A Feature-based Recommendation System for Mobile Number Portability

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Abstract. Mobile phones have become an inherent part of people's lives in contemporary days. Mobile numbers have become the digital identity of a person these days so, changing phone number requires one to change their phone number at all its registered places. Mobile number portability (MNP) enables users to switch their network operator without changing the phone number. After the emergence of MNP services in India, the Number of MNP requests has risen significantly since the last decade. This provides with the exemption from changing their number at every registered place. Despite such benefits of MNP service, people still face problems while switching to a new Mobile Network Operator(MNO). Network strength varies from MNO to MNO and from area to area, making it difficult for users to choose MNO. With the diversity of plans in terms of daily data, price and additional benefits, users are confounded and it becomes difficult to go through all the plans and decide the one that fulfils all their requirements. Thus authors came up with a k-medoids clustering-based recommendation system that takes users' requirements as input and recommends plans to choose from.

Keywords: Mobile Number Portability, Clustering, Mobile Network Operator, Recommendation system

1 Introduction

With an annual sales of 162 million mobile phones in 2021, India has marked a 12% percent increase compared to 2020 [6]. Such an increase in numbers indicates the rise in mobile phone usage, resulting in an increase in MNP requests. Mobile number portability is a service using which mobile number users can change their telecom company without changing their phone number. Before November

2010, when Mobile Number Portability (MNP) was introduced in India, users were forced to stick to the same telecom company despite the dwindling service standards. Shifting to another telecom company is cumbersome as it requires one to change their phone number. After the advent of MNP services in India, many MNP requests increased. Fig. 1 shows the number of MNP requests in India; based on the growth observed in recent past years. We infer that number of requests is likely to be doubled by 2027 [5] due to the advent of the 5G and beyond the network in 2022. India is predicted to have 500 million subscribers of 5G by 2027 [3]. This significant change from 4G to 5G might produce many MNP requests as all network operators try to provide different quality services so that a user stays with the same network operator.

People primarily use mobile networks to communicate, align their business

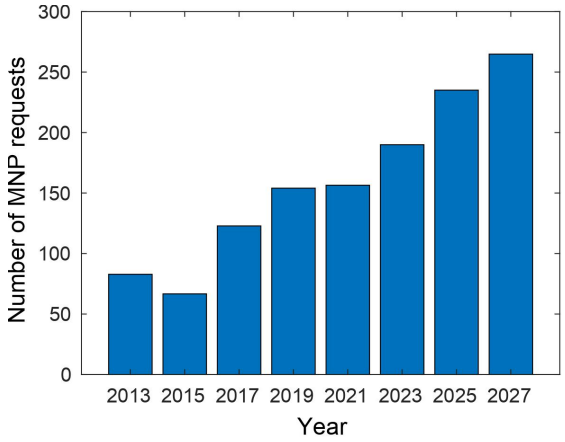


Fig. 1: Number of MNP requests in India.

operations online, and access the Internet quickly. Individuals rely extensively on network connectivity in this era of the Internet for various reasons, including education, businesses, work-from-home, etc. Hence, people want robust, reliable, and affordable network access for many of these reasons. For an individual, affordable pricing is more important than robust network connectivity. As a result of the Covid-19 pandemic, businesses have shifted to work-from-home, requiring their employees to work in remote areas, and the education industry has shifted to e-learning, requiring students to study online. Therefore, the demand for a reliable and robust internet connection has skyrocketed[1]. People want to choose the best Mobile Network Operator (MNO) that can provide a network connection that is fast, cost-effective, and reliable.

There are various MNOs in India, and within these network operators, there is a wide range of plans available to the users. Even though all the information regarding the plans is available online, people still face a huge dilemma in changing their current mobile network operator (MNO) [6-8]. The user needs

to browse through each MNO's website, compare all the available plans, and choose the best MNO and plan according to their requirement. Sometimes, for better clarity regarding network plans, the customer needs to visit the nearby telecom office or connect with the customer care of a particular MNO. Moreover, users who require international calls in their plan need to compare the rates of all the MNOs and then decide which plan and provider are best suitable for them. Additionally, the strength of a particular MNO varies with the area and state in which the customer is residing, making it difficult for them to decide which MNO to opt for. For example, [2] shows the speed of Indian MNO's on different states, and one can clearly see that there is a significant difference in speed between other states. This makes mobile number portability tedious and the selection of a plan confounding. Even after selecting a specific plan, the user is not satisfied with the quality of service and experience.

