

IEMS 5730 Spring 2019 Homework 3

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Q1: Kafka Integration with Storm

(a) Multi-node Kafka Cluster Setup

Download and install

```
wget http://ftp.cuhk.edu.hk/pub/packages/apache.org/kafka/2.1.0/kafka_2.11-2.1.0.tgz
tar -xzf kafka_2.11-2.1.0.tgz
mv kafka_2.11-2.1.0 ~/kafka
cd ~/kafka
bin/kafka-server-start.sh config/server.properties --override delete.topic.enable=true &
```

Test kafka

```
bin/kafka-topics.sh --create --zookeeper ip-172-31-13-50:2181 --replication-factor 1 --partitions 1 --
bin/kafka-topics.sh --list --zookeeper ip-172-31-13-50:2181
bin/kafka-console-producer.sh --broker-list ip-172-31-13-50:9092 --topic test
This is a message
This is another message
# open another terminal
bin/kafka-console-consumer.sh --bootstrap-server ip-172-31-13-50:9092 --topic test --from-beginning
```

(a) Find the most Frequently used Words: Using Kafka to Guarantee Message/Tuple Processing (At-least-once mode)

Run my topology input by kafka

Code:

WCTopology.java

```

package myapp;

import org.apache.storm.Config;
import org.apache.storm.LocalCluster;
import org.apache.storm.StormSubmitter;
import org.apache.storm.kafka.spout.KafkaSpout;
import org.apache.storm.kafka.spout.KafkaSpoutConfig;
import org.apache.storm.topology.TopologyBuilder;

public class WCTopology {

    public static final String ID_KAFKA_SPOUT = "kafka-spout";
    public static final String ID_SPLIT_BOLT = "split-sentence-bolt";
    public static final String ID_COUNT_BOLT = "word-count-bolt";
    public static final int NUM_KAFKA_SPOUT = 1;
    public static final int NUM_SPLIT_BOLT = 5;
    public static final int NUM_COUNT_BOLT = 3;

    public static void main(String[] args) {
        TopologyBuilder builder = new TopologyBuilder();

        KafkaSpoutConfig<String, String> config =
            KafkaSpoutConfig.builder("ip-172-31-13-50:9092", "kafkawc").build();

        builder.setSpout(ID_KAFKA_SPOUT, new KafkaSpout<String, String>(config), NUM_KAFKA_SPOUT);

        builder.setBolt(ID_SPLIT_BOLT, new SplitSentenceBolt(), NUM_SPLIT_BOLT).shuffleGrouping(ID_KAF
        builder.setBolt(ID_COUNT_BOLT, new WordCountBolt(), NUM_COUNT_BOLT).globalGrouping(ID_SPLIT_BO

        Config conf = new Config();
        conf.setDebug(false);

        try {
            if (args != null && args.length > 0) {
                conf.setNumWorkers(4);
                StormSubmitter.submitTopologyWithProgressBar(args[0], conf, builder.createTopology());
            } else {
                conf.setMaxTaskParallelism(4);
                LocalCluster cluster = new LocalCluster();
                cluster.submitTopology("kafkawc", conf, builder.createTopology());
                Thread.sleep(1000);
                cluster.shutdown();
            }
        } catch (Exception e) {
        }
    }
}

```

SplitSentenceBolt.java

```

package myapp;

import java.util.Map;

import org.apache.storm.task.OutputCollector;
import org.apache.storm.task.TopologyContext;
import org.apache.storm.topology.OutputFieldsDeclarer;
import org.apache.storm.topology.base.BaseRichBolt;
import org.apache.storm.tuple.Fields;
import org.apache.storm.tuple.Tuple;
import org.apache.storm.tuple.Values;

/**
 * SplitSentenceBolt
 */
public class SplitSentenceBolt extends BaseRichBolt {

    private OutputCollector collector;

    @Override
    public void prepare(Map stormConf, TopologyContext context, OutputCollector collector) {
        this.collector = collector;
    }

    @Override
    public void execute(Tuple input) {
        String sentence = input.getStringByField("value");
        String[] words = sentence.split(" ");

        for (String word : words) {

            if (!word.isEmpty()) {
                word = word.toLowerCase();
                this.collector.emit(input, new Values(word));
            }
        }
        this.collector.ack(input);
    }

    @Override
    public void declareOutputFields(OutputFieldsDeclarer declarer) {
        declarer.declare(new Fields("word"));
    }
}

```

WordCountBolt.java

```

package myapp;

import java.io.BufferedWriter;
import java.io.FileWriter;
import java.io.IOException;
import java.util.ArrayList;
import java.util.Collections;
import java.util.Comparator;
import java.util.LinkedHashMap;
import java.util.List;
import java.util.Map;

import org.apache.storm.task.OutputCollector;
import org.apache.storm.task.TopologyContext;
import org.apache.storm.topology.OutputFieldsDeclarer;
import org.apache.storm.topology.base.BaseRichBolt;
import org.apache.storm.tuple.Tuple;

/**
 * WordCountBolt
 */
public class WordCountBolt extends BaseRichBolt {

    private OutputCollector collector;
    private LinkedHashMap<String, Integer> counts;
    private static final int TARGET_FAIL_COUNT = 10;
    private int failCounter = 0;
    public static final String OUTPUT_FILE_PATH = "/home/ubuntu/output-word-count.txt";

    //sort hash map by value
    static <K, V> void sortByValue(LinkedHashMap<K, V> m, final Comparator<? super V> c) {
        List<Map.Entry<K, V>> entries = new ArrayList<Map.Entry<K, V>>(m.entrySet());

        Collections.sort(entries, new Comparator<Map.Entry<K, V>>() {
            @Override
            public int compare(Map.Entry<K, V> lhs, Map.Entry<K, V> rhs) {
                return c.compare(lhs.getValue(), rhs.getValue());
            }
        });

        m.clear();
        for(Map.Entry<K, V> e : entries) {
            m.put(e.getKey(), e.getValue());
        }
    }

    @Override
    public void prepare(Map map, TopologyContext topologyContext, OutputCollector outputCollector) {
        this.collector = outputCollector;
        this.counts = new LinkedHashMap<String, Integer>();
    }

    @Override
    public void execute(Tuple input) {

