Selection of Mobile Communication Plans

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Abstract

The goal of this project is to create an empirical model that incorporates quantitative and qualitative criteria for evaluation and selection of the best individual smartphone plan. This hierarchical model creates a quantitative framework applying semi-absolute scale to measure the value of each factor that contributes to the overall score of a plan. It integrates the relative desirability of the factors in the decision-making criteria with their priority assigned by the experts. The developed model with four levels of Objectives, Criteria, Factors and Plan desirability measures decode the complicated process of evaluating available phone plans. The result of the process is a subjective score that provides a relative desirability measure that helps with the selection of the best plan. In the effort to stay objective and away from personal preferences, this model is not considering the phone hardware as well as the provider.

1. Introduction

With the increasing popularity of smart phones, mobile carriers have been launching various mobile communication plans providing voice, text, data and other services. The changes are primarily influenced by the increasing usage of mobile devices. The changes the market has experienced have progressed from the saturation of voice usage, to the massive utilization of text messaging, to the exponential increase of data usage; including services to other categories of mobile devices like hotspot [1] capabilities. Facing fiercer competition mobile operators are implementing differentiated pricing strategies in LTE (Long Term Evolution) having experienced the traffic burden in 3G with fixed-fee data plans. In fact, the usage-based pricing has already been a mainstream pricing strategy for LTE data services. The upcoming VoLTE (Voice over LTE) service, which is expected to launch by 2013 [2], will make innovative changes on bundling voice and data into single rates. This comes from the fact that mobile operators have to ensure their voice offerings remain competitive in terms of pricing and features in the current environment [3].

Currently, the telecommunications market is in a transition from voice to data in terms of mobile pricing plans. This phenomenon is generated by an increase in multi-data consumption (one user-multiple devices) and the development of new technologies. In the US, there are eleven major mobile operators including MVNOs (Mobile Virtual Network Operators) [4]. They provide a variety of mobile communication plans based on user's preferences and implement very dynamic pricing strategies in order to obtain sustainable profits.

In this project, we will research mobile communication plans for smart phones users. This category of users typically consumes high volumes of mobile data, but at the same time it remains sensitive to pricing. Based on the most important factors for selecting mobile communication plans, we will develop a decision model for identifying the criteria and their degree of importance through analyzing literature review, obtaining experts' opinions and conducting qualitative and quantitative research. Our goal is utilizing market research, study and analysis to develop an empirical model useful in analyzing and measuring the desirability of any mobile communication plan.

2. Literature Review

The speed of innovation in the information technology era has drastically changed the rate at which new products and services are brought to the market. We, as technology consumers, are faced with the dilemma of making investments knowing that that next big innovation might be just around the corner and the decision that seems perfect today might not be an ideal for tomorrow. What doesn't change in this process is the limited amount of financial resources and time that consumers and organizations have access to, in order to make decisions.

This paper presents the process for building and applying a Hierarchical Decision Model for evaluation and selection of the best relative mobile communications plan by consumers. Based on the classification proposed by Cleland and Kocaoglu [5] the decisions that need to be made in order to select a plan can be classified as 'Multiple-Criteria Decisions Under Certainty', given that the information presented to the decision maker is collected from real plans that include myriad combinations of services.

The criteria that the decision maker uses to make a decision when picking a plan are part of the large 'telecommunications market' socio-technical system, i.e. a system comprised of technical (e.g. 2G, 3G) and social (e.g. content providers, end users) elements [6]. According to Linstone [7] these systems can be looked at through three different perspectives: Technical (T), Organizational (O) and Personal (P). The *Technical* perspective reduce the decision making process to a matter of facts, data, money or any other components that can be quantified in an analytical or scientific perspective. The *Organizational* criteria have to do with what is in the best interest of an organization or group according to their current strategy, mission or goal. The *Personal* criteria relates to people's perceptions based on their experience, interests and gut feeling, which are often subjective parameters difficult to measure and explain. In this paper the analyzed criteria was restricted to the *Technical* and *Personal* consumer perspectives.

In addition to the T and P criteria, the "discounting" effect was also accounted for in order to help experts create a model that was as objective as possible. "Discounting" influences the way decision makers weigh and evaluate *O* and *P* criteria adding undesired subjectivity to the weighting process. This concept is better explained with Linstone's analogy [8]: "O and P look at the future through the wrong end of the telescope – the distant objects look smaller than they appear", this refers to the fact that the human factor in people and organizations often underestimates the possibility of future events and consequences of their actions in the mid or long term. Linstone suggests "discounting" effect can be reduced in two ways: (a) moving the distant crisis or opportunity within the actor's planning horizon, or (b) extending the actor's planning horizon [9]. We believe in the case of evaluating mobile communication plan alternatives extending the planning horizon (b) can be extremely challenging due to the market dynamics with the constant appearance of new alternatives. Because of this, we consider option (a) as the sole viable alternative to reduce "Discounting" so our research instruments were designed for experts to express their judgment with immediacy in mind.

Researchers also considered the concept of *utility*, as it plays a central role in the decision making process. Utility is defined as the *relative value that the decision makers assign to the various outcomes*. This concept is subjective in nature and reflects the decision makers' unique perceptive of value composition. Utility helps understand the analysis of multicriteria decisions where the criteria have different measures along different dimensions [5].

Finally, the methodology followed through this paper is largely inline with the PICMET paper "A Quantitative Model for the Strategic Evaluation of Emerging Technologies" [10]. This PICMET paper describes a process for building a decision making model based on expert opinions and semi-absolute scales to quantify the desirability of the alternative technologies. The advantage of using semi-absolute scales is that model builders have the flexibility to build scales in wider spectrums than what currently exist in the market, leaving room for new alternatives that might become available at a future time. This a major advantage over traditional pair-wise comparison HDMs where models can quickly face obsolescence as soon as new alternatives appear in the market, which requires rebuilding HDM models to keep them relevant.

3. Methodology

HDM (Hierarchical Decision Model) is developed by building a hierarchical structure to analyze strategic decisions. The impact of each decision element branches to its trunk element and determined by using objective and/or subjective data. HDM is a mission-oriented method for evaluation and/or selection among alternatives. A wide range of application including but not limited to selection of different technologies, projects, markets, jobs, products, cities to live in, energy resources to use [11] and many other similar decisions. In this paper, HDM is used to evaluate different mobile communication plans [12].

The Mission-Objective-Goal-Strategy-Action (MOGSA) model is a generalized form of the HDM as shown in Figure 1. There is no limit to the number of levels or the number of elements in each level. However, the elements at each level must be "preferentially independent". The lowest level of HDM contains the alternatives. The second lowest level of HDM contains the ultimate sub-criteria which are the components of the upper level(s). Once the HDM structure is given, the selection of the alternatives by the experts depends on two factors: the weights of the sub-criteria in the second lowest level and the performance evaluation of the alternatives (in the lowest level) according to the sub-criteria (in the second lowest level). The weights and the performance evaluation of alternatives usually can be expressed by the weights obtained by pairwise comparison [13], [14].

The performance evaluation is also known as "utility" or "desirability", meaning how desirable or usable different alternatives are according to the sub-criteria in the corresponding second lowest level.