Furthermore, the users are also utilizing the benefits of the Over The Top (OTT) platform subscription other than strong and affordable connections. There is a significant rise of OTT platform's global subscriber count from 104 million to 116 million at the end of the third quarter of 2021 [4] and thus stating the rise in the number of people interested in watching shows on such OTT platforms. Thus, many MNOs have started providing free subscriptions of such OTT platforms, benefiting users. However, it incurs a lot of challenges when one has to obtain the best plans; this is because all MNO's plans are very close, and it is difficult for one to choose the best plan efficiently. Many MNO's also provide post-data consumption speed; if a user consumes their entire data for the day, they can continue using the internet at the provided speed (generally 64 kbps). On the other hand, specific MNO's offers unlimited data for the time 12:00 AM to 6:00 AM in some of their plans. Some users also wish to have these extra services included in their plans.

Several researchers have delivered solutions to pave the way to provide the best recommendation of plans to the users. For example, the research community has focused on predicting churn behavior by analyzing the customer's data. In [9] focused on the predictive factors and predicting churn behavior for MNP. In [11] authors have proposed a game theory-based machine learning model to predict potential subscribers who are likely to move to other MNO [12]. In [13] authors have focused on analyzing factors that lead to customer satisfaction when using telecom services. They concluded that reliability, price, and coverage were the three most important customer preferences for an MNO. [10] conducted a study to analyze user switching behavior and concluded that there is more number of unhappy customers in India in terms of services received by MNO. In [7] authors have proposed a system that analyzes user call rate, data usage, and a number of messages sent. Further, they mentioned that, due to unlimited call services and the emergence of IP messaging, the rage of call rate and simple messages, i.e., Short Messaging Service (SMS), are getting down. However, they have not studied the most critical parameter, i.e., the signal strength of an MNO. Since MNP is available across many countries in the world, there is a strong requirement for a system that provides the potential parameter that helps in recommend-

ing suitable plans according to the user's needs. Therefore, in this paper, we considered all the essential and desirable parameters for users to select the best MNO and plan. The essential characteristics of machine learning can assist a user in conveying the best MNO and their optimal plans according to the user's requirement. Firstly, a dataset is formed using the data provided on the official websites of all the Indian MNOs with all the parameters such as price, data per day, etc. Then the dataset is divided in 4 clusters using k-medoids clustering. Then, user's requirements are taken as input in order to assign a cluster to them, Followed by extraction of the plans satisfying user's requirements. Finally, the user is recommended plans from this extracted plans which are ranked on the basis of signal strength and data per day.

Table 1: List of Symbols

Symbol	**Meaning**
N	Set of Users desiring the MNP
A	Set of areas
K	Set of MNOs
P	Set of plans offered by all MNOs
λ	set of clusters
μ	Set of price per day
$\rho_{\mathrm{r}}{}^{(\mathrm{w})}$	Signal strength of network provider K_r in area A_w
χ_i	Rank of a plan on the basis of ρ
ψ_i	Rank of a plan on the basis of μ
Υ	All plans better than the existing plan the user has.
θ_{N_h}	Daily data used by user N_h
θ_{P_j}	Daily data provided by plan P_j

1.1 Motivations

The motivation of this article can be defined as follows

- The number of MNP requests has increased since the last decade. In 2021, 156 million MNP requests were registered in India; moreover, the diversity of plans available, along with the variety of MNOs, makes the task of MNP difficult for the user. Hence, reflecting the demand for a recommendation system that can assist this huge demand of MNP.
- Even after choosing a plan, the user is not satisfied with the service provided against the money paid for the service. Requirements such as signal strength worthiness of the plan remain unsatisfied even after paying the price. Therefore, the recommendation system has considered the signal strength, price, etc., to recommend the user the most suitable plan.
- Features such as data rollovers OTT platform subscriptions are some of the complementary features provided by the service provider; many users are

unaware of the network operator's features and blindly choose an obscure plan. Therefore, there is a requirement for a system that can provide a flexible and reliable recommendation of MNO's plan.

1.2 Contributions

Choosing a suitable plan is a troublesome task due to the variety and diversity of plans and varying signal strength of MNO's across different places. Previously researchers have not focused on a comprehensive view of the parameters that shape a user's choice in choosing a plan. Given this, the following are the objectives of the paper.

- We prepared the dataset consisting of the plans along with all features, such as price, data per day, etc., provided by mobile network operators.
- Clustering-based recommendation system is presented that takes into account user's requirement and suggests plans with optimal price and reliable internet connection
- Evaluation of the recommendation system is performed using a testing dataset made by varying requirements from the users and analysis of the result is performed.

