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Temporal Forecast Demand of Cloud Based Media Streaming Applications for Efficient Resource Allocation

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ABSTRACT: Media streaming applications assumed importance as they can render multimedia services to subscribers. They became popular of late with innovative technologies like cloud computing. Cloud data centres and their scalability and availability made these applications prosper. They are associated with Video on Demand (VoD). These applications do have huge number of subscribers across the globe. Provided this fact, the subscriptions are increasing in exponential fashion. This has caused the cloud based media streaming providers an issue pertaining to resource allocation. The main problem is that when more resources are allocation, the streaming quality is good but there is wastage of resources. In the same fashion, when fewer resources are allocated, it may cause deterioration of quality besides denial of services to subscribers when there is sudden and unprecedented increase in the number of subscribers. The existing reservation based resource allocation needs to be improved for efficiency. In this paper we proposed and implemented a time-series based forecast algorithm that can have accurate predictions to help service providers. The algorithm helps in optimizing the resource allocation to media streaming applications in cloud. We built a prototype application that demonstrates the proof of concept. The empirical results revealed that the forecast is useful for efficient cloud resource allocation.

Index Terms: Cloud computing, media streaming applications, time series analysis, and resource allocation

I. INTRODUCTION

Media streaming is the term which refers to the live streaming of data from a pre-recorded or live event. For instance live cricket match can be provided to viewers through Internet. This phenomenon is known as media streaming. With innovations of technologies like cloud computing, video streaming applications became significant and popular. However, they are suffering from sudden increase of decrease of subscribers that cause fluctuations in the system with respect to resource allocations. There are two problems with that. First problem is that when more resources are allocations, it improved performance but wasted resources. Second problem is when less computing resources are allocated; it resulted in deterioration of quality and denial of service even. The existing resource reservation method has issues when there is sudden increase in the subscribers to media streaming applications.

As the media streaming applications in question are cloud based, let us understand how cloud can help in hosting such services. As shown in Figure 1, cloud has support for various services that include software, hardware and applications. Different types of cloud deployments such as private cloud, public cloud, community cloud and hybrid cloud are available. Whatever be the deployment, it is equipped with unlimited resources that can be shared to users through Internet in pay per use fashion. The cloud services consumed by users are charged with affordable prices. With cloud computing available, the media streaming applications are moved to cloud based infrastructure. Especially Video on Demand (VoD) concept became popular. It is also integrated with Internet Protocol Television (IPTV) which now has become a reality.

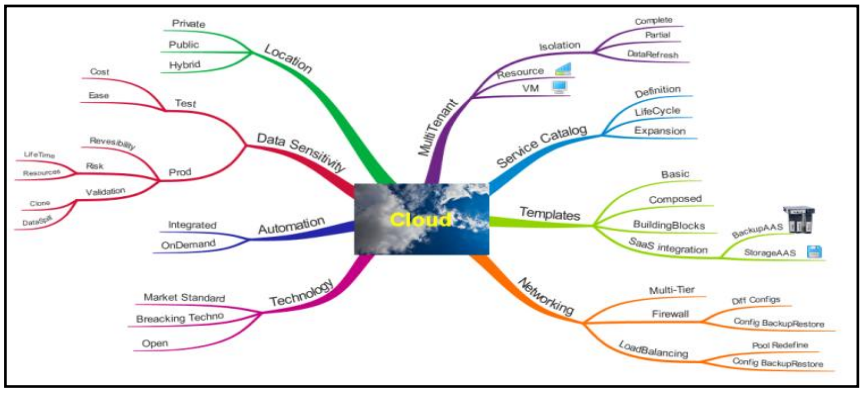

Figure 1: Mind Map of Cloud Computing

The media streaming applications deployed in cloud and given access to users across the globe can provide many benefits to their owners. They include cheaper means of storage, efficient way of rendering and flexibility in investments besides possibility to generate revenues in large scale. The problem with such applications is the resource allocation. When resource allocation is not optimized, it results in skewed performance that can deteriorate satisfaction of customers. This can lead to problems to service providers. In order to overcome the problems with resource allocation, it is good to have an efficient prediction algorithm so as to accommodate resources in a better way.