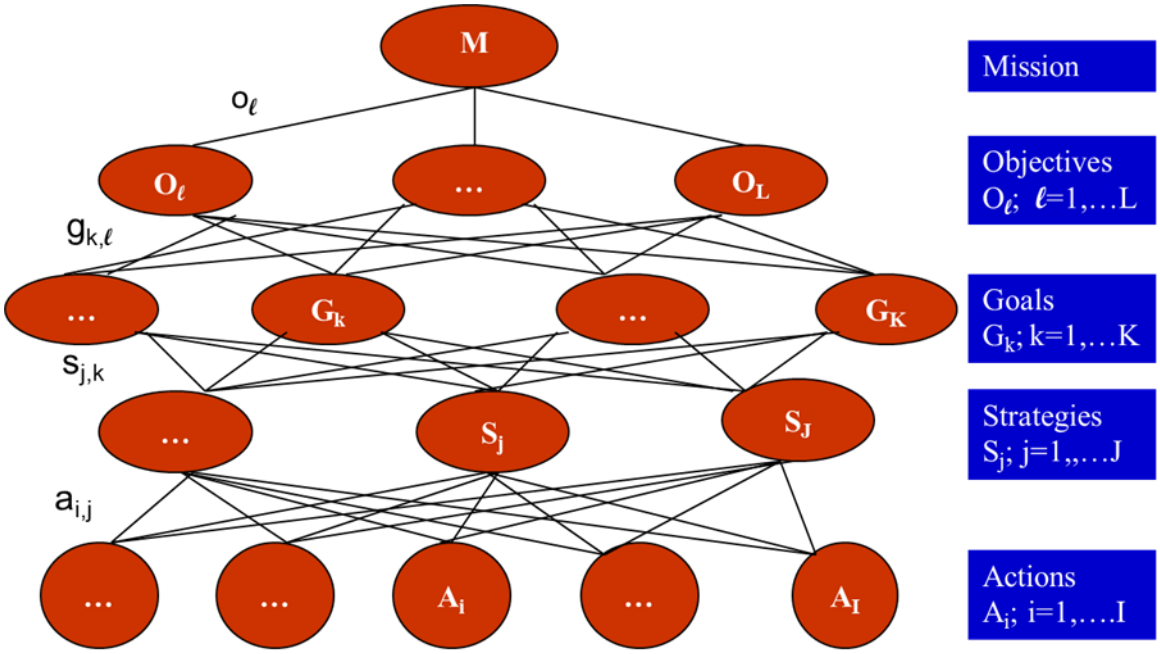

Figure 1: MOGSA Decision Hierarchy for illustration of HDM computation

Nathasit Gerdsri and Dundar F. Kocaoglu used desirability functions to obtain the desirability measures of alternatives to different factors/sub-criteria [10]. Desirability functions are used in this paper to evaluate different plans. $t_{n,jk,k}$, the metrics and values under each factor and criterion are first obtained by data collection, then the research method is conducted through sending the research instruments out to the experts to obtain the desirability values of a wide range of data points on each metric. These values could also be obtained from a linear or a nonlinear function based on the developed functional relationship defined by the experts. In this paper, the desirability functions are derived from the relationships between the metrics and corresponding desirability value. Then the technological metrics are mapped to the desirability values. The calculation of the Technology Value [TV_n] as based on the equation below:

$$TV_n = \sum_{k=1}^{K} \sum_{jk=1}^{Jk} w_k \cdot f_{jk,k} \cdot V(t_{n,jk,k})$$

Equation 1 - Calculation of the Technology Value (TV)

Where,

TV_n : Technology value of alternative (n) determined according to an objective

w_k: Relative priority of criterion (k) with respect to the company objective

$f_{jk,k}$: Relative importance of factor (jk) with respect to criterion (k)

$t_{n,jk,k}$: Performance and physical characteristics of technology (n) along with factor (jk) for criterion (k)

$V(t_{n,jk,k})$: Desirability value of the performance and physical characteristics of technology (n) along factor (jk) for criterion (k).

5. Hierarchical Decision Model

To develop the HDM model, the research team conducted a series of brainstorming sessions and market analysis. The goal was to design an empirical model using the most important criteria but not exhaustive to the point of inefficiency. The result of this process is the model depicted in Figure 2.

Three steps were followed to build the model:

- The first step is a top-to-bottom brain storm, in which the objective of selecting a personal mobile communication plan is divided into three criteria; cost, service and flexibility. Then each criterion is further separated into factors. Different factors are tried in this step.
- The second step is a bottom-to-top data examination. The research team looked at the alternatives, which are the mobile communication plans. The plans on the market are given out mainly by the features of cost (plan prices or monthly cost, additional minutes/text/data/hotspot price, and early termination fee), services (voice, minutes, text, and data amount, communication speed, etc.) and flexibility (whether the contract is allowed to change, and the contract length).
- The third step is a top-to-bottom process, in which the model is represented by a Hierarchical Decision Model (HDM) as shown in Figure 2.

The research team followed two approaches, top-to-bottom and bottom-to-top to ensure the HDM is supported by real mobile communication plans data from the market because the desirability functions needed to be measured by the metrics of these plans. If there is a factor that can't be supported by the plan data, that factor should not be included in both the HDM model and the desirability functions.