```

```

String word = input.getStringByField("word");

if (word.equals("the") && failCounter < TARGET_FAIL_COUNT) {
    this.collector.fail(input);
    failCounter += 1;
    return ;
}
if (counts.containsKey(word)) {
    counts.put(word, counts.get(word) + 1);
} else {
    counts.put(word, 1);
}
this.collector.ack(input);
}

@Override
public void declareOutputFields(OutputFieldsDeclarer outputFieldsDeclarer) {
}

@Override
public void cleanup() {
    sortByValue(counts, new Comparator<Integer>() {
        @Override
        public int compare(Integer i1, Integer i2) {
            return i2.compareTo(i1);
        }
    });

    FileWriter fw = null;
    BufferedWriter bw = null;
    try {
        fw = new FileWriter(OUTPUT_FILE_PATH);
        bw = new BufferedWriter(fw);
        for (Map.Entry<String, Integer> entry : counts.entrySet()) {
            bw.write(entry.getKey() + "\t" + String.valueOf(entry.getValue()) + "\n");
        }
    } catch (IOException e) {
        e.printStackTrace();
    } finally {
        try {
            if (bw != null) {
                bw.close();
            }
            if (fw != null) {
                fw.close();
            }
        } catch (IOException e) {
            e.printStackTrace();
        }
    }
}
}
}

```

Package and submit to Storm cluster

```
mvn clean assembly:assembly -DdescriptorId=jar-with-dependencies
storm jar target/kafkawc-1.0-SNAPSHOT-jar-with-dependencies.jar myapp.WCTopology kafkawc
bin/kafka-console-producer.sh --broker-list ip-172-31-13-50:9092 --topic kafkawc < StormData.txt
```

Result (Top 10 most frequently used words)

At-least-once mode	At-most-once mode(Homework#2)
the 86178	the 86178
and 71395	and 71392
of 49258	of 49250
to 28038	to 28035
i 23545	i 23545
in 20895	in 20895
that 20800	that 20800
a 19127	a 19126
he 14970	he 14970
for 14923	for 14923

Performance

	At-least-once mode	At-most-once mode(Homework#2)
Runing Time	55 s	38 s
#Emmited	1709220	1710100
#Acked	1884500	1709880

Two results are not same, the result of at-most-once mode is always equal or less than that of at-least-once mode. This is because that the messages are acked in the at-least-once mode, and if they are failed to send, they should be resent. However, at-most-once mode does not need ack messages are sent successfully or failed. Therefore, the time cost is less than that of at-least-once mode.

(c) Scaling the topology

Result

#KafkaSpout,#SplitBolt,#CountBolt	Runing time	#tuple emmitted	#tuple acked
-----------------------------------	-------------	-----------------	--------------

#KafkaSpout,#SplitBolt,#CountBolt	Runing time	#tuple emmitted	#tuple acked
3,3,3	57 s	1709330	1905540
1,3,3	47 s	1709910	1905540
1,1,3	52 s	1708090	1905540
3,10,10	55 s	1709650	1905540

With the number of spouts and bolts increasing, the runing time decreases first and increases later because the communication cost. Increasing number of KafkaSpout is useless, because there is little computation. Increasing number of SplitBolt can reduce running time because the parallel computing. However the dataset is small, if we set the number of bolts too large, communication cost becomes the main cost rather than computation cost.

Q2: PageRank Algorithm on GraphLab Create

(a) install GraphLab Create

Install Anaconda and create conda environment

```
wget https://repo.continuum.io/archive/Anaconda2-4.0.0-Linux-x86_64.sh
bash Anaconda2-4.0.0-Linux-x86_64.sh
conda create -n gl-env python=2.7
source activate gl-env
conda update pip
```

Install GraphLab Create and ipython notebook

```
pip install --upgrade --no-cache-dir https://get.graphlab.com/GraphLab-Create/2.1/your_registered_email
conda install ipython-notebook
```

(b) compute the Top 100 nodes for the given dataset

Code

```

import graphlab as gl
import time

def pagerank_update_fn(src, edge, dst):
    if src['__id'] != dst['__id']: # ignore self-links
        dst['pagerank'] += src['prev_pagerank'] * edge['weight']
    return (src, edge, dst)

def sum_weight(src, edge, dst):
    if src['__id'] != dst['__id']: # ignore self-links
        src['total_weight'] += edge['weight']
    return src, edge, dst

def normalize_weight(src, edge, dst):
    if src['__id'] != dst['__id']: # ignore self-links
        edge['weight'] /= src['total_weight']
    return src, edge, dst

def pagerank_triple_apply(input_graph, reset_prob=0.15, threshold=1e-3,
                          max_iterations=20):
    g = gl.SGraph(input_graph.vertices, input_graph.edges)

    # compute normalized edge weight
    g.vertices['total_weight'] = 0.0
    g = g.triple_apply(sum_weight, ['total_weight'])
    g = g.triple_apply(normalize_weight, ['weight'])
    del g.vertices['total_weight']

    # initialize vertex field
    g.vertices['prev_pagerank'] = 1.0
    it = 0
    total_l1_delta = len(g.vertices)
    start = time.time()
    while(total_l1_delta > threshold and it < max_iterations):
        g.vertices['pagerank'] = 0.0
        g = g.triple_apply(pagerank_update_fn, ['pagerank'])
        g.vertices['pagerank'] = g.vertices['pagerank'] * (1 - reset_prob) \
                                + reset_prob

        g.vertices['l1_delta'] = (g.vertices['pagerank'] - \
                                g.vertices['prev_pagerank']).apply(lambda x: abs(x))
        total_l1_delta = g.vertices['l1_delta'].sum()
        g.vertices['prev_pagerank'] = g.vertices['pagerank']
        print 'Iteration %d: total pagerank changed in L1 = %f' % (it, \
                                                                    total_l1_delta)

        it = it + 1
    print 'Triple apply pagerank finished in: %f secs' % (time.time() - start)
    del g.vertices['prev_pagerank']
    return g

# Load graph
g = gl.load_graph('https://snap.stanford.edu/data/web-Google.txt.gz', 'snap')
g.edges['weight'] = 1.0

# Run triple apply sssp