In this paper we proposed an algorithm which is based on time series and prediction of video streaming applications in terms of demand. By forecasting demand it is possible to have intelligent allocation of resources that overcome the problems aforementioned. We built an application to demonstrate the proof of concept. Our empirical results revealed that the proposed algorithm has good utility in forecasting demand of video streaming applications. This paper is structured as follows. Section II provides review of literature. Section III presents the proposed system in detail. Section IV presents experimental results while section V concludes the paper.

II. RELATED WORKS

This section reviews literature on resource allocation in cloud and its related research. Many applications such as e-Commerce applications are web based and they need to predict CPU utilization and access made by user base from time to time in order to have optimized resource allocations [1]. Radial Basis Function (RBF) is used for prediction of demand in different kinds of networks. Especially its focus was on web based applications as explored in [2]. In the same fashion, recently, the research was carried out on the prediction of demand for media streaming applications as explored in [3], [4], [5] and [6]. In [3] the research was focusing on access behaviour of users involved in Peer-to-Peer (P2P) streaming where time-series based techniques are employed for prediction.

In [4] also time serried based prediction is made based on wavelet analysis. In case of [5] principal component analysis (PCA) method is employed for finding access patterns of users who gain access streaming applications. Though the studies aforementioned are able to predict average streaming capacity demands very few focused on volatilityissues and sudden bursts in demand. In [6] research is carried out on the risk factors and handling burst of requests. An adaptive resource allocation method was explored in [7] for optimization of bandwidth utilization of streaming applications in order to ensure high level of QoS.

There were different approaches found in the literature for resource allocation and utilization in cloud. Cisco visual networking index [8], video streaming over P2P [9], data centre visualization [10], and Amazon cloud approach [11]. Amazon reserved instances [12], predictable data centre networks [13], forecast and performance prediction [14] and prediction based federated management are the other research works found in the literature for handling resource allocations. In this paper our focus is on a new prediction algorithm that is based on double exponential smoothing to have efficient prediction that reduces error rate.

III. PROBLEM DEFINITION

The emergence of cloud made it possible to have video streaming applications in cost effective fashion. Service providers of VoD shifted their platform to cloud so as to provide scalable services effectively. The environment Figure 2 shows sample infrastructure used for VoD. The infrastructure includes VoD server and VoD clients besides storage media and set top box connected to television. With cloud based video streaming applications, the servers are associated with cloud and computing resources are consumed from cloud. In this context, it is essential to have resource allocation to satisfy growing needs of customers. With growing subscribers exponentially, resource allocation becomes a challenging problem. The existing resource reservation mechanism is good for resource allocation. However, it has drawbacks as resource allocation is dynamic process and prediction of demand is important to have optimal resource allocation.

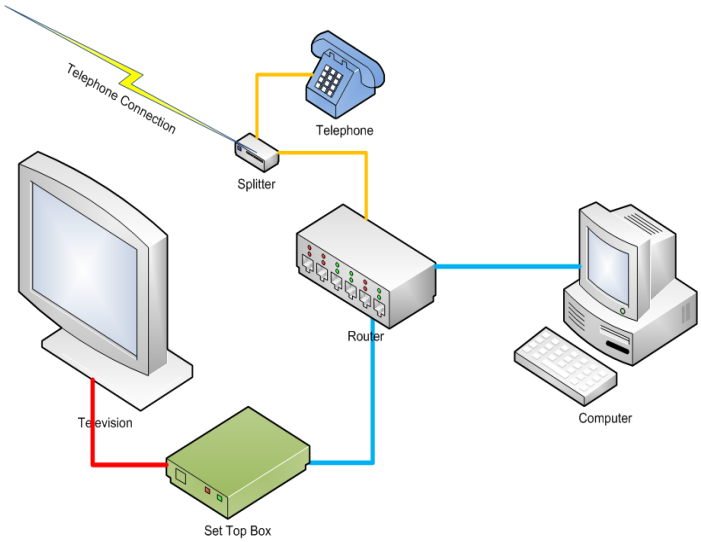

Figure 2: VoD Infrastructure for Internet Protocol TV (IPTV)

With a good prediction algorithm in this context, resource allocation can be optimized. However, it is a challenging task as the demand is not static. This is the main focus of the paper. We proposed an algorithm based on time series data which can help in reducing error rate in prediction. It also helps to have better forecasting model.

