Comparison of network performance of India and Pakistan using PingER data

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***Abstract*—This research work has studied the internet network performance in India and Pakistan over the years. The comparison is made on various factors which were prevailing in the country during that time, and how it affected the network in those areas. PingER is acronym for Ping end-to-end reporting. This project was started in the year 1995 and aimed at measuring the internet performance over various reasons. It uses a simple ping command to find the Round-trip Travel Time(RTT) between two nodes of the internet.**

Keywords—PingER; clustering; K-Means; Internet Performance; Network Monitoring

I. INTRODUCTION

PingER project was started for High Energy Particle research community. The community had to collect huge amount of data from various laboratories which were located across the world [1]. It became necessary to monitor the network, and identify the solutions if any problem was persisting. Using ping, the RTT for the server or the lack of response is recorded. Today, this project has 40 MAs in 140 countries. Collectively they monitor 700 websites spread across 160 countries [2].

The PingER data is freely available in the SLAC website [3]. We have collected data for 2 years, the period ranging from 1st January 2017 to 31st July 2019. Clustering is applied on the data using the K-means algorithm. By this clustered data, key factors prevailing in the country were identified and how they affected the network performance there was analyzed.

II. LITERATURE SURVEY

A. History of PingER

PingER project was started in 1995 by SLAC laboratory. The lab had to transfer huge amount of data from various parts of the globe. This project aided to monitor the network performance. There are various MAs(40) situated across the globe, which ping these sites maintained under beacon list[4], and store the ping data in servers.

This data is collected from across various years. This data is very useful for finding out performance of network country wise and region wise. It can be found useful to help less developed countries get good telecom services and an emerging market for such services.

B. Data Mining Techniques

Data mining means the extraction and retrieval of data stored in huge databases. There are various methods involved. Different types and distribution of data requires various techniques. Some of the most common methods include association, classification and clustering. For this particular data set we are dealing with, clustering is the best and most suitable method [5].

C. *Clustering*

Clustering is a machine learning algorithm which groups the sets of objects into clusters. These clusters are determined on the basis of some common attributes. So, one group/cluster has more similar characteristics as compared to other. There are several clustering algorithms. Some common approaches are Centroid, Density, Connectivity and Distribution. The most common clustering algorithms are Hierarchical and K-Means clustering.

This analysis uses K-Means clustering based on centroid. The algorithms follow iterative approach, and on each iteration, it locates the maxima. The basic steps in the algorithm are[6]-

1. Identification of data points into K clusters.
2. Find the mean of the cluster, also known as seed point.
3. Assigning the closest mean point to each data points.
4. Repeat from step 2 until the assignment of data points is over.

D. *Metrics used in PingER management*

The network traffic should cross Internet at the highest speed, but due to some problems like queuing in routers, packet loss, etc., some extra delays are added. There are five know metrics are considered to judge the network performance of our data.

1) Round-Trip Time (RTT)

It is measured by calculating the time required to establish the TCP connection. This metric is available for TCP connections only. The process of buffer queuing changes the Round-Trip Time (RTT). The application does not affect the time for TCP handshake, unless there is the flaw in the operating system itself.

2) Packet Loss

It is measured as the percentage of the total packets lost when we send a particular ping. A ping comprises of several packets, and the performance is measured by taking into consideration of all the packets received back and lost in the way. In several cases, packet loss plays a very crucial role, such as video conferencing, where it should be very low. While other for other non-interactive tasks like sending e-mails, it does not pose much of a problem.

3) Unreachability

Unreachability is the case when we send our ping, but receive 0 packets in response. This is also a major factor which should be taken into consideration as some of the notes are unreachable many a times. In our analysis, such data is discarded, and only the active servers were considered.

4) Quiescence

If all the packets sent to the remote node are received, then the network is said to be quiescent or non-busy. If a network is occupied 8 hours on each workday in a week, it is said to have a dormant percentage of 85%.

5) Unpredictability

Unpredictability is obtained by calculating the performance based on packet loss and RTT. The success rate of the ping is the proportion of data responses obtained from the number of packets sent, and the ping ratio is twice that of the ping payload as compared to the average RTT.