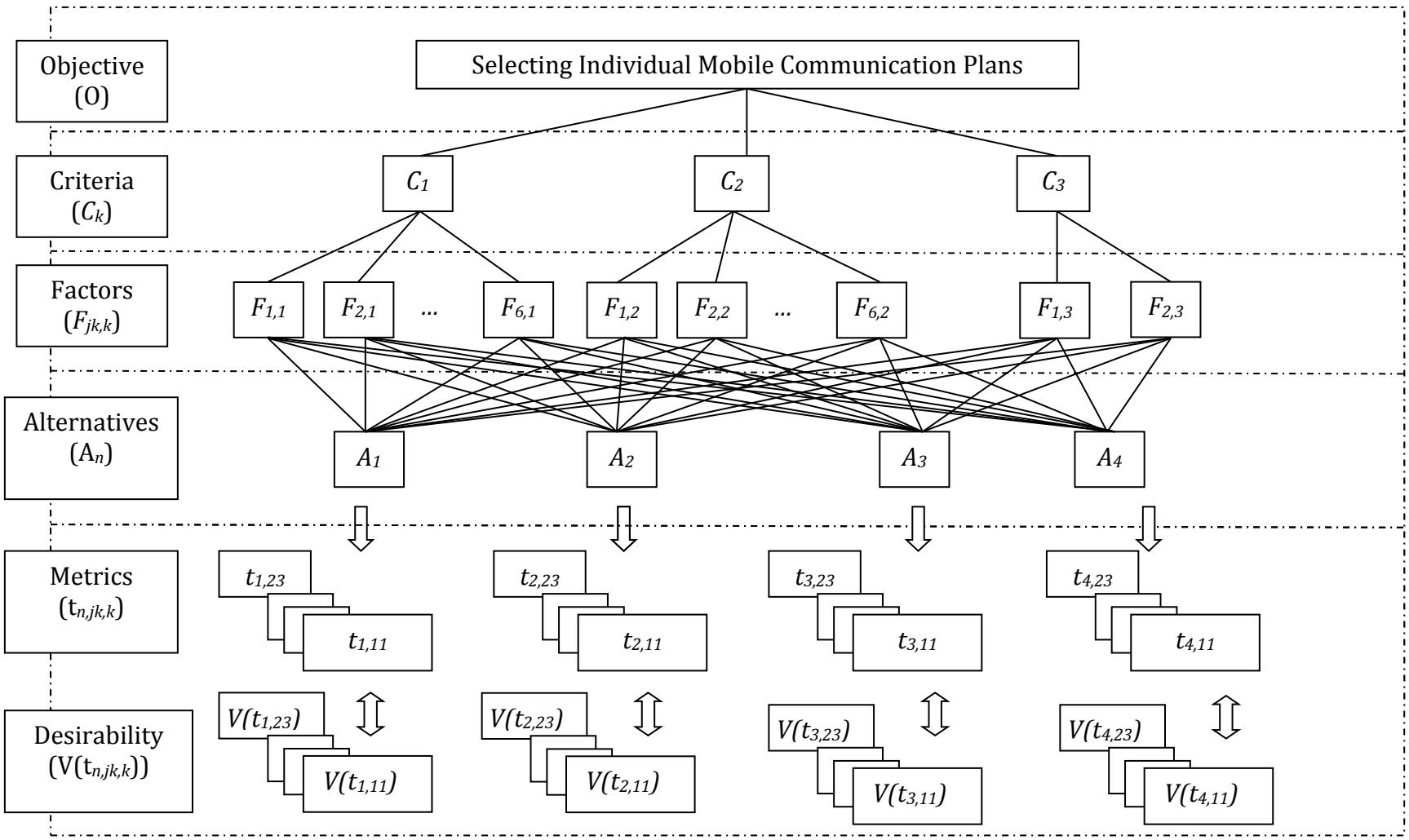

Figure 2: HDM for selecting a personal mobile communication plan

The HDM criteria, factors and alternatives are listed below:

Model Element	Description
C_1	Cost
C_2	Service
C_3	Flexibility
$F_{1,1}$	plan price
$F_{2,1}$	Additional data price
$F_{3,1}$	Additional voice price
$F_{4,1}$	Additional text price
$F_{5,1}$	Additional hotspot price
$F_{6,1}$	Early termination fee
$F_{1,2}$	Data included in the plan
$F_{2,2}$	Text included in the plan
$F_{3,2}$	Voice included in the plan
$F_{4,2}$	Speed
$F_{5,2}$	Reception quality
$F_{6,2}$	Mobile hotspot
$F_{1,3}$	Changeability
$F_{2,3}$	Contract length
A_1	Sprint plan
A_2	Verizon plan
A_3	T-Mobile plan
A_4	AT&T plan

Table 1 - Model elements

6. Data Collection and Analysis

To conduct the pairwise judgment value analysis, the HDM was sent to 15 experts who assigned weights to the criteria and factors. Through pairwise comparison, the weights are calculated out as shown in Appendix I Table 4. The calculated F-test value from all the participants, as depicted in Table 5 in Appendix I, indicates a high degree of agreement. The obtained value of 8.35 is well over the benchmark value of 2.34(for 99% confidence level). This proves that our collected priority values, with over 99% confidence, are in agreement and we can confidently accept and use these weights in our model.

Thereafter, the researchers gathered the limiting values on measure of effectiveness by doing the research from the existing plans in the mobile communication market. Then, the matrix for lower and upper bound were created as shown in the Table 2 below. For the lower bound, the value will be the lowest in cost, data, minutes, and number of messages even though this value might not be offered in the market. The value of the upper bound will come from the highest possible values of the mobile plans. Then, the researcher will improve the values by adding up about 20% to 50% of what the mobile operators currently offer in the market. This is to broaden the spectrum in which the plan are being evaluated so that the model can be applied to the near future analysis given the factors improve over time and the model doesn't become obsolete in near future.

Objective	Criteria	Factors	Measures of Effectiveness			
			Feature	Unit	Lower bound	Upper bound
Selecting most desirable individual mobile communications plan	Cost	Plan	Monthly cost	$/month	0	250
		Additional Data	Cost per additional MB of data	$/GB	0	30
		Additional Voice	Cost per additional minute	$/min	0	2
		Additional Text	Cost per additional text message	$/text	0	1
		Additional Hotspot	Cost of adding hotspot functionality	$/month	0	20
		Termination	Cost of terminating the plan	$	0	500
	Service	Data	MBs of data per month included in the plan	MB/month	0	Unlimited
		Text	No. of text messages per month included in the plan	#/month	0	Unlimited

		Voice	Minutes of talking time per month included in the plan	min/month	0	Unlimited
		Speed	Speed of the plan	Generation	2G	Next Gen.
		Reception Quality	Level of 24/7 reception	%	0	100
		Mobile hotspots	Availability of mobile hotspots	Yes/No	0	1
	Flexibility	Changeability	Plan change possibility	Yes/No	0	1
		Contract length	Length of the plan	Year	0	3

Table 2 - List of Criteria and Factors along with their limiting values on Measure of Effectiveness

The next step was determining each measure of effectiveness by creating JQIs (Judgment Qualification Instruments) where a group of experts can assign their judgment values between 0 and 100 to represent their desirability measures. The JQIs and its matrix values ($t_{n,jk,k}$) are shown in Appendix I – HDM Weighting and Validation

Mobile Communication Plan	Plan	Additional Data	Additional Voice	Additional Text	Additional Hotspot	Termination	Data	Text	Voice	Speed	Reception Quality	Mobile hopspots	Changeability	Contract length	Inconsistency
Bing Wang	0.18	0.07	0.07	0.04	0.02	0.03	0.11	0.1	0.1	0.04	0.04	0.03	0.08	0.08	0.01
Charles Tsai	0.18	0.1	0.11	0.11	0.05	0.04	0.01	0.02	0.02	0.02	0.08	0.01	0.2	0.07	0.01
Christine Chong	0.12	0.08	0.05	0.05	0.06	0.07	0.08	0.04	0.04	0.06	0.05	0.05	0.1	0.14	0
Chun Fan Pai	0.22	0.07	0.06	0.06	0.02	0.08	0.03	0.02	0.01	0.04	0.1	0.01	0.19	0.1	0.06
Ignacio Castillejos	0.14	0.17	0.11	0.05	0.01	0.03	0.1	0.05	0.14	0.03	0.05	0	0.1	0.03	0.07
Jejung Ha	0.12	0.07	0.06	0.05	0.06	0.07	0.08	0.04	0.04	0.06	0.05	0.05	0.14	0.1	0
Noshad Rahimi	0.21	0.07	0.07	0.07	0.02	0.02	0.09	0.11	0.11	0.04	0.11	0.01	0.02	0.04	0
Onnicha Khusawangsri	0.22	0.24	0.06	0.14	0.03	0.1	0.04	0.02	0.01	0.04	0.02	0.01	0.01	0.06	0.03
Rachanida K	0.26	0.21	0.06	0.04	0.03	0.12	0.07	0.01	0.02	0.06	0.02	0.01	0.06	0.03	0.03
Rodney Danskin	0.13	0.07	0.06	0.07	0.06	0.06	0.02	0.05	0.09	0.04	0.07	0.03	0.12	0.13	0.01
Saeid Monsef	0.07	0.1	0.14	0.11	0.02	0	0.04	0.05	0.12	0.04	0.2	0	0.08	0.03	0.12
Sarah Smith	0.36	0.18	0.05	0.06	0	0.12	0.04	0.02	0.04	0.02	0.03	0	0.08	0.01	0.06
Thanaporn Ngarmnil	0.02	0.02	0.01	0.02	0.01	0.01	0.09	0.08	0.07	0.11	0.09	0.07	0.37	0.03	0.01
Victor Valle	0.09	0.16	0.06	0.02	0.01	0.02	0.1	0.04	0.07	0.06	0.11	0.02	0.21	0.02	0.06

