Seasonal forecasting of mobile data traffic in GSM networks with linear trend

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Received: Feb. 24, 2020, Accepted: Apr. 30, 2020

Recently, the popularity of predictive analytics has grown in many areas. For mobile networks, it is the most critical technique that can offer the advantages of mobile network planning to operators for predicting the mobile traffic of each Long Term Evolution (LTE) market. It can help operators spend the least investment on new sites and new communities but can guarantee an excellent service experience for mobile broadband users. Mobility management essentially has two databases: one is the Home Location Register (HLR) and the other the Visitor Location Register (VLR) is. The mobile user can move to call tracking from anywhere in the network location registry. In mobile data networks, an essential factor is a demand for telecommunications containing the number of subscribers and the prices for the required service data. To understand what subscribers need to build customer satisfaction, this requirement needs to be precisely predicted. In this context, the approach to forecasting mobile telephony used in Indian telecommunications, in our view, does not fully take into account the demand for data already recorded on its core network. In this paper, we are analyzing the Seasonal Forecast Time series model (SFT). This approach is used in this paper to first analyze the transferred data traffic from the core network of the operator to find a suitable model describing the inherent characteristics of data traffic and the use of model for future predictive loading in VLR database.

Keywords: Mobile Data Traffic; Seasonality forecasting; Time series analysis; HLR-VLR databases

http://dx.doi.org/10.6180/jase.202009_23(3).0011

1. Introduction

The mobile phone industry has grown in the last decade. They play an important role in people's lives. One of which is an introduction to many of the best service technologies (Over-the-top), which helps drive the demand for information and voice traffic in mobile networks to grow at a steady rate at a relatively high level, the data flow is rapidly increasing [1]. Customers are concentrating increasingly on the use of mobile data. For example, between 2010 and 2015, multimedia traffic accounts for 10% to 50% [2]. Compared to revised estimates of transport demand for 2005 and 2020 estimates made in 2012 show that previous forecasts significantly underestimate future levels of mobile data [3]. Third-generation technology developed by the mobile network (3G) to enable the efficient delivery of high-traffic networks has altered the operating conditions and technical complexity. In many ways, 3G technology can be seen as GSM and GPRS having made changes related to the network access segment. As well as the subscribers expanding rapidly, the service providers face challenges in meeting customer needs [4]. The number of subscribers is increasing as new users. The company is calculating ability as technology expands available networks to handle traffic and provide customers at the lower end of the service quality they need. Capacity forecasting and network preparation based on expected traffic are necessary to properly manage data explosions. It should be noted that in a low-traffic environment, allocating a large number of resources would result in low resource utilization, a waste of costly radio transmitters. Allocating certain resources to high-traffic areas can result in congestion in the system that ultimately leads to poor quality service units [5].

Therefore, realistic mobile forecast models should be created, with a major impact on the design and management of a profitable and high-quality network. According to our observations, current network traffic in Indian telecommunications uses projected trends to monitor population demography, population growth and other percentages of parameters and other economic policy forecasts [6]. The main drawback of such an approach is that it does not use information like customer development, and the demand and use of data involved in network traffic control.

Mobile station registration

A. Procedure for mobile user registration

On any cellular telecommunications system, users profile needs to carefully manage and register the setup calls. Cellular telecommunications networks need to provide not only fast and efficient services to their legitimate customers but also the ability to provide users and the network with a high level of security. It must be able to communicate with a wireless communications network when a mobile phone is turned on. The phone has no assigned channel, time slot, or smart code (depending on the type of method of access used). Therefore, methods or devices on the cellular telecommunications network should be usable, through which the newly excluded mobile stations will communicate with the network and create structured communications [7]. Even if the call is not made immediately, the network must be able to communicate with the mobile device to know its location. It allows the network to route any call through the appropriate multiple base stations, the network can overwhelm quickly.