```



```
pagerank_graph = pagerank_triple_apply(g)
pagerank_graph.get_vertices().topk('pagerank', k=100).print_rows(100)
```

Result(20 Iterations)

Triple apply pagerank finished in: 245.020883 secs

+-----+			
__id	pagerank	ll_delta	
+-----+			
597621	566.295618529	0.47063360727	
41909	565.157596192	0.517123293091	
163075	554.223138085	0.475008648261	
537039	550.982085941	0.418437405617	
384666	482.777994244	0.427023609989	
504140	469.186673359	0.419081022143	
486980	444.956194763	0.55557661939	
605856	440.237558819	0.428568773856	
32163	436.92253417	0.375475630961	
558791	435.225904247	0.501200037774	
551829	430.237698017	0.389080956712	
765334	418.379481548	0.222943983621	
751384	405.459147338	0.381829675243	
425770	382.250589347	0.375375375545	
908351	380.454953155	0.270861736478	
173976	373.729627433	0.417174017285	
7314	367.115866047	0.358687181048	
213432	365.134240445	0.320754552052	
885605	359.334860051	0.219421330349	
819223	356.661891432	0.220083446468	
691633	356.224282512	0.344909049674	
452291	351.006512295	0.300370322719	
407610	347.362630733	0.323040961674	
905628	345.237268245	0.224972469654	
459074	345.16510023	0.2686753956	
687325	339.443327197	0.255119076457	
396321	337.667834307	0.260846927074	
828963	336.201604401	0.335405754065	
226374	325.699992401	0.235726595374	
172133	324.604854454	0.327033194753	
277876	322.981288519	0.355602518128	
599130	311.6663523	0.314445719093	
448961	311.360771675	0.270405734437	
324502	305.95869237	0.260674676001	
804489	301.101272003	0.32655222427	
726490	299.145146516	0.252114898522	
486434	296.580061613	0.237778631991	
182121	292.904228848	0.259777740916	
323129	291.128670295	0.240938267921	
54147	290.863572734	0.253354038605	
621670	285.661398305	0.194971293297	
555924	283.373304488	0.269013462352	
587935	278.544816447	0.270436140543	
245186	278.153407572	0.254100696061	
721816	277.783830514	0.249598082499	
57791	275.727346898	0.269692447967	
185067	269.892610373	0.223504569236	
402132	266.83682927	0.236709362148	
74397	265.974224434	0.223684484494	
434134	264.456780848	0.262527415265	

21682	261.845858463	0.336984544664	
185821	261.834665652	0.173991412323	
191990	261.76258942	0.237867913829	
870811	261.730479171	0.234906897873	
399699	259.909252521	0.268551907565	
438491	248.964265781	0.237609231709	
614831	241.181950669	0.17336640973	
183501	240.044367358	0.260669811152	
846221	237.548100541	0.106124177028	
36292	237.285461062	0.169875021926	
666882	235.575403679	0.169427629934	
1536	233.544710323	0.346165549334	
468736	232.767292985	0.213760145301	
699754	230.526852095	0.20869890426	
354640	227.423017619	0.226170046126	
187242	222.036389918	0.26109285206	
715883	221.278197496	0.156525909067	
596972	220.038738972	0.206179716407	
232639	216.225038215	0.0623145901106	
626893	215.912170333	0.169547888831	
587721	211.237548029	0.168911186774	
818382	208.51894313	0.207761356407	
557124	208.355090614	0.0946165878871	
466323	202.764754317	0.182589929629	
495084	201.059015558	0.053605710544	
798584	200.755793905	0.100360885986	
438493	198.701495137	0.201317910103	
522190	195.691785154	0.199510673672	
483532	195.065838671	0.14279225352	
637936	193.693852934	0.178740696554	
223236	193.587884164	0.220137437512	
837478	191.366154148	0.00186969591437	
227675	191.353702812	0.158916717102	
138746	190.593660936	0.187598029572	
812640	185.192167616	0.17874269182	
298511	183.787752685	0.130617927058	
369102	179.727728681	0.135475026749	
772466	178.3886433	0.0938640196036	
427629	178.387201713	0.119866842024	
655158	174.072424993	0.138794756359	
717644	166.829942601	0.150462736539	
133962	166.75992885	0.118017331481	
260644	163.690364222	0.18989512088	
704396	162.714867653	0.107049766804	
914474	162.167777136	2.751926707	
673065	161.259539667	0.13092755422	
48888	160.731697103	0.14976924862	
564521	158.686370204	0.245358864666	
8316	158.289494389	0.0935660689891	
539241	154.230150306	0.115033602971	
+-----+			

(c) compute the Top 100 nodes with 10, 20, 40, 60, 80, 100 iterations respectively
10 iterations

