Czech University of Life Sciences in Prague

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Application of MCDM approaches for choosing a mobile operator in a multinational company

Bachelor Thesis

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BACHELOR THESIS ASSIGNMENT

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Thesis title

Application of MCDM approaches for choosing a mobile operator in a multinational company

Objectives of thesis

Every company is in need of mobile operators for handling wireless telecommunications, wireless networking etc. So, the objective of my thesis is to select an appropriate mobile operator for a multinational company to reduce costs or enhance services received from the operator.

Methodology

- Literature review
- Analyze problems in a company
- Selection methods for finding operators
- Components of the MCDM model
- Mathematical model
- Data processing model of decisions
- Results and its interpretation

Schedule for processing

11/2011- Choosing of subject
12/2011- Consultation with my subject related teacher for choosing supervisor
5/2012- Outline of the thesis
7/2012- Data collection
7-9/2012- working with the MCDM methodology
10/2012- interpretation and work through spreadsheets
12/2012- correction of work, editing etc.
3/2013 – final work and conclusion.
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Keywords
mobile operators, multinational company, multi-criteria decision, decision methods, analysis, economical view

Recommended information sources

Belton, V., Stewart, T.J. 2002. Multiple Criteria Decision Analysis: An Integrated Approach, Berlin: Springer.
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Declaration

I declare that I have worked on my bachelor thesis titled “Application of MCDM approaches for choosing a mobile operator in a multinational company.” by myself and I have used only the sources mentioned at the end of the thesis.

In Prague on: 3/14/2013 Sajjan Ghimire

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Application of MCDM approaches for choosing a mobile operator in a multinational company

Aplikace rozhodovacích modelů při výběru mobilního operátora pro mezinárodní společnost

Abstract

The analytic hierarchy process (AHP) provides a structure on decision-making processes where there are a limited numbers of choices but each has a number of attributes. This paper explores the use of AHP for selecting suitable mobile operators. In the context of selecting, it is crucial to include elements that provide attributes that make VB bank decision-making easier, comfortable and therefore, lead to selection. As the banking sector becomes more competitive, there is a greater need of mobile operator that provides better technology, customer care, data and voice, signal quality, security etc. in the Czech Republic.

The purpose of this thesis is to discuss about the selection process of mobile network operator (MNO) in a multinational company. Virtual Bank VB bank has been created and chosen as a multinational bank. As a selection method, this thesis is more concentrated on Analytic Hierarchy Process (AHP) techniques. A pairwise comparison has been made within the criteria and alternatives. The degree of consistency has been measured on each pairwise comparison. The weighted average rating for each decision alternative has been calculated and the one with highest score has been chosen. The operator Telefonica O2 has been chosen as the best alternative for the bank.

Keywords: MNO, VB bank, AHP, Pairwise comparison, Average Weight, Degree of consistency, Normalization

Abstrakt

Cílem práce je popsat postup výběru mobilního operátora v prostředí velké nadnárodní firmy. Pro tento účel byla zvolena Virtuální banka VB. Výběr byl realizován prostřednictvím metody analytického hierarchického procesu (AHP).

Metoda AHP umožňuje dobře popsat strukturu vícekriteriální rozhodovací úlohy a je vhodná zejména pro úlohy, kdy nelze příliš dobře objektivně měřit charakteristiky hodnocených variant a počet hodnocených variant není příliš velký. Oba požadavky řešená úloha splňuje. Jako kritéria výběru operátora byly zvoleny použitá technologie, zákaznická podpora, rozsah datových a hlasových služeb, kvalita signálu, bezpečnost, apod.

Hodnocení výhodnosti nabídek bylo založeno na párovém porovnání. Konzistence všech matic, ve kterých bylo porovnání prováděno, byla ověřena a je v normě. Na základě hodnocení byla jako nejlepší vybrána nabídka společnosti Telefonica 02, která byla doporučena k realizaci.

Klíčová slova: Mobilní operátor, VB banka, analytický hierarchický proces, párové porovnání, váhy, index konzistence, normalizace

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1 Introduction

1.1 Study Background

The decision making is a highly complicate process of choosing the best one among alternatives to achieve an objective or a set of objectives under constraints (Malczewski, 2006). The decision problems typically involve a large number of feasible alternatives and multiple, tangible and intangible evaluation criteria. The alternatives are often determined through the market research or obtained according to the evaluation of a number of individuals (decision-makers, judgments, key person of a company). The individuals are mainly focused on unique preferences with respect to the relative need of criteria on the basis of which the alternatives are determined (Eldrandaly k., Tyler, 2007). The decision makers need different tools or methods to find out the best solution. There are different methods defined and are being used since the very earlier years. However, MCDM has a very significant role in a decision making process and is being used in a wide area.

Multi Criteria Decision Making (MCDM) was introduced as managerial techniques with more than one criterion as a decision making method. Over the last decades, wide verities of methods have been developed which uses pairwise comparison to solve one method over many criteria for decision–making in a company or organization. Saaty proposed the analytical hierarchy process (AHP) based on MCDM and it ultimately brought a drastic change in decision making process. AHP provides the technique of using traditional method that helps to put problems into a hierarchy of alternatives, criteria and sub-criteria (Saaty, 1980). It has given flexibility in decision making processes. The judgment made by the decision makers might not be perfect and could lead to a wrong decision. It is always required to have absolute consistent judgments. Consistency in a decision making model is always a useful key factor that helps to achieve the better solution for any organizations. It is always needed that the set of decision makers provides a higher level of consistence before choosing any alternatives so that there is maximum expected utility possessed by the alternative criterion. Selection process of choosing best alternative is most crucial part in any company. The process of selection and decision adapted should be qualitative, effective, flexible and

long term in nature (Patton, 2002). Since the company has to make a long term contract with a mobile operator for using its services, the qualitative method that AHP provides will be very useful to sort out the problem. It helps to indicate or find the problem looking through the nature of alternative and also the effectiveness & consistency of a selection.

The main challenge of MCDM techniques is how to factor psychological time into a decision in order to anticipate and deal with the future more successfully through prediction, planning or judgments. Many efforts are being made and new techniques are being developed in this decision process. Books and papers have been published that deal with the future and with planning using the prioritization process described in this paper.

2 Objectives and Methodology

Every company is in need of mobile operators for handling wireless telecommunications, wireless networking etc. The central problem of the study is to set the favorable alternative (choice) for a company regarding the total weights of several criteria offered by different mobile operators. The use of MCDM has been rapidly growing in the field of decision making. The different methods used in decision making are quite relevant in practice to solve the real problems and also to determine their quality. So, the objective of this thesis is to select an appropriate mobile operator for a multinational company to reduce costs and enhance services received from the operator. Specifically, the present study aims at the selection of a suitable operator, which would be the best alternative for VB bank to get enhanced services among the mobile network operators in the Czech Republic.

The study was carried out by taking secondary information from the webpages (Google scholar, internet explorer, yahoo answers, etc.). I have talked about the basic terminology used in thesis, MCDM techniques, use of AHP method, Saatys' method and so on. In the present study, I took the different case studies of various companies in Czech Republic though the web. I emailed to Human Resource Department (HRM) of each banks situated in Czech Republic. However, I was replied with an objection for data collection. I could not find essential data needed for the case analysis. It was an urge to make a hypothetical bank. The hypothetical bank (Virtual Bank) was created to show the case studies for the selection process of mobile network operators. I used an estimation method to find the significant criteria that mobile operators offer to a bank. I gave each criteria and alternatives (MNO) their respective weights and ranked the data in AHP method. Random consistency index values (R.I.) are used as proposed by Saaty (Saaty, 1980). All data presented in the tables were analyzed in excel 2007 with the use of various excel functions.

3 Literature Review

3.1 Basic Terminology

3.1.1 Alternative:

It is a choice between two or more than two exclusive possibilities. Alternative is also sometimes used to refer to a variant or substitute in cases where there is no element of choice involved, as in we will do our best to secure alternative. For a company, alternative may refers to choices among which a company can deploy or use it for its benefit or to get certain services or solve the company's problems (Nakanishi, 1997).

3.1.2 Criterion:

Whenever we talk about the criterion, we can say it is a standard, rule, or test on which a judgment or decision can be based. In our daily lives or in commercial settings, there are usually multiple conflicting criteria that require to be evaluated in creating selections. The most important criteria in a company could be cost or price. However, the alternative criteria may possess higher priority than value of cost or price. A company or individual may choose high quality services that are costly rather than low quality services with low cost. So, it is necessary to focus in having high returns but at the very time reducing our risks. It is essential to give a higher priority for a given criteria with a use of certain disciplines or methods (Byun, 2001).

3.1.3 Matrix:

For having a finite number of alternatives, evaluation of all alternatives with respect to all attributes could be shown in Matrix form. It is very useful tool to do a pairwise comparison of criteria and alternatives. A matrix is a rectangular arrangement of mathematical expressions that can be simply numbers (Brown, 1991). The horizontal and vertical lines in a matrix are called rows and columns, respectively. The numbers in the matrix are called its entries or its elements. To specify the size of a matrix, a matrix with m rows and n columns is called an m-by-n matrix or m × n matrix, while m and n are called its dimensions.

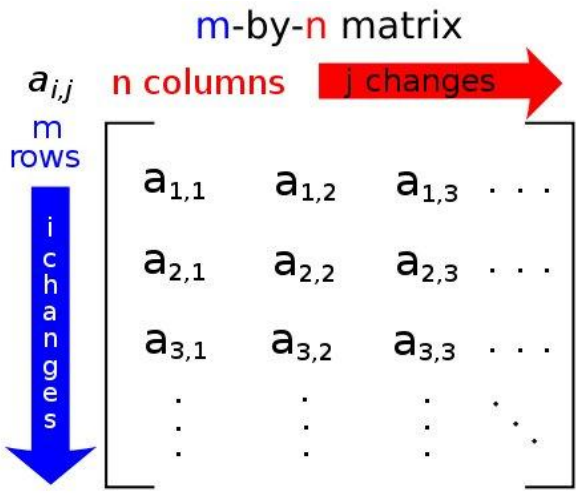


Figure 1: Example of Matrix (Robhar)

3.1.4 Weight:

In science and engineering, the weight of an object is usually taken to be the force on the object due to gravity (Morrison, 1999). However, if we talk about the weighting in field of pairwise comparison or MCDM methods, it directly compares the attributes of length, area, weight/mass and capacity, relative temperature of relative criteria or alternatives. It is use to directly compare two objects with a measurable attribute in common, to see which object has "more of"/"less of" the attribute and describe the difference. It is essential to weight all criteria and alternatives when using a pairwise comparison. By obtaining the average weight of them, we can say the attribute with the highest value of weight is the best one to select (Saaty & Vargas, 2000). Normally, value of weights is taken with the judgments provided by the decision makers. It could be either estimated or experts decision and also could be a real measured value.

3.1.5 Utility:

Utility is a measure of satisfaction, which helps to determine the quality or condition to be useful of a certain thing. All attribute values can be expressed by utility value and also partial utility values can be combined into global utility value. Utility of an attribute or criteria could

be shown by a utility function which shows a preference relation among them. Mapping of attribute values is given as (0, 1) (Malczewcki, 1999). The maximization of expected utility is considered to be the principle of rational behavior. However, Simon claims that instrumental rationality stands only if individual choice is based on the following hypotheses (Simon, 1965):

- attributes of all available alternatives are known

- the probability distribution of uncertainties of results is known

- the principle of expected utility maximization is used

Practically, this hypothesis seems to be unrealistic cause of various problems.

3.2 Decision-Making in General

The decision-making method involves characteristic issues, constructing preferences, evaluating alternatives, and weighting or ranking the alternatives and criteria (Saaty, 1980). However, once decision-makers assess the alternatives with multiple criteria, several issues, like the weights of the standards, preference dependence, and conflicts among criteria, appear to complicate the decision-making method so this could be resolved by additional refined ways.

Generally from the perspective from the management after setting mission and vision the company moves forward to planning. For the formulation and implementation of planning the management needs to make a right decision at right time at right place in right order. Thus to formulate plan the decision making process is the main center idea that need to be judged by the management. Generally the decision making process means the selection of best course of action among the available opportunities. According to Dr. Pam Brown, for making a decision, the following feature needs to be analyzed (Brown, 2007).

1. Outline your goal and outcome.

2. Gather data.

3. Develop alternatives (i.e., brainstorming)

4. List pros and cons of each alternative.

5. Make the decision.

6. Immediately take action to implement it.

7. Learn from and reflect on the decision.

Decision-making is very intuitive once considering single criterion issues, since we tend to solely ought to select the choice with the best preference rating. However, adopting a data management system isn't simply one criterion downside. Decision-makers ought to assess the alternatives supported multiple criteria (Malczewcki, 1999).

3.3 Multiple Criteria Decision Making

The decision making process is the selection of method or courses of action from different alternative acts or courses of actions such that it will produce optimal results under some criteria of optimization. What makes MCDM complex is the plurality of the criteria involved in the problem (Tabucanon, 1988)The process of making quality choices using MCDM depends on the procedures for scoring alternatives, discovering relevant criteria, weighting the criteria and not the least, for structuring the criteria trees (Bruga, 2004).

As defined by the International Society on Multiple Criteria Decision Making (MCDM), MCDM is the study of methods and procedures by which concerns about multiple conflicting criteria can be formally incorporated into the management planning process (Web2). Dealing with Multiple Criteria deciding (MCDM) issues involves following key steps (Malczwski, 1999).

Setting Goals: A goal or a set of goals the company or any individual (interest group) attempts to achieve.

Identification of the downside/issue: Decision-makers ought to determine the character of the analysis problem. They need to confirm specifically those criteria to be thought-about and that decision-making ways needs to be adopted.

Problem structuring: practitioners/decision-makers helps to determine the goals, values, constraints, external setting, key issues, uncertainties and stakeholders of this enterprise. During this step, we want to gather the acceptable information or info in order that the preferences of decision-makers will be properly known and regarded.

Model building: decision-makers then specify the alternatives, outline all criteria and elicit values for model building. This method permits them to compile a group of doable alternatives or ways so as to ensure that the goals are going to be achieved.

Using the model to tell and challenge established thinking: particularly decision-makers collect and synthesize info, challenge people's intuition, recommend alternative new alternatives and analyze the strength and sensitivity of the model.

Developing associate action plan: within the final step, associate action set up is built as an answer. In alternative words, we will choose the acceptable methodology to assist the selection and rank the doable alternatives. (i.e., confirm the simplest alternative).

3.4 Methods used

3.4.1 AHP Method

The Analytic Hierarchy Process (AHP) is a Multi-criteria decision making (MCDM) technique proposed by Saaty (Saaty, 1977), that integrates pairwise comparison ratios into a ratio scale. The AHP is a straight forward technique for creating and analyzing decision in practice. The process was created to get a specific category of problem which involves the prioritization of related alternate solution (Byun, 2001). This method is forced on three major components (Wind & Saaty, 1980).

1) AHP starts by separating a complicated problem into a hierarchy, every level consisting of number of manageable components of every part is then divided into another set of components. This method continues down to most core elements of the problem. There could be different data structure. One of the best parts of this method is the flexibility it permits decision makers.

2) A measurement methodology is employed to ascertain priorities among the criteria within every branch of the hierarchy. Normally, this process is done by asking the decision makers

(judges) to focus each set of criteria in priory's comparison, with respect to its relevant elements. The main purpose in this methodology is to collect data and analysis the model. Basically, the hierarchy is split into series of paired comparison matrices and the judges are asked to give their judgments regarding the relationship between criteria or alternatives. The pair wise comparison represents the nine-point scale rule and is usually used in AHP analysis.

Intensity of Importance	Definitions
1	Equal Importance
3	Moderated importance over another
5	Strong or essentials importance of one over another
7	Very strong importance
9	Absolute importance
2,4,6,8	Intermediate values between to adjust judgments
Reciprocals of Above	If factor I has one of the above numbers assigned to it then factors j at adjacent diagonal will have reciprocals value when compared with i.

Table 1: AHP Comparison Scale (Saaty & Vargas, 2000)

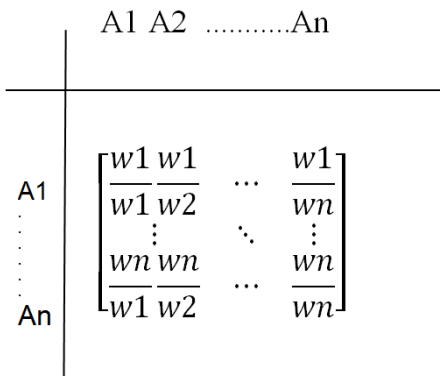
3) A measurement theory helps to establish the priorities of the hierarchy and the consistency in the judgments made by several participants. Thus stage includes calculation of priorities (Quaddus & Siddique, 2001) and also consistency. After measuring consistency, the further

process of calculating the total utility of the alternatives is done. The utility is calculated by multiplying average normalized mean of criteria to respective average normalized mean of alternatives. Finally, total utility for each alternative is calculated. The alternatives with higher weight are selected as best alternatives.

3.4.2 Saatys' Method

The process of making quality choices using MCDM depends on the procedures for scoring alternatives, discovering relevant criteria, weighting the criteria and not the least, for structuring the criteria trees (Bruga, 2004). Saaty (Saaty, 1980) has suggested a solution to this problem. Let $\omega_i \geq 0$, i= 1, 2… n be the degree of belonging of the n members. From the matrix of relative weights whose i, jth element is ω_i/ω_j. Then Saaty observes that the vector $(\omega_1, \omega_2 \ldots \omega_n)^T$ is an eigenvector corresponding to the largest eigenvalue. All the other eigenvalues are zero.

The main theme is to estimate the matrix of relative weights and then get an estimate of the vector $(\omega_1, \omega_2 \ldots \omega_n)^T$ as an eigenvector corresponding to the largest eigenvalue of the relative weight matrix. For the comparison of a set of n objects in pairs with their relative weights, Saaty denotes the objects by A1 …An and their weight by $\omega_1, \omega_2 \ldots \omega_n$. The pairwise comparisons are given by the matrix below:



$$\begin{bmatrix} \frac{w1}{w1} & \frac{w1}{w2} & \cdots & \frac{w1}{wn} \\ \vdots & & \ddots & \vdots \\ \frac{wn}{w1} & \frac{wn}{w2} & \cdots & \frac{wn}{wn} \end{bmatrix}$$

Figure 2: Matrix Representing Pairwise Comparison (Own source as of (Saaty, 1980))

The matrix presented above is called as reciprocal matrix, has positive entries everywhere and satisfies the reciprocal property $a_{ji} = 1/a_{ij}$, multiplying this matrix by the vector $\omega = (\omega_1 \ldots \omega_n)^T$.

$$A\omega = n\omega \quad (1)$$

$$(A-nI)\,\omega = 0 \quad (2)$$

This is a system of homogeneous linear equation which has a non-trivial solution if and only if the determinant of (A-nI) vanishes ,that is ,n is an eigenvalue of A. Matrix A is also consistent.

In the general case, the precise values of the $\omega_i/\ \omega_j$ are not known and must be estimated. Since the eigenvalues are perturbed by a small perturbation of the coefficients, equation (1) becomes

$$A'\omega' = \lambda_{max}\omega' \quad (3)$$

where λ_{max} is the largest eigenvalue of A'. To simplify the notation, equation (3) is expressed in the form

$$A\omega = \lambda_{max}\omega \quad (4)$$

where A is Saatys' matrix of pairwise comparisons. The eigenvector associated with the largest eigenvalue is the desired vector of weights (Saaty & Vargas, 2000; Saaty T.L and vargas L.G, 2000; Saaty T.L and vargas L.G, 2000).

Numerical methods for obtaining the largest eigenvalue and associated eigenvector are discussed in this paper. A new imbedding method applied to the eigenvector problem is emphasized. Numerical results are given for an example and compared with Saatys' results.

3.4.3 Consistency measures

For finding the consistency of a positive reciprocal pairwise comparison matrix, $A = (a_{ij})$, as the cardinal transitivity between the decisions, that is shown as,

$A_{ij}a_{jk} = a_{ik}$, i, j, k =1, … n, Saaty suggested that the inconsistency in Conventional–AHP, where the Right Eigenvector Method (EVM) is used as prioritization procedure, can be calculated by a single number ($\lambda_{max} - n$) which reflects the deviations of all a_{ij} from the estimated ratio of priorities ω_i/ω_j.

Under this method, to give a measure independent of the order of the matrix, n, Saaty proposed the use of the consistency Ratio (CR). This is captured by taking the ratio between ($\lambda_{max} - n$) to its expected value over a large number of positive reciprocal matrices of order n, whose entries are randomly chosen in the set of values {1/9, …,1, …, 9}. For this consistency measure, he designed a 10% threshold for the CR (5% and 8% for the 3*3 and 4*4 matrices, respectively) to accept the estimation of ω (Saaty, 1994). When the CR is greater than 10%, then, in order to improve the consistency, most inconsistency decisions, which reflects, those with a greater difference between a_{ij} and ω_i/ω_j, are usually modified and new ω was derived.

3.4.4 Row Geometric Mean Method

Although Saaty School (Saaty & Vargas, 1990;1994;1997) made a strong defense of the EVM, the use of the Row Geometric Mean Method (RGMM), or Logarithmic Least Squares Method, as a prioritization procedure in AHP was introduced and has been a successful consistency measuring tool.

In the conventional-AHP (Saaty, 1980) the priorities (ω_i, i = 1… n) are obtained by solving the eigenvector problem

$$A\omega = \lambda_{max}\omega \sum_{i=0}^{n} \omega i \qquad (5)$$

where A is a positive pairwise comparison matrix of order n, λ_{max} is the principal eigenvalue of A and ω is the priority vector.

For this prioritization procedure, the EVM, Saaty (Saaty, 1980) proposed a measure of the consistency in judgment, called the consistency index (CI), that is given by

$$CI = \frac{(\lambda \max - n)}{(n-1)} \qquad (6)$$

Where λ_{max} is the principal eigenvalue of the judgment matrix and n is its order.

When the reciprocal comparison matrix is consistent, λ_{max} = n and CI is equal to zero; otherwise, its value is positive. To overcome the order dependency of the CI, Saaty proposed a normalized measure, called the CR that is given by

$$CR = \frac{CI}{(RI(n))} \quad (7)$$

where RI(n) is the Random (consistency) Index for the matrices of order n. This term is defined as the expected value of the CI corresponding to matrices of order n (RI=E[CI(n)]), where the judgments are simulated in the set {1/9,…,1,…9} and the EVM is used as the prioritization procedure.

n	1	2	3	4	5	6	7	8	9	10
R.I.	0	0	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.49

Table 2: Random consistency index values R.I. (Saaty, 1980)

The CR gives a measure of where the judgments in the pairwise comparison matrix lie between totally consistent and totally random. When CR=1, then CI=E[CI(n)] and the judgments are totally random (low precision). High values of CR reflect more inconsistency and thus we are interested in values of CR as low as possible. To accept the consistency of the matrix, Saaty (Saaty, 1980) suggested as a rule of thumb a threshold of 10% or less (CR< 0.1). More recently, Saaty (Saaty, 1994) suggested thresholds of 5% and 8% for 3*3 and 4*4 matrices, respectively.

4 Selection of Mobile operator for VB bank in Czech Republic

Today's environment is very competitive, resulting to great changes in the history of business. Day by day, the use of resulting creativity, innovation, modernization, huge demands, technological changes, etc. has put in every business sector in a complex and competitive environment by providing maximum facilities to the customer. Business organizations, especially the banking sectors are using the different concepts modifying itself into a flexible and easy one.

The advancement in technology facilitates payments and creates various alternatives for making transactions. This has led to the development of a worldwide, boundless and internet enabled 24-hour business of banking, m-banking, internet banking etc. Telecommunication and mobile network operators (MNO) make task easier providing different services like wide range of networking and technologies, voice services, internet, data (3G, 4G, LTE, etc.),GPRS, GPS etc. MNO have become a key to different banks and without it bank will be malfunction leading to collapse.

There are many mobile network operators that provide various services to banks as well as to other companies. In order to have an agreement with such provider's banks need to go through the offer provided by them. At the same time different factors are needed to be overlooked such as features, quality, costs, etc.

There used to be the traditional method to select the targeted MNO and in this case it wasn't so efficient or wasn't comprehensive enough to meet the various criteria of a bank. For e.g. it wasn't cost efficient or wasn't able to enhance better services. It was needed to use the certain techniques that would bring the entire criterion together and would evaluate the possible chances of having maximum benefits for any firms.

In this thesis, I am going to use this method to make a choice (MNO) among the set of different alternatives (MNO's offers) for the virtual bank created by me.

This bank is a virtually created bank to give a path for writing my thesis. It doesn't exist in real.

The details of Virtual bank are as below:

Virtual bank, a.s. (“VB”):

-is located in Czech Republic and is a parent company of VB group.

-ranks among the finest banking institutions in the Czech Republic and Central as well as Eastern Europe.

-is a leading bank providing various services in retail, corporate and investment banking.

-provides various services such as i-banking, funding, insurance, telebanking, renting, factoring, consumer lending, trade financing etc.

Total Assets	CZK 1005.4 billion
Number of VB Clients	6178544
Number of Branches	725
Average Number of Employees	12224
Number of Payment Cards	4145785
Number of ATMs	1875

Table 3: Key Facts as of 09/18/2012

Banks connects with customers, firms, etc. by accessing the various services to them through different channels such as Automated Teller Machines (ATM), branch, call center, mail, mobile banking, online banking, relationship managers, telephone banking, video banking, etc. Today’s banks enable customer payments via current accounts, cash, checks and other payment methods such as Automated Clearing House (ACH), Wire transfers or EFTPOS,

telegraphic transfer and automated teller machine (ATMs). All off these varieties of technical payments as well as other services are managed by MNO.

How mobile operators have come so closer to various banks? There is considerable impetus behind every effort to deliver more personalized services for a bank customer. Banks are ready to offer various services as per customers' interest and reliability of modern services provided through banks. With the growing technology introduced by mobile operators in the banking sector has become a boon for banks to get high success within a limited time (Salz, 2011).

4.1 SWOT Analysis of VB Bank Regarding MNO

Simply it is: Strength, Weakness, Opportunity and Threat. A SWOT analysis helps to identify the positives and negatives if an organization internally and externally. I have used SWOT as to describe situation of VB bank which is needed for strategic planning and decision-making. SWOT is essential to keep a long track record of effectiveness. Usually, SWOT is compared with external tools to find out the right approach for our situation (Web3, 2013). The positive point of this method is its simplicity and application to a variety of levels of operation. The basic terms of SWOT prepared for VB bank are as follows:

4.1.1 Strength

Higher interest rate: VB bank has first mover advantage in many of banking and financial services. It is the first bank in Czech Republic to introduce complete mobile banking solutions. Since it uses internet banking, the interest rate offered to customer is comparatively higher than other banks and is successful to achieve maximum number of clients. The reason behind offering higher rate is that VB bank has a lower overhead than regular banks. This higher interest rate given is covered with the expenses to maintain branches and employee's salary. Since an online bank obviously doesn't need to pay these infrastructures they are able to pay a higher amount.

Sufficient ATM's machines: VB bank has maximum number of ATMs machines in Czech Republic. It will be easy to find ATM's machines in every city corners, major stores, metro

station, bus stations, inside and outside bank, etc. Just see the ATM's machine in your mobile map you will be able to find it within the range of 1-2 kilometers apart.

Various flexible services: VB bank has also introduced mobile payments, online banking, online customer services, telephone banking, video banking and many others that have become a key of success. These services have been upgrading this bank to the position of number one in mobile banking.

High speed internet: VB bank uses high speed internet so that the data is transmitted really very fast. Online banking is only possible through high speed internet. Banks started to use the internet not only as an innovative payment method but also to increase customer convenience, as a way to reduce costs and enhance profits. Customer are happy to save their time since all works could be done online and necessary help could be taken sitting at home.

4.1.2 Weakness

Additional charges: Bank service charges are comparatively higher. For all services like internet banking, mobile payment etc. may cost some additional charges. It might be expensive for those who do not want to pay extra.

Technical problems: There are also complaints of customer assault and abuse while updating a transaction through online banking because sometime there could be some technical errors. Even though you have already settled the balance, it might not be updated. This is a frequently occurring issue in a bank and VB bank is going through this problem.

Insufficient and costly online services: An online customer service in VB bank does not seem to be more successful comparatively. Even if a client calls to a customer's help toll number, it might not solve his/her problem(s) because of various reasons like language, low networking range, inaudible call, etc. and during this call, the customer is paying every second of the call cost. It might take several minutes to make him/her understand what the problem is and what steps to follow to solve that problem. It takes your time and money.

4.1.3 Opportunities

Developing modern techniques: Banking sector is expected to grow rapidly with the use of modern technologies like voice services, video services and data transfer. The new strategy changes the focus of the branch from being a high cost transaction center to a provider of a wide range of services like mobile payments, telebanking, internet banking and many other features to be implied soon in near future.

Cost reduction: High costs for the employees are reduced due to the use of mobile operators. The need of recruiting the employees are balanced due to the services like mobile payment, customer themselves can check their account and also they can withdraw or transfer the money through various means of services provided. This is the key to success for VB bank.

Entry into rural areas: VB Bank is planning to open many more branches in the rural areas. With the entry of MNO in the village area, nowadays VB bank is ready to open new branches. If so, the bank can provide the services as they have given in the urban areas.

4.1.4 Threats

Hacking privileges: There is high risk that hacker could get into the main operating system. Hackers control access to system resources and gets through the secure system of a bank,

which may lead to loss of data, restricted money transfer and many other threats. VB bank might be one of the victims.

Switching account: Unsatisfied customer may switch their account to other bank. High cost services, data errors, bank's competitor, etc. may lead the customer to choose other bank. This will hamper the bank to maintain its targeted number of clients. VB bank does not desire to see this in future.

Strength	Weakness
➢ Higher interest rate ➢ Sufficient ATM's machines ➢ Various flexible services ➢ Internet	➢ Additional charges ➢ Technical problems ➢ Insufficient and costly online services
Opportunity	**Threats**
➢ Developing modern techniques ➢ Cost reduction ➢ Opportunity for new branches	➢ Hacking privileges ➢ Switching the bank account ➢ Bank's competitors ➢ Charges for mobile operators

Figure 3: SWOT Analysis for VB bank regarding mobile operators (own source as of (Humphrey, 2005))

Bank's competitors: There are competitors for VB bank and other upcoming banks which may impose a major threat. Increasing number of banks and financial crisis is very risky for any bank. The limited number of customer will move to different banks and that results low number of customer in a bank.

Charges for mobile operators: Mobile operators may charge with high cost since bank is using maximum services provided by them. Since, there are limited numbers of mobile operators in the country.

Internally, VB bank has some advantages in banking services. The expensive services are obvious since they are accepted by the majority of customers. VB bank is planning to reduce additional charges for the online services, reducing ATM's charges by maintaining mutual co-operation with other banks. Also, VB bank has decide to make free toll number to enhance better services for the customer who do not want to pay money for calling to bank i.e. free online customer service.

Beside this, VB bank is going to introduce high speed internet (LTE, 4G) and more other sophisticated technologies with a hope to overcome the technical errors and problems. This approach will be really helpful to reduce the weakness of VB bank.

If we speak about the external factor of VB bank, it does have a good opportunity to put itself in a highly organized and managed bank. The emerging of new mobile operators could be a great relief for VB bank to reduce the cost and provide maximum services to the clients. With the opening of new branches, VB has expected to make a record of maximum clients. Regarding the security and hackers, VB bank is using new and enhanced security. VB bank is spending millions of dollars each year to upkeep their IT infrastructure and boast of some most sophisticated computer defenses available.

4.2 Selection of Criteria

4.2.1 Cost

Lower the cost overheads for MNOs, higher the profit will be for VB bank. The increase in the new technology of MNOs is the cost factors driving the upcoming cost crunch for MNOs. It directly touches the financial part of a bank. It means any bank has to search MNO which can provide the better services for low cost. Herrmann, Huber, Xia, & Monroe mentioned that price perceptions directly influence satisfaction judgments as well as indirectly through perceptions of price fairness. (Herrmann, Huber , Xia, & Monroe, 2007)

4.2.2 Security

VB bank knows the need and importance of maintaining better security protocols which in future will be beneficial for the clients and bank. So, VB bank is much focused, aware and ready to tackle upcoming threats.

MNOs provide the various services to the bank. The bank must be secured in all services. As long as there is a highly secured MNO, it automatically reduces the threats to a bank. Bank requires security system to be tight and immediate messaging service to stay in touch with ongoing problems and to receive fastest feedback. The network misuses and fraud prevention, malware and virus prevention, IP blacklisting prevention, malicious website protection, botnet protection etc. are the major security solutions that should be identified easily. It should provide real time visibility and control of various threats that happens in a bank externally and internally. This is a key feature that a bank should look in order to obtain secured system (Dimitriadis, 2006).

4.2.3 Technology

The future is inevitable and the changes are being continuously. A newer technology may be efficient for the bank and deployment may result the new system of services that can be provided. There could be large installed bases of users connected with bank or bank itself which only support older technology and machine-to-machine applications that have long life cycles. It is beneficial for bank if operators can support technologies for many years, such that the operators have to deploy its services to multiple generations of technology at the same time. Operators should offer more features in a regular basis instead of using same old technologies (Web4).

4.2.4 Voice and Data Service

Mobile network operators should provide very high quality of voice termination with existing advanced features such as support for international voice traffic on roaming number ranges (MSNR) worldwide, delivery of fax calls to a large number of destinations and also could be monitored through dedicated procedures. Besides this, other instrafractures that supports video

telephony, MMS (multimedia messaging services) and more advanced 3G, 4G or LTE networking voice service is very useful in banks for providing an outstanding customer experience, increasing trend of voice self-service adoption and automation rates, improving the effectiveness of collections, reducing fraud loss and risk, arranging quick and urgent meetings. Success in using them depends on MNO how the services is provided or implemented. It also reduces the need for callers to speak to expensive live agent (Web5).

4.2.5 Signal Quality/ Coverage Area

When using mobile phones or any wireless networking systems, it is very often that it doesn't take much to lose that precious signal just being underground or riding on a train. The annoying 'black hole' in wireless coverage could be a problem for a bank. So, signal quality/ coverage area is very essential term that should be considered which choosing any MNOs. MNOs with an improved and effective spectrum are always the best one to choose. The network coverage depends by proximity to a network tower, its frequency and other factors. The MNOs having 3G, LTE, 4G services are the better options, also the one having number of additional towers could be additional instrafractures.

4.2.6 Frequency Utilization / Call density

The smartphones, palm, tablets and laptops are being used tremendously causing huge data traffics which have overwhelmed the mobile networks. This has been a challenge for network operators to control over it. Bank is connected with thousands of clients for which there should be perfect call density. The new technology such as the use of heterogeneous networks (HetNets) based on Wi-Fi and LTE small cells could be adopted by MNOs. If operators can deploy these new technologies in its main targeted or hotspots place like centers, arenas, companies etc. may help to reduce the call traffic. Hence, bank must be wise enough to choose any MNOs looking through this feature.

4.2.7 Customer Care

MNOs plays a vital role in a bank to give 24*7*365 customer care services either online or through video and audio call. Whenever customer is in need of help or gets into some

technical problems, MNOs could be helpful tool like in the case of billing and payments through online customer services. As long as there is good customer care, bank will be benefited by getting credits from customers. Homburg, Hoyer and Koschate (Homburg, Hoyer, & Kostchate, 2005) wrote that customer satisfaction is explained as post-consumption evaluation that relies from comparison between customer expectation and the actual product or service performance. If there is higher number of subscribers of same mobile operators, then it will be beneficial for majority of client for cheap and tariff calling to banks. Bank should utilize this feature while choosing MNO (Ghazri, 1998).

4.3 Introduction of SAATY'S Method

This method is applicable to ensure the reliability and effectiveness of the selection process. I have used the well-known multi-criteria decision approach that is Analytic Hierarchy Process (AHP) for making a relevant decision. Each bank needs to choose mobile operators that provide the necessary services needed for bank. Each operator offers reliable, interesting and varied services which could be essential factors that bank needs to look through and choose its operators. However, the most important factor could be quality services, cost, enhanced technology, excellent network and so on. These factors could be compared accordingly to its numerical values and under the condition of no measuring scale such as reliability of customer care, quality of voice, audio and so forth. After each-each criteria and alternatives uses AHP analyzed, it will produce or order of priority rating for each-each element being compared and especially in choosing a mobile operator to find out what criteria determines choice.

4.4 Prioritizing the Criteria

The most important and critical phase in designing the selection process model is to structure the decision problem. The main goal is to select the alternatives that exist as an option for a bank with the sets of criteria for evaluation. It is also needed to develop main criteria and its sub-criteria leading to give more useful or excellent output for achieving the goal. These criteria includes: C1. Cost, C2.Security, C3.Technology, C4.Voice and Data Service, C5.Signal Quality, C6.Call Density, C7.Customer Care. Hierarchical problem structure of VB bank is given below:

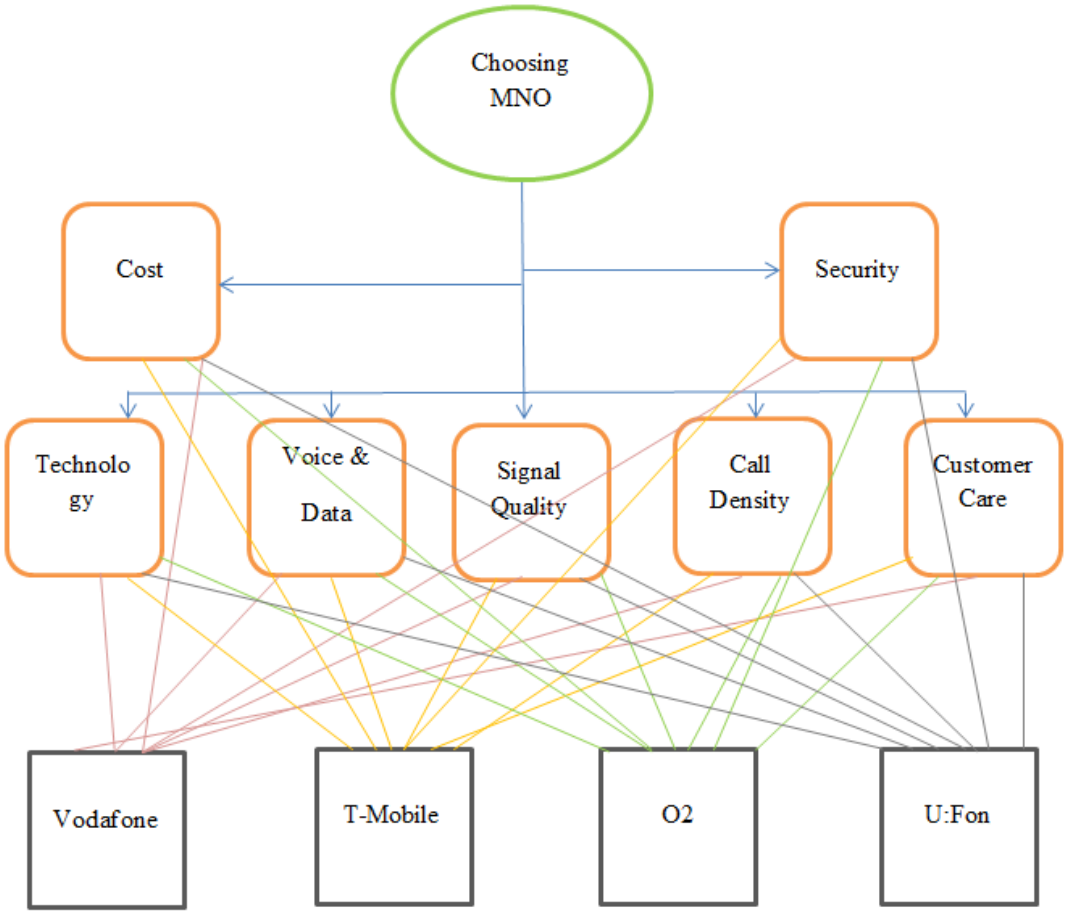


Figure 4: Hierarchical problem structure of VB Bank (own source modeled according (Saaty T.L and vargas L.G, 2000))

Factor	C1	C2	C3	C4	C5	C6	c7	GM	Normalized GM
C1	1.00	0.14	0.11	0.14	0.50	1.00	0.33	0.32	0.03
C2	7.00	1.00	1.00	2.00	5.00	5.00	3.00	2.70	0.29
C3	9.00	1.00	1.00	2.00	2.00	5.00	3.00	2.46	0.26
C4	7.00	0.50	0.50	1.00	3.00	7.00	0.33	1.43	0.15
C5	2.00	0.20	0.50	0.33	1.00	1.00	0.33	0.58	0.06
C6	1.00	0.20	0.20	0.14	1.00	1.00	0.33	0.41	0.04
c7	3.00	0.33	0.33	3.00	3.00	3.00	1.00	1.37	0.15
								9.27	

Table 4: Normalization and Pairwise Comparison between the Criteria

4.5 Mobile Operators in Czech Republic

There are four mobile operators providing mobile network services within the Czech Republic: Vodafone, Telefónica O2, T-Mobile and U:Fon. Czech Republic has 14.244 million subscribers in total, or a 138% penetration rate (December 2011) (Web1). All of these MNO provides various services such as voice and data, networking, customer care, e-payments, etc. These mobile operators are the alternatives for a VB bank to choose or hire them as an official mobile operator. VB bank is interested to find out the total weights of these operators, regarding its cost, services and reliability. The operator with the highest weight will be selected as long term official operator for VB bank.

4.5.1 T-Mobile:

T-Mobile Czech Republic a.s. started its services since 1996. Formerly, it was named as Paegas. In 2002, the company changed its brand and subsequently its name. Now, it provides a

public mobile communication network on GSM standard (900, 1800 MHz) bands. In addition, it uses technology such as 2100 MHz UMTS, HSDPA, HSP+, DC-HSPA+, HSUPA and so on. It has also introduced 1800 MHz LTE which is the fastest network on today's date (Nakanishi, "A proposal of a new viewpoint in analytic hierarchy ", 1997). T-Mobile is evolved its microwave mobile backhaul network by moving from a MINI-LINK to a MINI-LINK TN based network. Now, the mobile backhaul network is ready for high speed class roads in the country. This company is focused on constantly expanding its service offering data service in addition to voice. The total number of subscribers has reached up to 5.34 million as on December 2012 (Web11).

4.5.2 Telefonica O2:

Telefonica Czech Republic, which is now operating more than six million, lines both fixed and mobile line. Formerly, it was named Eurotel and owned by Telefonica. It has been active since 2006 and was originated with the collaboration of Cesky Telecom and EurotelPraha. The most comprehensive portfolio of voice and data service is being provided by this company continuously. It is paying attention and offering various services to enhance data and internet services. It operates the largest fixed and mobile networking including a 3rd generation network, CDMA (for data), UMTS and EDGE, enabling voice, data and video transmission. It is also notable provider of ICT service in Czech Republic. As of December 2011, the total subscriber reaches to 4.942 million (web9).

4.5.3 Vodafone:

Vodafone is a British multinational telecommunications company head quartered in London and with its registered office in Newbury, Berkshire. It is active worldwide and it's the world's second largest mobile telecommunication company and had 439 millions of subscribers. Vodafone Czech Republic, formerly named Oskar is the operator of GSM and UMTS mobile telecommunications network. On January 2013, the total subscribers reached to 3.36 million. It received its license for operating GSM 900/1800 network on October 8, 1990. Vodafone has been providing converged communication services like voice and data services

on fixed and mobile platform. It provides very good customer services. It hasn't introduced LTE yet in Czech Republic (Web7).

4.5.4 U:Fon :

U:Fon is the latest mobile operator in the Czech Republic which arrived in the mid of 2007. It is the fourth mobile operator in Czech Republic entering insolvency proceeding of its own volition. At the beginning of 2010, it changed its ambitious plans and announced it wanted to be a low cost operator. The U:Fon network was developed on the basis of CDMA 2000 technology which is considered as 3rd generation mobile network. Apart from this, it is going to introduce nationwide digital radio transmitters. U:Fon has started to offer voice and data services to retail and wholesale basis. The total subscribers has reached to 0.136 million, which is comparatively very low. The new technologies are needed to be brought for a better future (web8).

4.6 Pairwise Comparison and Normalization between the Alternatives

Cost	T-Mobile	Vodafone	O2	U-Fon	GM	Normalized GM	u_{ij}
T-Mobile	1.00	0.20	0.14	0.17	0.26	0.0486	0.0017
Vodafone	5.00	1.00	0.50	0.25	0.89	0.1643	0.0058
O2	7.00	2.00	1.00	0.50	1.63	0.3006	0.0105
U-Fon	6.00	4.00	2.00	1.00	2.63	0.4865	0.0170
					5.41		

Table 5: Pairwise Comparison and Normalization between the Alternative

Security	T-Mobile	Vodafone	O2	U-Fon	GM	Normalized GM	u_{ij}
T-Mobile	1.00	2.00	0.25	5.00	1.26	0.2135	0.0622
Vodafone	0.50	1.00	0.20	4.00	0.80	0.1350	0.0393
O2	4.00	5.00	1.00	8.00	3.56	0.6038	0.1759
U-Fon	0.20	0.25	0.13	1.00	0.28	0.0477	0.0139
					5.89		

Table 6: Pairwise Comparison and Normalization between the Alternatives

Technology	T-Mobile	Vodafone	O2	U-Fon	GM	Normalized GM	u_{ij}
T-Mobile	1.00	5.00	1.00	8.00	2.51	0.4329	0.1147
Vodafone	0.20	1.00	0.33	6.00	0.80	0.1369	0.0363
O2	1.00	3.00	1.00	9.00	2.28	0.3924	0.1040
U-Fon	0.13	0.17	0.11	1.00	0.22	0.0378	0.0100
					5.81		

Table 7: Pairwise Comparison and Normalization between the Alternatives

Voice & Data	T-Mobile	Vodafone	O2	U-Fon	GM	Normalized GM	u_{ij}
T-Mobile	1.00	2.00	0.25	5.00	1.26	0.2341	0.0361
Vodafone	0.50	1.00	0.25	3.00	0.78	0.1457	0.0225
O2	4.00	4.00	1.00	5.00	2.99	0.5569	0.0859
U-Fon	0.20	0.33	0.20	1.00	0.34	0.0633	0.0098
					5.37		

Table 8: Pairwise Comparison and Normalization between the Alternatives

Signal q.	T-Mobile	Vodafone	O2	U-Fon	GM	Normalized GM	u_{ij}
T-Mobile	1.00	3.00	0.33	5.00	1.50	0.2760	0.0173
Vodafone	0.33	1.00	0.20	2.00	0.60	0.1115	0.0070
O2	3.00	5.00	1.00	5.00	2.94	0.5431	0.0340
U-Fon	0.20	0.50	0.20	1.00	0.38	0.0694	0.0043
					5.42		

Table 9: Pairwise Comparison and Normalization between the Alternatives

Call Density	T-Mobile	Vodafone	O2	U-Fon	GM	Normalized GM	u_{ij}
T-Mobile	1.00	3.00	0.20	5.00	1.32	0.2123	0.0094
Vodafone	0.33	1.00	0.14	3.00	0.61	0.0992	0.0044
O2	5.00	7.00	1.00	7.00	3.96	0.6382	0.0281
U-Fon	0.20	0.33	0.14	1.00	0.31	0.0504	0.0022
					6.20		

Table 10: Pairwise Comparison and Normalization between the Alternatives

Customer care	T-Mobile	Vodafone	O2	U-Fon	GM	Normalized GM	u_{ij}
T-Mobile	1.00	0.20	0.33	0.25	0.36	0.0667	0.0099
Vodafone	5.00	1.00	5.00	3.00	2.94	0.5465	0.0807
O2	3.00	0.20	1.00	0.33	0.67	0.1242	0.0183
U-Fon	4.00	0.33	3.00	1.00	1.41	0.2626	0.0388
					5.39		

Table 11: Pairwise Comparison and Normalization between the Alternatives

4.7 Consistency Analysis

Table No.	λ_{max}	CI	RI	CR
3	7.5483	0.0914	1.35	0.0677
4	4.1456	0.0485	0.90	0.0539
5	4.1342	0.0447	0.90	0.0497
6	4.1590	0.0530	0.90	0.0589
7	4.2041	0.0680	0.90	0.0756
8	4.1308	0.0436	0.90	0.0484
9	4.2396	0.0799	0.90	0.0887
10	4.1891	0.0630	0.90	0.0700

Table 12: Consistency Analysis of Each Pairwise Comparison

4.8 Total Utility of each Alternative

Factor	C1	C2	C3	C4	C5	C6	C7	Total
T-Mobile	0.0017	0.0622	0.1147	0.0361	0.0173	0.0094	0.0099	0.2512
Vodafone	0.0058	0.0393	0.0363	0.0225	0.0070	0.0044	0.0807	0.1959
O2	0.0105	0.1759	0.1040	0.0859	0.0340	0.0281	0.0183	0.4568
U-Fon	0.0170	0.0139	0.0100	0.0098	0.0043	0.0022	0.0388	0.0960

Table 13: Calculation of Total Utility of Each Alternative

4.9 Case Analysis:

The main goal of this thesis was to select appropriate mobile network operators for the VB bank in the Czech Republic. Telefonica O2, U:Fon, Vodafone and T-Mobile are the existing MNOs here in Czech Republic. They represent the alternatives for VB bank so that it can use its services. The criteria are set up regarding the necessity of VB bank: security, cost, technology, signal quality, voice and data service, call density and customer care are the criteria that VB bank is interested to see while choosing a MNO.

The following steps were taken while calculating total utility of each alternative using AHP method:

1. The decision-making problem was decomposed into a hierarchy of criteria and alternative.

2. The decision alternative for each criterion was rated as of AHP model.

3. Pairwise comparison matrix was developed for each criterion.

4. The resulting matrix was normalized after averaging the values in each row to get the corresponding ratings.

5. Calculation and checking of the consistency ration was done.

Similarly, the process was repeated for alternative pairwise matrix correspondence with each criterion. Lastly, the total was calculated for each alternative pairwise matrix correspondence with each criterion.

The decision making methods used above has shown the best alternative that could be used in VB bank. According to the results obtained, O2 has higher priority among the mobile operators in Czech Republic. The decision supports O2 to be a future mobile operator for VB bank (0.4568). From the result above, we can be assured that O2 is highly secured, is providing good voice and data service, technologies, call density and has good signal quality. Although O2 doesn't have good pricing and customer care service, it covers all other essential criteria that are needed for the VB bank. Vodafone provides good customer care service but it doesn't covers other services, T-Mobile provides overall all services but in a moderate way, but compared with O2, it would be a second option.

5 Conclusion:

This thesis allows the application of the AHP method in the process of choosing MNO for VB bank. One of a crucial part in the application of this method is to know the value of all criteria relative to the alternative's weight. Choosing a mobile operator is of vital importance for any bank to achieve its goals on time. Decision making must be logical in order to have or maintain standard within the company. Each mobile operator does have their own strength in the business world.

The different methods of decision-making can be applied in this situation depending upon particular case and circumstances in which that business system functions. AHP method can also be used as a useful technique for preparation of alternative models of business system, especially when a company needs to choose among the many alternatives. This method could be more accurate if input is taken from several participants for a decision making. Pair-wise comparison looks more like artificial way of comparing a set of items. In practical, it is found that bank uses one or more than one mobile operator to reduce the cost overhead and to provide enhanced services.

The main challenge of MCDM techniques is how to factor psychological time into a decision in order to anticipate and deal with the future more successfully through prediction, planning or judgments. Many efforts are being made and new techniques are being developed in this decision process. Books and papers have been published that deal with the future and with planning using the prioritization process described in this thesis.

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Acronyms

MCDM: Multi-Criteria Decision-Making

AHP: Analytic Hierarchy Process

3G: Third Generation

4G: Fourth Generation

LTE: Long-term evolution

CDMA: Code Division Multiple Access

MNO: Mobile Network Operator

GPS: Global Positioning System

ATM: Automated Teller Machine

ACH: Automated Clearing House

EFTPOS: Electronic Funds Transfer at Point of Sale

MSNR: Maximal Signal –to-Noise Ratio

MMS: Multimedia messages

HetNets: Heterogeneous network

Wi-Fi: Wireless Fidelity

GM: Geometric Mean

MHz: Mega Hertz

UMTS: Universal Mobile Telecommunications System

HSDPA: High-Speed Downlink Packet Access

HSPA+: High Speed Packet Access

DC-HSPA+: Dual Cell High Speed Packet Access

HSUPA: High-Speed Uplink Packet Access

TN: Transmission Node

EDGE: Enhanced Data-rate for GSM Evolution

ICT: Information and Communications Technology

VB: Virtual Bank