PROPOSED SYSTEM

In this paper we proposed framework with an underlying algorithm that focuses on time series data for prediction of demand from subscribers of VoD. The purpose of the framework is to have an accurate prediction or optimizing resource allocation in cloud. Thus it could improve Quality of Service (QoS) and customer satisfaction that leads to growth of cloud based video streaming business. The existing resource reservation system has flaws as it can jeopardise interests of service providers and consumers in the wake of sudden bursts in the requests to VoD infrastructure. Keeping this in mind, in this paper we proposed a double smoothing based prediction algorithm which could reduce error rate significantly. The forecast made using the algorithm helps domain experts to make strategies to ensure QoS and Quality of Experience (QoE). The real time prediction of the proposed framework can contribute to the optimization of resource allocation in cloud. The overview of the framework is shown in Figure 3.

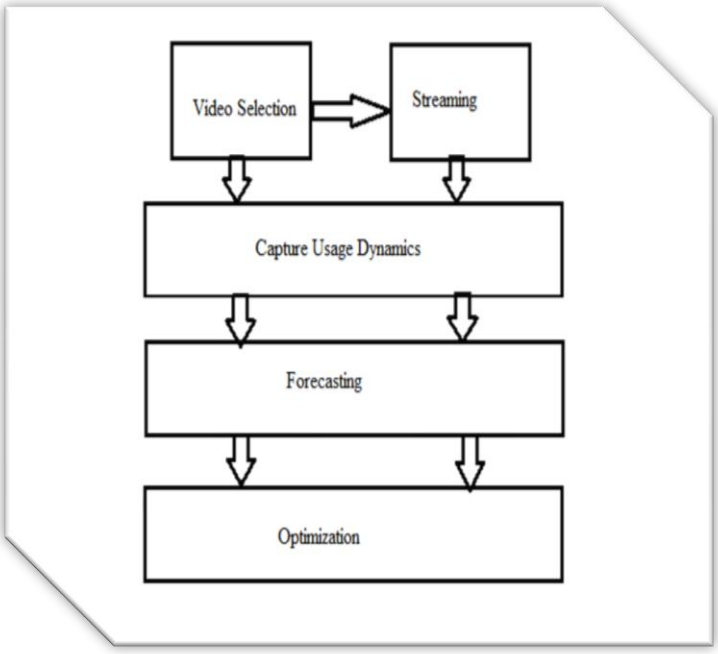

Figure 3: Overview of the Proposed Framework

Different phases in the proposed framework are video selection, streaming, capturing usage dynamics, forecasting and optimization. As the VoD infrastructure can render thousands of videos to subscribers, it is important to know the demand for any selected video. That is the reason video is selected first for forecasting demand. Then the steaming and its related usage dynamics are captured in order to subject it to time series analysis by employed the proposed algorithm. The actual forecasting is made using our algorithm. Optimization is the process of using intelligence provided by the forecasting algorithm in order to have optimal utilization of cloud resources. This will ensure that cloud resources are not wasted and at the same time customers do not feel deterioration of QoS in rendering video streams.

IV. PROPOSED MEDIA STREAMING FORECAST ALGORITHM

We proposed an algorithm for improving forecasting of video usage dynamics in the presence of ever increasing customer base. The proposed forecast algorithm is based on double smoothing model which can reduce error rate in prediction significantly. This algorithm can have its impact on the video streaming industry which is cloud based as the algorithm provides administrators real time forecast to make well informed decisions from time to time.