Zara Faridany	0.09	0.08	0.07	0.07	0.08	0.08	0.06	0.05	0.04	0.06	0.06	0.06	0.11	0.11	0.02
Mean	**0.16**	**0.11**	**0.07**	**0.06**	**0.03**	**0.06**	**0.06**	**0.05**	**0.06**	**0.05**	**0.07**	**0.02**	**0.12**	**0.07**	
Minimum	**0.02**	**0.02**	**0.01**	**0.02**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.02**	**0.02**	**0.02**	**0.01**	**0.01**	
Maximum	**0.36**	**0.24**	**0.14**	**0.14**	**0.08**	**0.12**	**0.11**	**0.11**	**0.14**	**0.11**	**0.2**	**0.07**	**0.37**	**0.14**	
Std. Deviation	**0.08**	**0.06**	**0.03**	**0.03**	**0.02**	**0.04**	**0.03**	**0.03**	**0.04**	**0.02**	**0.04**	**0.02**	**0.09**	**0.04**	
Disagreement															**0.04**

Table 4 - Calculation of Factors Weights

Source of Variation	Sum of Square	Deg. of freedom	Mean Square	F-test value
Between Subjects:	0.27	13	.021	**8.35**
Between Conditions:	0.00	14	0.000	
Residual:	0.45	182	0.002	
Total:	**0.72**	**209**		
Critical F-value with degrees of freedom 13 & 182 at 0.01 level:				**2.23**
Critical F-value with degrees of freedom 13 & 182 at 0.025 level:				**1.98**
Critical F-value with degrees of freedom 13 & 182 at 0.05 level:				**1.77**
Critical F-value with degrees of freedom 13 & 182 at 0.1 level:				**1.56**

Table 5 - The F-test for Evaluating the Null Hypothesis

Appendix I. Fourteen questions were asked to the experts to identify how desirable was for them paying, having, and changing services in the plan.

After all the experts gave their values, the means for each of the relative values were calculated. The results were fourteen desirability curves for each measure of effectiveness. The desirability function for cost criteria was shown in Figure 3 below for cost criterion; monthly cost, additional cost of data, minutes, and text, termination cost, and cost for adding a hotspot feature. Other desirability curves including service and flexibility criteria were also shown in Appendix VI.

Most of the desirability curves from each criterion tend to have the same direction. The curves in Figure 3 show that all the experts prefer to pay a lower price rather than a high price as expected. However, they understand that it is impossible to find the mobile plan at $0 cost, so the desirability value at the lowest cost is not 100% desirable. Similarly in the service criterion, most of the experts prefer to have unlimited data, minutes of calls, and text messages. Moreover, the mobile operators need to have best reception quality and should include the mobile hotspot feature within their plan.

In addition, from the desirability function of available MB of data, as shown in Figure 4 below, the curve has a flat line between 2048MB (or 2GB) and 51200MB (or 50GB). This shows that, in relative terms, it is not important for the experts to have higher volume of data for more than 2GB. Thus, the experts will not be significantly more satisfied as the number of GB increases, unless it is increased to unlimited.

