A combined approach of AHP and TOPSIS methods applied in the field of integrated software systems

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Abstract. Adopting the most appropriate technology for developing applications on an integrated software system for enterprises, may result in great savings both in cost and hours of work. This paper proposes a research study for the determination of a hierarchy between three SAP (System Applications and Products in Data Processing) technologies. The technologies Web Dynpro -WD, Floorplan Manager - FPM and CRM WebClient UI - CRMWCU are multi-criteria evaluated in terms of the obtained performances through the implementation of the same web business application. To establish the hierarchy a multi-criteria analysis model that combines the AHP (Analytic Hierarchy Process) and the TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) methods was proposed. This model was built with the help of the SuperDecision software. This software is based on the AHP method and determines the weights for the selected sets of criteria. The TOPSIS method was used to obtain the final ranking and the technologies hierarchy.

1. Introduction
The implementation of a business project on the SAP NetWeaver platform requires a proper study regarding the appropriate technology selection. A flexible technology is always responsive to the customer requirements. Selecting an inappropriate technology for the implementation of a project, leads not only to a high execution time and memory consumption, but also to a high maintenance. Therefore, the performance of the project is significantly affected [1].

This paper, introduces a hybrid model for selecting between three SAP ABAP UI technologies, based on the concepts of multi-criteria analysis and the methods AHP and TOPSIS. The main particularity of the multi-criteria analysis is based on the judgment strengths of the decision makers to determine the objectives and the criteria, to estimate the relative weights of criteria and partly to evaluate the contribution of each alternative in order to achieve each criterion [2-4].

This proposed model combines the AHP and the TOPSIS methods. The AHP is used to score and set the share of importance of the relative weights for the decision criteria-sets and the TOPSIS method is used to obtain the final ranking.
2. Objectives of the study
The aim of this study is to develop a hybrid multi-criteria model for selecting the most efficient ABAP UI technology used in the development of SAP business applications. The proposed research methodology combines the TOPSIS and AHP methods, usually used in the decision-making process. The model requires the prioritization of the technologies using the TOPSIS method, in which the relative weights of the criteria result from the combination, between the weights of importance defined and the values determined with AHP method. According to the concepts of multi-criteria analysis related in [5] and [6], to determine a hierarchy for the SAP UI technologies, the objectives of this work are outlined as follows:

- Determining the alternatives.
- Finding the most relevant criteria sets that normally results from implementing and testing the same business application with Web Dynpro ABAP, Floorplan Manager and CRM WebClient UI technologies.
- Building the performance matrix that describes the consequences or the performance of alternatives regarding the fulfilment of the decision criteria.
- Scoring and setting the share of importance of the relative weights for the decision criteria-sets through the AHP method.
- Selecting a normalization process for the criteria values expressed by different units, to be transformed into a common scale.
- Implementing the TOPSIS algorithm in order to obtain the technologies prioritization.

3. Results and interpretation
In the context of achieving the objectives set, the alternatives in the hierarchy are the three ABAP UI technologies: Web Dynpro, Floorplan Manager and CRM WebClient UI.

The process of identifying the most relevant and variable criteria that are normally used in the selection process is facilitated using the SAP Business Transaction Analysis and HTTP Watch for Internet Explorer tools. For each business application are measured a set of parameters: response time (RT), database (DBRT) request time, CPU time consumed at the end of a transaction and the time obtained in front-end (HTTP Watch time). Another set of parameters considered to be relevant and frequently mentioned in the literature [7-10] are the effort for: development (DE), maintenance (ME) and enhancement (EE) a business application implemented with a certain ABAP UI technology. These two sets of parameters will represent the criteria for our selection process in the model.

The elements of the Table 1 represent the values of the criteria regarding the alternatives. For the first set of criteria (CPUT, DBRT, HTTPWT, RT), the values derived from the measurements performed by implementing the business application through the three UI technologies. For the second set of criteria (DE, ME, EE), the values are selected according to the conversion scale from the Table 2, which represents the Saaty’s intensity scale [11]. In the proposed hybrid multi-criteria model the composition of the Table 1 corresponds to the decisional matrix.