Triple apply pagerank finished in: 140.061539 secs

__id	pagerank	l1_delta
41909	578.993090466	3.10907468301
597621	578.865033366	3.76650817187
163075	570.020169451	4.20641411302
537039	563.764883738	3.55917837012
384666	493.015733213	2.64418124393
504140	480.369583506	3.24045366279
486980	465.588129258	5.59473821955
605856	455.902873501	4.55152989278
558791	452.482662727	4.20216238705
32163	448.418436129	3.21594030139
551829	446.481844054	5.45759934926
765334	424.25692686	1.5452026017
751384	419.54399499	3.98028735604
425770	393.611550097	2.82765443851
908351	388.246376411	1.89234111654
173976	387.207445794	3.91470433108
7314	378.748524553	3.35856692134
213432	376.095869122	2.7279045819
885605	371.50421724	4.54010740402
691633	369.021850566	3.47879474697
819223	363.482359299	2.05455060453
407610	359.938356466	4.05537619491
452291	358.348416513	1.61898163489
459074	353.02291308	1.91511934168
905628	349.697590094	0.740488182054
828963	348.425717832	3.66222114839
687325	346.214989692	1.52952412389
396321	345.710131345	2.06303184517
172133	334.593278298	2.64338884737
277876	334.439793215	2.96939561772
226374	331.636853707	1.38786983725
599130	322.759267241	3.02989301545
448961	320.359380596	2.4525037738
324502	314.457949011	2.3107143
804489	312.675480981	3.26368421103
726490	306.218668623	1.76083196351
486434	305.277582726	2.97172386066
54147	301.428531471	2.87590254455
323129	300.934741101	3.05995404768
182121	300.574216505	1.84077593486
555924	293.542130045	3.11068763019
621670	292.928296986	1.99854494556
721816	287.679637983	3.03254485739
245186	287.204172597	2.67174008848
57791	286.195158533	3.37865475786
587935	285.93727781	1.46567569723
185067	279.462632632	3.05741281491
74397	276.028264014	3.43159712069
402132	273.571741795	1.62826245604
434134	271.693299028	1.8353379485

870811	271.30456849	2.88180386238	
21682	271.209936486	3.05513829955	
399699	269.670463642	3.02425240702	
191990	268.645521944	1.85457367756	
185821	268.502506023	1.70781047099	
438491	258.307683177	3.52827071391	
183501	250.121451198	2.77043339864	
614831	247.035224499	1.73191525736	
666882	244.526673972	3.40785577328	
846221	244.425802157	2.86214505721	
36292	242.961849839	1.80425214807	
468736	239.822490931	2.03147099857	
699754	238.430245391	2.37978176984	
354640	236.15020828	3.004670575	
187242	231.097089745	2.78812059555	
1536	230.934640302	7.91099350378	
715883	228.084229847	2.5196082993	
596972	227.541522295	2.24328390575	
626893	219.451438351	0.532899093995	
587721	218.518604812	2.24400338284	
232639	217.541107315	0.285646729449	
818382	215.206833886	2.0793858486	
557124	214.899466915	2.34314492696	
466323	209.063614062	1.69148343024	
438493	206.233040326	2.03011345807	
798584	204.9846237	0.447950562986	
495084	204.640725943	0.958202473848	
483532	200.935377151	2.0727826175	
223236	200.743933627	1.82380217689	
522190	200.195012533	0.786855857297	
637936	199.910594371	1.50941551097	
138746	196.109796282	1.42520019724	
227675	195.339804821	0.7882014137	
837478	191.305223694	0.0146614765505	
812640	190.524443415	1.39889779081	
298511	189.201307383	1.94704819071	
772466	182.827079946	1.5476670884	
369102	182.619413998	0.45506399355	
427629	182.546232479	1.37552856305	
260644	178.7691944	1.59306588007	
655158	177.924737231	1.55545011911	
717644	171.531512012	1.29072579344	
133962	169.291927879	0.416296852225	
704396	168.608301537	2.13096499706	
914474	167.325740704	13.9780827082	
673065	166.398582272	1.8660254009	
564521	166.339037012	1.67804658073	
48888	165.298567192	1.2459064683	
8316	162.37779943	1.49548006874	
577518	159.74523386	59.5418458915	
+-----+	+-----+	+-----+	+

20 iterations

Triple apply pagerank finished in: 245.020883 secs

+-----+			
__id	pagerank	ll_delta	
+-----+			
597621	566.295618529	0.47063360727	
41909	565.157596192	0.517123293091	
163075	554.223138085	0.475008648261	
537039	550.982085941	0.418437405617	
384666	482.777994244	0.427023609989	
504140	469.186673359	0.419081022143	
486980	444.956194763	0.55557661939	
605856	440.237558819	0.428568773856	
32163	436.92253417	0.375475630961	
558791	435.225904247	0.501200037774	
551829	430.237698017	0.389080956712	
765334	418.379481548	0.222943983621	
751384	405.459147338	0.381829675243	
425770	382.250589347	0.375375375545	
908351	380.454953155	0.270861736478	
173976	373.729627433	0.417174017285	
7314	367.115866047	0.358687181048	
213432	365.134240445	0.320754552052	
885605	359.334860051	0.219421330349	
819223	356.661891432	0.220083446468	
691633	356.224282512	0.344909049674	
452291	351.006512295	0.300370322719	
407610	347.362630733	0.323040961674	
905628	345.237268245	0.224972469654	
459074	345.16510023	0.2686753956	
687325	339.443327197	0.255119076457	
396321	337.667834307	0.260846927074	
828963	336.201604401	0.335405754065	
226374	325.699992401	0.235726595374	
172133	324.604854454	0.327033194753	
277876	322.981288519	0.355602518128	
599130	311.6663523	0.314445719093	
448961	311.360771675	0.270405734437	
324502	305.95869237	0.260674676001	
804489	301.101272003	0.32655222427	
726490	299.145146516	0.252114898522	
486434	296.580061613	0.237778631991	
182121	292.904228848	0.259777740916	
323129	291.128670295	0.240938267921	
54147	290.863572734	0.253354038605	
621670	285.661398305	0.194971293297	
555924	283.373304488	0.269013462352	
587935	278.544816447	0.270436140543	
245186	278.153407572	0.254100696061	
721816	277.783830514	0.249598082499	
57791	275.727346898	0.269692447967	
185067	269.892610373	0.223504569236	
402132	266.83682927	0.236709362148	
74397	265.974224434	0.223684484494	
434134	264.456780848	0.262527415265	