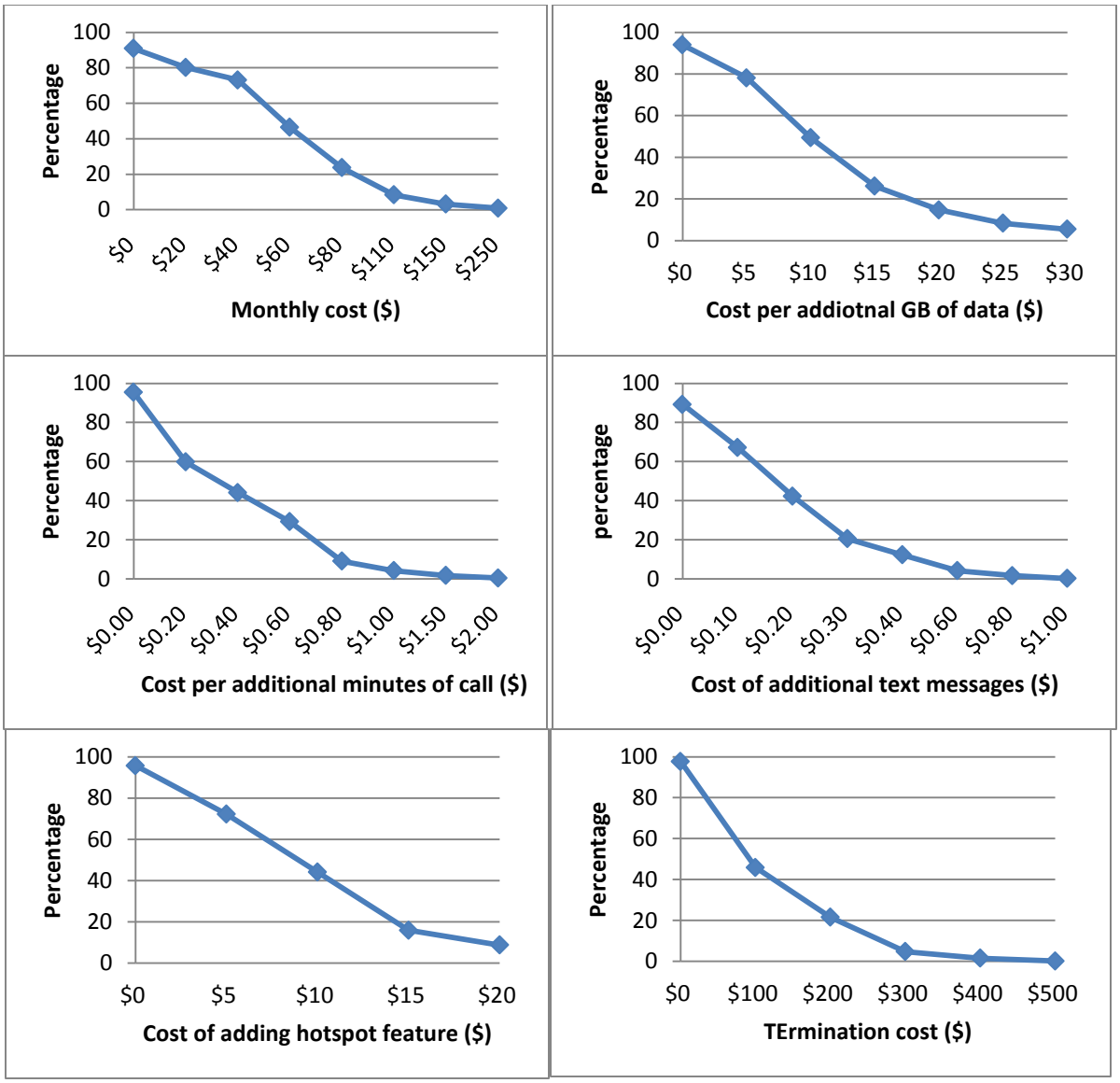

Figure 3: Cost Desirability Functions

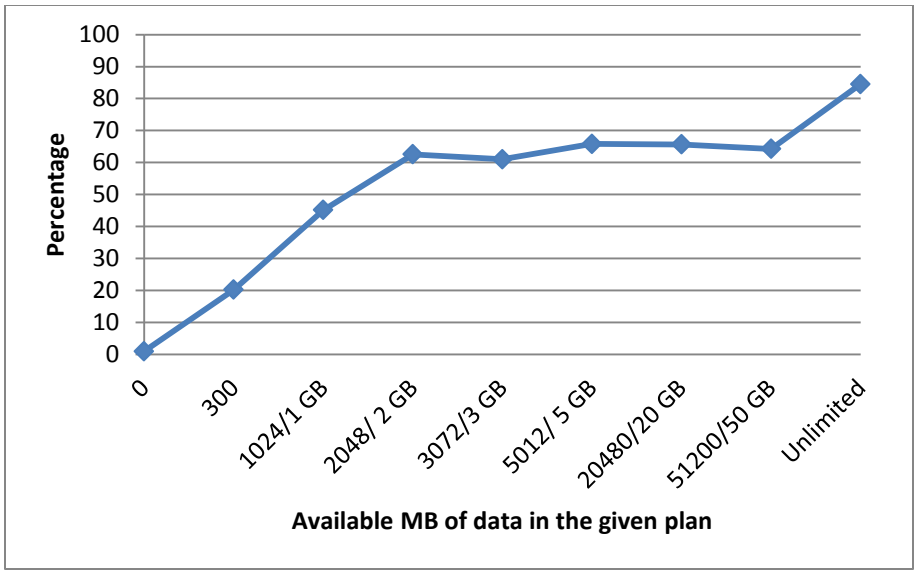

Figure 4: Desirability Function of Available MB of data in the given plan

In addition, the next generation of data speed is not the value that the experts prefer at this point, as shown in Figure 5. The curve slightly decreases for the next generation of data speed from the 4G speed that most mobile operators provide today. This is an indicator that most experts are satisfied with what they have as opposed to having the next generation that still does not exist in the US market.

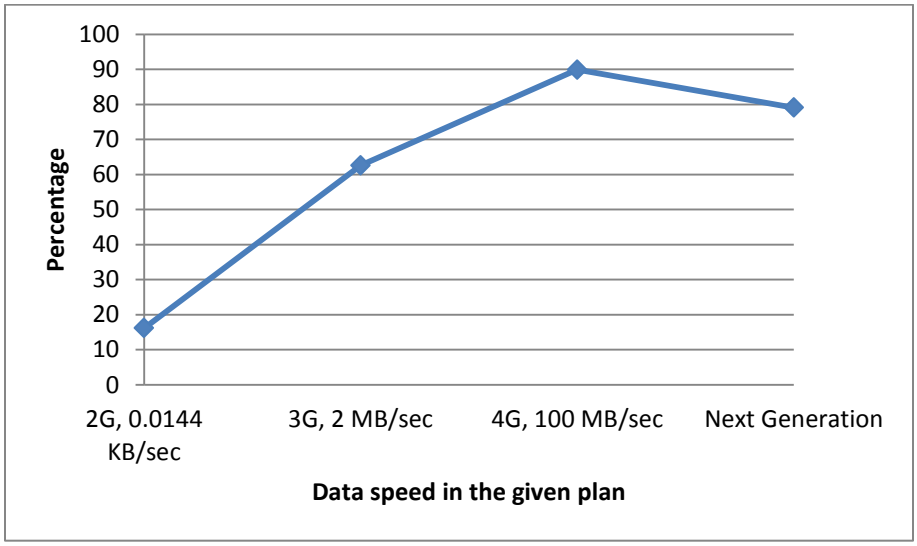

Figure 5: Desirability Function of Data speed in the given plan

The next step quantification the score for each mobile plan (TV_n). After researchers got the desirability functions for each measure of effectiveness or $V(t_{n,jk,k})$, the metrics of factors for each existing plan from the four major mobile operators in the US market (i.e. Sprint, Verizon, T-Mobile, and AT&T) were created. Then, each factor from each plan was multiplied by the value obtained in the HDM model ($f_{jk,k}$), this value represents the weight experts had put on each factor. After the score for each of the factors were calculated, the total score for each plan

can be calculated by adding the score of individual factors to obtain the score of each plan. Table 3 below shows an example for a Sprint plan that has 52% of the ideal score. The score for the other mobile operators is shown in Appendix II.

Factor	unit	HDM weight	Sprint plan	Score/Factor	Sprint plan Score
Plan	$/month	0.16	109.99	0.0838	0.01
Additional Data	$/GB	0.11	0	0.9392	0.10
Additional Voice	$/min	0.07	0	0.9538	0.07
Additional Text	$/text	0.06	0	0.8921	0.05
Additional Hotspot	$/month	0.03	19.99	0.0873	0.00
Termination Fee	$	0.06	350	0.03	0.00
Data	GB/month	0.06	Unlimited	0.8454	0.05
Text	#/month	0.05	Unlimited	0.9193	0.05
Voice	min/month	0.06	Unlimited	0.9279	0.06
Speed	Generation	0.05	3G	0.6257	0.03
Reception quality	1~10	0.07	6	0.4242	0.03
Mobile Hotspot	Yes/No	0.02	No	0.3323	0.01
Changeability	Yes/No	0.12	No	0.2538	0.03
Contract length	year	0.07	2	0.3705	0.03
Score					0.52
Score (%)					**52%**

Table 3 - Computation of Sprint mobile operator of a mobile plan

7. Results

The result shows that the fifteen experts' collective opinion selected the T-mobile plan as the best plan, bringing the most utility and desirability. This plan is outstanding in pricing, cost of additional data and additional hotspot, unlimited data, high access speed and mobile hotspot availability. However, it also has some drawbacks including fewer minutes of voice, ordinary reception quality and inability to change the plan. However, the result shows that T-Mobile has a similar score to Verizon because of the relative inflexibility in changing features and low rating in reception quality. From the economic perspective, the monthly payment favored by experts is a wide range of pricing, from $0 to $110. However, even though AT&T plan is competitively priced, the limited voice minutes and low reception quality, similar to the T-Mobile plan, makes the AT&T plan the least desirable one among the plans being evaluated.

In data usage, unlimited data option is not as much of a crucial factor, which contradicted our initial expectations. We could also assume that pricing strategy relies on the quality of the service provided, with Verizon plan scoring the best in this category. Verizon strengthens its competiveness with unlimited voice and text making up for the lack of an unlimited data offering. Sprint is the only operator providing unlimited data, voice, and text. However, no mobile hotspots service option and additional fees influence the low score obtained in addition to relatively low network quality and high monthly payment.

8. Conclusion

This research is conducted to demonstrate a method for evaluating and selecting best individual smartphone plans. The HDM is designed based on the most important aspects of a smartphone plan, which are cost, service and flexibility. The model is refined into factors such as plan monthly cost, additional charges, available voice/text/data included in the plan, as well as changeability and terminating fee. The desirability of each alternative plan according to the factors is derived from a questionnaire response from customers. Desirability reflects the utility of different plans according to the different factors respectively. The experts' opinions are aggregated by the arithmetic mean methods. The sum of desirability multiplied by the factors' weights reflects how desirable a plan is to the experts.

