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Analytics Hierarchy Process for Decision-making in Network Infrastructure Replacement

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***Keywords*— Analytics Hierarchy Process, Multicriteria decision-making, Telecommunication.**

***Abstract*— Among all methodologies to support multi-criteria decision making, the Analytics Hierarchy Process is widely used in the most diverse situations. Different authors treat it as one of the best alternatives when there is a need to introduce subjective criteria within the decision-making process, in addition to having adaptability to situations with a high number of alternatives using ratings. In this work, a comparison was made between the ranking results of 30 areas for replacing the network infrastructure with fiber optic networks through numerical criteria and reordering by decision makers and through a model using AHP with ratings. As a result, a similar final ranking can be seen, which enables the use of AHP as a tool to improve the decision-making process for this situation.*

I. INTRODUCTION

Decision making in the corporate world is ruled, most of the time, with the goal of increasing the company's profitability, whether by a new product or service, media, brand recognition, production cost reduction, increasing productivity, among others. The telecommunications industry is not different. Due to technological advances in terms of network infrastructure, the current Brazilian scenario involves a need to replace older networks infrastructures by more recent ones, which are based on the use of optical fibers.

The demand caused by the evolution of telecommunication technologies, as well as the need for greater bandwidth by products and services linked to internet access, year after year companies in the sector invest billions of reais to increase and improve their infrastructure (CONEXIS, 2022) and consequently the service coverage.

The time required for the financial return is long due to the high value of the initial investment made by the operators before having any customer subscribing to the service (FRIGO, 2004). In this way, when case studies of deployment of networks entirely built with fiber optic are investigated, they are rated as economically difficult, given this combination of high initial investment and the uncertainty of how many customers will subscribe to the services and in how long the network will reach the amount of customers projected (DOMINGO, 2014).

In general, two main points are evaluated for choosing a new area: technical feasibility and market data. By technical feasibility, it is understood the analysis of the existing infrastructure and the identification of future needs, thus determining the physical possibility of implantation of the network in the place. Therefore, there are only two possible results for such an analysis, the location is viable or not. The analysis of market data, on the other hand, basically considers the population, the number of households, the distribution of social classes of these households, the verticalization of the analyzed area, the number of businesses, financial indicators, and consumption profiles.

Although difficult, this is a critical part of decision making, defining the best combinations between indicators and what weights each of them will have in the result. This aspect is defined according to the strategy of each company, however, a common factor for all of them is that these are all numerical indicators and do not consider the peculiarities and qualitative information of each area, which are essential and powerful to make choosing a particular region a commercial success or failure.

In this work, the numerical model used by one of the largest telecommunication operators in Brazil to decide on the constructive order of replacing the current network infrastructure by an optic fiber network in 30 areas of the Brazilian territory was the start point and a new qualitative variable was inserted to incorporate the vision of commercial success into the result. For this, the model based on weights of each numerical criteria and subsequent inference of qualitative characteristics was replaced by a model based on Analytics Hierarchy Process (AHP), which allowed the use of this type of variable.

II. METHOD

Decision making is intrinsic to human biology and is the most central activity of their lives, being done consciously or unconsciously and it is extremely necessary for survival (SAATY, 2016). All people in the world make decisions daily, some more difficult, some easier, but regardless of the situation, decision-making is constant. We live in an interdependent universe, where everything depends on everything else and if we know how to measure the intangible, a much wider horizon of scientific interpretation will open (SAATY, 2008). We are inclined to believe that the more types of information and the greater the amounts of it, the better decision-making will be. However, too much information can be as bad as too little information. For decisions to be made properly, the ideal is to have all relevant criteria under evaluation (GOMES et al, 2010).

Developed by Thomas L. Saaty in 1980, the AHP method divides the problem into hierarchical levels, seeking to make it easier to understand and evaluate, helping the decision maker to prioritize or classify the alternatives after the method has been applied (SILVA et al, 2010).

According to Saaty (2006), to make a decision in a structured way and generate priorities, it is necessary to decompose the process into the following steps:

a) Define the problem and determine the type of answer needed.

b) Structure the decision hierarchy from the top with the decision goal and using a broader perspective, then moving to the intermediate levels, until reaching the lowest level, which is usually a set of alternatives.

c) Build a set of pairwise judgment matrices, with each element in the higher levels being used to compare the elements in the level immediately below.

d) Use the priorities obtained from the judgments to weight the priorities at the next level. Then, for each element of the lower level, the weighted values are added, and the overall or global priority is obtained. This process must be followed until the final priorities of the alternatives at the lower levels are obtained.

In this work, the telecommunication company provided the constructive order resulted from the weighted numerical model already changed after many hours of reunions discussing the qualitative features of each area, as well as the criteria considered and their respective values and weights. This rank can be found below in Table 1.

Table.1: Ranking provided by the company

Alternative	Ranking	Alternative	Ranking
Area 1	1	Area 16	30
Area 2	15	Area 17	20
Area 3	14	Area 18	16
Area 4	19	Area 19	21
Area 5	6	Area 20	27
Area 6	7	Area 21	22
Area 7	8	Area 22	23
Area 8	9	Area 23	5
Area 9	10	Area 24	3
Area 10	11	Area 25	4
Area 11	13	Area 26	24
Area 12	12	Area 27	28
Area 13	17	Area 28	29
Area 14	2	Area 29	25
Area 15	18	Area 30	26

For comparison purposes, the same criteria weights and values were used in the construction of the model in AHP, except for the qualitative variable created and introduced to provide the perception of commercial success in the model.

In the AHP method with ratings (SILVA and BELDERRAIN, 2009) the evaluation structure is fixed, and the alternatives must be evaluated according to their performance in each criterion. Thus, the main advantage observed is the reduction of the number of judgments necessary when facing a decision with many alternatives.

As the study situation has a high number of alternatives and what is expected as a result is a preference ranking, the

AHP method with ratings was used with the help of a free software called Super Decisions to perform the calculations.

The mathematics calculations will not be showed in this work as well as the calculation steps once the software will be used to do so and the weights and criteria will also be the same as the company. The model in AHP with ratings is shown in the Fig. 1 below, where the left block contains the same criteria that the company used and, at the right, the new criteria inserted to translate commercial perception.

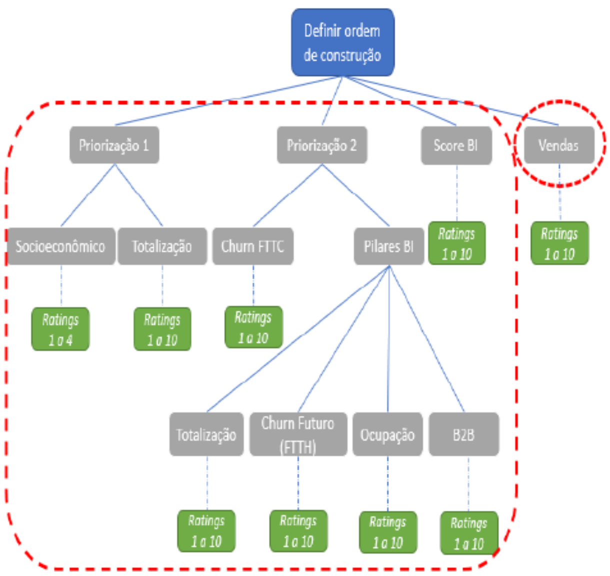

Fig. 1: Hierarchy structure for AHP with qualitative criteria in the right

III. RESULTS

After creating the hierarchical structure within the Super Decisions software, weights were assigned and pairwise comparisons were performed, and each alternative was linked to a rating value for each criterion. The software itself performs inconsistency index checks and for both ratings ranging from 1 to 4 and for those ranging from 1 to 10, the indexes satisfied the requirements, as can be seen in Fig. 2 for the case of ratings from 1 to 4:

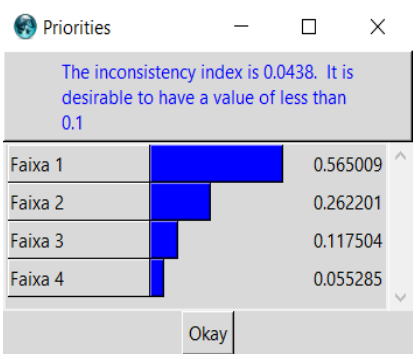

Fig. 2: inconsistency index for ratings from 1 to 4

With every parameter configured properly in the software, the result from the calculations of the model in AHP with ratings is the following:

Table.2: Ranking from the model in AHP with ratings-software result

Alternative	Ranking	Alternative	Ranking
Área 1	1	Área 16	28
Área 2	20	Área 17	29
Área 3	21	Área 18	26
Área 4	23	Área 19	27
Área 5	7	Área 20	30
Área 6	15	Área 21	6
Área 7	9	Área 22	10
Área 8	8	Área 23	17
Área 9	18	Área 24	5
Área 10	3	Área 25	16
Área 11	25	Área 26	4
Área 12	19	Área 27	12
Área 13	22	Área 28	11
Área 14	2	Área 29	13
Área 15	24	Área 30	14

IV. DISCUSSION

With both rankings on hands, it is possible to place them side to side and compare the results, as in the Table 3.

Table.3: Results comparison

Alternative	Company	AHP	Absolute Difference
Area 1	1	1	0
Area 2	15	20	5
Area 3	14	21	7
Area 4	19	23	4
Area 5	6	7	1
Area 6	7	15	8
Area 7	8	9	1
Area 8	9	8	1
Area 9	10	18	8
Area 10	11	3	8
Area 11	13	25	12

Area 12	12	19	7
Area 13	17	22	5
Area 14	2	2	0
Area 15	18	24	6
Area 16	30	28	2
Area 17	20	29	9
Area 18	16	26	10
Area 19	21	27	6
Area 20	27	30	3
Area 21	22	6	16
Area 22	23	10	13
Area 23	5	17	12
Area 24	3	5	2
Area 25	4	16	12
Area 26	24	4	20
Area 27	28	12	16
Area 28	29	11	18
Area 29	25	13	12
Area 30	26	14	12
Average Variation			7,9

It was expected that the AHP model with the sales perception variable inserted would be in line with the company's result obtained after evaluating the numbers and rounds of discussion among decision makers, as the variables and objective were the same.

However, it is worth mentioning that there are differences, but they can be adjusted by redoing the pairwise judgments in the AHP model or even including or excluding new criteria for this decision.

V. CONCLUSION

Decision making is present in all professional and personal aspects and in the business sphere it is directly linked to the success or failure of operations. The possibility of reducing the duration of exhaustive meetings by including a subjective criterion together with numerical criteria can bring greater speed in decision making and consequently a monetary advantage for the company.

It is extremely important to use methodologies to aid decision making, since when setting up the hierarchical structure with real market data and incorporating the subjectivity into the model, the result is less influenced by decision makers' guesswork.

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