21682	261.845858463	0.336984544664	
185821	261.834665652	0.173991412323	
191990	261.76258942	0.237867913829	
870811	261.730479171	0.234906897873	
399699	259.909252521	0.268551907565	
438491	248.964265781	0.237609231709	
614831	241.181950669	0.17336640973	
183501	240.044367358	0.260669811152	
846221	237.548100541	0.106124177028	
36292	237.285461062	0.169875021926	
666882	235.575403679	0.169427629934	
1536	233.544710323	0.346165549334	
468736	232.767292985	0.213760145301	
699754	230.526852095	0.20869890426	
354640	227.423017619	0.226170046126	
187242	222.036389918	0.26109285206	
715883	221.278197496	0.156525909067	
596972	220.038738972	0.206179716407	
232639	216.225038215	0.0623145901106	
626893	215.912170333	0.169547888831	
587721	211.237548029	0.168911186774	
818382	208.51894313	0.207761356407	
557124	208.355090614	0.0946165878871	
466323	202.764754317	0.182589929629	
495084	201.059015558	0.053605710544	
798584	200.755793905	0.100360885986	
438493	198.701495137	0.201317910103	
522190	195.691785154	0.199510673672	
483532	195.065838671	0.14279225352	
637936	193.693852934	0.178740696554	
223236	193.587884164	0.220137437512	
837478	191.366154148	0.00186969591437	
227675	191.353702812	0.158916717102	
138746	190.593660936	0.187598029572	
812640	185.192167616	0.17874269182	
298511	183.787752685	0.130617927058	
369102	179.727728681	0.135475026749	
772466	178.3886433	0.0938640196036	
427629	178.387201713	0.119866842024	
655158	174.072424993	0.138794756359	
717644	166.829942601	0.150462736539	
133962	166.75992885	0.118017331481	
260644	163.690364222	0.18989512088	
704396	162.714867653	0.107049766804	
914474	162.167777136	2.751926707	
673065	161.259539667	0.13092755422	
48888	160.731697103	0.14976924862	
564521	158.686370204	0.245358864666	
8316	158.289494389	0.0935660689891	
539241	154.230150306	0.115033602971	
+-----+			

Triple apply pagerank finished in: 558.325935 secs

+-----+			
__id	pagerank	l1_delta	
+-----+			
597621	564.313803439	0.00951044677561	
41909	562.740465903	0.0113813652817	
163075	552.25442072	0.00693194885378	
537039	549.104125545	0.00842960473699	
384666	480.730949295	0.00982627161198	
504140	467.420001433	0.00844157440986	
486980	442.860139081	0.00481797944849	
605856	438.59149205	0.00452828133007	
32163	435.316095259	0.00679855559503	
558791	433.24009802	0.00573986696935	
551829	428.855407419	0.00345019561865	
765334	417.24578466	0.00642617636566	
751384	403.923289176	0.00453268788516	
425770	380.6059519	0.00634561968519	
908351	379.228752081	0.00526752944148	
173976	372.123345275	0.00458844173892	
7314	365.67865571	0.00509046673784	
213432	363.695137317	0.00495040067545	
885605	358.62906365	0.00117535935294	
819223	355.71522665	0.00415727119059	
691633	354.759364908	0.0047032004365	
452291	349.554089852	0.00690794378204	
407610	346.168930131	0.00307079654323	
905628	344.064468933	0.00687011965243	
459074	343.948032839	0.00533002819003	
687325	338.188270419	0.00580452863511	
396321	336.497441456	0.0047906250519	
828963	334.961097189	0.00307256844673	
226374	324.549614875	0.00589678745365	
172133	323.259170123	0.0049333282189	
277876	321.554503562	0.0043871279014	
599130	310.406462872	0.00393489742572	
448961	310.214117216	0.00398087494034	
324502	304.843969825	0.00426444019553	
804489	299.780077528	0.00421943130749	
726490	298.004324243	0.00519167380003	
486434	295.631435204	0.00303841771171	
182121	291.75469505	0.00481335601893	
323129	290.246983373	0.00214218239074	
54147	289.837043515	0.00191317081163	
621670	284.794722468	0.00344444631759	
555924	282.39355075	0.00251634318869	
587935	277.36010085	0.00503639835114	
245186	277.149529809	0.00324758665903	
721816	276.863714478	0.00225403692707	
57791	274.765928946	0.0025682726735	
185067	269.108039714	0.00178685237643	
402132	265.759935294	0.0046243970699	
74397	265.200396806	0.0016799000212	
434134	263.291892475	0.00476641837275	