	A	B	C	D	E	F	G	H	I	J	K
1	source_host_name	source_host_addr	destination_host_name	destination_host_addr	size	unix_epoch_time	sent	rcvd	min	avg	max
2	pinger.slac.stanford.edu	134.79.104.80	www.mitpune.com	203.199.134.21	100	1483229599	10	10	250.941	251.563	252.974
3	pinger.slac.stanford.edu	134.79.104.80	www.mitpune.com	203.199.134.21	1000	1483229608	10	10	251.236	251.645	251.886
4	pinger.slac.stanford.edu	134.79.104.80	www.mitpune.com	203.199.134.21	100	1483231394	10	10	250.612	251.192	251.486
5	pinger.slac.stanford.edu	134.79.104.80	www.mitpune.com	203.199.134.21	1000	1483231403	10	10	251.357	251.598	251.963
6	pinger.slac.stanford.edu	134.79.104.80	www.mitpune.com	203.199.134.21	100	1483233197	10	10	250.711	251.185	251.413
7	pinger.slac.stanford.edu	134.79.104.80	www.mitpune.com	203.199.134.21	1000	1483233206	10	10	251.283	251.689	251.912
8	pinger.slac.stanford.edu	134.79.104.80	www.mitpune.com	203.199.134.21	100	1483234989	10	10	250.958	251.227	251.403
9	pinger.slac.stanford.edu	134.79.104.80	www.mitpune.com	203.199.134.21	1000	1483234999	10	10	250.981	251.614	251.896
10	pinger.slac.stanford.edu	134.79.104.80	www.mitpune.com	203.199.134.21	100	1483236787	10	10	250.833	251.205	251.911
11	pinger.slac.stanford.edu	134.79.104.80	www.mitpune.com	203.199.134.21	1000	1483236796	10	10	251.446	251.721	251.891
12	pinger.slac.stanford.edu	134.79.104.80	www.mitpune.com	203.199.134.21	100	1483238592	10	10	250.971	251.314	251.445
13	pinger.slac.stanford.edu	134.79.104.80	www.mitpune.com	203.199.134.21	1000	1483238601	10	10	251.025	251.663	251.893
14	pinger.slac.stanford.edu	134.79.104.80	www.mitpune.com	203.199.134.21	100	1483240389	10	10	250.837	251.236	252.134
15	pinger.slac.stanford.edu	134.79.104.80	www.mitpune.com	203.199.134.21	1000	1483240398	10	10	251.221	251.522	251.867
16	pinger.slac.stanford.edu	134.79.104.80	www.mitpune.com	203.199.134.21	100	1483242194	10	10	250.902	251.175	251.459
17	pinger.slac.stanford.edu	134.79.104.80	www.mitpune.com	203.199.134.21	1000	1483242204	10	10	250.952	251.493	252.082
18	pinger.slac.stanford.edu	134.79.104.80	www.mitpune.com	203.199.134.21	100	1483243997	10	10	251.079	251.318	251.445
19	pinger.slac.stanford.edu	134.79.104.80	www.mitpune.com	203.199.134.21	1000	1483244007	10	10	251.097	251.502	252.036
20	pinger.slac.stanford.edu	134.79.104.80	www.mitpune.com	203.199.134.21	100	1483245792	10	10	250.679	251.126	251.719
21	pinger.slac.stanford.edu	134.79.104.80	www.mitpune.com	203.199.134.21	1000	1483245801	10	10	251.235	251.557	251.82
22	pinger.slac.stanford.edu	134.79.104.80	www.mitpune.com	203.199.134.21	100	1483247588	10	10	250.678	251.202	251.46
23	pinger.slac.stanford.edu	134.79.104.80	www.mitpune.com	203.199.134.21	1000	1483247597	10	10	251.004	251.49	251.878

Fig. 1. Collected PingER data India

III. METHODOLOGY

The methodology followed for this analysis are discussed here:

1. Collection of data: First step involved collection of free data from SLAC website. The required data was collected from the servers located in India and Pakistan, collected over the period of 1st January 2017 to 31st July 2019. The extracted data is the stored in ".csv" file format.