Algorithm: Media Streaming Forecasting Algorithm

Inputs : D, a, g, init, n

Outputs : P

```
P[sizeof(D) + sizeof(n)]
s[sizeof(D)]
b[sizeof(D)]
 i = 1
 j = 1
P[0]=s[0]=D[0]
IF init=0 THEN
   Assign first element of b with difference between first two elements of D
END IF
IF im=1 AND length of D>4 THEN
   Assign first element of b with difference between third and first of D divide by 3
END IF
IF im=2 THEN
   Assign first element of b with difference between last and first of D divide by last
element
END IF
For Each d in D
 s[i] = a* D[i] + (1 - a) * (s[i - 1]+b[i - 1])
b[i] = g * (s[i] - s[i - 1]) + (1-g) * b[i-1]
y[i+1] = s[i] + b[i]
 i=i+1
End For
For each forecast number fc in n
   Compute y[j]
   j=j+1
End For
Return y
```

Algorithm 1: Media Streaming Forecast Algorithm

As mentioned above, the algorithm is built with double exponential smoothing for reduction of error rate. It takes many parameters such as number of forecasts, visualization method, gamma value, alpha value and time series data as inputs. Least error rate is achieved by employing alpha and gamma appropriately.

NOTATION	DESCRIPTION
D	Time series data
a	Alpha
g	Gamma
init	Initialization method
P	Predictions for given data
n	Number of forecasts

Table 1: Shows Notations Used in the Algorithm

We implemented a prototype application to demonstrate the proof of concept. The empirical study is made using web based three-tier application which revealed useful insights. An important observation is that the algorithm is able to forecast demand which is closely matching the real usage dynamics. The following two sections provide implementation details and empirical results respectively.

IMPLEMENTATION

We built a prototype application to simulate non only the video streaming phenomenon but also the time series prediction process. The application for video streaming is web based and provides scalable solution to multiple users who can view videos in VoD fashion. The application in the live environment keeps tracking voluminous data regarding usage dynamics. Such data is associated with videos being given to subscribers. Video based time series analysis has been made using our proposed algorithm. Two experiments are shown in Figure 4 and Figure 5.