1.3 Organization

The organization of the paper is as follows, Section 2 consists of a system model which describes the various attributes and variables used in the paper followed by the problem formulation that generalizes the problem solved by the proposed model. Section 3 describes the architecture of the proposed clustering-based recommendation system. Section 4 consists of the analysis of the result of the proposed system. Finally, Section 5 concludes the paper. Table 1 shows the symbols and their corresponding representations used in the paper.

2 System Model and Problem Formulation

2.1 System Model

Fig. 2 shows the proposed architecture to provide suitable recommendation of plans to the user. In this architecture, there are (N) users such as $\{N_1, N_2, \ldots, N_i\}$ $\in$ N, residing in a particular area (A) such as $\{A_1, A_2, \ldots, A_m\} \in A$, and poses network operators (K) such as $\{K_1, K_2, \ldots, K_z\} \in K$ that provides telecom services. We have gathered a dataset (D) from different network operators, consisting of rows (P) such as $\{P_1, P_2, \ldots, P_r\}$ that represents the plans of various network operators and columns (C) such as $\{C_1, C_2, \ldots, C_q\}$ represents various attributes of a particular plan. We have divided plans into clusters (λ) such as $\{\lambda_1, \lambda_2, \ldots, \lambda_t\} \in \lambda$ using k-medoids clustering algorithm. A new user $N_h \notin N$ residing in area $A_i \in A$ who is using network operator $K_{\mathrm{x}} \in K$ is facing problems with the current network operator and wants to port his/her number to

some other network operator K_y where $y \neq x$. Based on N_h's requirements we choose a cluster $\lambda_g \in \lambda$ and recommend plans from that cluster only. After choosing a cluster for the N_{h}, in order to recommend the best possible plan, we extract plans that satisfy N_{h}'s requirements like daily cellular data and OTT subscription, etc. We get a set of plans E where $E = \{E_1, E_2, E_3, ..., E_v\} \subseteq \mathrm{D}$ $(v \leqslant p)$ is the set of plans that satisfy N_{h}'s requirements. The recommendation of the extracted plans depends on two features price per day (μ) and probability of strong signal strength $({\rho_{\mathrm{r}}}^{(\mathrm{w})})$. ${\rho_{\mathrm{r}}}^{(\mathrm{w})}$ represents signal strength of network operator K_r in area A_w, θ_{N_h} represents the daily data used by user N_h and θ_{P_j} represents the daily data provided by plan P_j . Then the plans are sorted on the basis of ${\rho_{\mathrm{r}}}^{(\mathrm{w})}$ (in decreasing order) and μ(in increasing order). Consequently, the plans are ranked. The rank of plan i on the basis of ${\rho_{\mathrm{r}}}^{(\mathrm{w})}$ is χ_{i} and on the basis of μ is ψ_{i}. Therefore, in the proposed architecture we have described the system that optimizes our recommendation.

2.2 Problem Formulation

Consider a user N_h residing in area A_x encountering problems with his current service provider and wishes to port their number towards a new plan. Additionally, he is wondering which MNO and plan to choose to obtain the best service alongside fulfilling their requirements.

$$N_h \xrightarrow[in]{\text{resides}} A_x \tag{1}$$

Where $A_x \in \mathrm{A}$. Further, the user N_h has a current plan $P_i \in P$ which has price per day μ_i , signal strength indicator ${\rho_{\mathrm{r}}}^{(\mathrm{x})}$, daily data usage of the user θ_{N_h} and daily data provided by plan θ_{P_j} are the differentiator features compared with other plans of an area A_x.

$$N_h \xrightarrow{\text{has}} P_i(\mu_i, {\rho_{\mathrm{r}}}^{(\mathrm{x})}, \theta_{N_h}, \Theta_{P_j}) \tag{2}$$

Due to the current obscure plan P_i, the N_h chooses to switch to some another plan p_j

$$N_h \xrightarrow{\text{currently has}} P_i \tag{3}$$

$$N_h \xrightarrow{\text{switches to}} P_j \tag{4}$$

Every plan P has a set of feature Υ such that, $\{\Upsilon_1, \Upsilon_2, \ldots, \Upsilon_j\} \in \Upsilon$, where a Υ_j represents a specific benefit in terms of higher ${\rho_{\mathrm{r}}}^{(\mathrm{x})}$, lower (μ_i), etc. to make the plan P_j better than P_i.