2. Data cleaning: Next the missing data values was omitted for calculating the results. As this may give faulty answers.

	A	B	C	D	E	F	G	H	I	J	K
1	source_host_name	source_host_addr	destination_host_name	destination_host_addr	size	unix_epoch_time	sent	rcvd	min	avg	max
2	pinger.slac.stanford.edu	134.79.104.80	www.upesh.edu.pk	121.52.147.5	100	1483229625	10	10	311.861	311.962	312.089
3	pinger.slac.stanford.edu	134.79.104.80	www.upesh.edu.pk	121.52.147.5	1000	1483229634	10	10	312.092	312.199	312.41
4	pinger.slac.stanford.edu	134.79.104.80	www.upesh.edu.pk	121.52.147.5	100	1483231424	10	10	311.879	312.02	312.206
5	pinger.slac.stanford.edu	134.79.104.80	www.upesh.edu.pk	121.52.147.5	1000	1483231433	10	10	312.096	312.198	312.369
6	pinger.slac.stanford.edu	134.79.104.80	www.upesh.edu.pk	121.52.147.5	100	1483233229	10	10	311.867	311.983	312.079
7	pinger.slac.stanford.edu	134.79.104.80	www.upesh.edu.pk	121.52.147.5	1000	1483233238	10	10	312.079	312.2	312.313
8	pinger.slac.stanford.edu	134.79.104.80	www.upesh.edu.pk	121.52.147.5	100	1483235020	10	10	311.852	311.978	312.125
9	pinger.slac.stanford.edu	134.79.104.80	www.upesh.edu.pk	121.52.147.5	1000	1483235029	10	10	312.075	312.181	312.246
10	pinger.slac.stanford.edu	134.79.104.80	www.upesh.edu.pk	121.52.147.5	100	1483236816	10	10	311.868	312.081	312.414
11	pinger.slac.stanford.edu	134.79.104.80	www.upesh.edu.pk	121.52.147.5	1000	1483236826	10	10	312.09	312.181	312.294
12	pinger.slac.stanford.edu	134.79.104.80	www.upesh.edu.pk	121.52.147.5	100	1483238619	10	10	311.865	312.026	312.225
13	pinger.slac.stanford.edu	134.79.104.80	www.upesh.edu.pk	121.52.147.5	1000	1483238629	10	10	312.062	312.196	312.331
14	pinger.slac.stanford.edu	134.79.104.80	www.upesh.edu.pk	121.52.147.5	100	1483240421	10	10	311.939	312.051	312.245
15	pinger.slac.stanford.edu	134.79.104.80	www.upesh.edu.pk	121.52.147.5	1000	1483240431	10	10	312.206	312.279	312.372
16	pinger.slac.stanford.edu	134.79.104.80	www.upesh.edu.pk	121.52.147.5	100	1483242226	10	10	311.916	312.009	312.166
17	pinger.slac.stanford.edu	134.79.104.80	www.upesh.edu.pk	121.52.147.5	1000	1483242235	10	10	312.067	312.167	312.267
18	pinger.slac.stanford.edu	134.79.104.80	www.upesh.edu.pk	121.52.147.5	100	1483244026	10	10	311.792	312.013	312.11
19	pinger.slac.stanford.edu	134.79.104.80	www.upesh.edu.pk	121.52.147.5	1000	1483244036	10	10	312.091	312.21	312.296
20	pinger.slac.stanford.edu	134.79.104.80	www.upesh.edu.pk	121.52.147.5	100	1483245820	10	10	311.767	311.955	312.096
21	pinger.slac.stanford.edu	134.79.104.80	www.upesh.edu.pk	121.52.147.5	1000	1483245830	10	10	312.084	312.195	312.315
22	pinger.slac.stanford.edu	134.79.104.80	www.upesh.edu.pk	121.52.147.5	100	1483247619	10	10	311.892	312.128	313.025
23	pinger.slac.stanford.edu	134.79.104.80	www.upesh.edu.pk	121.52.147.5	1000	1483247628	10	10	312.138	312.269	312.34
24	pinger.slac.stanford.edu	134.79.104.80	www.upesh.edu.pk	121.52.147.5	100	1483249418	10	10	311.902	312.06	312.43
25	pinger.slac.stanford.edu	134.79.104.80	www.upesh.edu.pk	121.52.147.5	1000	1483249427	10	10	312.094	312.213	312.384