B. Network Elements

User database which allows users to login to a particular network. Considering that mobile stations can usually access all available channels in one country, a method is needed to ensure that the mobile station is registered to the proper network and the account is legitimate. It's also needed for purposes in billing. To this purpose, the network uses an entity commonly called an authentication center (AuC). Networks, wireless communications, and user numbers. User data is checked here to provide authentication and encryption settings for verifying user identity and maintaining privacy for every call, thus protecting users and network operators from fraud. Two additional registrars are generally required until to accept the network. These are register of Home Location (HL) and register of Visitors Location (VL). Such two service providers are expected to track the mobile station in such a way that the network always knows where it is to allow direct calls to the appropriate base station or network area. Such records are used to store the last known location on the device [8]. The registrar is therefore updated when registering, and then the mobile station constantly changes its location, even if the mobile station is inactive, it frequently interacts with the network to change its location and position. This will give a disconnect notification when the cell phone is turned off. This will inform the network of its closure and allow the mobile station to update its nearest known location [9].

The subscription process for the mobile network is a process in which the Member State informs the system of its current location. Based on the IS-41 or GSM management protocol, the mobile management strategy uses a two-tier download and database system. The HLR is known to mobile phone users as home system. Like HLR, VLR is the visitor location register in the visit system, i.e. VLR is another role register used to retrieve information from mobile visitors about call management [10].

When a mobile user accesses the current region's new PCS network area during the new registration process, the VLR states the following:

1. The mobile station (MS) requests information from new visitors to register in new VLR database.

2. The new VLR notifies HLR of the mobile subscriber of the current location of the MS and the new VLR's address. HLR sends acknowledgment including profile of MS.

3. New VLR communicates information to MS about current registered users.

4. The HLR sends the old VLR a logout message, and the old VLR confirms the logout.

Existing work

In telecom networks, as stated in various literatures, the mobile traffic characteristic dictates the selection of suitable predictive models. The conventional circuit-switched voice service has a well-understood traffic showing short-range dependence and call-incoming. However, with the emergence of modern technologies and services, such as the Universal Mobile Telecommunication System (UMTS) and conversational Voice over IP, the network is becoming more complex and other predictive models are being initiated.

From Samuel Medhn et al. [11] the data traffic is first analyzed by the past UMTS data traffic load obtained from the operators core network to find a suitable model describing the inherent characteristics of the data traffic and secondly by using the model for future prediction. Such results would be useful in preparing future upgrades of the network in such a way as to guarantee better customers.

In 2017, Arvid Baarnhielm [12] stated that to assess the performance of a mobile network forecasting model based on a multivariate dataset consisting of time series of traffic characteristic performance data. Francis Kwebena et al.

[13] aims to build a model that will help to predict 2G network voice traffic in telecommunication networks. The structural breaks in the data were defined using the Zivot-Andrews test for new, trendy and then new trend-levels.

Tran, Q. T., Li, H., & Trinh, Q. K. [14], the network planning and management and wireless traffic prediction plays an important role particularly for the real-time decision making and short-term prediction. Systems include predictive methods with high precision, low cost and low computational complexity. Bastos, Joao [15] states the optimizing the use of mobile network resources is an imperative activity for fostering positive returns on network investment, avoiding bandwidth bottlenecks and providing good end user experience. This study explores the efficiency of several mathematical models for forecasting mobile network voice and data traffic.

Proposed Work

Short-term prediction and real-time decisions are best served in network planning and management by means of simple and low-cost prediction methods with high precision. Seasonal Forecast Time series model (SFT) is applied to forecast traffic on GSM network. However, a more detailed study was required to determine the use of various methods of seasonal forecasting model in more forms of wireless traffic, such as data, which is becoming more relevant along with the advancement of communication technology. In both hourly and daily voice traffic cases the forecast series was close to the original series and showed good ability to forecast daily data traffic as well. In addition, the classification can be further applied depending on the different cellular network specifications.

The network traffic can be predicted using different time series forecasting methods, based on the availability, characteristics and patterns of past data. Analysis and forecasting of time series is useful in many different fields and for a lot of different datasets. One important area where analysis and forecasting of time series can have a big impact is when attempting to forecast mobile traffic in the mobile network. Good mobile traffic forecasting could help improve the network performance in a number of ways. Below are a few possible use-cases where mobile traffic forecasts could be helpful.

i. Load-balance

By knowing in advance when high load is about to occur in the network, measures can be taken to prevent an overload situation. Data can be reallocated, users can be redirected to nearby cells, and other measures can be taken. That will help to improve the service quality for all users.

ii. Saving Energy

The data traffic for most network cells will sometimes be very low, e.g. during night time. In some cases, especially where the cells are close enough to overlap their respective covered areas, not all of the components, or even all of the cells, need to be active. If cells could be partially or completely deactivated when they are not needed, it could save energy while also extending the components' lifetime. However, it is important to have knowledge about the amount of data traffic in the future for a sufficient amount of time to avoid switching the components on and off repeatedly.