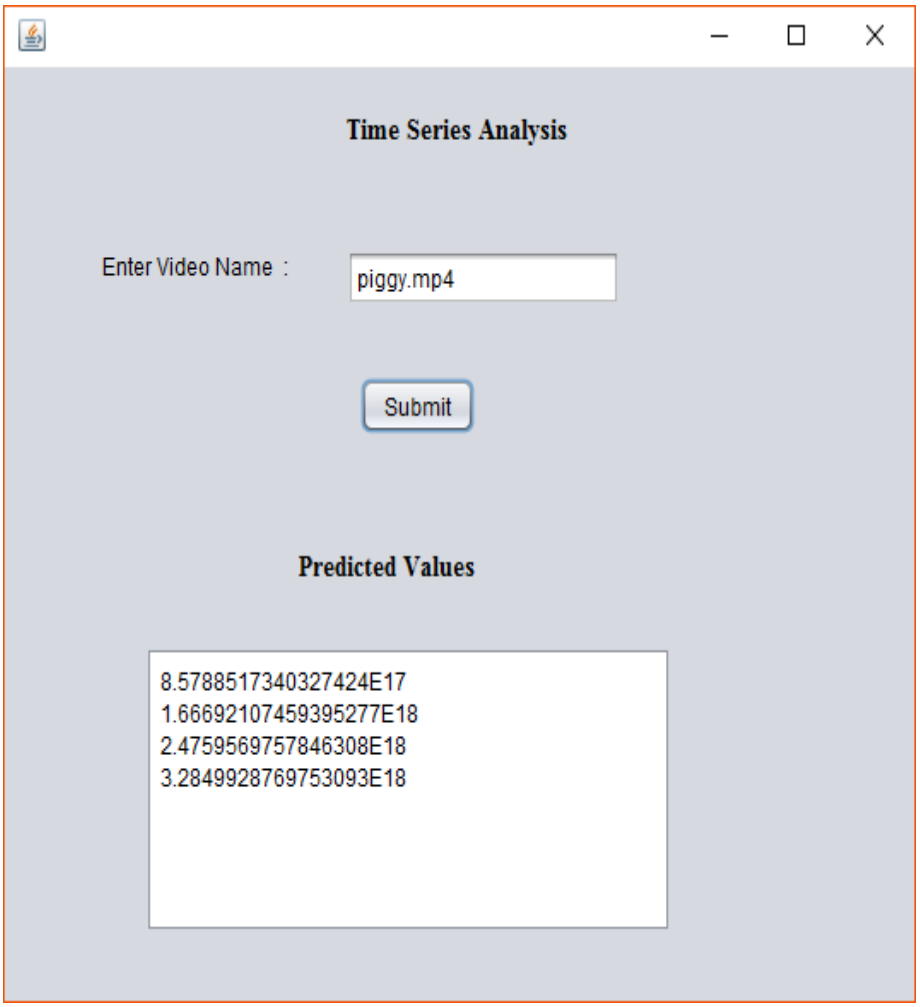

Figure 4: Prediction of VoD Usage for Piggy.mp4

As shown in Figure 4, it is evident that the piggy.mp4 is selected for time series analysis. The algorithm proposed in this paper works when user submits the video name as input. After processing the time series data associated with the video, the results are presented.