9. Discussion

As it was described earlier HDM model is designed based on subjective expert judgments. Over half of the expert participants in our research were students, which results in the model primarily valuing the monthly plan cost as the highest priority, making the cheapest plan most desirable. As described in the Result section, other strong features of the plan can compensate for this value and evaluate the plan on a range of factors that are identified as key to select the ideal plan.

This paper has conducted the evaluation for four identified smartphone plan, however this quantitative model can be readily applied for evaluating any other plan in the market. From a user perspective, one can easily enter the specifications of the candidate plans in the model to obtain overall scores that can be compared to help identifying the best plan. This model could also help companies when designing their plan offerings. From a provider perspective, they can not only identify the key features and degree in which users are interested in, but can also prioritize their efforts on factors that achieve higher desired scores. For example, by studying the Score Calculator in Table 6 - Evaluation of mobile plans from different mobile operatorsSprint can identify that it can improve its competitiveness by decreasing its monthly plan cost, providing hotspot capability as part of the plan and decreasing their termination fee. Sprint, however can identify that among all these, monthly cost has the highest value for the users and therefore lowering it can help its plan achieve better score faster. Similarly, T-Mobile can conclude that when trying to improve the desirability of its plans, it can focus on providing

more voice minutes, improving reception quality and providing flexibility to change the plan. Surprisingly, the flexibility in changing the plan has a higher priority than the other two features, so T-Mobile is advised to prioritize improving the flexibility of its plans to achieve better overall relative score.

10.Recommendation

This research is based on the collective opinion of the fifteen experts selected. However, the market of mobile communications plans is for individual consumers to choose, in a situation similar to voting [15], [16]. There are thousands of plans for numerous customers to select in order to fulfill different needs. In reality, selection of the plans is based more on individual decisions than on collective decisions. In this way, the market share of different plans is dependent on the individual preferences and desirability functions.

A more detailed market research can be conducted to implement models specific to each user group. The research can be based on a stratified large sample survey or simply a representative of each user group. It will be meaningful to know about the characteristics like demographic data and their requirements like need for hotspot or speed requirements of different groups of users to design a model tailored to their needs and preferences. Having these detailed information is helpful for the telecom operators to design plans that fulfill the demands of different market groups. These models also provide measures for the relative value of improvement of different factors for each plan type (based on the customer group designed for) to maximize their desirability resulting in higher customer satisfaction and market share.

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12. Appendix I – HDM Weighting and Validation

Mobile Communication Plan	Plan	Additional Data	Additional Voice	Additional Text	Additional Hotspot	Termination	Data	Text	Voice	Speed	Reception Quality	Mobile hopspots	Changeability	Contract length	Inconsistency
Bing Wang	0.18	0.07	0.07	0.04	0.02	0.03	0.11	0.1	0.1	0.04	0.04	0.03	0.08	0.08	0.01
Charles Tsai	0.18	0.1	0.11	0.11	0.05	0.04	0.01	0.02	0.02	0.02	0.08	0.01	0.2	0.07	0.01
Christine Chong	0.12	0.08	0.05	0.05	0.06	0.07	0.08	0.04	0.04	0.06	0.05	0.05	0.1	0.14	0
Chun Fan Pai	0.22	0.07	0.06	0.06	0.02	0.08	0.03	0.02	0.01	0.04	0.1	0.01	0.19	0.1	0.06
Ignacio Castillejos	0.14	0.17	0.11	0.05	0.01	0.03	0.1	0.05	0.14	0.03	0.05	0	0.1	0.03	0.07
Jejung Ha	0.12	0.07	0.06	0.05	0.06	0.07	0.08	0.04	0.04	0.06	0.05	0.05	0.14	0.1	0
Noshad Rahimi	0.21	0.07	0.07	0.07	0.02	0.02	0.09	0.11	0.11	0.04	0.11	0.01	0.02	0.04	0
Onnicha Khusawangsri	0.22	0.24	0.06	0.14	0.03	0.1	0.04	0.02	0.01	0.04	0.02	0.01	0.01	0.06	0.03
Rachanida K	0.26	0.21	0.06	0.04	0.03	0.12	0.07	0.01	0.02	0.06	0.02	0.01	0.06	0.03	0.03
Rodney Danskin	0.13	0.07	0.06	0.07	0.06	0.06	0.02	0.05	0.09	0.04	0.07	0.03	0.12	0.13	0.01
Saeid Monsef	0.07	0.1	0.14	0.11	0.02	0	0.04	0.05	0.12	0.04	0.2	0	0.08	0.03	0.12
Sarah Smith	0.36	0.18	0.05	0.06	0	0.12	0.04	0.02	0.04	0.02	0.03	0	0.08	0.01	0.06
Thanaporn Ngarmnil	0.02	0.02	0.01	0.02	0.01	0.01	0.09	0.08	0.07	0.11	0.09	0.07	0.37	0.03	0.01
Victor Valle	0.09	0.16	0.06	0.02	0.01	0.02	0.1	0.04	0.07	0.06	0.11	0.02	0.21	0.02	0.06
Zara Faridany	0.09	0.08	0.07	0.07	0.08	0.08	0.06	0.05	0.04	0.06	0.06	0.06	0.11	0.11	0.02
Mean	**0.16**	**0.11**	**0.07**	**0.06**	**0.03**	**0.06**	**0.06**	**0.05**	**0.06**	**0.05**	**0.07**	**0.02**	**0.12**	**0.07**	
Minimum	**0.02**	**0.02**	**0.01**	**0.02**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.02**	**0.02**	**0.02**	**0.01**	**0.01**	
Maximum	**0.36**	**0.24**	**0.14**	**0.14**	**0.08**	**0.12**	**0.11**	**0.11**	**0.14**	**0.11**	**0.2**	**0.07**	**0.37**	**0.14**	
Std. Deviation	**0.08**	**0.06**	**0.03**	**0.03**	**0.02**	**0.04**	**0.03**	**0.03**	**0.04**	**0.02**	**0.04**	**0.02**	**0.09**	**0.04**	
Disagreement															**0.04**

Table 4 - Calculation of Factors Weights

Source of Variation	Sum of Square	Deg. of freedom	Mean Square	F-test value
Between Subjects:	0.27	13	.021	**8.35**
Between Conditions:	0.00	14	0.000	
Residual:	0.45	182	0.002	
Total:	**0.72**	**209**		
Critical F-value with degrees of freedom 13 & 182 at 0.01 level:				**2.23**
Critical F-value with degrees of freedom 13 & 182 at 0.025 level:				**1.98**
Critical F-value with degrees of freedom 13 & 182 at 0.05 level:				**1.77**
Critical F-value with degrees of freedom 13 & 182 at 0.1 level:				**1.56**

Table 5 - The F-test for Evaluating the Null Hypothesis

13. Appendix II - JQIs (Judgment Qualification Instruments)

1. How desirable each of the following monthly cost is to you?
   $0, $20, $40, $60, $80, $110, $150, and $250.

2. How desirable each of the following cost per additional GB of data is to you?
   $0, $5, $10, $15, $20, $25, and $30.

3. How desirable each of the following cost per additional minutes of call is to you?
   $0.00, $0.20, $0.40, $0.60, $0.80, $1.00, $1.50, and $2.00.

4. How desirable each of the following cost per additional text message is to you?
   $0.00, $0.10, $0.20, $0.30, $0.40, $0.60, $0.80, and $1.00.