II. MOBILE CALL DELIVERY POLICY

While attempting to transmit a network call to a mobile user, location monitoring is required after the mobile station has been registered. When a mobile user or landline is attempting to contact a mobile operator, the caller must be aware of the location of the party on the mobile networks. First, the calling party's requesting VLR asks for information of the so called HLR [9, 16, 17].

1. The caller's VLR queries the HLR to find MS's current VLR (called party). HLR query VLR where MS is located to get routable address.

2. Callee's VLR returns routable address to the HLR, and the HLR also returns the address to originating VLR.

3. Use a routable address from VLR of caller to callee MSC.

III. CALL DELIVERY TO A ROAMING USER IN GSM

The registration must also be notified to HLR. In order to access the MS, the HLR must find the current MS VLR. The registration process for MS is as follows when moving from one VLR to another.

1. The MS reacts to BCCH transmitted regularly from BSS. If the MS detects that it has reached the new area, use the SDCCH interface, it sends the registration message to the VLR.

2. The new VLR communicates with the old VLR to recognize the HLR of the MS. The new VLR then did the authentication process.

3. The new VLR sends a registration request to the HLR after authentication with MS. If the notification to register is accepted HLR will provide a new VLR with new call management subscriber information.

4. The new VLR notifies MS of successful registration.

5. After Step 3, the HLR sends the cancellation message to the old VLR. The old VLR cancels the record for MS and sends a receipt to the HLR about the cancellation.

6. If the MS is disconnected due to turn off or removal of SIM, it transmits a detachment from the network to be registered. MS must regularly send a message of registration to the network. Period durations can vary slightly between

6 minutes and 24 hours.

IV. SEASONAL FORECAST

Seasonal and trend forecasting is clearly more difficult than trend forecasting because compensating for these two factors is more difficult than either alone. One can also use other methods to consider both trends and Seasonal, but we will do the following:

1. Estimated seasonal quantity - seasonal indicators (factors)
2. Estimated trend (rate demand is growing)
3. Straight line forecast for future demand
4. Adjust seasonal linear projections to get seasonal forecasts

By using linear regression based on minimizing the sum of squares to get the best fit line error. With the seasonal data, some points will be far from the trend line, which can be a supply voltage line and give a lower R^2 value, which will lead us to obtain linear regression values. Here we use the following terminology as:

- F_i as demand forecast for the period i.
- A_i as the real demand during the period i^{th} and the forecast made at time t.

A. Estimate Seasonal Relatives

We have to think about seasonality seasonal demand has a recurring pattern depending on the seasonal relationship of each month (or fifth, week, etc ..). There is a seasonal pattern to the demand for network traffic that recur every 12 months. Some firms can review annual seasonal plans quarterly. Month referring to periods (or quarters or weeks, etc.). With the annual seasonal model, there is a cycle depending on whether the demand lasts 12 cycles if the periods are months or the periods are quadrants and 4 periods. There can also be seasonality, a short period of time per week. A seasonal factor means that demand for the given period is higher or lower than average demand. For this reason, we imply that for the first phase of the cycle we must have an average output, and so on for the second. Compare then these average needs over time with the average request. It may be the previous cycle's average output, or several cycles.

B. Seasonality and Trend

We use the following data presented in Figure 1 as an example. The data clearly had a 4-period cycle.

C. To estimate the growth rate

To predict growth, we break down individual demand figures to see how demand increases or decrease over time.

D. Making Seasonal Forecasting

To produce a seasonal forecast multiply the linear forecast by the seasonal variables.

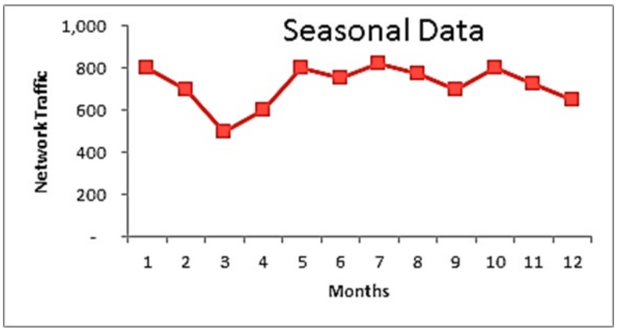

Fig. 1. Seasonal Data of Users.