Fig. 2. Collected PingER data Pakistan

3. Clustering and analysis: The last step involves applying the K-Means algorithm using the scikit-learn Python library. The number of clusters are then defined using the Silhouette method. This gives us the score for each of cluster. The least one should be best suitable for determining the number of clusters. The snapshot of the Python code is shown in the figure 3.

IV. EXPERIMENTAL SETUP

This section discusses the tools used, the datasets, scripts, and determination of K using Silhouette method.

A. *Metadata about Data*

The data is obtained form SLAC website 'slac.stanford.edu'. We have considered the attributes source_host_address, source_host, size, destination_host_address,

destination_host_name, min, max, avg, rcvd, sent, unix_epoch_time, seq_rev and rtt_rcv. We have considered min, max, avg, hosts name and address and epoch time for our analysis. For clustering we will be using RTT only, and min, max and average means their respective RTTs. There were several values which were empty. They were dropped. India's data had 65632 tuples, out of which 42972 were obtained. Pakistan's data had 74584 tuples, out of which 58889 tuples were obtained. The data ranged from year 2017 to 2019.

Indian hosts were 'pingeramity.in', 'mitpune.com', 'speedtest.hns.net.in' and 'mail.prl.res.in' having IP addresses 202.12.103.71, 203.199.134.21, 120.88.46.30 and 210.212.155.234 . Pakistani hosts were 'giki.edu.pk', 'numl.edu.pk', 'pieas.edu.pk', 'uob.edu.pk', 'vu.edu.pk' and 'upesh.edu.pk' having IP addresses 119.159.235.52, 111.68.97.117, 111.68.99.196, 121.52.157.105, 111.68.103.35 and 121.52.147.5.

B. *Datasets*

The data collected was combined into one '.csv' file. For the analysis, three main attributes, min, max and average RTT were considered. For deeper analysis, unix_epoch_time was also considered. This is depicted in Fig 1 and Fig 2 for India and Pakistan respectively.

```
from sklearn.preprocessing import MinMaxScaler
import seaborn as sns
import matplotlib.pyplot as plt

train = pd.read_csv("combined3.csv")
print("***** Train_Set *****")
cols = ['min', 'avg', 'max']

# Selecting Cols
train = train[cols]

# Cleaning of data by removing nan
print(train.shape)
train = train.dropna()
print(train.shape)

# Clustering
kmeans = KMeans(n_clusters=6, random_state=0).fit(train)

dict = {}

for n_clusters in range(2, 11):
    clusterer = KMeans(n_clusters=n_clusters)
    preds = clusterer.fit_predict(train)
    centers = clusterer.cluster_centers_
    score = silhouette_score(train, preds, metric='euclidean')
    dict[n_clusters] = score
    print("For n_clusters = {}, silhouette score is {}".format(n_clusters, score))

print(sorted(dict.items(), key=lambda x: x[1]))
```

Fig. 3. Python Script

C. *Tools and scripts used*

Python scripts were used for clustering and analyzing the data. For clustering, scikit-learn(0.21.3) library was used. While for analyzing, Pandas(0.25.1) was used. The Fig. 3 and Fig. 6 shows a snippet of the script.

D. *Identification of K using Silhouette method*

Silhouette method was used to find out the best fit value of 'K'. The value of 'K' should be such that it is suitable for our analysis. For achieving this, silhouette_score of each value of 'K' was taken. The function was run for the values of 'K' ranging from 2 to 20. It was then sorted accordingly to the least value of score. The lower the score, the better the cluster. So, the silhouette scoring was run for 2 separate files, one for India, and one for Pakistan. For India, the best score was for 8 clusters. For Pakistan, the best score was for 4 clusters. This can be seen in Fig. 4 and Fig. 5.

