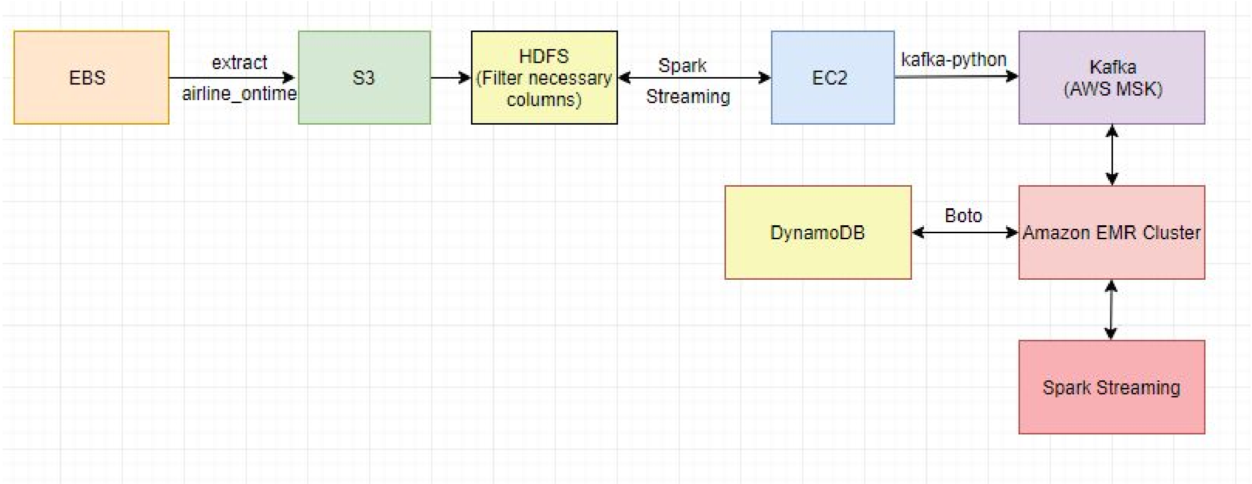
Overall Design



- For Task 2, I have adopted Kafka + Spark Streaming
- Airline_ontime folder is unzipped to S3.
- Relevant columns from CSV are filtered and stored in HDFS which is then streamed to EC2. EC2 instance then writes the data to Kafka topic
- AWS MSK is used to set up a Kafka Cluster with replication factor = 3 one m5.x2large node in each of the 3 regions. Kafka version used in 2.1.0
- Data in Kafka topic is consumed by EMR cluster, task2 queries are processed and the results stored in DynamoDB using boto python library.

Data Extraction

EBS Volume is mounted on EC2 and then only the required folder (airline_ontime) is unzipped to S3.

```
./ebs_to_s3.sh $EBS_MOUNTED_FOLDER $S3_BUCKET
```

Source
Extraction Script

Data in S3 is copied to HDFS and relevant columns filtered using spark streaming

Source
streamFiltering.py (discards cancelled flights)
streamFilteringWithCancelled.py (includes cancelled flights)
streamFiltering_2008.py (includes info only for 2008 flights and discards cancelled flights)

- Filtered data is moved to kafka cluster under different topics. Kafka-python library is used for this

  Some optimization flags used to prevent data drop and speed up write

  ```
  batch_size=98304 (default batch size is 16k)
  linger_ms=100
  acks='all' (acks set to false by default)
  ```

  Source
  kafkaProducer.py
  kafkaProducer_2008.py

- Kafka Consumer is EMR cluster with Spark 2.4.2 which reads from the topics and stores final answers in dynaoDB

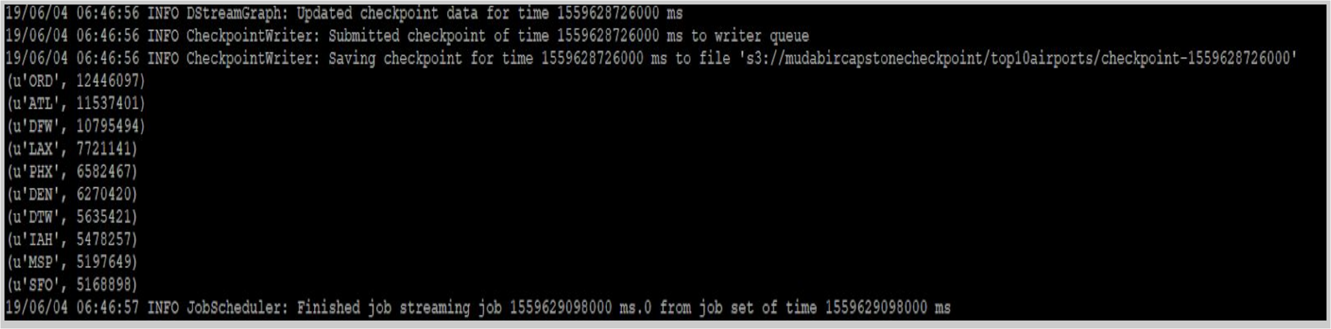
Problem 1.1

Strategy:

1. map() each airport_id to (airport_id,1)
2. reduce() count for each airport_id to get (airport_id,count)
3. filter out top 10 airports with highest counts

```
spark-submit --executor-memory 6g --packages
org.apache.spark:spark-streaming-kafka-0-8_2.11:2.1.0 --conf
spark.streaming.backpressure.enabled=true --conf
spark.streaming.kafka.maxRatePerPartition=250000 g1_1.py
```

Source:
g1_1.py
Results:
Format: (AirportID, Count)



```
19/06/04 06:46:56 INFO DStreamGraph: Updated checkpoint data for time 1559628726000 ms
19/06/04 06:46:56 INFO CheckpointWriter: Submitted checkpoint of time 1559628726000 ms to writer queue
19/06/04 06:46:56 INFO CheckpointWriter: Saving checkpoint for time 1559628726000 ms to file 's3://mudabircapstonecheckpoint/top10airports/checkpoint-1559628726000'
(u'ORD', 12446097)
(u'ATL', 11537401)
(u'DFW', 10795494)
(u'LAX', 7721141)
(u'PHX', 6582467)
(u'DEN', 6270420)
(u'DTW', 5635421)
(u'IAH', 5478257)
(u'MSP', 5197649)
(u'SFO', 5168898)
19/06/04 06:46:57 INFO JobScheduler: Finished job streaming job 1559629098000 ms.0 from job set of time 1559629098000 ms
```

Problem 1.2

Strategy

1) Filter for all non cancelled flights and map (flightID, ArrivalDelay)
2) Get (flightID, (`delaySum,count,avgArrivalDelay`) //see updateStateByKey
3) Filter top 10 flights with best Arrival delay

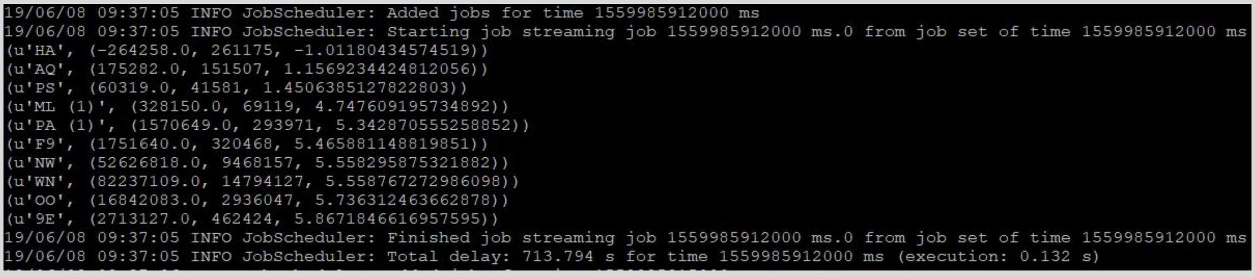
Source:

g1_2.py

Results:

Format: FlightID [totalDepDelay, totalCount, AvgArrivalDelay]