185821	261.010566494	0.00324806303809	
870811	260.889277216	0.00180468057744	
191990	260.732737366	0.00404510082973	
21682	260.716909458	0.00304643653413	
399699	258.886289438	0.00275866502511	
438491	248.20597805	0.00154713173552	
614831	240.443527928	0.00299013220248	
183501	239.069353946	0.00213662074722	
846221	237.237091889	0.000412185951717	
36292	236.598599708	0.00257525798162	
666882	234.980286796	0.00104047428317	
1536	232.446362684	0.00809261344156	
468736	231.900116473	0.00308174145565	
699754	229.750193906	0.00217691115685	
354640	226.643075866	0.00179979707013	
187242	221.192363087	0.00263778462013	
715883	220.730612345	0.0013028294612	
596972	219.238860098	0.00222140608608	
232639	215.834017637	0.00309809436655	
626893	215.034990226	0.0051200465885	
587721	210.623690587	0.0015938665959	
557124	207.99643542	0.000628921926676	
818382	207.713567124	0.00271524401995	
466323	202.050116869	0.00267134546422	
495084	200.637488289	0.00148148515203	
798584	199.984253076	0.0033834510686	
438493	197.916103336	0.0020213145547	
522190	194.717647587	0.0048420070745	
483532	194.532103433	0.00160969930891	
637936	192.910665678	0.00259495309516	
223236	192.70737273	0.00265298113237	
837478	191.372217599	1.53277196375e-05	
227675	190.596830468	0.00350120724727	
138746	189.7684251	0.00347262976166	
812640	184.408450478	0.00328943665068	
298511	183.304380423	0.00153256932538	
369102	179.029866873	0.00406580545851	
772466	177.915635307	0.00192080718725	
427629	177.864952237	0.00227591618548	
655158	173.670432927	0.00270431032104	
717644	166.174664118	0.00277636130321	
133962	166.15217134	0.00353847175282	
260644	162.445064856	0.00223913001159	
704396	162.36665216	0.000644832478628	
914474	160.952385881	0.106663388742	
673065	160.785200103	0.00112479323414	
48888	160.075387729	0.00276581881161	
8316	157.93163039	0.00106855429775	
564521	157.693088962	0.00286602224102	
839863	155.956633033	0.453228954527	
+-----+			

Triple apply pagerank finished in: 753.401312 secs

+-----+			
__id	pagerank	l1_delta	
+-----+			
597621	564.271535257	0.000201757702257	
41909	562.687396708	0.000252045747061	
163075	552.224556163	0.000115551772296	
537039	549.065129165	0.000182473318091	
384666	480.685492629	0.00021001649958	
504140	467.382884029	0.000174960991956	
486980	442.840389317	5.28603201246e-05	
605856	438.573469041	5.47317615087e-05	
32163	435.285372089	0.000141108070125	
558791	433.216697906	7.57018816557e-05	
551829	428.841769499	4.40162231143e-05	
765334	417.21408656	0.000176133564537	
751384	403.904316518	6.494631333e-05	
425770	380.578178654	0.000108558307204	
908351	379.204849351	0.000107262258211	
173976	372.105160544	5.73062037006e-05	
7314	365.657372019	8.28095719498e-05	
213432	363.672697495	8.09399103332e-05	
885605	358.624650163	1.14145420866e-05	
819223	355.696236306	8.97483052995e-05	
691633	354.739209268	7.44562053114e-05	
452291	349.52198216	0.000147659212928	
407610	346.156789538	3.64186391266e-05	
905628	344.030457977	0.000187901577647	
459074	343.923752969	0.00011008055759	
687325	338.160699243	0.000125471225374	
396321	336.475539885	9.22097232205e-05	
828963	334.949331931	3.25316224234e-05	
226374	324.52145443	0.000136977859938	
172133	323.238727818	7.9582714136e-05	
277876	321.536424593	6.2404884261e-05	
599130	310.390029854	5.92116895746e-05	
448961	310.196843875	6.61931436525e-05	
324502	304.82497881	8.1788161026e-05	
804489	299.762514791	6.14181111587e-05	
726490	297.980469318	0.000111422360646	
486434	295.618800003	4.41610571329e-05	
182121	291.732832284	9.91075087313e-05	
323129	290.238654789	2.36761355268e-05	
54147	289.827823218	1.31413362396e-05	
621670	284.778995356	6.83693555175e-05	
555924	282.383823378	3.12521550541e-05	
587935	277.338884469	8.86740090777e-05	
245186	277.135853683	5.08673159629e-05	
721816	276.854916596	2.52619816479e-05	
57791	274.755367711	4.06383984455e-05	
185067	269.101115775	2.13793928765e-05	
402132	265.738921496	9.21518776522e-05	
74397	265.193888239	2.00436410296e-05	
434134	263.271095477	8.31190864687e-05	

185821	260.995640604	6.51932339224e-05	
870811	260.882507978	1.75946291279e-05	
191990	260.715152384	6.81183026927e-05	
21682	260.705661378	3.63329324387e-05	
399699	258.875422328	3.21311741232e-05	
438491	248.200551647	1.55150537751e-05	
614831	240.429962745	6.22339240124e-05	
183501	239.060752546	2.46392999088e-05	
846221	237.235637532	3.56622635422e-06	
36292	236.587550315	4.62943926607e-05	
666882	234.976070598	9.30179473357e-06	
1536	232.406942016	0.000215461240401	
468736	231.88678508	5.24419853889e-05	
699754	229.741698548	2.91454821308e-05	
354640	226.636342804	1.86205810166e-05	
187242	221.184764954	3.30449468038e-05	
715883	220.725555565	1.65906849361e-05	
596972	219.229809263	2.72022431602e-05	
232639	215.817306353	0.000110724883513	
626893	215.009619784	0.000140460115716	
587721	210.617682971	1.98643967337e-05	
557124	207.993793516	8.88433754653e-06	
818382	207.702348597	4.05980661071e-05	
466323	202.038767569	4.63313934631e-05	
495084	200.627057346	4.57719598046e-05	
798584	199.963369748	0.000102018486444	
438493	197.90799974	2.40697156073e-05	
522190	194.694909039	0.000108514086747	
483532	194.525419713	2.43616435114e-05	
637936	192.899409452	4.22486163814e-05	
223236	192.696448704	3.76231781729e-05	
837478	191.372057906	1.98021336928e-06	
227675	190.580733687	7.40521393254e-05	
138746	189.752589326	7.24999268584e-05	
812640	184.39344842	6.86982854177e-05	
298511	183.297806573	2.65187532307e-05	
369102	179.009705079	0.000111496231739	
772466	177.905831573	4.72862115828e-05	
427629	177.854504395	4.85274977109e-05	
655158	173.660232721	7.03378109677e-05	
717644	166.161920281	5.91356373434e-05	
133962	166.134623651	9.70060366399e-05	
260644	162.435773721	2.86435151793e-05	
704396	162.364091691	8.49385321544e-06	
914474	160.905277886	0.00413422293161	
673065	160.780919165	1.1903824003e-05	
48888	160.062763044	5.7907802443e-05	
8316	157.927064592	1.7617554164e-05	
564521	157.681493354	3.71014833433e-05	
839863	156.158709141	0.0175748940118	
+-----+			