5. How desirable each of the following cost for adding Hotspot feature to your plan is to you?
   $0, $5, $10, $15, and $20.

6. How desirable each of the following termination cost is to you?
   $0, $100, $200, $300, $400, and $500.

7. How desirable is to you to have each of the following available MB of data in a given plan?
   0, 300MB, 1024MB/1GB, 2048MB/2GB, 3072MB/3GB, 5012MB/5GB, 20480MB/20GB, 51200MB/50GB, and Unlimited.

8. How desirable each of the following number of text message is to you?
   0 and Unlimited messages.

9. How desirable is to you to have each of the following available minutes of calls in the plan?
   0, 200, 500, 900, 1400, and Unlimited minutes.

10. For each of the following speed, how desirable it to you to have them in the plan?
    2G or 0.0144 KB/sec, 3G or 2MB/sec, 4G or 100MB/sec, and Next generation.

11. For each of the following reception quality, how desirable is for a plan to have them?
    0, 10, 20, 30, 40, 50, 60, 70, 80, 90, and 100 percent.

12. How desirable is to you to have Hotspot service in a plan?
    Have hotspot or No hotspot.

13. How desirable is to you to be able to change the plan?
    Changeable or Unchangeable

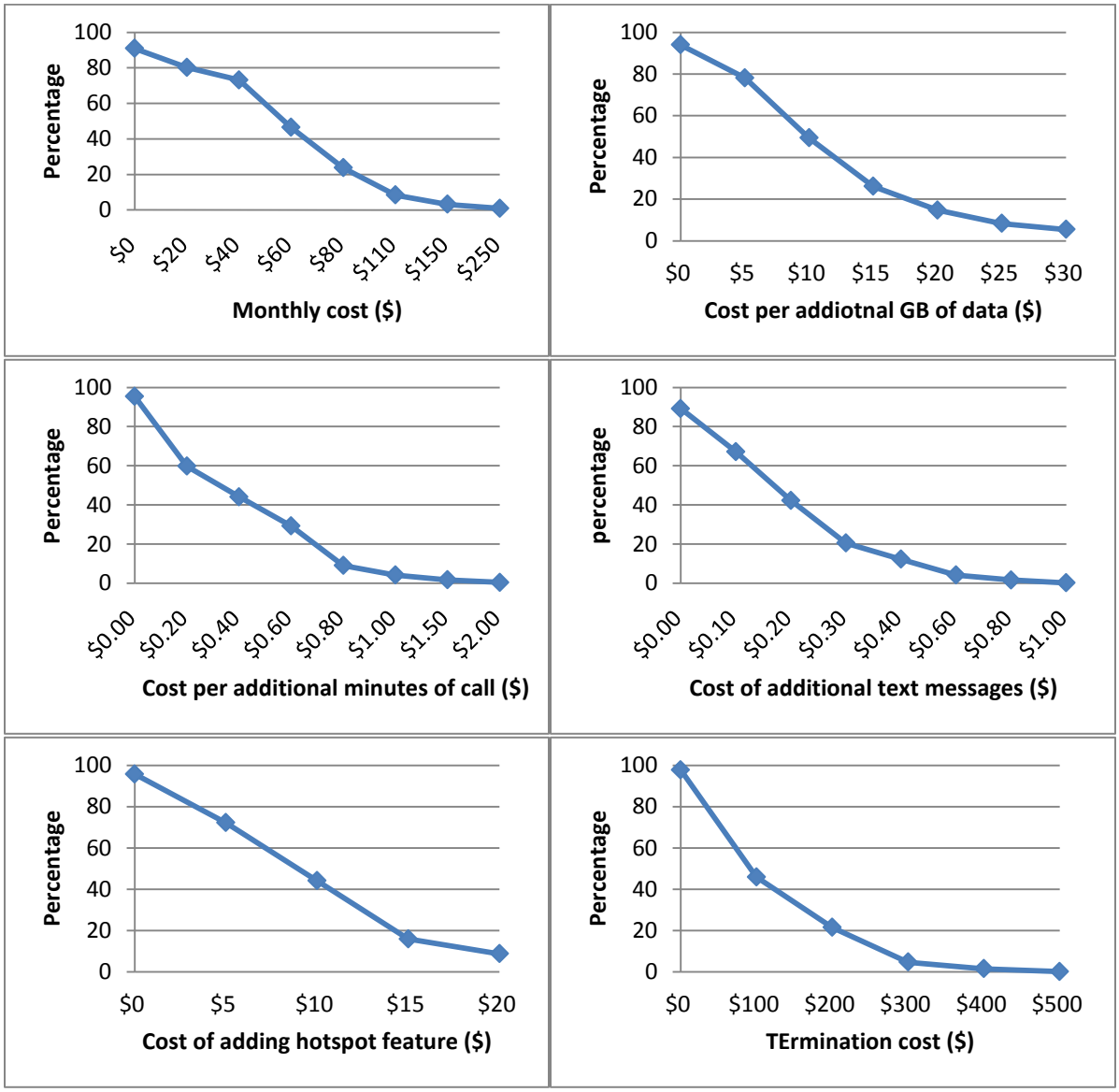
14. How desirable each of the following contract length is to you?
    0, 1, 2, and 3 years.

14. Appendix III – Evaluation of mobile communications plans

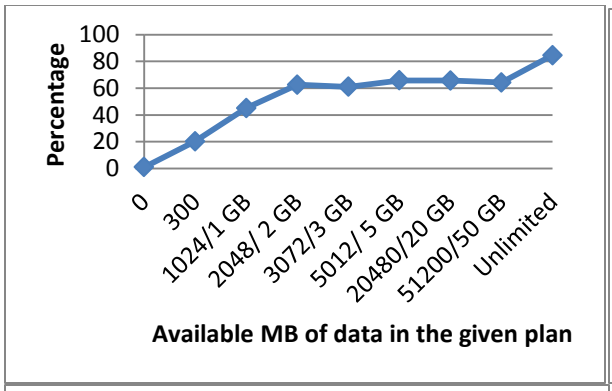
Factor	Unit	HDM weight	Sprint plan	Score/Factor	Sprint plan Score	Verizon Plan	Score/ Factor	Version Score	T-Mobile Plan	Score/ Factor	T-Mobile Score	ATT Plan	Score/ Factor	ATT Score
Plan	$/month	0.16	109.99	0.0838	0.01	100	0.1255	0.02	85	0.2939	0.05	89.99	0.2	0.03
Additional Data	$/GB	0.11	0	0.9392	0.10	15	0.2608	0.03	0	0.9392	0.10	10	0.4933	0.05
Additional Voice	$/min	0.07	0	0.9538	0.07	0	0.9538	0.07	0.1	0.7758	0.05	0.45	0.4	0.03
Additional Text	$/text	0.06	0	0.8921	0.05	0	0.8921	0.05	0	0.8921	0.05	0	0.8921	0.05
Additional Hotspot	$/month	0.03	19.99	0.0873	0.00	0	0.9571	0.03	0	0.9671	0.03	20	0.0873	0.00
Termination Fee	$	0.06	350	0.03	0.00	350	0.03	0.00	200	0.215	0.01	325	0.04	0.00
Data	GB/month	0.06	Unlimited	0.8454	0.05	2 GB	0.6258	0.04	Unlimited	0.8454	0.05	3 GB	0.61	0.04
Text	#/month	0.05	Unlimited	0.9193	0.05	Unlimited	0.9193	0.05	Unlimited	0.9193	0.05	Unlimited	0.9193	0.05
Voice	min/month	0.06	Unlimited	0.9279	0.06	Unlimited	0.9279	0.06	500	0.4923	0.03	450	0.43	0.03
Speed	Generation	0.05	3G	0.6257	0.03	4G LTE	0.8987	0.04	4G LTE	0.8987	0.04	4G LTE	0.8987	0.04
Reception quality	1~10	0.07	6	0.4242	0.03	10	0.9279	0.06	7	0.5369	0.04	6	0.4242	0.03
Mobile Hotspot	Yes/No	0.02	No	0.3323	0.01	Yes	0.6793	0.01	Yes	0.6793	0.01	No	0.3323	0.01
Changeability	Yes/No	0.12	No	0.2538	0.03	Yes	0.74	0.09	No	0.2538	0.03	Yes	0.74	0.09
Contract Length	Year	0.07	2	0.3705	0.03	2	0.3705	0.03	2	0.3705	0.03	2	0.375	0.03
Score					0.52			0.58			0.58			0.48
Score (%)					**52%**			**58%**			**58%**			**48%**