(u'HA', (-264258.0, 261175, -1.01180434574519))
(u'AQ', (175282.0, 151507, 1.1569234424812056))
(u'PS', (60319.0, 41581, 1.4506385127822803))
(u'ML (1)', (328150.0, 69119, 4.747609195734892))
(u'PA (1)', (1570649.0, 293971, 5.342870555258852))
(u'F9', (1751640.0, 320468, 5.465881148819851))
(u'NW', (52626818.0, 9468157, 5.558295875321882))
(u'WN', (82237109.0, 14794127, 5.558767272986098))
(u'OO', (16842083.0, 2936047, 5.736312463662878))
(u'9E', (2713127.0, 462424, 5.8671846616957595))



```
19/06/08 09:37:05 INFO JobScheduler: Added jobs for time 1559985912000 ms
19/06/08 09:37:05 INFO JobScheduler: Starting job streaming job 1559985912000 ms.0 from job set of time 1559985912000 ms
(u'HA', (-264258.0, 261175, -1.01180434574519))
(u'AQ', (175282.0, 151507, 1.1569234424812056))
(u'PS', (60319.0, 41581, 1.4506385127822803))
(u'ML (1)', (328150.0, 69119, 4.747609195734892))
(u'PA (1)', (1570649.0, 293971, 5.342870555258852))
(u'F9', (1751640.0, 320468, 5.465881148819851))
(u'NW', (52626818.0, 9468157, 5.558295875321882))
(u'WN', (82237109.0, 14794127, 5.558767272986098))
(u'OO', (16842083.0, 2936047, 5.736312463662878))
(u'9E', (2713127.0, 462424, 5.8671846616957595))
19/06/08 09:37:05 INFO JobScheduler: Finished job streaming job 1559985912000 ms.0 from job set of time 1559985912000 ms
19/06/08 09:37:05 INFO JobScheduler: Total delay: 713.794 s for time 1559985912000 ms (execution: 0.132 s)
```

Problem 2.1

```
'''
        The incoming data format is
        Year|Month|date|DayofWeek|UniqueCarrier|FlightNum|Origin|Dest|CRSDeptime|DepD
        elay|ArrDelay
        '''
```

(For each origin airport X, rank top 10 carriers in decreasing order of ontime departure)

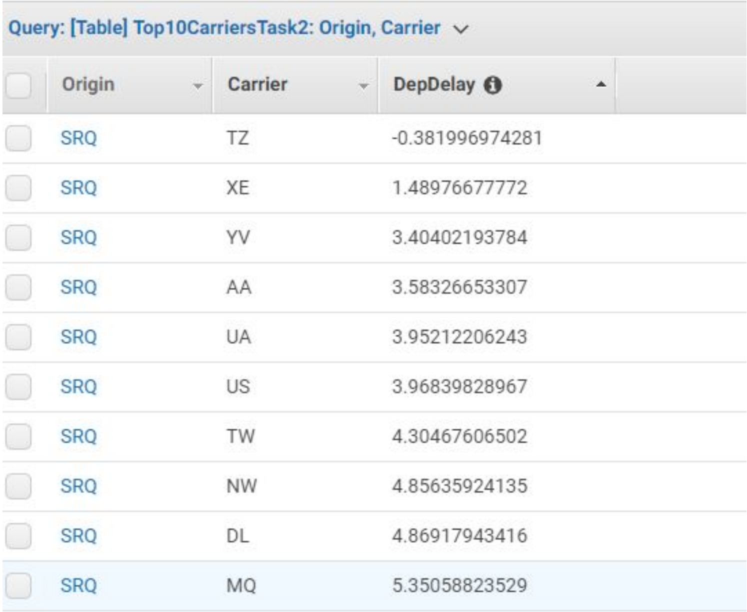
Strategy:

1) Filter for all non cancelled flights and map ((OriginAirport,carrier), DepDelay)
2) Get ((OriginAirpor,carrier), (depDelaySum,count, avgDepDelay)) // see `flightsDelay.updateStateByKey(updateFunction)`
3) For each OriginAirport, filter 10 best carriers in terms of Dep delay
4) Store results in dynamoDB
    - Main DB has OriginAirport as Partition key and Carrier as Sort key
    - Also created a Secondary index mapped to main DB with Partition key as OriginAirport and sort key as DepDelay. Hence querying the Secondary index returns results sorted in increasing order of DepDelay.

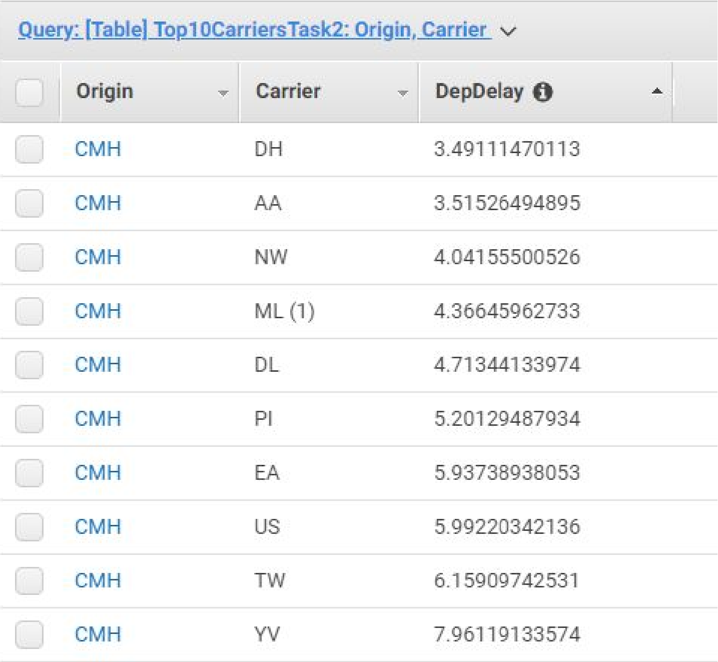
Source:

g2_1.py

Results:

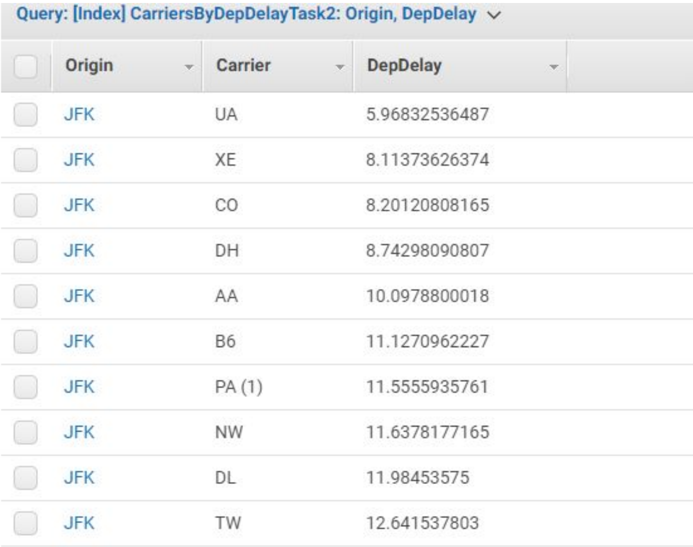


□	Origin	Carrier	DepDelay
□	SRQ	TZ	-0.381996974281
□	SRQ	XE	1.48976677772
□	SRQ	YV	3.40402193784
□	SRQ	AA	3.58326653307
□	SRQ	UA	3.95212206243
□	SRQ	US	3.96839828967
□	SRQ	TW	4.30467606502
□	SRQ	NW	4.85635924135
□	SRQ	DL	4.86917943416
□	SRQ	MQ	5.35058823529



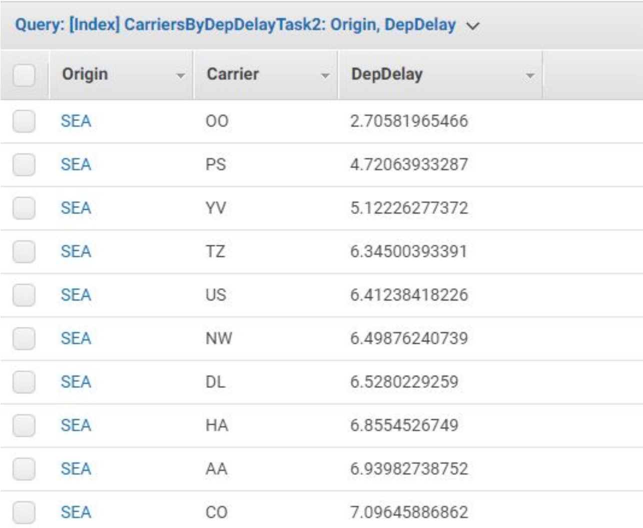
Query: [Table] Top10CarriersTask2: Origin, Carrier