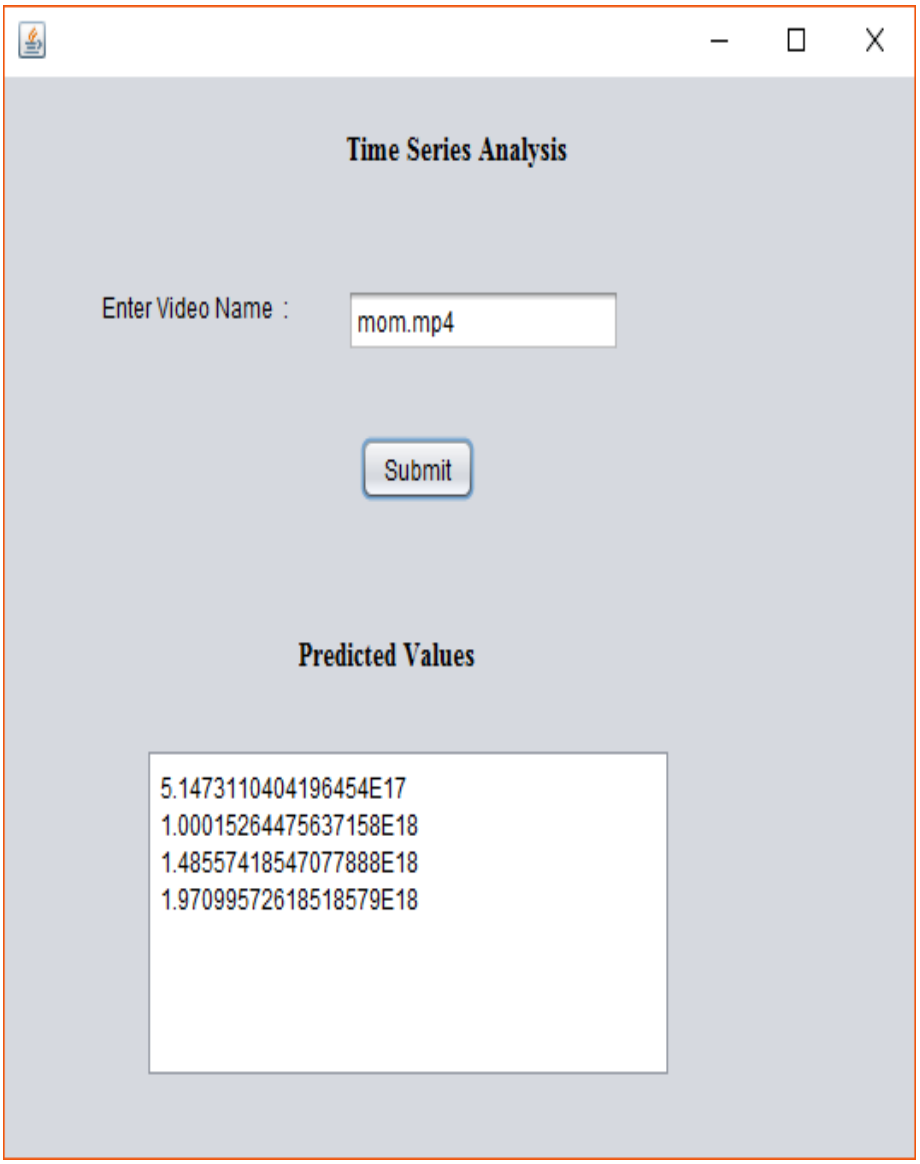

Figure 5: Prediction of VoD Usage for Piggy.mp4

As shown in Figure 5, it is evident that the mom.mp4 is selected for time series analysis. The algorithm proposed in this paper works when user submits the video name as input. After processing the time series data associated with the video, the results are presented.

V. EXPERIMENTAL RESULTS

Our prototype application is used to do experiments on forecasting of usage dynamics for different videos. The application shows the video streaming live with given videos. The usage statistics are stored in a structured database created in MY SQL. These results are taken for time series analysis according to the algorithm proposed in this paper. The results are presented in this section. Before presenting our empirical results, we present the growth rate of VoD of late. The results presented in Figure 6 show VoD play time from the year 2009 to 2012.

Table 1: Shows Comparison of Free Video on Demand and All Video on Demand between 2009 and 2012.As shown in Table 1, it is clear that the VoD growth rate is increased over a period of time. It is at steady growth that is 20% in 2011 and 2012. In 2009 and 2010 it is less than 15%. These details are related to free video on demand.

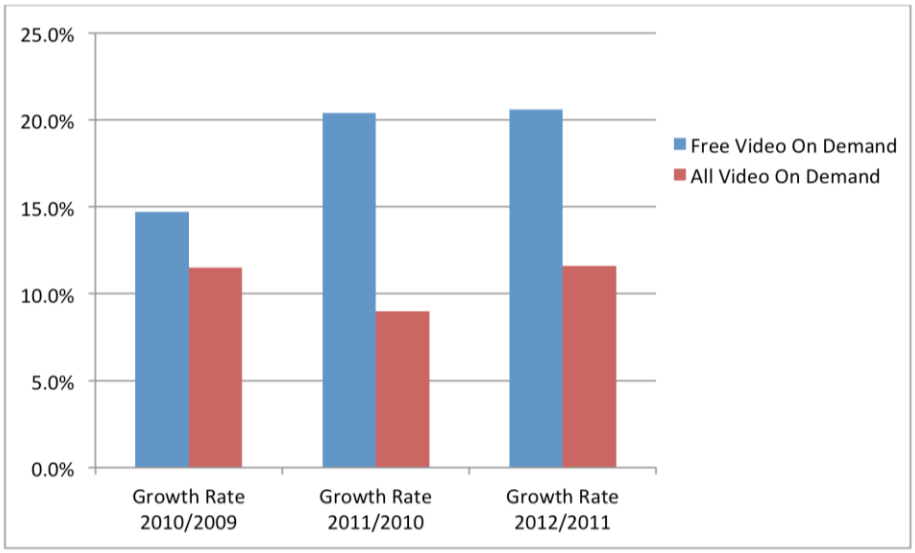

Figure 6: General Forecast of growth rate of VoD play time between 2009 and 2012

The estimated growth rate is increased every year and the free video on demand has more forecast when compared with all other videos. In this paper we focused on the empirical study of different videos with forecast made by the proposed algorithm. Every video has associated with it statistical data based on usage dynamics. This is valuable information which contains both temporal and space domain. This data is analyzed by the proposed time series basedalgorithm. The prediction results are presented in Figure 7. The statistical results of forecast are presented in Table 2.

Video	Day	Forecast	Actual
Piggy.mp4	Day1	4.56	5.5
	Day2	10	12
	Day3	14.6	16.5
	Day4	3.1	3.5
mom.mp4	Day1	1.5	1.5
	Day2	5.6	6
	Day3	3.16	2.5
	Day4	11.01	11.5
cricket.mp4	Day1	9.8	10.5
	Day2	17.4	19.5
	Day3	4.5	5
	Day4	3.1	3.5
Ipl.mp4	Day1	8.06	6.5
	Day2	2.9	3.5
	Day3	3.9	4
	Day4	6.8	7

Table 2: Forecast Results

The forecast results for different videos are presented for four consecutive days. This data can help service providers of video streaming applications to have enough intelligence to make well informed decisions. The error rate is reduced due to the double exponential smoothing and the usage of alpha and gamma values. In fact there is no much difference between actual and forecast that provides evidence for the efficiency of the proposed time series based prediction algorithm.