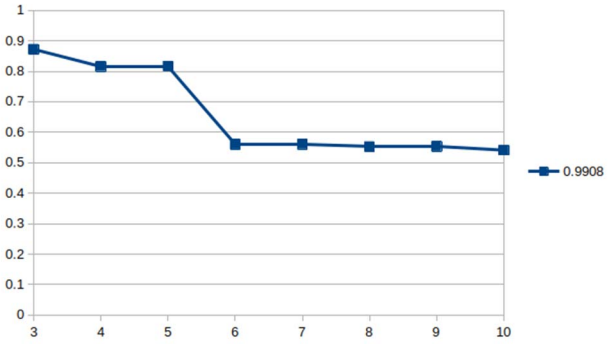

Fig. 4. Silhouette scores for K (India)

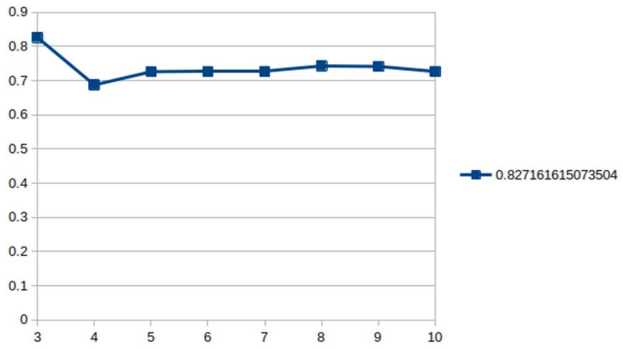

Fig. 5. Silhouette scores for K (Pakistan)Output and Analysis

V. Output and Analysis

A. *India*

It was observed that overall the servers were best working during the first half of the years, with February, March, April and May being the most active months.

A total of 8 clusters were obtained. The best RTT was for cluster 1, 258.15 ms in which fairly good number of tuples were obtained. The period 1st January to 4th July 2017 was the most responsive. The node 'www.mitpune.com' contributed majority 82% of the ping data. A notable slowdown was on 12th July 2017 in the node 'mail.prl.res.in' which observed the RTT of 3310.6 ms. Another notable cluster was cluster 7, where 19855 tuples were collected. It had a great RTT of

277.03 ms. 'mail.prl.res.in' showed the most active performance and constituted 3/4th of the entire cluster.

We got 2 best performing cluster based on RTTs. It was observed that nodes 'www.mitpune.com' and 'mail.prl.res.in' showed an excellent performance and accounted for fairly large amount in their clusters. The time period 1st January to 14th July 2017 was most active server-wise.

B. Pakistan

The Pakistan data has 4 clusters. On noticing the most prominent clusters, tuples wise in India and Pakistan, it can be seen that Indian nodes were performing better than Pakistani nodes for the same time duration. However, India had only 3 active nodes, while Pakistan has 5 active nodes. All nodes are performing good and consistent. The slower RTT may be due to poor network providers in Pakistan. The best RTT was for cluster 2 and was found to be 291.89 ms.

The nodes 'ns3.pieas.edu.pk' and 'www.numl.edu.pk' were the best performing nodes. While the node 'www.uob.edu.pk' sometimes showed poor performance.

Cluster 0 had 25281 tuples, of which www.upesh.edu.pk comprised 24.88% of the data. The average RTT was 314.10 ms for this cluster. Cluster 1 consisted 4930 tuples, and had the average RTT of 398.85 ms. Cluster 2 was the largest cluster and consisted 28676 tuples and showed the best RTT of 291.90 ms, where www.numl.edu.pk had 30.24% of tuples. Cluster 3 had only 2 tuples and the worst RTT of 899.86 ms. The values obtained on 3rd January 2017 and 22nd March 2017. These were the outliers.