□	Origin	Carrier	DepDelay
□	CMH	DH	3.49111470113
□	CMH	AA	3.51526494895
□	CMH	NW	4.04155500526
□	CMH	ML (1)	4.36645962733
□	CMH	DL	4.71344133974
□	CMH	PI	5.20129487934
□	CMH	EA	5.93738938053
□	CMH	US	5.99220342136
□	CMH	TW	6.15909742531
□	CMH	YV	7.96119133574



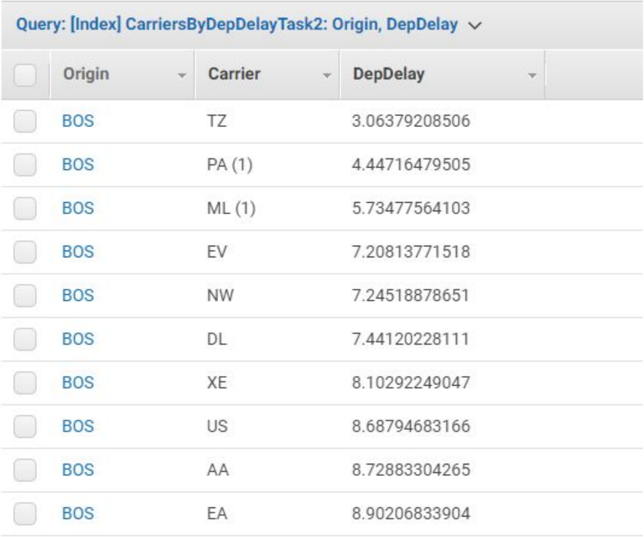
Query: [Index] CarriersByDepDelayTask2: Origin, DepDelay

□	Origin	Carrier	DepDelay
□	JFK	UA	5.96832536487
□	JFK	XE	8.11373626374
□	JFK	CO	8.20120808165
□	JFK	DH	8.74298090807
□	JFK	AA	10.0978800018
□	JFK	B6	11.1270962227
□	JFK	PA (1)	11.5555935761
□	JFK	NW	11.6378177165
□	JFK	DL	11.98453575
□	JFK	TW	12.641537803



Query: [Index] CarriersByDepDelayTask2: Origin, DepDelay

□	Origin	Carrier	DepDelay
□	SEA	OO	2.70581965466
□	SEA	PS	4.72063933287
□	SEA	YV	5.12226277372
□	SEA	TZ	6.34500393391
□	SEA	US	6.41238418226
□	SEA	NW	6.49876240739
□	SEA	DL	6.5280229259
□	SEA	HA	6.8554526749
□	SEA	AA	6.93982738752
□	SEA	CO	7.09645886862



Query: [Index] CarriersByDepDelayTask2: Origin, DepDelay

□	Origin	Carrier	DepDelay
□	BOS	TZ	3.06379208506
□	BOS	PA (1)	4.44716479505
□	BOS	ML (1)	5.73477564103
□	BOS	EV	7.20813771518
□	BOS	NW	7.24518878651
□	BOS	DL	7.44120228111
□	BOS	XE	8.10292249047
□	BOS	US	8.68794683166
□	BOS	AA	8.72883304265
□	BOS	EA	8.90206833904

Problem 2.2

Strategy:

Same as problem 2.1 except replace carrier with DestAirport

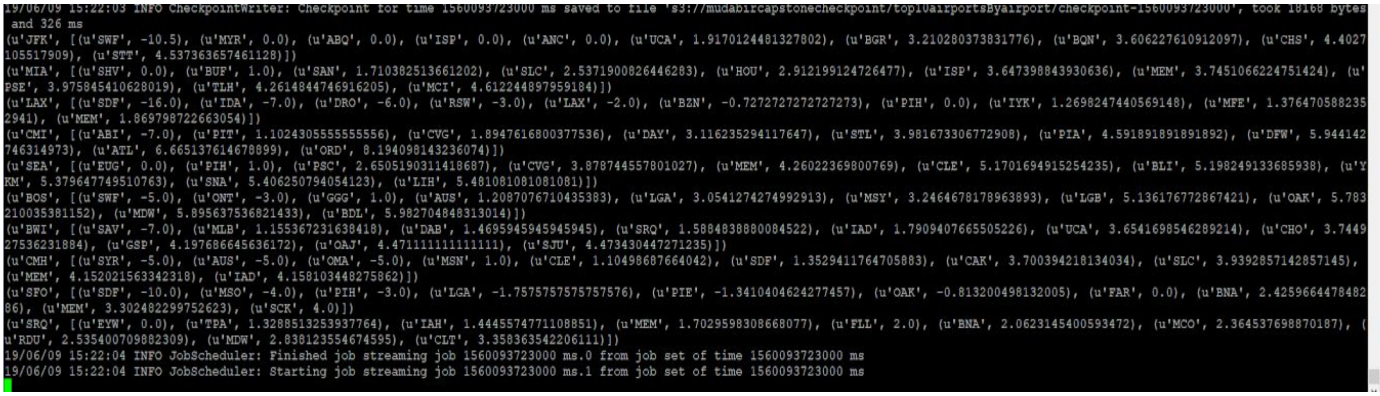
Source:

g2_2.py

Result:

Output format:

Origin, ((dest1, delay), (dest2,delay)....)