$$\forall\ P\ \exists\ \Upsilon,\ \text{where}\ \Upsilon = \{\Upsilon_1, \Upsilon_2, ...\Upsilon_j\} \subseteq \mathrm{P} \tag{5}$$

$$P_i(\Upsilon_j) \leq P_j \tag{6}$$

$$P_i(\Upsilon_j) \geq P_j \tag{7}$$

We want to recommend P_j such that N_h's requirements are satisfied with minimal price and best possible internet connection using higher signal strength ${\rho_{\mathrm{r}}}^{(\mathrm{x})}$.

$$P_j(\mu_j, {\rho_{\mathrm{r}}}^{(\mathrm{x})}, \theta_{N_h}, \Theta_{P_j}) = \begin{cases} Max({\rho_{\mathrm{r}}}^{(\mathrm{x})}) \\ Min(\mu_j) \\ \Theta_{P_j} \geq \theta_{N_h} \end{cases} \tag{8}$$

3 Proposed Architecture

3.1 MNP recommendation system

Fig. 2 shows the proposed architecture for the recommendation system, where we have acquired prepaid mobile plans from the official website of different MNO to form a dataset. All the plans included in the dataset comprise unlimited local talk time. Further, there are trivial plans on the website that are less important in the dataset. Therefore, to reduce the complexity of the dataset, we have not used such plans in our dataset. Additionally, most users do not want recommendations for such plans as they only have one feature. The inclusion of these plans would have resulted in the non-uniform dataset. So, formally we have 96 plans in our final dataset, and each plan has a competent feature by which we have created a recommendation system. Consider that the daily data used by the user N_h is θ and daily data provided by a particular plan is Ω; then, the recommender system should recommend the plans such that $\Omega \geq \theta$ a. Because the user can afford to have more data after his daily requirement, however, we cannot compromise his daily requirement. The system removes all the plans that do not satisfy the user's requirement of daily data. Many plans provide

Algorithm 1 MNP recommendation system.

Input: $D_1, D_2, ..., D_p \in D$
Output: Best plan (E_b)

procedure RECOMMENDATION$(D_1, D_2, ..., D_p)$
    Form a dataset consisting of all the plans .
    Remove irrelevant features
    Form clusters of the dataset
    Extract plans on the basis of user requirement for example OTT subscription, data per day, etc.
    Sort plans in descending order on the basis of signal strength$({\rho_{\mathrm{r}}}^{(\mathrm{w})})$
    Sort plans in ascending order on the basis of price per day(μ)
    $(\chi_{\mathrm{i}}) \leftarrow$ ranks for signal strength of plan i
    $(\psi_{\mathrm{i}}) \leftarrow$ ranks for price per day of plan i
    $Rank_i \leftarrow \chi_i + \psi_i$
    Sort plans in increasing order on the basis of $Rank$ assigned to each plan
    Best plan (E_b) = Plan with min(Rank)