Triple apply pagerank finished in: 1065.954587 secs

+-----+			
__id	pagerank	l1_delta	
+-----+			
597621	564.270616621	4.37201890691e-06	
41909	562.686220968	5.59637805964e-06	
163075	552.224045041	2.13286955386e-06	
537039	549.064282845	3.98455256345e-06	
384666	480.684524203	4.47088831379e-06	
504140	467.382100818	3.65159820603e-06	
486980	442.840158013	7.16868839845e-07	
605856	438.573245972	7.31662794351e-07	
32163	435.284720628	3.0854747024e-06	
558791	433.216377286	1.12628413262e-06	
551829	428.841586914	6.67089125272e-07	
765334	417.213222333	4.77009018596e-06	
751384	403.904039346	1.02628581544e-06	
425770	380.577700466	1.89950651475e-06	
908351	379.204355021	2.32186130233e-06	
173976	372.104923546	8.44598218919e-07	
7314	365.657018047	1.44946000091e-06	
213432	363.672314778	1.36267868811e-06	
885605	358.624602735	1.62596734299e-07	
819223	355.695820093	1.99868054551e-06	
691633	354.738885584	1.27165509411e-06	
452291	349.521298753	3.14552067948e-06	
407610	346.156638218	5.18547835782e-07	
905628	344.029532209	5.07857976118e-06	
459074	343.923246983	2.33457882359e-06	
687325	338.160109326	2.70325665497e-06	
396321	336.475111443	1.84862039987e-06	
828963	334.949201855	4.12421172769e-07	
226374	324.520800301	3.14893958375e-06	
172133	323.238396823	1.36810524509e-06	
277876	321.53615741	1.0351143942e-06	
599130	310.389772928	1.04040174165e-06	
448961	310.196552214	1.17915493547e-06	
324502	304.824606527	1.6848267137e-06	
804489	299.762253452	9.87440841982e-07	
726490	297.979951217	2.47936003461e-06	
486434	295.618612514	6.97304471942e-07	
182121	291.732372883	2.18451185674e-06	
323129	290.238559686	2.99331702536e-07	
54147	289.827726754	4.84067186335e-08	
621670	284.778684525	1.36879765478e-06	
555924	282.383697226	4.85650616611e-07	
587935	277.338511437	1.58751726076e-06	
245186	277.13563224	8.92163427579e-07	
721816	276.854811713	3.47200113993e-07	
57791	274.75518302	8.79067840742e-07	
185067	269.101027483	3.2297538155e-07	
402132	265.738501067	1.87126562423e-06	
74397	265.193803613	3.25533221712e-07	
434134	263.270730987	1.48834902802e-06	

185821	260.995342912	1.3356465729e-06	
870811	260.882438099	2.19585103878e-07	
191990	260.714853669	1.1686611856e-06	
21682	260.705516562	5.18374918101e-07	
399699	258.87529205	4.25768234891e-07	
438491	248.200492283	2.11870457179e-07	
614831	240.429672309	1.42695671457e-06	
183501	239.060646837	3.85257038715e-07	
846221	237.235623248	4.87511329084e-08	
36292	236.587348551	9.03688288645e-07	
666882	234.976026901	1.15021776992e-07	
1536	232.40592709	5.23727950963e-06	
468736	231.886553587	9.59355162422e-07	
699754	229.741582202	4.58084912225e-07	
354640	226.636268223	2.42091175551e-07	
187242	221.184681306	5.00365246126e-07	
715883	220.725486406	2.78050009683e-07	
596972	219.229690104	3.90963407426e-07	
232639	215.816732034	3.54837371219e-06	
626893	215.00892739	3.80299042035e-06	
587721	210.617605905	2.9931348422e-07	
557124	207.993755112	1.59106406272e-07	
818382	207.702174676	6.81371318478e-07	
466323	202.038564282	8.52408930996e-07	
495084	200.626770787	1.32758663085e-06	
798584	199.962787267	2.91182792012e-06	
438493	197.907899822	3.45799861634e-07	
522190	194.694401026	2.41236818965e-06	
483532	194.525313412	4.42158324176e-07	
637936	192.899223482	7.58426267566e-07	
223236	192.69628721	6.30559867432e-07	
837478	191.372046484	8.42375982302e-08	
227675	190.5803906	1.6210394449e-06	
138746	189.752253094	1.59070017958e-06	
812640	184.393129789	1.50768821072e-06	
298511	183.297687665	5.20998895581e-07	
369102	179.009154914	3.0189453355e-06	
772466	177.905601314	1.12025571752e-06	
427629	177.854281406	1.03911494875e-06	
655158	173.659947653	1.84976354944e-06	
717644	166.161645226	1.30857736735e-06	
133962	166.134144912	2.62650172544e-06	
260644	162.43565496	4.10598460121e-07	
704396	162.364054473	1.56560560072e-07	
914474	160.903452002	0.000160240542215	
673065	160.780871637	1.55453477646e-07	
48888	160.062494413	1.27162857666e-06	
8316	157.926986135	3.34623024401e-07	
564521	157.681338924	5.46459432371e-07	
839863	156.166505654	0.000681339508446	
+-----+	+-----+	+-----+	+