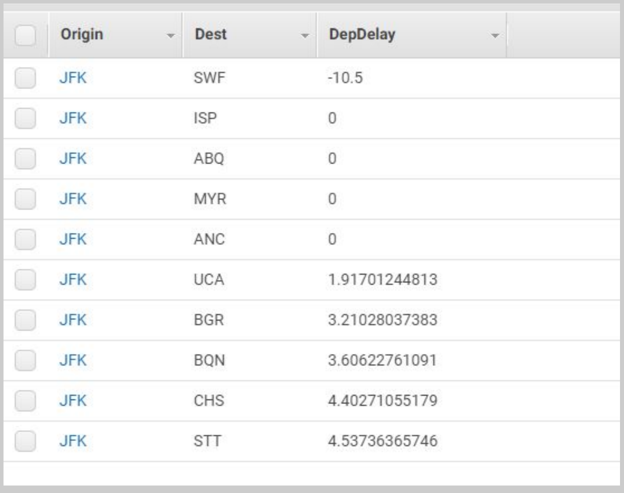


```
19/06/09 15:22:03 INFO CheckpointWriter: Checkpoint for time 1560093723000 ms saved to file 's3://mudabircapstonecheckpoint/top10airportsByairport/checkpoint-1560093723000', took 18168 bytes
 and 326 ms
(u'JFK', [(u'SWF', -10.5), (u'MYR', 0.0), (u'ABQ', 0.0), (u'ISP', 0.0), (u'ANC', 0.0), (u'UCA', 1.9170124481327802), (u'BGR', 3.210280373831776), (u'BQN', 3.606227610912097), (u'CHS', 4.4027
105517909), (u'STT', 4.537363657461128)])
(u'MIA', [(u'SHV', 0.0), (u'BUF', 1.0), (u'SAN', 1.710382513661202), (u'SLC', 2.5371900826446283), (u'HOU', 2.912199124726477), (u'ISP', 3.647398843930636), (u'MEM', 3.7451066224751424), (u'
PSE', 3.975845410628019), (u'TLH', 4.2614844746916205), (u'MCI', 4.612244897959184)])
(u'LAX', [(u'SDF', -16.0), (u'IDA', -7.0), (u'DRO', -6.0), (u'RSW', -3.0), (u'LAX', -2.0), (u'BZN', -0.7272727272727273), (u'PIH', 0.0), (u'IYK', 1.2698247440569148), (u'MFE', 1.376470588235
2941), (u'MEM', 1.869798722663054)])
(u'CMI', [(u'ABI', -7.0), (u'PIT', 1.1024305555555556), (u'CVG', 1.8947616800377536), (u'DAY', 3.116235294117647), (u'STL', 3.981673306772908), (u'PIA', 4.591891891891892), (u'DFW', 5.944142
746314973), (u'ATL', 6.665137614678899), (u'ORD', 8.194098143236074)])
(u'SEA', [(u'EUG', 0.0), (u'PIH', 1.0), (u'PSC', 2.6505190311418687), (u'CVG', 3.878744557801027), (u'MEM', 4.26022369800769), (u'CLE', 5.1701694915254235), (u'BLI', 5.198249133685938), (u'Y
KM', 5.379647749510763), (u'SNA', 5.406250794054123), (u'LIH', 5.481081081081081)])
(u'BOS', [(u'SWF', -5.0), (u'ONT', -3.0), (u'GGG', 1.0), (u'AUS', 1.2087076710435383), (u'LGA', 3.0541274274992913), (u'MSY', 3.2464678178963893), (u'LGB', 5.136176772867421), (u'OAK', 5.783
210035381152), (u'MDW', 5.895637536821433), (u'BDL', 5.982704848313014)])
(u'BWI', [(u'SAV', -7.0), (u'MLB', 1.155367231638418), (u'DAB', 1.4695945945945945), (u'SRQ', 1.5884838880084522), (u'IAD', 1.7909407665505226), (u'UCA', 3.6541698546289214), (u'CHO', 3.7449
27536231884), (u'GSP', 4.197686645636172), (u'OAJ', 4.471111111111111), (u'SJU', 4.473430447271235)])
(u'CMH', [(u'SYR', -5.0), (u'AUS', -5.0), (u'OMA', -5.0), (u'MSN', 1.0), (u'CLE', 1.10498687664042), (u'SDF', 1.3529411764705883), (u'CAK', 3.700394218134034), (u'SLC', 3.9392857142857145),
(u'MEM', 4.152021563342318), (u'IAD', 4.158103448275862)])
(u'SFO', [(u'SDF', -10.0), (u'MSO', -4.0), (u'PIH', -3.0), (u'LGA', -1.7575757575757576), (u'PIE', -1.341040462427457), (u'OAK', -0.813200498132005), (u'FAR', 0.0), (u'BNA', 2.4259664478482
86), (u'MEM', 3.302482299752623), (u'SCK', 4.0)])
(u'SRQ', [(u'EYW', 0.0), (u'TPA', 1.3288513253937764), (u'IAH', 1.4445574771108851), (u'MEM', 1.702959830866077), (u'FLL', 2.0), (u'BNA', 2.0623145400593472), (u'MCO', 2.364537698870187), (
u'RDU', 2.535400709882309), (u'MDW', 2.838123554674595), (u'CLT', 3.358363542206111)])
19/06/09 15:22:04 INFO JobScheduler: Finished job streaming job 1560093723000 ms.0 from job set of time 1560093723000 ms
19/06/09 15:22:04 INFO JobScheduler: Starting job streaming job 1560093723000 ms.1 from job set of time 1560093723000 ms
```

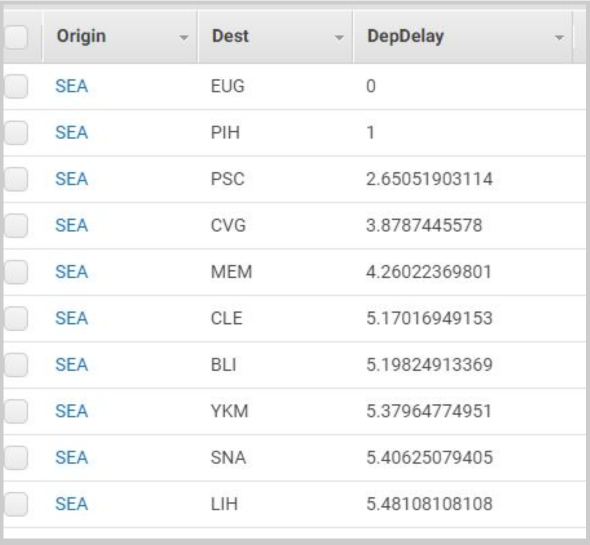
From logs:

```
 and 322 ms
(u'JFK', [(u'SWF', -10.5), (u'MYR', 0.0), (u'ABQ', 0.0), (u'ISP', 0.0), (u'ANC', 0.0), (u'UCA', 1.9170124481327802), (u'BGR', 3.210280373831776), (u'BQN', 3.606227610912097), (u'CHS', 4.4027105517909), (u'STT', 4.537363657461128)])
(u'MIA', [(u'SHV', 0.0), (u'BUF', 1.0), (u'SAN', 1.710382513661202), (u'SLC', 2.5371900826446283), (u'HOU', 2.912199124726477), (u'ISP', 3.647398843930636), (u'MEM', 3.7451066224751424), (u'PSE', 3.975845410628019), (u'TLH', 4.2614844746916205), (u'MCI', 4.612244897959184)])
(u'LAX', [(u'SDF', -16.0), (u'IDA', -7.0), (u'DRO', -6.0), (u'RSW', -3.0), (u'LAX', -2.0), (u'BZN', -0.7272727272727273), (u'PIH', 0.0), (u'IYK', 1.2698247440569148), (u'MFE', 1.3764705882352941), (u'MEM', 1.869798722663054)])
(u'CMI', [(u'ABI', -7.0), (u'PIT', 1.1024305555555556), (u'CVG', 1.8947616800377536), (u'DAY', 3.116235294117647), (u'STL', 3.981673306772908), (u'PIA', 4.591891891891892), (u'DFW', 5.944142746314973), (u'ATL', 6.665137614678899), (u'ORD', 8.194098143236074)])
(u'SEA', [(u'EUG', 0.0), (u'PIH', 1.0), (u'PSC', 2.6505190311418687), (u'CVG', 3.878744557801027), (u'MEM', 4.26022369800769), (u'CLE', 5.1701694915254235), (u'BLI', 5.198249133685938), (u'YKM', 5.379647749510763), (u'SNA', 5.406250794054123), (u'LIH', 5.481081081081081)])
(u'BOS', [(u'SWF', -5.0), (u'ONT', -3.0), (u'GGG', 1.0), (u'AUS', 1.2087076710435383), (u'LGA', 3.0541274274992913), (u'MSY', 3.2464678178963893), (u'LGB', 5.136176772867421), (u'OAK', 5.783210035381152), (u'MDW', 5.895637536821433), (u'BDL', 5.982704848313014)])
(u'BWI', [(u'SAV', -7.0), (u'MLB', 1.155367231638418), (u'DAB', 1.4695945945945945), (u'SRQ', 1.5884838880084522), (u'IAD', 1.7909407665505226), (u'UCA', 3.6541698546289214), (u'CHO', 3.744927536231884), (u'GSP', 4.197686645636172), (u'OAJ', 4.471111111111111), (u'SJU', 4.473430447271235)])
(u'CMH', [(u'SYR', -5.0), (u'AUS', -5.0), (u'OMA', -5.0), (u'MSN', 1.0), (u'CLE', 1.10498687664042), (u'SDF', 1.3529411764705883), (u'CAK', 3.700394218134034), (u'SLC', 3.9392857142857145), (u'MEM', 4.152021563342318), (u'IAD', 4.158103448275862)])
(u'SFO', [(u'SDF', -10.0), (u'MSO', -4.0), (u'PIH', -3.0), (u'LGA', -1.7575757575757576), (u'PIE', -1.341040462427457), (u'OAK', -0.813200498132005), (u'FAR', 0.0), (u'BNA', 2.425966447848286), (u'MEM', 3.302482299752623), (u'SCK', 4.0)])
```