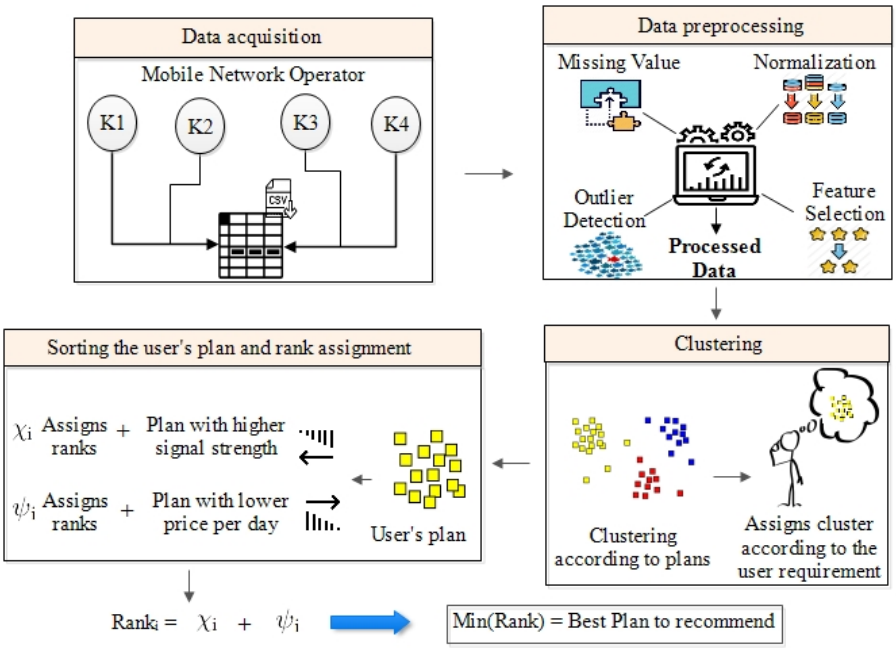


Fig. 2: Proposed architecture to recommend the best plan

subscriptions to the OTT platform for a year. If N_h wants the subscription of OTT with his plan, then the system should only recommend the plans that comprise the subscription of OTT. On the other hand, if the user does not want a subscription to OTT, then the system should only recommend the plans that do not provide an additional subscription to the OTT because the subscription of OTT costs extra than the base price of the plan. The recommendation should strictly emphasize the user's choice; thus, we remove the plans that do not match N_h's choice of OTT subscription. After picking out the plans fulfilling the user's basic requirements, we have focused on the extra benefits, the relative strength of a network provider in the user's area, and the price per day for a particular plan E_b. If the validity of a plan is τ and price is Φ then the price per day μ is calculated using the formula.

$$\mu = \frac{\Phi}{\tau} \tag{9}$$

dividing the price of the plan by its validity. In order to calculate signal strength $(\rho_{\mathrm{r}}{}^{(\mathrm{w})})$ in an area w, system uses the below formula

$$\rho_{\mathrm{r}}{}^{(\mathrm{w})} = \frac{\Phi_j{}^{(\mathrm{w})}}{\sum_{i=1}^{h} \Phi_j{}^{(\mathrm{w})}} \tag{10}$$

where $\Phi_j{}^{(\mathrm{w})}$ represents the number of users who chose operator j to be best network provider in area w. Then, the final rank for recommending the best

plan can be calculated through,

$$\delta_i = \chi_i + \psi_i \tag{11}$$

For finding the plan that satisfies the user's requirement, δ needs to be sorted in increasing order and the plan with minimum value of δ is the best plan for the user.

3.2 Clustering Analysis

As the validity of a plan increases, the price increases proportionally. A user cannot spend more than his budget on buying a plan. Therefore, the plans in our dataset were for one month, two months, three months, and up to one year. Using the price and validity of the plans as input parameters, we have divided the plans into 4 clusters using a k-medoids clustering algorithm. The reason behind choosing the k-medoids clustering algorithm is that we know the number of clusters we want to form in the dataset. Moreover, k-medoids also handle outliers, unlike k-means, and thus improve the clusters formation [8]. When a user asks for a recommendation using his previous subscriptions, we assign one of the four clusters to a user and only recommend plans from the given cluster. If a new user asks for a recommendation, we can assign the user one of the clusters based on validity and price.

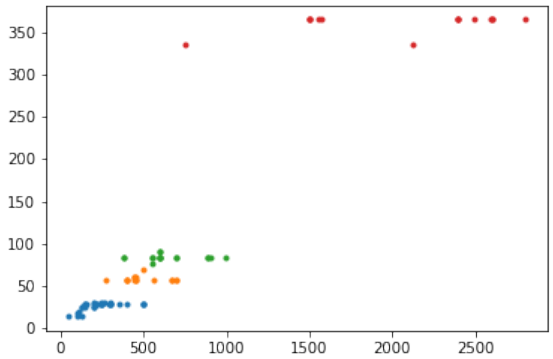


Fig. 3: Clustering of plans on the basis of their duration and price.

4 Result Discussion

This section discusses the performance evaluation of the proposed scheme.

4.1 Dataset Description

Dataset used in the research was taken from the official website of the Indian mobile network operators. There were many plans whose price changed state wise. In the dataset, only plans that are common across all states were included. The data collected has seven features, which are as follows.

- *Price*: Price of the plan
- *Validity*: Duration for which the mentioned service is provided
- *Operator*: Network operator which provides the plan
- *Data-per-day*: Amount of cellular data user can utilize in one day
- *OTT-subscription*: Represents the complimentary subscriptions provided in addition to the plan
- *Post-data-speed*: Data rate(in Kbps) at which user can continue using internet after completion of the daily data usage.
- *Total-data*: Total cellular data for the validity of the plan

4.2 Implementation Interface

The MNP recommendation system has a user-friendly interface in which the user can match their requirements and corresponding plans are displayed as shown in Fig. 4. The user simply needs to select the duration of plan and the plans that suits him/her best would be displayed rank-wise along with its price, data per day and signal strength.