Table 1. The decisional matrix

| ABAP UI Technology/Parameters | Criteria Set1(c1,c2,c3,c4) | Criteria Set2(c5,c6,c7) |
|------------------------------|--------------------------|--------------------------|
| C1                           | C2                       | C3                       | C4 | C5 | C6 | C7 |
| CPUT (ms)                    | 315.00                   | 187.24                   | 1830.2         | 476.53 | 7  | 3  | 3  |
| DBRT (ms)                    | 384.57                   | 300.43                   | 2254.33        | 628.76 | 5  | 5  | 5  |
| HTTPWT (ms)                  | 2249.25                  | 805.43                   | 5824.0         | 2722.24 | 3  | 7  | 7  |
| RT (ms)                      |                          |                          | 476.53         | 7    | 3  | 3  | 3  |
| DE                           |                          |                          | 628.76         | 5    | 5  | 5  | 5  |
| ME                           |                          |                          | 2722.24        | 3    | 7  | 7  | 7  |
| EE                           |                          |                          |                |      |    |    |    |
Table 2. The Saaty rating scale [11]

| Intensity of importance | Definition                  |
|-------------------------|----------------------------|
| 1                       | Equal importance           |
| 3                       | Somewhat more important    |
| 5                       | Much more important        |
| 7                       | Very much more important   |
| 9                       | Absolutely more important  |
| 2,4,6,8                 | Intermediate values        |

In order to obtain the relative weights for the decision criteria, a decision model is achieved with the Super Decision software. The share of importance considered from the decision makers in providing weights for the two sets of criteria is different: the first criteria set will be considered with a share of 65% importance and the second criteria set with a share of 35% importance.

The Super Decision tool implements the AHP and the Analytic Network Process (ANP) methods for decision making. Decisional models using Super Decision uses the weighting ranking approach in evaluation and selection mode. The basic principle of the AHP method consists of splitting a problem in sub-problems that can be analysed independently of each other. The elements of the hierarchy are evaluated by comparing them sequentially two by two and orderings are converted into numerical values, which allow the aggregation of results in order to obtain the solution [12] and [13].

The decision model from Figure 1 built as hierarchy of objectives, criteria and alternatives makes the determining of relative weights for each decision criteria possible. Through the model, intangible information from our experience and intuition and tangible information provided as data are combined. The obtained weights for selection criteria are used in the hybrid model.

The three levels of the model contain nodes that define the elements of the problem: goal, criteria and alternatives. These are connected to each other in top-down direction. The criteria level is evaluated according to their importance, compared to the goal and the alternatives according to the preference regarding the criteria [14-16].

The comparisons between each criterion were performed using the Saaty’s scale from Table 2, where the values between 1 and 9 depend on the relative importance of the criterion. The calculated inconsistency value 0.01976, from the Figure 2, shows that the values of subjective judgment are considered acceptable.

Figure 1. The SuperDecisions Hierarchical Model

Figure 2. The criteria relative weights
The final stage in order to achieve the proposed objectives is to apply the TOPSIS method. The basic principle of this method is that the optimal decision shall be as close as the most advantageous solution and as far away as the worst solution. The ideal solution should have a rank of one and the worst alternative should have a rank approaching 0 [17] and [18]. Through the proposed model, the TOPSIS method involves the following steps:

- Construction of the decision matrix. This step leads to the Table 1 whose configuration is the decisional matrix.
- Calculation of the normalized decision matrix. The goal of normalization is to transform different dimensional attributes into dimensionless attributes.

The literature review [19-22] describes several methods of normalization. One of these methods is the vector normalization who is applied to the performance matrix. The corresponding equation is:

$$ CN_{ij} = \frac{C_{ij}}{\sum_{i=1}^{m} C_{ij}^2} $$  \hspace{1cm} (1)

where $i$ is the criterion index ($i= 1\ldots n$), $j$ is the alternative index ($j= 1\ldots m$) and the $C_{ij}$ elements refer to the criteria $i$ with respect to alternative $j$.

The normalized values $CN_{ij}$ from the Table 3 denote the normalized decision matrix which represents the relative performance of the fixed alternatives. Table 3 contains also the relative weights provided by the Super Decision hierarchical model and the share of importance from the decision maker for the two sets of criteria.

**Table 3.** The normalized values related to the criteria

| Technologies | $V_j$ | $CN_{CPUT}$ | $CN_{DBRT}$ | $CN_{HTTPWT}$ | $CN_{RT}$ | $CN_{DE}$ | $CN_{ME}$ | $CN_{EE}$ |
|--------------|------|-------------|-------------|---------------|-----------|---------|---------|---------|
| WD           | $V_1$ | 0.1367      | 0.2128      | 0.2812        | 0.1681    | 0.7683  | 0.3293  | 0.3293  |
| FPM          | $V_2$ | 0.1669      | 0.3415      | 0.3464        | 0.2218    | 0.5488  | 0.5488  | 0.5488  |
| CRM          | $V_3$ | 0.9764      | 0.9155      | 0.8949        | 0.9605    | 0.3293  | 0.7683  | 0.7683  |
| Relative weights | $P_j$ | 0.05      | 0.3       | 0.2       | 0.1       | 0.01     | 0.31     | 0.03     |
| Pj           |      | 0.65       |            |            |          |         |         | 0.35     |