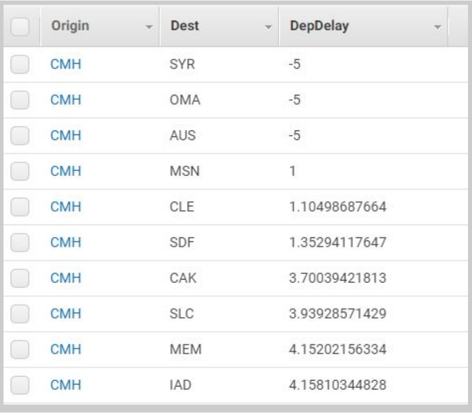
```
(u'SRQ', [(u'EYW', 0.0), (u'TPA', 1.3288513253937764), (u'IAH', 1.4445574771108851),
(u'MEM', 1.7029598308668077), (u'FLL', 2.0), (u'BNA', 2.0623145400593472), (u'MCO',
2.364537698870187), (u'RDU', 2.535400709882309), (u'MDW', 2.838123554674595), (u'CLT',
3.358363542206111)])
19/06/09 15:21:24 INFO JobScheduler: Finished job streaming job 1560093684000 ms.0 from
job set of time 1560093684000 ms
19/06/09 15:21:24 INFO JobScheduler: Starting job streaming job 1560093684000 ms.1 from
job set of time 1560093684000 ms
19/06/09 15:21:25 INFO JobScheduler: Finished job streaming job 1560093684000 ms.1 from
job set of time 1560093684000 ms
19/06/09 15:21:25 INFO JobScheduler: Total delay: 1.318 s for time 1560093684000 ms
(execution: 1.206 s)
19/06/09 15:21:25 INFO KafkaRDD: Removing RDD 21220 from persistence list
19/06/09 15:21:25 INFO JobGenerator: Checkpointing graph for time 1560093684000 ms
19/06/09 15:21:25 INFO DStreamGraph: Updating checkpoint data for time 1560093684000 ms
19/06/09 15:21:25 INFO DStreamGraph: Updated checkpoint data for time 1560093684000 ms
```



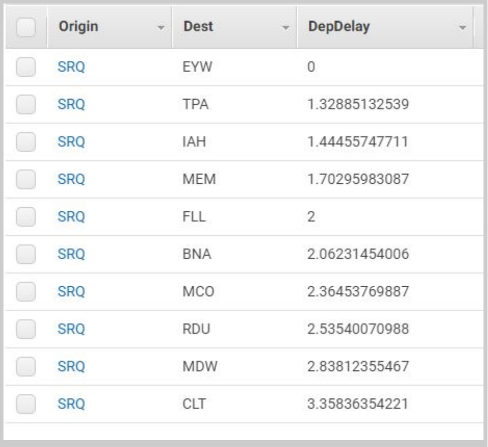
□	Origin	Dest	DepDelay
□	JFK	SWF	-10.5
□	JFK	ISP	0
□	JFK	ABQ	0
□	JFK	MYR	0
□	JFK	ANC	0
□	JFK	UCA	1.91701244813
□	JFK	BGR	3.21028037383
□	JFK	BQN	3.60622761091
□	JFK	CHS	4.40271055179
□	JFK	STT	4.53736365746



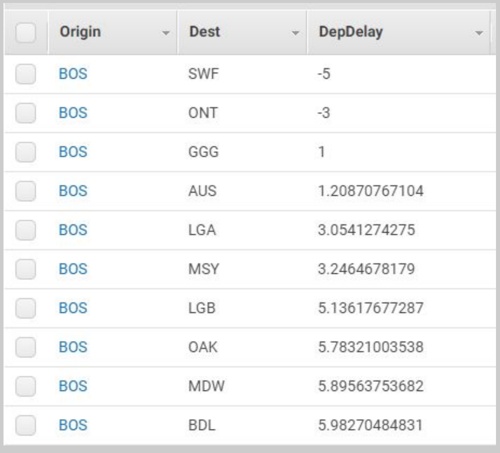
□	Origin	Dest	DepDelay
□	SEA	EUG	0
□	SEA	PIH	1
□	SEA	PSC	2.65051903114
□	SEA	CVG	3.8787445578
□	SEA	MEM	4.26022369801
□	SEA	CLE	5.17016949153
□	SEA	BLI	5.19824913369
□	SEA	YKM	5.37964774951
□	SEA	SNA	5.40625079405
□	SEA	LIH	5.48108108108



□	Origin	Dest	DepDelay
□	CMH	SYR	-5
□	CMH	OMA	-5
□	CMH	AUS	-5
□	CMH	MSN	1
□	CMH	CLE	1.10498687664
□	CMH	SDF	1.35294117647
□	CMH	CAK	3.70039421813
□	CMH	SLC	3.93928571429
□	CMH	MEM	4.15202156334
□	CMH	IAD	4.15810344828



□	Origin	Dest	DepDelay
□	SRQ	EYW	0
□	SRQ	TPA	1.32885132539
□	SRQ	IAH	1.44455747711
□	SRQ	MEM	1.70295983087
□	SRQ	FLL	2
□	SRQ	BNA	2.06231454006
□	SRQ	MCO	2.36453769887
□	SRQ	RDU	2.53540070988
□	SRQ	MDW	2.83812355467
□	SRQ	CLT	3.35836354221



□	Origin	Dest	DepDelay
□	BOS	SWF	-5
□	BOS	ONT	-3
□	BOS	GGG	1
□	BOS	AUS	1.20870767104
□	BOS	LGA	3.0541274275
□	BOS	MSY	3.2464678179
□	BOS	LGB	5.13617677287
□	BOS	OAK	5.78321003538
□	BOS	MDW	5.89563753682
□	BOS	BDL	5.98270484831

Problem 2.4

(determine the mean arrival delay (in minutes) for a flight from X to Y)

Strategy:

1. Filter for all non cancelled flights and map (origin,dest) -> (ArrDelay)
2. Get (origin, dest) -> `(ArrDelaySum,count, avgArrDelay) //` See flightsDelay.updateStateByKey(updateFunction)
3. Save to DB

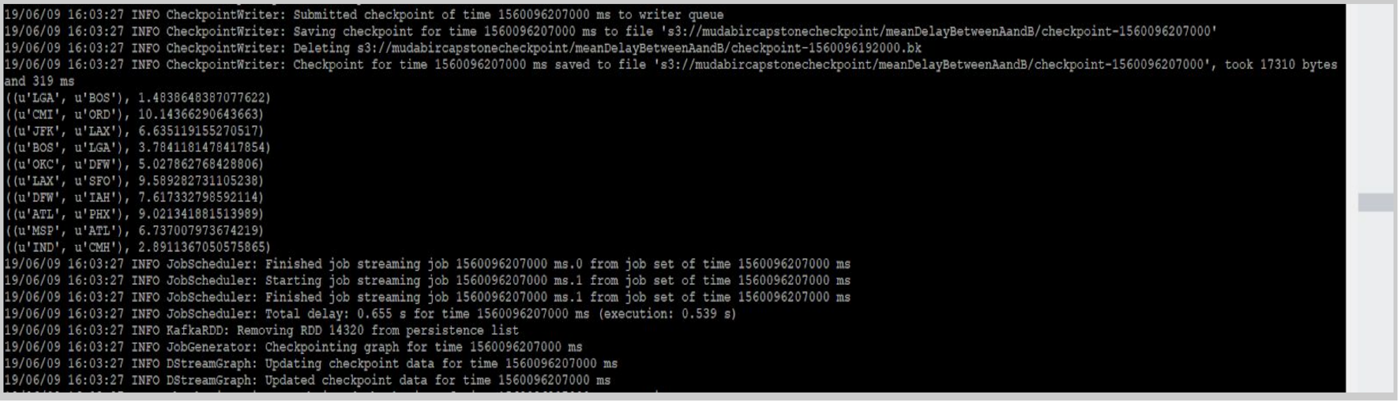
Source:

g2_4.py

Result:

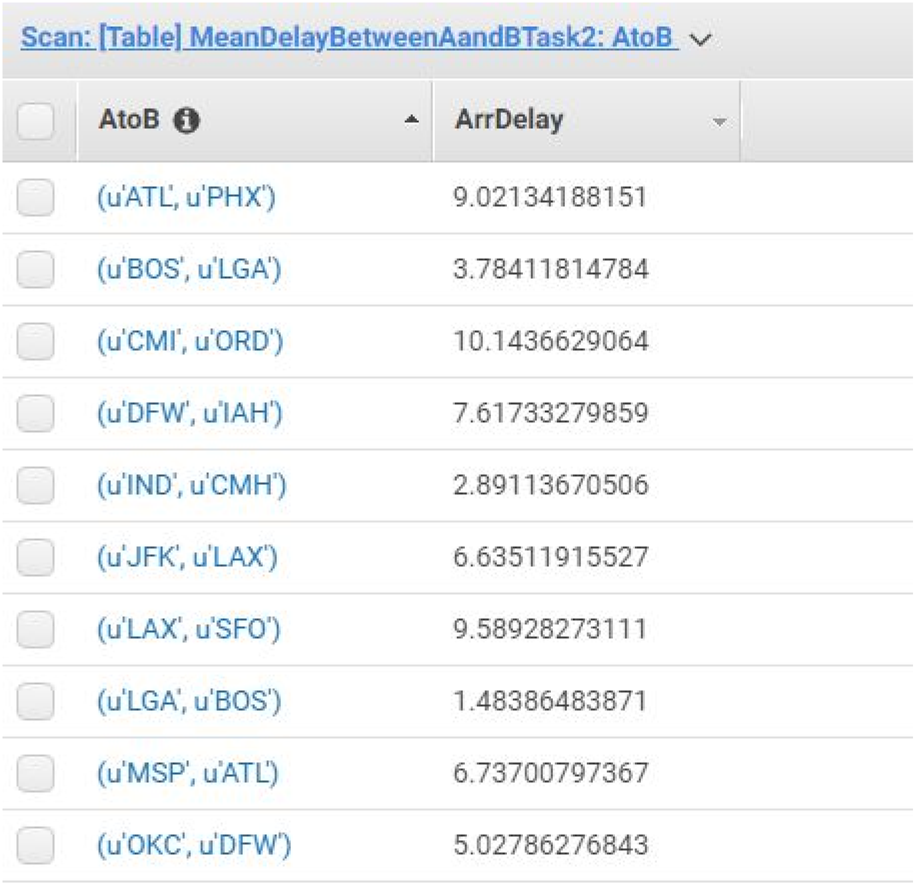
Format: { (<origin>, <dest>) ,<delay value> }

((u'LGA', u'BOS'), 1.4838648387077622)
((u'CMI', u'ORD'), 10.14366290643663)
((u'JFK', u'LAX'), 6.635119155270517)
((u'BOS', u'LGA'), 3.7841181478417854)
((u'OKC', u'DFW'), 5.027862768428806)
((u'LAX', u'SFO'), 9.589282731105238)
((u'ATL', u'PHX'), 9.021341881513989)
((u'DFW', u'IAH'), 7.617332798592114)
((u'MSP', u'ATL'), 6.737007973674219)
((u'IND', u'CMH'), 2.8911367050575865)



```
19/06/09 16:03:27 INFO CheckpointWriter: Submitted checkpoint of time 1560096207000 ms to writer queue
19/06/09 16:03:27 INFO CheckpointWriter: Saving checkpoint for time 1560096207000 ms to file 's3://mudabircapstonecheckpoint/meanDelayBetweenAandB/checkpoint-1560096207000'
19/06/09 16:03:27 INFO CheckpointWriter: Deleting s3://mudabircapstonecheckpoint/meanDelayBetweenAandB/checkpoint-1560096192000.bk
19/06/09 16:03:27 INFO CheckpointWriter: Checkpoint for time 1560096207000 ms saved to file 's3://mudabircapstonecheckpoint/meanDelayBetweenAandB/checkpoint-1560096207000', took 17310 bytes
and 319 ms
((u'LGA', u'BOS'), 1.4838648387077622)
((u'CMI', u'ORD'), 10.14366290643663)
((u'JFK', u'LAX'), 6.635119155270517)
((u'BOS', u'LGA'), 3.7841181478417854)
((u'OKC', u'DFW'), 5.027862768428806)
((u'LAX', u'SFO'), 9.589282731105238)
((u'DFW', u'IAH'), 7.617332798592114)
((u'ATL', u'PHX'), 9.021341881513989)
((u'MSP', u'ATL'), 6.737007973674219)
((u'IND', u'CMH'), 2.8911367050575865)
19/06/09 16:03:27 INFO JobScheduler: Finished job streaming job 1560096207000 ms.0 from job set of time 1560096207000 ms
19/06/09 16:03:27 INFO JobScheduler: Starting job streaming job 1560096207000 ms.1 from job set of time 1560096207000 ms
19/06/09 16:03:27 INFO JobScheduler: Finished job streaming job 1560096207000 ms.1 from job set of time 1560096207000 ms
19/06/09 16:03:27 INFO JobScheduler: Total delay: 0.655 s for time 1560096207000 ms (execution: 0.539 s)
19/06/09 16:03:27 INFO KafkaRDD: Removing RDD 14320 from persistence list
19/06/09 16:03:27 INFO JobGenerator: Checkpointing graph for time 1560096207000 ms
19/06/09 16:03:27 INFO DStreamGraph: Updating checkpoint data for time 1560096207000 ms
19/06/09 16:03:27 INFO DStreamGraph: Updated checkpoint data for time 1560096207000 ms
```

Arrival delay of some origin-dest pairs from dynamoDB



Scan: [Table] MeanDelayBetweenAandBTask2: AtoB

□	AtoB	ArrDelay
□	(u'ATL', u'PHX')	9.02134188151
□	(u'BOS', u'LGA')	3.78411814784
□	(u'CMI', u'ORD')	10.1436629064
□	(u'DFW', u'IAH')	7.61733279859
□	(u'IND', u'CMH')	2.89113670506
□	(u'JFK', u'LAX')	6.63511915527
□	(u'LAX', u'SFO')	9.58928273111
□	(u'LGA', u'BOS')	1.48386483871
□	(u'MSP', u'ATL')	6.73700797367
□	(u'OKC', u'DFW')	5.02786276843

Problem 3.1
(copy pasting my results from Task1 for this problem)

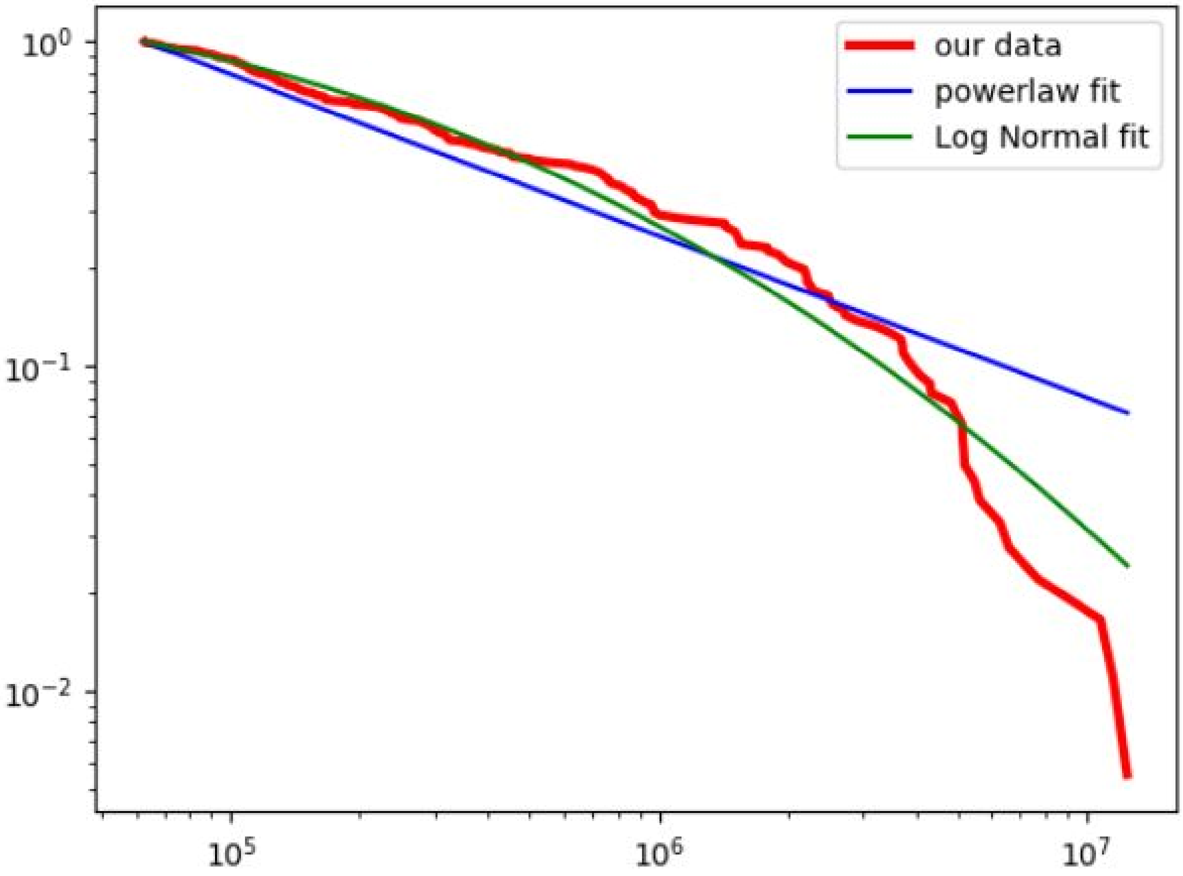
Strategy:

1) Collected ranking of all airports into a file using Spark
2) Used powerlaw library to plot the CCDF of the power law distribution and the lognormal distribution of the data collected in 1)

Source:
g3_1.py
pythonplot.py

Result:
g3_1.log (Ranking of airports with their count)

Our data resembles the log Normal fit better than the powerlaw fit. We can conclude that the popularity of airports doesn't follow Zipf distribution



Problem 3.2

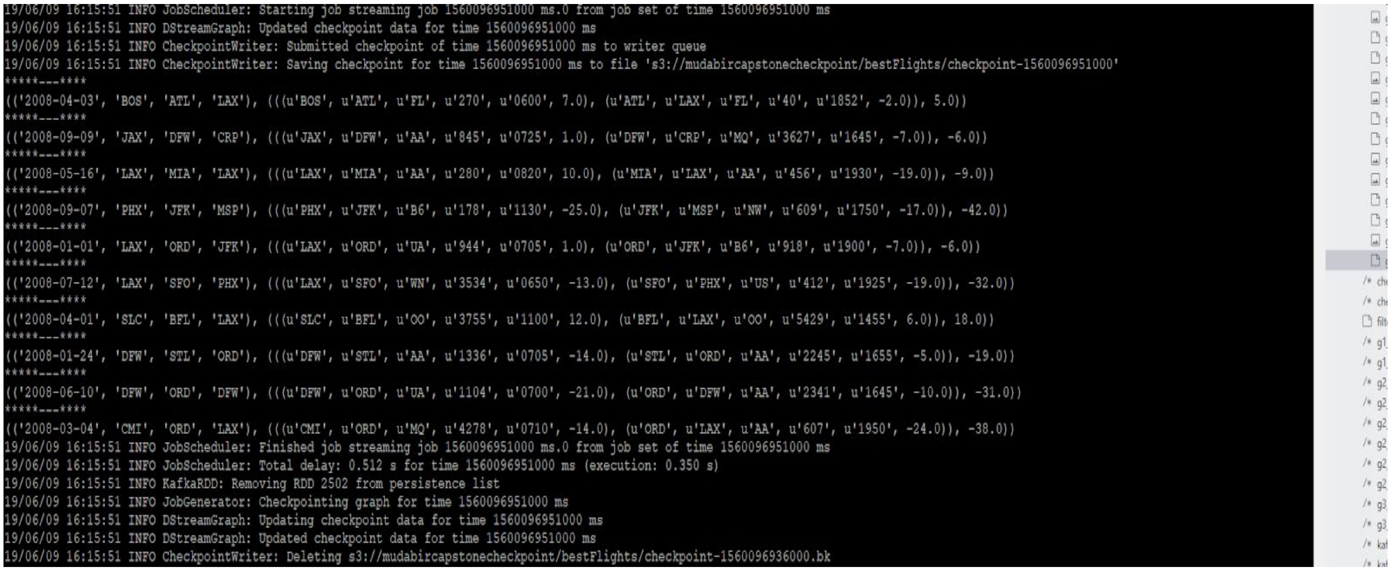
Strategy:

1. Filter non cancelled flights
2. Create RDD for all flights which fly before noon and dest as Y. key is (date, Y) -> (flight info)
3. Create RDD for all flights which fly after noon with origin as Y and departure date subtracted by 2 days
4. Join is done on (date,Y) as key. This gives all flights landing in Y before noon and all flights departing from Y two days later
5. For X->Y->Z route, filter the flight combo with minimum arrival delay
6. Write data to DynamoDB. Since a huge set of data was to be written, increased the write capacity of DynamoDB to 1500 to transfer the data faster.

Source:

g3_2.py

Result:



```
19/06/09 16:15:51 INFO JobScheduler: Starting job streaming job 1560096951000 ms.0 from job set of time 1560096951000 ms
19/06/09 16:15:51 INFO DStreamGraph: Updated checkpoint data for time 1560096951000 ms
19/06/09 16:15:51 INFO CheckpointWriter: Submitted checkpoint of time 1560096951000 ms to writer queue
19/06/09 16:15:51 INFO CheckpointWriter: Saving checkpoint for time 1560096951000 ms to file 's3://mudabircapstonecheckpoint/bestFlights/checkpoint-1560096951000'
*****___****
(('2008-04-03', 'BOS', 'ATL', 'LAX'), (((u'BOS', u'ATL', u'FL', u'270', u'0600', 7.0), (u'ATL', u'LAX', u'FL', u'40', u'1852', -2.0)), 5.0))
*****___****
(('2008-09-09', 'JAX', 'DFW', 'CRP'), (((u'JAX', u'DFW', u'AA', u'845', u'0725', 1.0), (u'DFW', u'CRP', u'MQ', u'3627', u'1645', -7.0)), -6.0))
*****___****
(('2008-05-16', 'LAX', 'MIA', 'LAX'), (((u'LAX', u'MIA', u'AA', u'280', u'0820', 10.0), (u'MIA', u'LAX', u'AA', u'456', u'1930', -19.0)), -9.0))
*****___****
(('2008-09-07', 'PHX', 'JFK', 'MSP'), (((u'PHX', u'JFK', u'B6', u'178', u'1130', -25.0), (u'JFK', u'MSP', u'NW', u'609', u'1750', -17.0)), -42.0))
*****___****
(('2008-01-01', 'LAX', 'ORD', 'JFK'), (((u'LAX', u'ORD', u'UA', u'944', u'0705', 1.0), (u'ORD', u'JFK', u'B6', u'918', u'1900', -7.0)), -6.0))
*****___****
(('2008-07-12', 'LAX', 'SFO', 'PHX'), (((u'LAX', u'SFO', u'WN', u'3534', u'0650', -13.0), (u'SFO', u'PHX', u'US', u'412', u'1925', -19.0)), -32.0))
*****___****
(('2008-04-01', 'SLC', 'BFL', 'LAX'), (((u'SLC', u'BFL', u'OO', u'3755', u'1100', 12.0), (u'BFL', u'LAX', u'OO', u'5429', u'1455', 6.0)), 18.0))
*****___****
(('2008-01-24', 'DFW', 'STL', 'ORD'), (((u'DFW', u'STL', u'AA', u'1336', u'0705', -14.0), (u'STL', u'ORD', u'AA', u'2245', u'1655', -5.0)), -19.0))
*****___****
(('2008-06-10', 'DFW', 'ORD', 'DFW'), (((u'DFW', u'ORD', u'UA', u'1104', u'0700', -21.0), (u'ORD', u'DFW', u'AA', u'2341', u'1645', -10.0)), -31.0))
*****___****
(('2008-03-04', 'CMI', 'ORD', 'LAX'), (((u'CMI', u'ORD', u'MQ', u'4278', u'0710', -14.0), (u'ORD', u'LAX', u'AA', u'607', u'1950', -24.0)), -38.0))
19/06/09 16:15:51 INFO JobScheduler: Finished job streaming job 1560096951000 ms.0 from job set of time 1560096951000 ms
19/06/09 16:15:51 INFO JobScheduler: Total delay: 0.512 s for time 1560096951000 ms (execution: 0.350 s)
19/06/09 16:15:51 INFO KafkaRDD: Removing RDD 2502 from persistence list
19/06/09 16:15:51 INFO JobGenerator: Checkpointing graph for time 1560096951000 ms
19/06/09 16:15:51 INFO DStreamGraph: Updating checkpoint data for time 1560096951000 ms
19/06/09 16:15:51 INFO DStreamGraph: Updated checkpoint data for time 1560096951000 ms
19/06/09 16:15:51 INFO CheckpointWriter: Deleting s3://mudabircapstonecheckpoint/bestFlights/checkpoint-1560096936000.bk
```