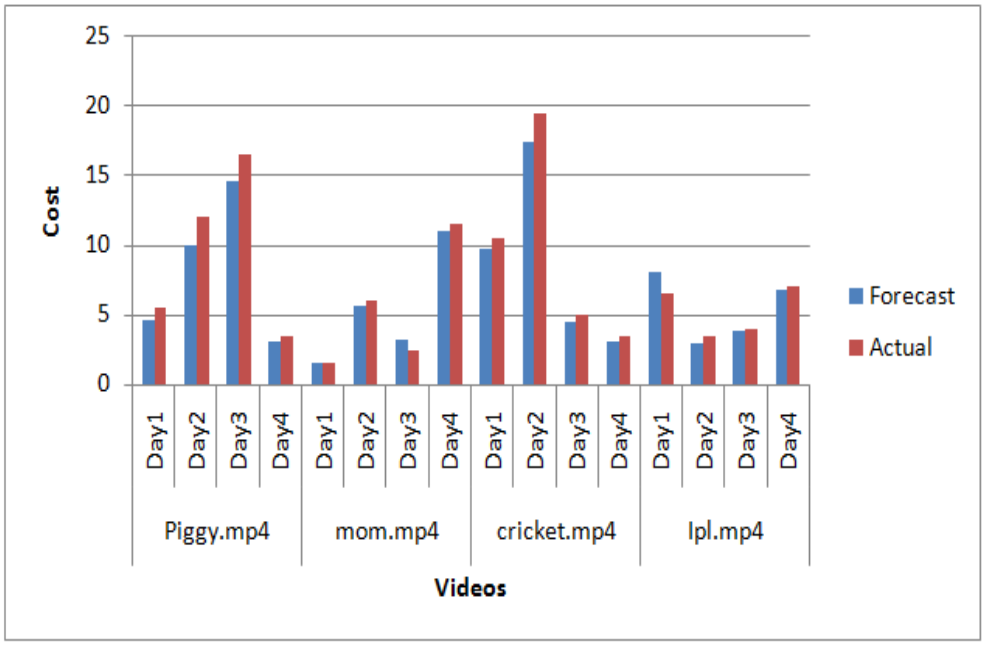

Figure 7: Empirical Results with Actual and Forecast Values

The results of forecast and the actual results are presented in Figure 7. The videos for which forecasting is made and the number of days for which observations are made are presented in horizontal axis while the vertical axis represents the cost. The window size and cost are understood from the results. Cricket.mp4 shows highest window size and cost. Mom.mp4 video exhibited least window size and cost. These details can help service providers to make well informed strategies to ensure quality of service besides high customer satisfaction. This can in turn lead to generating more revenues for service providers.

VI. CONCLUSONS AND FUTURE WORK

In this paper, we focused on the study of cloud based video streaming applications that became popular of late. The main problem we focused on is the resource allocations in cloud for those applications that show varied demand from time to time. Therefore it is challenging to have optimal resource allocation. This is the motivation behind taking up this work. We proposed an algorithm for efficient forecast of video streaming applications' usage dynamics. The forecast is used along with existing approaches in order to strike balance between resource exhaustion and resource wastage caused by existing method. Our algorithm is time series analysis based and it makes use of double exponential smoothing in order to have reduced error rate. The algorithm takes different videos as input and provide forecast of the usage dynamics of the videos. This can help service providers to have enough intelligence to optimize resource allocation. Our prototype application demonstrates the proof of concept. Our empirical results show the utility of the proposed algorithm for improving quality of services with respect to cloud based video streaming applications. This research can be extended further to focus on the prediction of demand in the context of Internet Protocol Television (IPTV).

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