Table 1. Months.

Months	Network Traffic	Months	Network Traffic
1	800	7	825
2	700	8	775
3	500	9	700
4	600	10	800
5	800	11	725
6	750	12	650

CONCLUSION The evaluation of mobile data traffic on mobile networks is analyzed in this study, by taking into consideration the demand for mobile data and network traffic. The estimation model is proposed and implemented based on the previous study of data traffic. The comparison of the reference values with the available data goes from January 1, 2015, to December 31, 2016. The results obtained confirm the efficiency of the estimation method, sufficient to estimate the data traffic. Telecom providers forecast data that will help them prepare and connect their networks to investment decisions related to infrastructure expansion based on the information available; current data suggest job creation based primarily on marketing information.

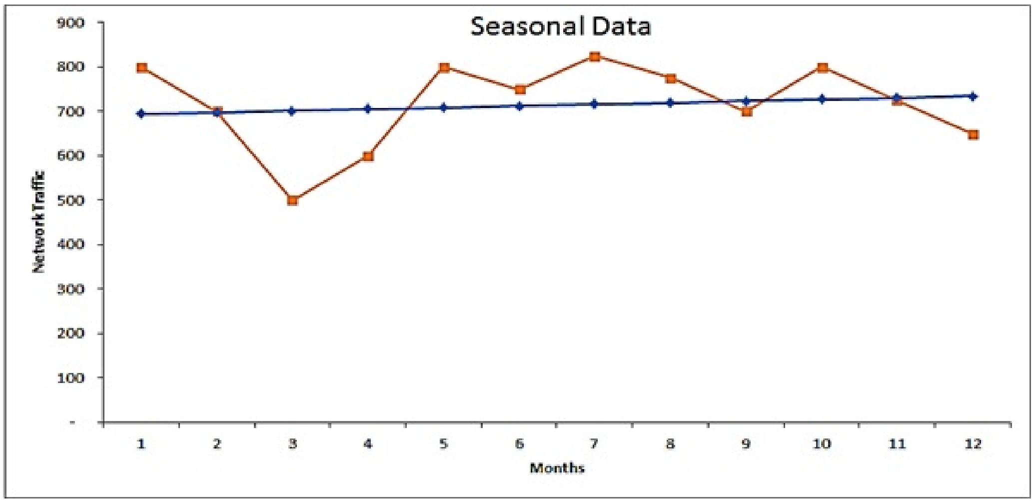

Fig. 2. Seasonal Data of Users with Linear Trend.

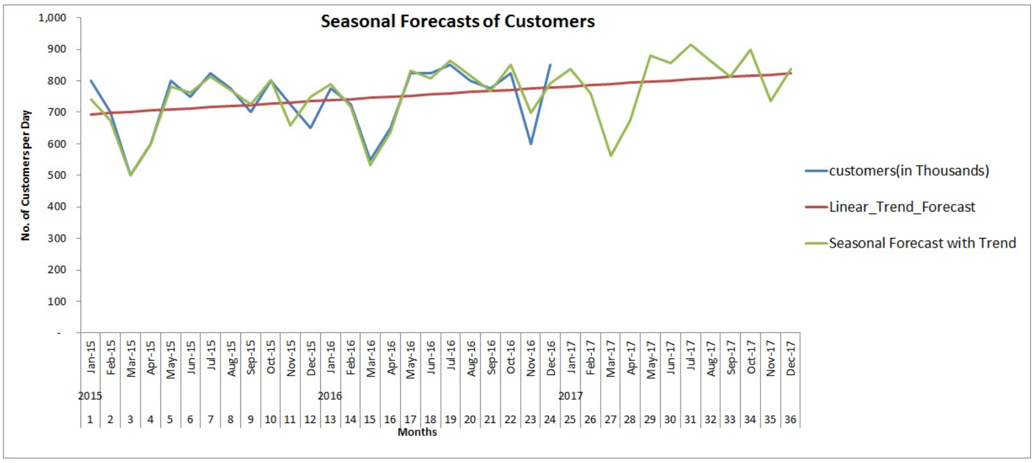

Fig. 3. Seasonal Forecast with Trend for Mobile traffic data.

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