100 iterations

Triple apply pagerank finished in: 1302.781387 secs

+-----+			
__id	pagerank	l1_delta	
+-----+			
597621	564.270596463	9.60905026659e-08	
41909	562.686194849	1.24611801766e-07	
163075	552.224035356	4.35433094026e-08	
537039	549.06426436	8.72225882631e-08	
384666	480.684503557	9.59361159403e-08	
504140	467.382084292	7.66702328292e-08	
486980	442.840154755	1.18169509733e-08	
605856	438.573242911	1.09368443191e-08	
32163	435.284706251	6.90520778335e-08	
558791	433.216372347	1.84276132131e-08	
551829	428.841584053	1.14980593935e-08	
765334	417.213198953	1.28685258005e-07	
751384	403.904034893	1.75197669705e-08	
425770	380.577692	3.43592887475e-08	
908351	379.204344159	5.29706767338e-08	
173976	372.104919892	1.47351784108e-08	
7314	365.657011743	2.69150177701e-08	
213432	363.67230784	2.27789200835e-08	
885605	358.624602013	2.93033508569e-09	
819223	355.695810769	4.50879724667e-08	
691633	354.738879983	2.30014620684e-08	
452291	349.521284188	6.75121896165e-08	
407610	346.156635958	8.80982042872e-09	
905628	344.02950722	1.3686587863e-07	
459074	343.923236199	5.02532770952e-08	
687325	338.160096645	5.85119437346e-08	
396321	336.475102699	3.88619696423e-08	
828963	334.949200119	6.4598566496e-09	
226374	324.520785177	7.2972113685e-08	
172133	323.238391096	2.53888856605e-08	
277876	321.536152824	1.95655047719e-08	
599130	310.389768236	2.11557562579e-08	
448961	310.196546962	2.20778133553e-08	
324502	304.82459877	3.60553258361e-08	
804489	299.76224913	1.78059735845e-08	
726490	297.979939587	5.67499114368e-08	
486434	295.618609489	1.20263621284e-08	
182121	291.732362628	5.01809722664e-08	
323129	290.238558444	4.38137703895e-09	
54147	289.827725521	8.9966079031e-10	
621670	284.778678299	2.76864398074e-08	
555924	282.383695222	9.01292196431e-09	
587935	277.338504703	2.96475377581e-08	
245186	277.135628267	1.69782765624e-08	
721816	276.85481016	6.00721250521e-09	
57791	274.755178821	2.19607159124e-08	
185067	269.101026086	5.75903413846e-09	
402132	265.738492485	3.8707355543e-08	
74397	265.193802165	6.27011331744e-09	
434134	263.270724382	2.79806613435e-08	

185821	260.995336793	2.7928081181e-08	
870811	260.882437178	3.37843175657e-09	
191990	260.714848486	2.07444372791e-08	
21682	260.705514385	8.4037878878e-09	
399699	258.875290261	6.59207444187e-09	
438491	248.200491421	3.4306424368e-09	
614831	240.429665529	3.47485524799e-08	
183501	239.060645135	7.13006897968e-09	
846221	237.235623038	8.77065531313e-10	
36292	236.587344601	1.86447834949e-08	
666882	234.976026253	2.05255901164e-09	
1536	232.405902702	1.2242963976e-07	
468736	231.886549275	1.89222078006e-08	
699754	229.741580355	8.10609890323e-09	
354640	226.636267196	3.80336473427e-09	
187242	221.184680159	8.69960103955e-09	
715883	220.725485181	5.50818413103e-09	
596972	219.229688231	6.72460487294e-09	
232639	215.816713956	1.0770213521e-07	
626893	215.008908672	1.02592281337e-07	
587721	210.617604699	5.34154764864e-09	
557124	207.993754411	3.12576275974e-09	
818382	207.702171665	1.27542989503e-08	
466323	202.038560483	1.62504250056e-08	
495084	200.626762996	3.74947717319e-08	
798584	199.962771315	8.11850782156e-08	
438493	197.907898321	6.02926775173e-09	
522190	194.694389727	5.36779225513e-08	
483532	194.525311395	9.42389988268e-09	
637936	192.899220066	1.47903165271e-08	
223236	192.696284404	1.20683125715e-08	
837478	191.372046038	2.86343038169e-09	
227675	190.580383022	3.66412109543e-08	
138746	189.752245668	3.56343718977e-08	
812640	184.39312275	3.37815890816e-08	
298511	183.297685282	1.09193649678e-08	
369102	179.009140042	8.14507359337e-08	
772466	177.905595961	2.58254999608e-08	
427629	177.854276627	2.2342135253e-08	
655158	173.659939831	4.87852389597e-08	
717644	166.16163911	2.94121775823e-08	
133962	166.134131971	7.08635923274e-08	
260644	162.435653221	6.44536157779e-09	
704396	162.364053756	3.3495837215e-09	
914474	160.903381232	6.21084811314e-06	
673065	160.780870983	2.49579557021e-09	
48888	160.062488476	2.84976238163e-08	
8316	157.926984614	6.85543000145e-09	
564521	157.681336587	8.9577270046e-09	
839863	156.166807205	2.64109351349e-05	
+-----+			

The top 100 (pagerank) change a lot in the initial period.

Gradually the place of them change a little, and the value of pagerank are stable.