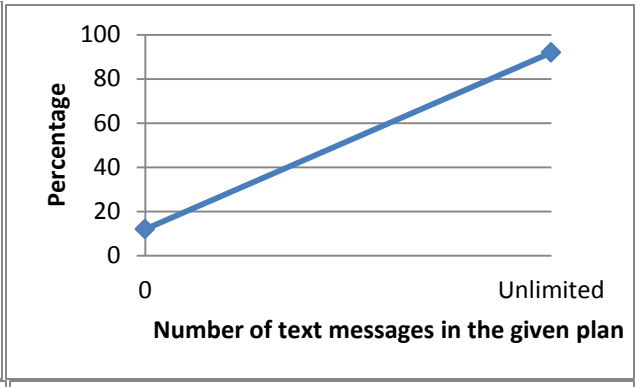
Table 6 - Evaluation of mobile plans from different mobile operators

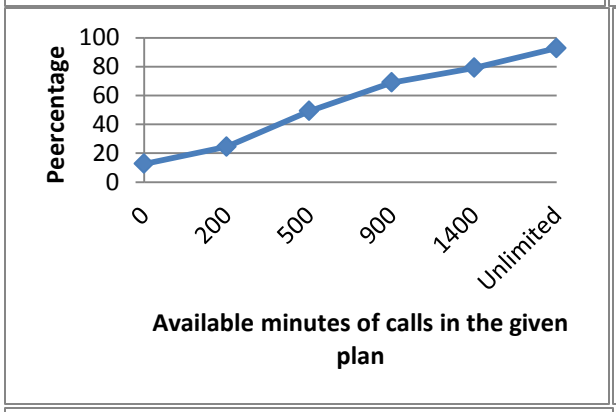
15. Appendix VI – Desirability Functions

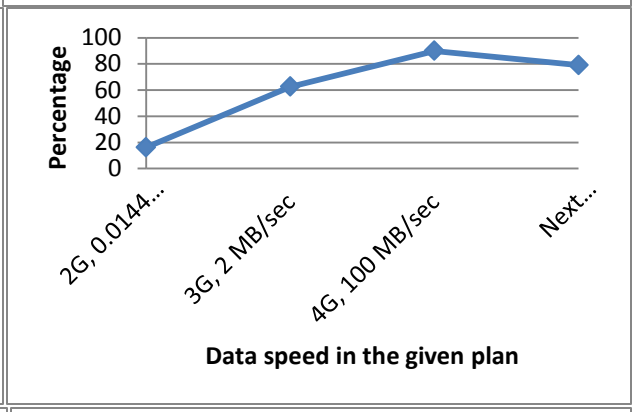


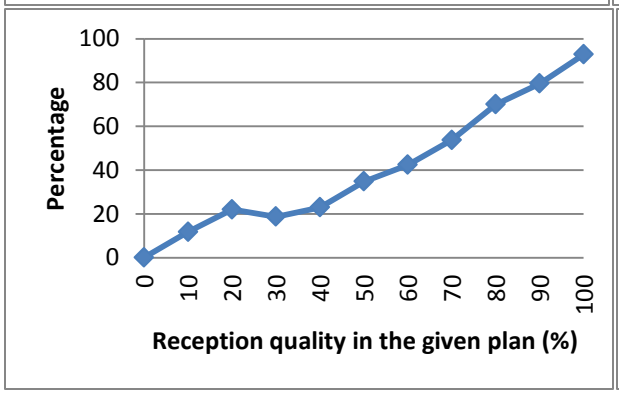
Desirability Functions - Cost

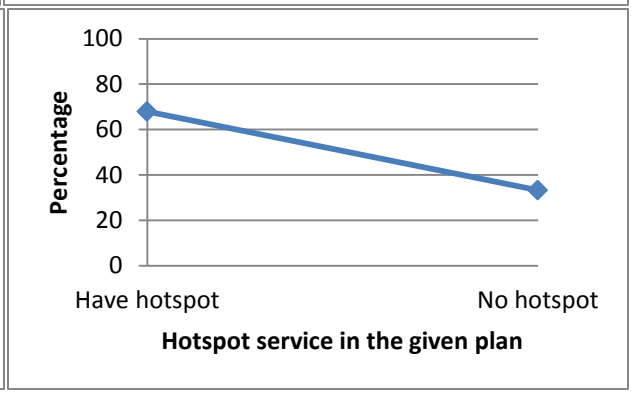




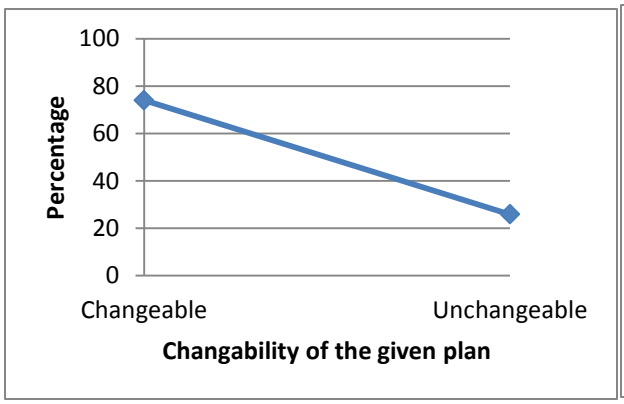


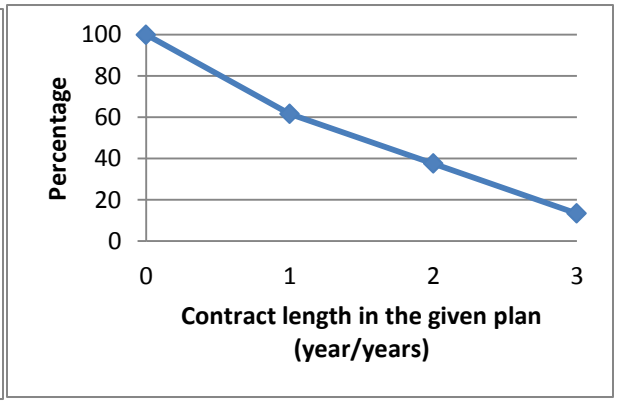






Desirability Functions - Service





Desirability Functions - Flexibility