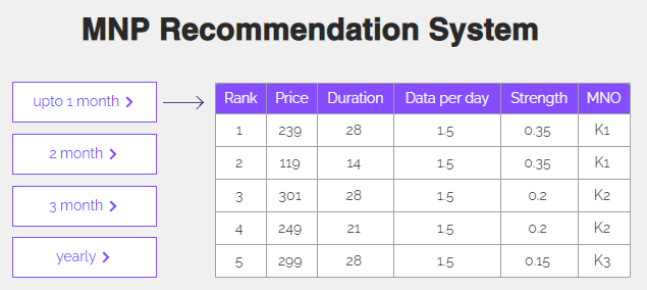
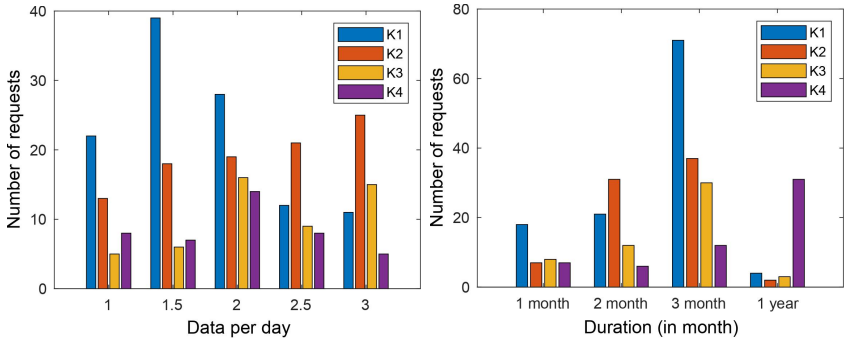


Fig. 4: User Interface for plan recommendation

4.3 Analytic-based results

In order to test the results of our recommendation system, the authors made a testing dataset of varying requirements and tested the output of the system. The recommendation differed significantly according to a user's requirement.

Fig. 5a shows the number of times an MNO was recommended for a particular value of data per day. As we can see in Fig. 5a K1 is recommended for the highest



(a) Recommendations based on the value of data per day.

(b) Recommendation based on the validity of plan.

Fig. 5: Number of user data request

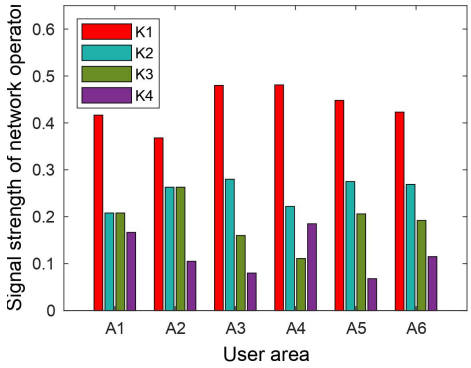


Fig. 6: Area wise signal strength of MNOs.

amount of times when the daily data requirement is 1, 1.5, and 2 GB. Next, when the daily data requirement is 2.5 or 3 GB, the K2 operator is recommended multiple times. Fig. 5b shows the number of times an MNO is recommended for a particular validity of the plan. Moreover, we can see in Fig. 5b nearly half of the people chose a validity of 3 months, and hence, K1 is recommended multiple times when the validity is one and three months. K4 is recommended almost always in the case of yearly plans because K4 provides very low prices for yearly plans. This signifies that the recommendation of a plan depends on the duration of the plan required by the user. Fig. 6 shows the signal strength of different operators in all the areas. As one can observe clearly, K1 provides the best network strength across all areas with a significant margin compared with other operators. K2 and K3 provide almost similar network strength across all the areas. On the other hand, K4 provided inferior signal strength that is not suitable for a qualified plan for the user. The difference between recommendations of

different MNO is not very large, which indicates that no company dominates in providing plans with affordable prices and strong network connection.

5 Conclusion

Choosing a suitable plan with the best possible network operator is a difficult task due to the variety of plans and differing network strength of MNOs. One plan is not the optimal choice for everyone because requirement differs from user to user, making it challenging to decide on the best-personalized plan for users. Thus, this paper proposed a clustering-based recommendation system that chooses plans that satisfy users' requirements and provide users with the best possible network connectivity. We have observed from the graphs that no single MNO satisfies all of the criteria for a perfect MNO. The proposed recommendation system remedies this problem of identifying the most suitable plan and MNO for the users.

In the future, we will make the proposed system universal worldwide and also incorporate machine learning algorithms for higher accuracy.

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