wait 5.0s sec for S3 eventual consistency"
!sleep 5

!python Driver_Hw72.py \
-r emr \
--initFile s3://patng323-w261-hw74/init/ \
--interSsspFolder s3://patng323-w261-hw74/inter/ \
--num-ec2-instances 4 \
--ec2-instance-type m1.xlarge \
--destNode 13466359 \
--srcNode 6176135
```

```
Wait 5.0s sec for S3 eventual consistency
iteration 1: (0 sec since started)
No handlers could be found for logger "mrjob.conf"
iteration 2: (1117 sec since started)
iteration 3: (1920 sec since started)

Shortest path: [6176135, 11607791, 13466359] ; Cost: 3

Total time: 2747 sec
```

In [136]:

```
%%writefile graph_distance.out
6176135
11607791
13466359
```

```
Overwriting graph_distance.out
```

In [137]:

```
print "Shortest Path"
!python ./innerjoin.py ./wikipedia/indices.txt --file graph_distance.out -q
```

```
Shortest Path
"Ireland"       "->"
"Seamus Heaney" "->"
"University of California, Berkeley"    " "
```

HW 7.5: Conceptual exercise: Largest single-source network distances===

Suppose you wanted to find the largest network distance from a single source, i.e., a node that is the furthest (but still reachable) from a single source. How would you implement this task? How is this different from finding the shortest path graph distances? Is this task more difficult to implement than the shortest path distance? As you respond, please comment on program structure, runtimes, iterations, general system requirements, etc...

Answer

Implementation for largest network distance from a single source:

This can be implemented by doing a BFS similar to the shortest path proble
m. For an unweighted
graph or a graph with equal weights, I would employ the same approach as u
sed for shortest path above.
The minor difference would be that the loop would not terminate when the d
estination is seen but rather
when there are no more nodes that can be visited or that there are no more
"queued" nodes for the next
iteration. The latter condition ensures that we do not continue looping fo
r nodes that are not reachable
from the source. The no. of iterations that ran till this point (the sour
ce node would be traversed in
iteration 0) would denote the largest network distance to the furthest no
de. The nodes that were
traversed/visited in the last iteration can be considered the furthest nod
es from the source.
For weighted graphs, the same approach can be employed but the condition o
f termination is different as we
would need to revisit nodes as weights via other paths may be higher. In t
his scenario, we would re-queue
nodes if the new total weight of the path is higher than the previous valu
e (unlike the shortest path
solution where the node is re-queued only if the weight is less). Also, un
like unweighted graphs, we need
to track the node and respective path for the highest seen total weight an
d keep it updated during each
iteration. For weighted graphs, nodes visited in the last iteration need n
ot be the farthest from the source.

In [ ]: