NETWORKS BASELINES AND ANALYTIC HIERARCHY PROCESS: AN APPROACH TO STRATEGIC DECISIONS

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ABSTRACT

In complex decision problems, associate to service portfolio management, in general, many criteria can be necessary to have a final choice among different alternatives. The Multi-criteria Decision Analysis standardizes the decision making process through mathematical modeling, helping the decision maker to solve problems, in which there are several objectives to be achieved simultaneously. Amongst the methods developed in Multi-criteria Decision environment, deserves prominence the Analytic Hierarchy Process – AHP, which is based on decision problem division in hierarchic levels for its better comprehension and evaluation. However, the AHP has a deficiency related to obtaining data from trusted sources. To confront this problem, this paper presents the combination of baselines network, obtained through the Automated Management of a Backbone (ABM) with the AHP. The advantage of this approach is to reduce the interference in the pairwise comparison consists of a hierarchy of criteria and alternatives.

KEYWORDS

Baseline Networks, IT Governance, AHP Method.

1. INTRODUCTION

The management of services in organizations is required as services have become crucial for the cost-effective creation of customer value. On a business level, these services are driven by service strategies (Groenroos, 2007) and service-oriented business models, which impacts organizational structures and individuals. On a technical level, services are implemented as encapsulations of autonomous, valuable software capabilities (Krafzig et al., 2006). This close relation between business and technology has become known as business/IT alignment (Avison et al. 2004).

There are frameworks and sets of best practices related to the theme such as ITIL (ITSMF, 2007) and COBIT (ITGI, 2005) and that the decision-making, through portfolio management, is present in both. The decision process in a complex environment often involves inaccurate data and/or incomplete, multiple criteria and multiple decision makers (Gomes and Moreira, 1998).

In addition, the decision problems generally involve multiple targets, and these in turn are mutually conflicting. Thus, the contribution to one of them implies over the other one. The decision-making, therefore, must seek the option to provide the best performance, the best rating, or even the best agreement between the decision maker's expectations and their availability in adopting it, considering the relationship between objective and subjective elements (Smith, 2003).

In this context, getting rapid and accurate information to support decisions in a systematic way has become a challenge. This paper aims to present how the network baselines in conjunction with criteria (for decision makers) can be used to prioritize investment in IT services by the method Analytic Hierarchy Process (AHP) (Gomede and Barros, 2012).

2. REFERENCE

To establish the normal behavior of the CI's (Configuration Items) a CMBD (Configuration Management Database), such as switches, servers or workstations, is fundamental to the design capacity most appropriate infrastructure to support IT services. In this normal behavior is given the name of baseline.

A baseline is a kind of reference to be used in a changing process, as an anchor. Therefore, the entire process of building/development must be anchored in a baseline, so that they can manage changes in an organized manner (Rocha and Maldonado, 2001). The baseline itself would not be the only solution for proactive management, but it certainly constitutes a major component so that it will be achieved (Proença Junior, 2005).

Another important component of management is to measure its performance. For its purpose, it is essential to define “what”, “how” and “why” something is measured, necessarily aligned with strategic objectives. Indicators are data or information adopted to measure the performance of the organization in general or of processes, projects and areas, in this particular case, IT services.

According to Takashina and Flores (1996) an indicator should be used carefully, noticing its importance in the process and ensuring the availability of information in the shortest time possible using reliable data. It must meet several criteria emphasizing among them the importance and selectivity, simplicity and clarity, completeness, traceability and accessibility, comparability, stability and speed of availability and low cost of obtaining it.

The search for indicators to support decisions is a challenging task. Incipient indicators and inadequate amount (many or few) end up generating interference to the process of decision-making. The quality of the indicators is linked in direct proportion to the quality of the data source.

After obtaining the indicators, a decision requires a consistent method. The use of AHP starts by decomposing the problem into a hierarchy of defined criteria and that have relevance to the goal. From the time at which the logical hierarchy is built, the decision-makers evaluate the alternatives comparing them, two by two in each of the criteria. This comparison can use concrete data of the alternatives or human judgment as a mean of information given (Saaty, 2008).

2.1 Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP) was first proposed by Thomas L. Saaty (Saaty, 1980) and its main characteristic is the pairwise comparison consists of a hierarchy of criteria and alternatives. It is often used to analyze problems of decision-making multi-criteria. By using AHP, the structure of the problem must be decomposed into a hierarchy.

A hierarchy is a specific system based on the assumption that the entities can be grouped into disjoint sets with a group of entities which affects the other ones (Saaty, 1980). Pairwise comparison is an important component of the AHP. Two criteria are compared using a nine-point scale, where 1 (a) means “equal” importance, three (3) is “low” importance, five (5) “indicates” clearly “superior”, seven (7) is “very” important and 9 (nine) denotes “extremely” important. With pair numbers being used to indicate intermediate values, if necessary. If there are n criteria to consider, $n(n-1)/2$ comparisons of pairs had to be done. Thereafter, the reciprocal nxn matrix is constructed and weights are then obtained.

The consistency of pair comparison matrix needs to be verified by means of the indices: Consistency Index (CI) and Consistency Rate (CR). They are defined in equation (1) and (2) with λ_{max} being the principal value (Eigen) and RI (Random Index) is as shown in Table 1. For consistency, CI and CR should be less than 0.1 for the AHP analysis is being acceptable (Gomede and Barros, 2012).

$$\text{C.I.} = (\lambda_{max} - n) / (n - 1) \quad (1)$$

$$\text{C.R.} = \text{C.I.} / \text{R.I.} \quad (2)$$

Table 1. Random Index (R.I.)

n	1	2	3	4	5	6	7	8	9	10
R.I.	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

3. METHOD

In a hypothetical scenario containing clients (hosts) requesting services (applications running on servers) derived from a local area network (LAN) and an external network (WAN) as shown in Figure 1.

Figure 1 - IT Infrastructure for a hypothetical scenario - where the workstations are the hosts on the LAN and notebooks are the hosts on the WAN

In this scenario baselines capacity of CI's are related to indicators such as: processing, memory, disk and network of each of the servers (Server1, Server2 and Server3). However, these indicators generated by baselines don't show which (and which features) of the services are consumed by the hosts, as indicated in Table 2.

Table 2. Baseline of CI's of a CMDB. AVG indicators, UCL and LCL represent, respectively, average, upper control limit and lower control limit

Criterion	Description	AVG	UCL	LCL
Server1	Processing	30 %	70 %	5 %
	Memory	80 %	90 %	5 %
	Disk (I/O)	10 %	50 %	5 %
	Network	15 %	50 %	5 %
Server2	Processing	10 %	70 %	5 %
	Memory	90 %	90 %	5 %
	Disk (I/O)	20 %	50 %	5 %
	Network	10 %	50 %	5 %
Server3	Processing	40 %	70 %	5 %
	Memory	90 %	90 %	5 %
	Disk (I/O)	10 %	50 %	5 %
	Network	10 %	50 %	5 %

These indicators can be used in operational decisions such as, for example, identify whether a particular service is consuming too much processing by a failure in a particular software. Now, assuming the monitoring of the backbone (in the hypothetical case only the switch) where requests for certain services (URL's) are captured by creating indicators related to requests per unit of time (hours) in a range $\Delta t = 24$ (twenty-four) hours. Obtained Table 3.

Table 3. Data ABM (Automatic Backbone Management). AMT indicators, AVG, MIN and MAX represent, respectively, total, average, minimum and maximum

URL	AMT	AVG	MIN	MAX
http://service1.server1.com	25032	1043	0	3300
http://service2.server2.com	20567	856.95	0	2800
http://service3.server3.com	28572	1190.5	0	3500

Within the obtained data, it is possible to build a baseline of IT services to be consumed. A real example of the network as a baseline, with the obtained data, by the ABM (Proença Junior, 2005) can be seen in Figure 2.

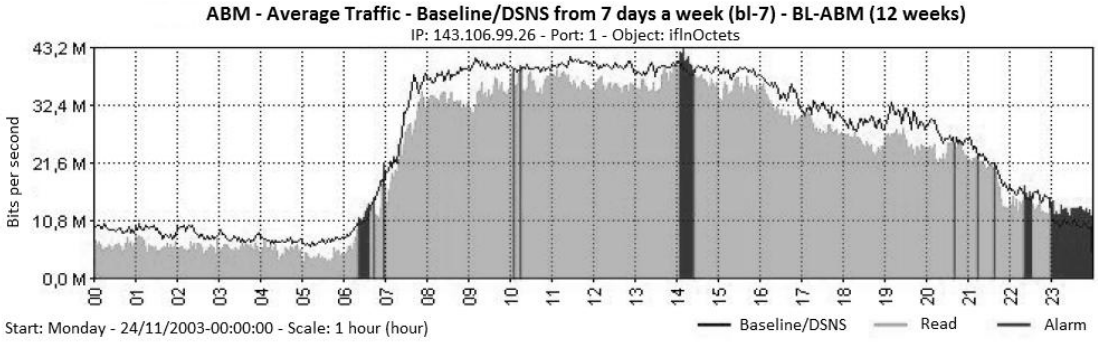

Figure 2 - Example of a real baseline (Proença Junior, 2005)

3.1 Obtaining the Data

With the baseline created and stored, there is a reference behavior of services. Over time, new measurements are made and new baselines are created. In the hypothetical scenario, was created 3 (three) times the baselines, t_0, t_1 and t_2 included in a range $\Delta t = 90$ (ninety) days, and the time difference between each baseline $\Delta t = 30$ (thirty) days.

With the tabulated data, according to Table 4 it can created indicators with relationship between the different baselines, and these indicators can be used as criteria for prioritization of investment related to monitored services.

Table 4. Data ABM (Automatic Backbone Management) - the shaded area represents the period where requests for service are considered as normal

	Service1			Service2			Service3		
Hour	t_0	t_1	t_2	t_0	t_1	t_2	t_0	t_1	t_2
00:00	0	0	0	0	0	0	0	0	0
01:00	0	0	0	0	0	0	0	0	0
02:00	0	0	0	0	0	0	0	0	0
03:00	0	0	0	0	0	0	0	0	0
04:00	0	0	0	0	0	0	0	0	0
05:00	0	0	0	0	0	0	0	0	0
06:00	0	0	0	0	0	0	0	0	0
07:00	2	4	3	2	4	3	2	4	3
08:00	700	800	600	700	800	600	700	800	600
09:00	2300	2300	2400	2300	2300	2400	2300	2300	2400
10:00	2500	2600	2700	2500	2600	2700	2500	2600	2700
11:00	2500	2400	2500	2500	2400	2500	2500	2400	2500
12:00	2300	2200	2330	2300	2200	2330	2300	2200	2330
13:00	1200	1400	1500	1200	1400	1500	1200	1400	1500
14:00	2300	2500	2700	2300	2500	2700	2300	2500	2700
15:00	2800	3200	3400	2800	3200	3400	2800	3200	3400
16:00	3300	3600	3700	3300	3600	3700	3300	3600	3700
17:00	2300	2400	2400	2300	2400	2400	2300	2400	2400
18:00	1800	1900	1900	1800	1900	1900	1800	1900	1900
19:00	800	900	900	800	900	900	800	900	900
20:00	200	200	400	200	200	400	200	200	400
21:00	20	20	40	20	20	40	20	20	40
22:00	10	5	3	10	5	3	10	5	3
23:00	0	0	0	0	0	0	0	0	0
Total	25032	26429	27476	25032	26429	27476	25032	26429	27476

Graphically the data related to the Service1 can be seen in Figure 3.

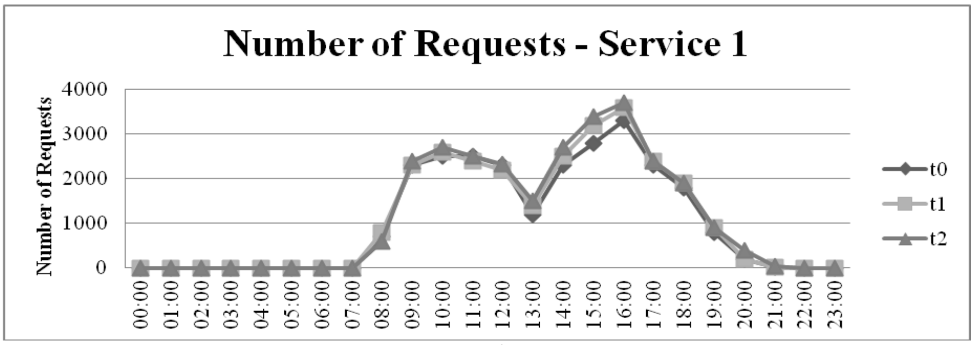

Figure 3 - Behavior service Service1 for each baselines in t_0, t_1 and t_2

3.2 Building the Indicators

For this hypothetical scenario, was created the following indicators, according to Table 5, constructed using data obtained by the ABM.

Table 5. Indicators constructed by data obtained by ABM

Acronym	Indicator	Definition	Formula
TxC	Growth Rate	Relationship between the total of requests of t_x and t_{x-1}	(t_{x-1}/ t_x)-100%
TxO	Idleness Rate	Total time with the amount of requests < 10 divided by 24	∑ hour where sum(request) < 10
TxD	Deviation Rate	Total requests outside standard time divided by the total requests within standard	∑ request(hour 21:00 – 07:00) / ∑ request(hour 08:00 – 20:00)

With the created indicators, it is possible to derive now the obtained data by the ABM and get the variations by comparing the baselines at t_0, t_1 and t_2, according to Table 6.

Table 6. Indicators derived from the data of the ABM (TxC indicators, TXO and TxD are expressed in %)

	Baseline in t_0				Baseline in t_1				Baseline in t_2			
Service	Amt.	TxC	TxO	TxD	Amt.	TxC	TxO	TxD	Amt.	TxC	TxO	TxD
Service1	25032	-	38	0.12800	26429	6	42	0.12800	27476	4	42	0.12799
Service2	20567	-	38	0.08273	21149	3	42	0.08273	21938	4	42	0.08272
Service3	28572	-	38	0.25263	33184	16	42	0.25263	33973	2	42	0.25261

To illustrate graphically the results, Figure 4 shows the indicator TxC (Growth Rate) to 3 (three) services (Service1, Service2, Service3) in t_0, t_1 and t_2.

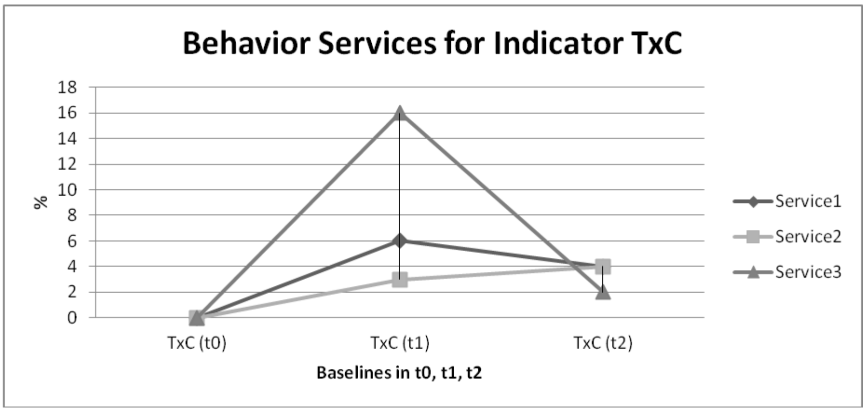

Figure 4 - Behavior services for indicator TxC

3.2 Creating a Hierarchy of Criteria

The next step for prioritizing investment in the monitored services is to create criteria to be evaluated. These criteria are associated to indicators: Growth Rate, Idleness Rate and Deviation Rate, as explained earlier. To illustrate how the criteria obtained in an automatic way can be combined with the criteria derived from strategic planning, it was added 3 (three) criteria suggested by (Jolly, 2003): Open Market Volume by Service, Scope of the Open Market Service and Sensitivity to Technical Factors. The criteria are displayed in Table 7.

Table 7. Criteria set

Aspects and Criterion	Description
A. Data ABM	
A1. Growth Rate	It aims to assess whether the service demand is increasing and what behavior (linear or exponential)
A2. Idleness Rate	It aims to assess whether demand by the service suffers from idleness
A3. Deviation Rate	It aims to assess whether there are requests being made for the service outside normal hours, this may generate a demand for security-related investments
B. Market Factors	
B1. Open Market Volume by Service	The market (local or global) is being obtained by the service
B2. Scope of the Open Market Service	As the market (global or local) can be obtained by the service
B3. Sensitivity to Technical Factors	Indicates whether the service has a sensitivity to technical factors, such as discontinuity of the technology by a supplier

With the defined criteria, it is applied the AHP to prioritize services according to established criteria. As part of the criteria (data ABM) it was obtained automatically, eliminating possible inconsistencies with data based on unreliable sources. The hierarchy of criteria (Saaty, 1980) can be seen in Figure 5.

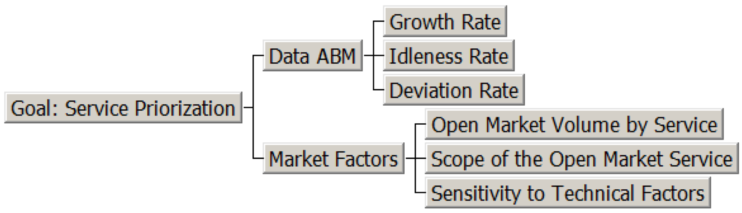

Figure 5 - Criteria Hierarchy

4. RESULT AND DISCUSSION

With the defined criteria, it is performed the AHP calculations (Gomede and Barros, 2012), resulting in the matrix below, as shown in Table 8. The calculations were made taking into account the relationship of baseline t_2 with baseline t_1.

4.1 Comparison Matrix

Table 8. Criteria weighted for aspects: Data ABM and Market Factors

Aspects and Criterion	Weighing (priority)		
	Aspect	Criterion	Overall
A. Data ABM	**0.250 (2)**		
A1. Growth Rate		0.753 (1)	0.188 (2)
A2. Idleness Rate		0.063 (3)	0.016 (6)
A3. Deviation Rate		0.184 (2)	0.046 (5)
For all criteria related to Data ABM: CI < 0.1 ; CR < 0.1			

B. Market Factors	**0.750 (1)**		
B1. Open Market Volume by Service		0.715 (1)	0.536 (1)
B2. Scope of the Open Market Service		0.218 (3)	0.164 (3)
B3. Sensitivity to Technical Factors		0.067 (3)	0.050 (4)
For all criteria related to Market Factors: CI < 0.1 ; CR < 0.1			
For all aspects: CI < 0.1 ; CR < 0.1			

4.2 Results of the Method

The result of the prioritization of investment in IT services for the hypothetical scenario is shown in Figure 6. In this way, it was given the criteria and their weights should be prioritized for investment in Service2.

Figure 6 - Results of the prioritization of investments in IT services

4.3 Overall Discussion

Despite of the criteria aspect Data ABM, it contributes with 25% of the overall goal as shown in Figure 8, it is noted that the criterion Growth Rate it was in secondly in the overall classification criteria, as shown in Figure 7, increasing the result consistency, it was given the automatic retrieval of data that makes this criterion.

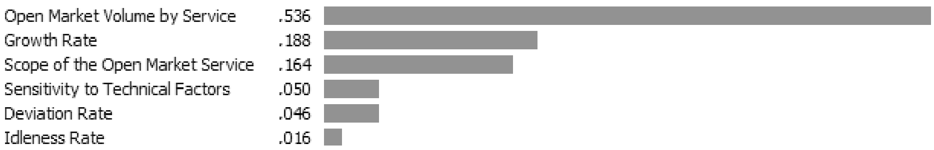

Figure 7 - Score (weighting) of the criteria in the hierarchy

The criteria of the aspect Market Factors contributed with 75% causing the Service2 51.8% obtained in preference to Service1 and Service3, as shown in Figure 8.

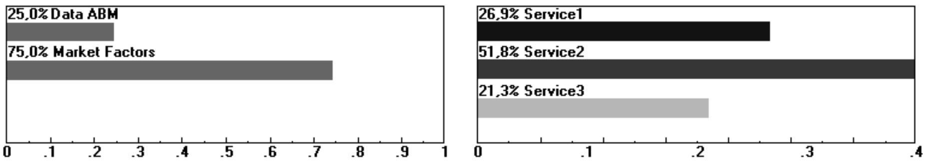

Figure 8 - General behavior of criteria and classification of IT services

Figure 9 shows the sensitivity of service to the criteria. Note that the Service1 has a greater adherence from the aspect Data ABM to the aspect of Market Factors, which leads to some questions:

Service1 has adherence to strategic planning?

Its behavior is out of the strategic objectives, but should it be considered?

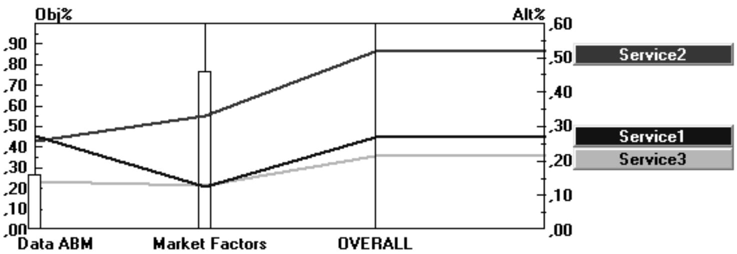

Figure 9 - Sensitivity of IT services to the criteria

5. CONCLUSION

The AHP has been attracting the interest of many researchers, mainly due to mathematical properties of the method and the fact that data entry is significantly simpler to be obtained (Triantaphyllou and Mann, 1995). The method provides decision makers with a mathematical tool that qualifies and quantifies the decisions allowing them to be justified beyond the ability to simulate the results.

Another important aspect is the quality of the assessments made by decision makers (Coyle, 2004). The consistency of responses can be calculated by the index of inconsistency. However, the index of inconsistency only allows evaluation of consistency and regularity of the opinions of decision makers and those views are not the most appropriate to the organizational context.

One benefit of using data generated by a source (ABM) eliminates the interference coming from unsubstantiated opinions. It can be worked using data generated by one isolated source, which guarantees the impartiality of the results or in conjunction with the preferences informed by experts, combining data obtained from the environment with qualitative data.

It is very important to highlight that, the decision-making requires a broader understanding and complex than the isolated use of a specific method. It assumes that the decision on the portfolio is the result of negotiation, and human aspects of strategic analysis. The AHP facilitates and guides the work done, but should not be used as the only criterion.

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