**Table 4.** The weighted normalized matrix

| Technologies | $V_j$ | $CNP_{CPUT}$ | $CNP_{DBRT}$ | $CNP_{HTTPWT}$ | $CNP_{RT}$ | $CNP_{DE}$ | $CNP_{ME}$ | $CNP_{EE}$ |
|--------------|------|-------------|-------------|---------------|-----------|---------|---------|---------|
| WD           | $V_1$ | 0.0068      | 0.0638      | 0.0562        | 0.0168    | 0.0085  | 0.1021  | 0.0089  |
| FPM          | $V_2$ | 0.0083      | 0.1024      | 0.0693        | 0.0222    | 0.0060  | 0.1701  | 0.0148  |
| CRM          | $V_3$ | 0.0488      | 0.2746      | 0.1790        | 0.0960    | 0.0363  | 0.2382  | 0.0207  |

- Determination of the weighted normalized matrix. Because the selection criteria are of different importance weight, the weighting decision matrix shown in Table 4 is constructed by multiplying each element of each column of the normalized decision matrix by the relative defined weights $P_j$ from Table 3 in according to the equation


\[ CNP_{ij} = p_j \times CN_{ij} \]  

(2)

- Identification of the positive \((C_j^+)\) and negative \((C_j^-)\) ideal solution are calculated according to the weighted decisional matrix. The equations below take into account that the type of criteria are minimized.

\[ C_j^+ = \min_{i \in s,m} \{ CNP_{ij} \} \]  

(3)

\[ C_j^- = \max_{i \in s,m} \{ CNP_{ij} \} \]

The calculated values are presented in the Table 5.

**Table 5.** The positive \((C_j^+)\) and negative \((C_j^-)\) ideal solution

| \(C_1\) | \(C_2\) | \(C_3\) | \(C_4\) | \(C_5\) | \(C_6\) | \(C_7\) |
|---|---|---|---|---|---|---|
| CPU | DBRT | HTTPWT | RT | DE | ME | EE |
| \(C_j^+\) | 0.0068 | 0.0638 | 0.0562 | 0.0168 | 0.0036 | 0.1021 | 0.0089 |
| \(C_j^-\) | 0.0488 | 0.2746 | 0.1790 | 0.0960 | 0.0085 | 0.2382 | 0.0207 |

- The separation distance of each competitive alternative from the ideal and non-ideal solution is calculated with the equations

\[
S_i^+ = \sqrt{\sum_{j=1}^{n} \left( CNP_{ij} - C_j^+ \right)^2 } \]  

(4)

\[
S_i^- = \sqrt{\sum_{j=1}^{n} \left( CNP_{ij} - C_j^- \right)^2 } \]  

(5)

The relative closeness of each location to the ideal solution \(S^*\) is measured for each alternative through the equation

\[
S_i^* = \frac{S_i^-}{S_i^- + S_i^+} \]  

(6)

Based on the obtained values presented in Table 6, the competitive alternatives are ranked in ascendent order towards the ideal solution.

**Table 6.** Ranking of alternatives

| The ABAP UI Technologies | \(S^+\) | \(S^-\) | \(S_j^*\) | The preference order |
|---|---|---|---|---|
| WD | 0.0048 | 0.2936 | 0.9838 | I |
| FPM | 0.0798 | 0.2312 | 0.7435 | II |
| CRM WCUI | 0.2936 | 0.0048 | 0.0162 | III |

After applying the TOPSIS algorithm the preferred technology in terms of performance is the Web Dynpro ABAP technology, because she results with minimum score. This hierarchy is considered valid for the defined selection criteria and their corresponding weights.

4. Conclusion

This work proposed a new methodology of selecting between three ABAP UI technologies through a hybrid multi-criteria selection model. The model underlies the process of multi-criteria analysis and is based on a combination between the AHP and TOPSIS methods. The relative weights for the seven
selected criteria determined from the Super Decision model with AHP, were combined with a share of importance defined by the decision makers. The TOPSIS method was applied to achieve the final ranking for the selected technologies. Web Dynpro ABAP was identified as the best technology that importance defined by the decision makers. The TOPSIS method was applied to achieve the final selected criteria determined from the Super Decision model with AHP, were combined with a share of importance defined by the decision makers. The TOPSIS method was applied to achieve the final ranking for the selected technologies. Web Dynpro ABAP was identified as the best technology that selection criteria or other methods to determinate the relative weights for criteria, it is possible to have a modified order of preference.

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