Fig. 6. Script for summarizing the data

```
df = train
df = df[cols]
print(df.count())

print(df.loc[df['labels'] == 1].count())
print("TOTAL LABEL COUNT")

# avg_arr = df.loc[df['labels'] == 0]['avg']
avg_arr = df.loc[df['labels'] == 1]
# print(np.average(avg_arr))

print(avg_arr['unix_epoch_time'].max())
print("MAX")
# clus = df.loc[df['labels'] == 0].loc[df['destination_host_name']=='pinger
# print(clus['destination_host_name'].count())
print(df['destination_host_name'].unique())
# avg_arr = df.loc[df['labels'] == 0]['avg']['destination_host_name']

for i in range(4):
    print("TOTAL OBJECT COUNT FOR CLUSTER {}:".format(i))
    total_object_count = df.loc[df['labels'] == i].count()
    print(df.loc[df['labels'] == i].count())

    avg_arr = df.loc[df['labels'] == i]['avg']
    print("AVERAGE RTT FOR CLUSTER {}".format(i))
    print(np.average(avg_arr))

    avg_arr = df.loc[df['labels'] == i]
    print("MAX EPOCH TIME FOR CLUSTER {}".format(i))
    print(avg_arr['unix_epoch_time'].max())

    print("MIN EPOCH TIME FOR CLUSTER {}".format(i))
    print(avg_arr['unix_epoch_time'].min())

    compo_list = df['destination_host_name'].unique()
    print("\n\n ***********************************************************")
    for j in compo_list:
```

VI. Conclusion and Future Work

The data analyzed here can be of help and reference for future projects which require the analysis for the same time period. For a fast-changing economy like India, internet performance and data speed play a very important role in its development. There have also been government situations in the country, where the internet services had been put off due to military tensions, curfews, strikes and protests. This way we can also see the drastic impact it has put on the businesses and economy of both the countries. It can be said that government should consider its actions and its impacts especially on the Silicon Valley world as per the conclusions derived from this work.

TABLE I. CLUSTER DATA PAKISTAN

Clusters	Objects	Composition	Avg. RTT
Cluster0	25281	www.upesh.edu.pk – 24.88% 121.52.144.65 – 24.26% www.numl.edu.pk – 21.41% ns3.pieas.edu.pk – 24.34% www.uob.edu.pk – 5.11%	314.10
Cluster1	4930	www.upesh.edu.pk – 22.82% 121.52.144.65 – 20.10% www.numl.edu.pk – 19.51% ns3.pieas.edu.pk – 22.98% www.uob.edu.pk – 14.58%	398.85
Cluster2	28676	www.upesh.edu.pk – 0.77% 121.52.144.65 – 17.10% www.numl.edu.pk – 30.24% ns3.pieas.edu.pk – 22.55% www.uob.edu.pk – 29.33%	291.90
Cluster3	2	www.upesh.edu.pk – 0.00% 121.52.144.65 – 0.00% www.numl.edu.pk – 50.00% ns3.pieas.edu.pk – 0.00% www.uob.edu.pk – 50.00%	899.86

TABLE II. CLUSTER DATA INDIA

Clusters	Objects	Composition	Avg. RTT
Cluster0	18207	www.mitpune.com – 81.98% mail.prl.res.in – 11.59% pingeramity.in – 6.42%	258.15
Cluster1	1049	www.mitpune.com – 0.67% mail.prl.res.in – 21.93% pingeramity.in – 77.41%	386.68
Cluster2	4	www.mitpune.com – 0.00% mail.prl.res.in – 0.00% pingeramity.in – 100.00%	1822.10
Cluster3	2	www.mitpune.com – 0.00% mail.prl.res.in – 100.00% pingeramity.in – 0.00%	3310.60
Cluster4	3518	www.mitpune.com – 0.57% mail.prl.res.in – 22.11% pingeramity.in – 77.32%	306.50
Cluster5	205	www.mitpune.com – 0.00% mail.prl.res.in – 96.10% pingeramity.in – 3.90%	607.56
Cluster6	19855	www.mitpune.com – 5.72% mail.prl.res.in – 75.62% pingeramity.in – 18.66%	277.03
Cluster7	10	www.mitpune.com – 0.00% mail.prl.res.in – 20.00% pingeramity.in – 80.00%	598.86

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