Format: ((startdate,X,Y,Z), ((XYdetails,YZdetails),totalArrivalDelay)

*****___****

(('2008-04-03', 'BOS', 'ATL', 'LAX'), (((u'BOS', u'ATL', u'FL', u'270', u'0600', 7.0), (u'ATL', u'LAX', u'FL', u'40', u'1852', -2.0)), 5.0))

*****___****

(('2008-09-09', 'JAX', 'DFW', 'CRP'), (((u'JAX', u'DFW', u'AA', u'845', u'0725', 1.0), (u'DFW', u'CRP', u'MQ', u'3627', u'1645', -7.0)), -6.0))

*****___****

(('2008-05-16', 'LAX', 'MIA', 'LAX'), (((u'LAX', u'MIA', u'AA', u'280', u'0820', 10.0), (u'MIA', u'LAX', u'AA', u'456', u'1930', -19.0)), -9.0))

*****___****

(('2008-09-07', 'PHX', 'JFK', 'MSP'), (((u'PHX', u'JFK', u'B6', u'178', u'1130', -25.0), (u'JFK', u'MSP', u'NW', u'609', u'1750', -17.0)), -42.0))

*****___****

(('2008-01-01', 'LAX', 'ORD', 'JFK'), (((u'LAX', u'ORD', u'UA', u'944', u'0705', 1.0), (u'ORD', u'JFK', u'B6', u'918', u'1900', -7.0)), -6.0))

*****___****

(('2008-07-12', 'LAX', 'SFO', 'PHX'), (((u'LAX', u'SFO', u'WN', u'3534', u'0650', -13.0), (u'SFO', u'PHX', u'US', u'412', u'1925', -19.0)), -32.0))

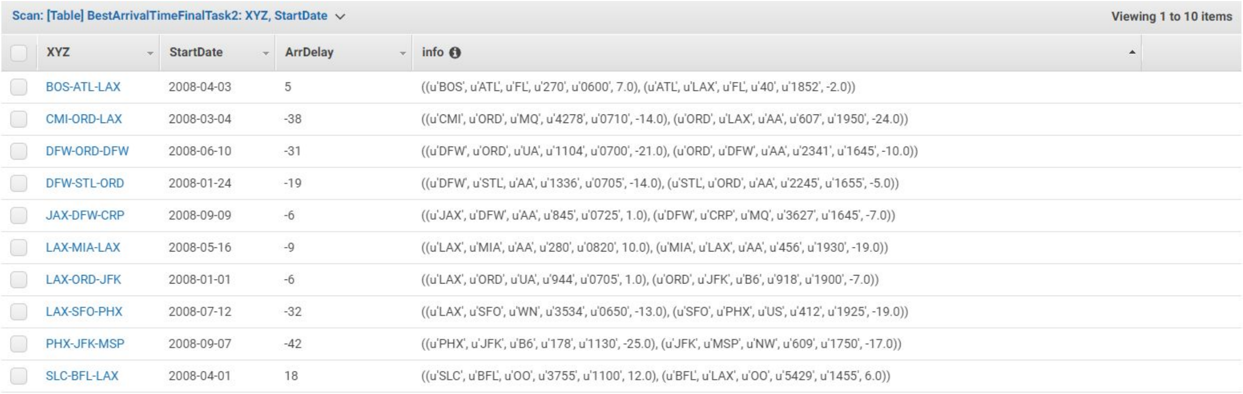
*****___****

(('2008-04-01', 'SLC', 'BFL', 'LAX'), (((u'SLC', u'BFL', u'OO', u'3755', u'1100', 12.0), (u'BFL', u'LAX', u'OO', u'5429', u'1455', 6.0)), 18.0))

*****___****

```
(('2008-01-24', 'DFW', 'STL', 'ORD'), (((u'DFW', u'STL', u'AA', u'1336', u'0705', -14.0), (u'STL',
u'ORD', u'AA', u'2245', u'1655', -5.0)), -19.0))
*****___****
(('2008-06-10', 'DFW', 'ORD', 'DFW'), (((u'DFW', u'ORD', u'UA', u'1104', u'0700', -21.0), (u'ORD',
u'DFW', u'AA', u'2341', u'1645', -10.0)), -31.0))
*****___****
(('2008-03-04', 'CMI', 'ORD', 'LAX'), (((u'CMI', u'ORD', u'MQ', u'4278', u'0710', -14.0), (u'ORD',
u'LAX', u'AA', u'607', u'1950', -24.0)), -38.0))
```

Snapshot from DynamoDB



Scan: [Table] BestArrivalTimeFinalTask2: XYZ, StartDate

Viewing 1 to 10 items

□	XYZ	StartDate	ArrDelay	info
□	BOS-ATL-LAX	2008-04-03	5	((u'BOS', u'ATL', u'FL', u'270', u'0600', 7.0), (u'ATL', u'LAX', u'FL', u'40', u'1852', -2.0))
□	CMI-ORD-LAX	2008-03-04	-38	((u'CMI', u'ORD', u'MQ', u'4278', u'0710', -14.0), (u'ORD', u'LAX', u'AA', u'607', u'1950', -24.0))
□	DFW-ORD-DFW	2008-06-10	-31	((u'DFW', u'ORD', u'UA', u'1104', u'0700', -21.0), (u'ORD', u'DFW', u'AA', u'2341', u'1645', -10.0))
□	DFW-STL-ORD	2008-01-24	-19	((u'DFW', u'STL', u'AA', u'1336', u'0705', -14.0), (u'STL', u'ORD', u'AA', u'2245', u'1655', -5.0))
□	JAX-DFW-CRP	2008-09-09	-6	((u'JAX', u'DFW', u'AA', u'845', u'0725', 1.0), (u'DFW', u'CRP', u'MQ', u'3627', u'1645', -7.0))
□	LAX-MIA-LAX	2008-05-16	-9	((u'LAX', u'MIA', u'AA', u'280', u'0820', 10.0), (u'MIA', u'LAX', u'AA', u'456', u'1930', -19.0))
□	LAX-ORD-JFK	2008-01-01	-6	((u'LAX', u'ORD', u'UA', u'944', u'0705', 1.0), (u'ORD', u'JFK', u'B6', u'918', u'1900', -7.0))
□	LAX-SFO-PHX	2008-07-12	-32	((u'LAX', u'SFO', u'WN', u'3534', u'0650', -13.0), (u'SFO', u'PHX', u'US', u'412', u'1925', -19.0))
□	PHX-JFK-MSP	2008-09-07	-42	((u'PHX', u'JFK', u'B6', u'178', u'1130', -25.0), (u'JFK', u'MSP', u'NW', u'609', u'1750', -17.0))
□	SLC-BFL-LAX	2008-04-01	18	((u'SLC', u'BFL', u'OO', u'3755', u'1100', 12.0), (u'BFL', u'LAX', u'OO', u'5429', u'1455', 6.0))

Optimizations

- Filtered only necessary fields from all the csv reducing the total data size to 4.5GB from 15 GB
- In the kafka producer side, increased batch size and linger_ms to dispatch larger amounts of data at a time to the kafka cluster without waiting or ack. Also make ack= True to make sure no data is dropped/lost while writing to kafka topic
- Made replication factor =3 to make the kafka cluster reliable. Kept the number of partitions to 1. Increasing the number of partitions seemed to make the read from consumer side slower

Streaming versus Batch processing

- For the given data, batch processing seemed a better option. Since we had to compute top 10 aiports/carriers etc based on entire data, doing stream processing as the data arrives seems like an overkill.
- However, stream processing is useful in analysing live how the parameters are changing over time.

Comparing Stacks

Since I used Spark for task1 and Spark Streaming for task2, the stacks were more of less similar. Using hadoop Map-reduce for task 1 would have made the process very slow.
